Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Appendix B

Economics

March 2015

LEONARDO, NEW JERSEY – ECONOMIC APPENDIX

INTRODUCTION

Purpose

This appendix presents the economic analysis used in the determination of the economic viability for federal participation in the Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey, Coastal Storm Risk Management Feasibility Study (Leonardo CSRM study). Benefits were calculated for plans that are anticipated to be the most effective with respect to local support, survivability, and flood risk management criteria. Alternatives were screened for relative cost-effectiveness based on the level of without and with-project damages, and preliminary estimates of benefits and costs. The initial screening of alternatives was performed in 2009 with October 2008 price levels and 4.375% interest rate. The result of the analysis determined that none of the structural alternatives were cost effective and the only economically viable plans were nonstructural alternatives. Rescreening the prior alternatives based on current hydrologic & hydraulic data as well as current structural and economic conditions will not change the prior findings that the structural plans were not cost-effective. This appendix will present the prior alternative screening analysis and the current nonstructural analysis.

Benefit Types

Benefits to be derived from the plan of improvement include:

1. Reduced inundation damage to structures and contents
2. Reduced public emergency costs
3. Reduced Federal Insurance Administration (FIA)[1] administrative costs
4. Reduced bulkhead and road damages

Conditions

This appendix presents a description of the method used to develop damages and benefit-to-cost ratios, and is in accordance with ER 1105-2-100. The screening of alternative plans used an October 2008 price level and 4.375% discount rate for cost and benefits calculations. The post Hurricane Sandy analysis will use the October 2014 price level and 3.375% interest rate.

DESCRIPTION OF STUDY AREA

The study area is located in the northeastern portion of Middletown Township in Monmouth County, New Jersey. It occupies a ½ square mile area of land along the coast of the Sandy Hook Bay and is dominated by a small knoll with a maximum elevation of +39 ft North Atlantic Vertical Datum of 1988 (NAVD88). The study area is defined by

[1] FIA is the former name of the Federal Insurance Mitigation Administration

the Sandy Hook Bay to the north, Wagner Creek to the east, New Jersey State Route 36 to the south, and the US Naval Weapons Station Earle (Naval Pier) to the west in the vicinity of Ware Creek. All creeks in the study area flow north into Sandy Hook Bay.

Leonardo is a fully developed, permanent year round residential community characterized by single family residences. The shoreline includes a mix of public and private land. The western shoreline (Beach Avenue and areas further west) is characterized by narrow beaches while the eastern area (east of Beach Avenue) contains a mixture of private bulkheads.

There is a private marina at Wagner Creek as well as a state-operated marina in the northwest part of town. The state marina contains 176 berths with a maximum draft of 6 feet and a maximum length of 50 feet. The marina also has charter/head boats, launch ramp, winter wet storage, gas and diesel fuel, holding tank pump out, ice, bait and tackle, luncheonette and shower/sanitary facilities.

Relatively little has changed in Leonardo since 1969 with regard to interior drainage and tidal flood control. Historically, the Leonardo area experiences most of its problems from tidal surges caused by severe storms resulting in the inundation of structures between the low-lying marsh near Ware Creek and Wagner Creek. Tidal floodwaters enter the marina and creeks, and quickly spread over the broad low-lying floodplain throughout the area. Past local efforts have been directed toward providing beach fill to prevent storm wave attack on shorefront properties.

Demographics

Population. According to the year 2010 Census, the population of Leonardo was 2,757 persons. Of these, 1,904 (69.1%) are of working age (16 years or older) and 1,421 (55.8%) are in the civilian labor force. The median age of the population in Leonardo is 40.2 years. Between 2000 and 2010, the population of Leonardo decreased by 2.3%. Tables 1 - 2 summarize the population data. Tables 3 - 4 provide a breakdown of employment statistics.

Table 1 – Population

Area Name	Census 2000	Census 2010	Percentage Change
New Jersey	8,414,350	8,791,894	4.5%
Monmouth County	615,301	630,380	2.5%
Leonardo	2,823	2,757	-2.3%

Table 2 - Population and Household Statistics Census 2010 Leonardo, Monmouth County, New Jersey						
	Leonardo		**Monmouth County**		**New Jersey**	
	Total	**%**	**Total**	**%**	**Total**	**%**
Total Population Sex and Age	2,757		630,380		8,791,894	
Male	1,337	48.5	306,654	48.6	4,279,600	48.7
Female	1,420	51.5	323,726	51.4	4,512,294	51.3
Under 5 years	168	6.1	34,755	5.5	541,020	6.2
18 years and over	2129	77.2	480,081	76.2	6,726,680	76.5
65 years and over	286	10.4	86,691	13.8	1,185,993	13.5
Median Age	40.2		41.3		37.4	

Table 3 – Employment Data U.S. Census 2009-2013 American Survey, 5-Year Estimate			
Employment Status	**Leonardo**	**Monmouth County**	**New Jersey**
Population Aged 16 years or over	1,904	501,783	7,028,795
In Civilian Labor Force	1,421	335,366	4,669,577
Employed	1,262	305,222	4,197,483
Unemployed	159	30,144	472,094
% Unemploymed	8.4%	6.0%	6.7%

TABLE 4 - Employed Civilian Population (workers 16 years and older) U.S. Census 2009-2013 American Community Survey 5-Year Estimate						
Industry	**Leonardo**		**Monmouth County**		**New Jersey**	
Agriculture, forestry, fishing and hunting, and mining	8	0.6%	1,359	0.4%	14,692	0.4%
Construction	98	7.8%	19,547	6.4%	233,339	5.6%
Manufacturing	42	3.3%	18,786	6.2%	369,927	8.8%
Wholesale trade	6	0.5%	10,412	3.4%	147,576	3.5%
Retail trade	154	12.2%	35,181	11.5%	469,108	11.2%
Transportation and warehousing, and utilities	109	8.6%	15,513	5.1%	236,692	5.6%
Information	83	6.6%	10,936	3.6%	123,121	2.9%
Finance, insurance, real estate, and rental and leasing	63	5.0%	31,717	10.4%	368,865	8.8%
Professional, scientific, management, administrative, and waste management services	199	15.8%	38,703	12.7%	529,294	12.6%
Educational, health and social services	275	21.8%	70,109	23.0%	981,817	23.4%
Arts, entertainment, recreation, accommodation and food services	109	8.6%	26,526	8.7%	344,102	8.2%
Other services (except public administration)	59	4.7%	12,193	4.0%	189,508	4.5%
Public administration	57	4.5%	14,240	5%	189,442	4.5%
Total	1,262	100%	305,222	100%	4,197,483	100%

Income. The median household income in Leonardo is $60,486 or $35,806 per capita. Approximately 8% of families and 10% of the population live below the poverty level, table 5. The total number of housing units in Leonardo is 1,055; of these, approximately 320 structures are in the study area of which approximately 190 structures are subject to damages resulting from a 1% annual chance storm. According to the Census Bureau, the median value of all owner occupied units is $320,400. The total depreciated structure value in the study area is approximately $47 million at October 2013 price levels.

Table 5 – Comparison of Incomes from U.S. Census 2009-2013 American Community Survey 5-Year Estimate			
Characteristic	**Leonardo**	**Monmouth**	**New Jersey**
Per Capita Income	$35,806	$42,749	$36,027
Median Household Income	$60,486	$84,526	$71,629
Families Below Poverty Line (% of Families)	8.0	5.1	7.9
Individual Below Poverty Line (% of Population)	9.9	7.0	10.4
Medium Value of Owner Occupied Housing Unit	$320,400	$389,900	$327,100

DESCRIPTION OF THE PROBLEM

Extratropical storms ("northeasters") and hurricanes historically impact the Raritan and Sandy Hook Bayshore areas. These storms produce wind and wave-driven surges that cause extensive flooding and erosion within the study area. The shoreline composition has been greatly altered with time. Storm-induced erosion has removed much of the beachfront and has accelerated deterioration of the existing coastal risk management and drainage structures. Storm surges also frequently block existing storm water outlets, resulting in interior flooding.

Table 6 shows the number of structures susceptible to flooding at various flood levels.

TABLE 6 – Structures Susceptible to Flooding		
Still Water Flood Level (+ft NAVD88)	Number of Structures Impacted	
	Ground Elevation Below flood level	Main Floor Below flood level
8.9	113	38
9.9	136	55
10.9	189	83
11.9	207	123
12.9	248	159

Historical storms impacting the area include the September 14, 1944, hurricane; extratropical storms of November 25, 1950, and November 6-7, 1953; Hurricane Donna (September 12, 1960); the March 6-8, 1962 Nor'easter; the March 12, 1984 Nor'easter; the December 11, 1992 Nor'easter; the March 12, 2010 storm, the 1993 Blizzard (March 12-14), and most recently, Hurricane Sandy from October 29-30, 2012. These storms have resulted in transportation problems such as damaged roads and bridges; damage or destruction of shoreline structures, utility lines and roadways; and the damage of homes and commercial properties.

During the December 11, 1992, northeaster (4% flood), low-lying homes adjacent to the state-operated marina suffered significant flood damage. The road at the intersection of North Leonard Avenue and Beach Avenue was undermined and washed out. Bulkheads and seawalls along the eastern shoreline were severely damaged exposing the nearby residences to direct storm impacts. The beach on both sides of the marina experienced severe erosion. Sections of dunes were destroyed and the remaining section was severely eroded. The berm elevation was lowered by approximately 2.5 feet, exposing structures to future storm damage.

During Hurricane Sandy, within Middletown Township (Leonardo is an unincorporated community within Middletown: 322 structures experiences superficial damage (lost tiles, shingles, more severe damage to lighter structures); 98 had minor damage (missing roof segments; destroyed or displaced lighter structures); 8 had major damage (missing roofs, partial collapse of structure walls); and 3 structures were completely destroyed or washed away.

WITHOUT PROJECT FUTURE CONDITIONS

It is expected that storms will continue to occur in the future, causing damage in Leonardo, NJ. Tidal inundation is expected to increase gradually over time, in direct relation to the anticipated rise in relative sea level. Based upon long-term trends measured at Sandy Hook, 0.014-foot per year increase anticipated, resulting in a 0.7-foot increase over the 50-year period of analysis for the project.

FLOOD DAMAGE

General

The analysis of flood damage utilized the following steps:

- Inventory floodplain development
- Estimate depreciated replacement costs
- Assign damage functions
- Assign evaluation reaches
- Calculate aggregate stage vs. damage relationships

The flood damage calculations were performed using Microsoft Excel with Palisade's @ Risk for Excel add-in. This program adds Monte Carlo simulation capabilities and incorporates uncertainty inputs to calculate expected damage values. The following areas of uncertainty were incorporated into the calculation of flood damage:

- stage-frequency for each flood event
- first floor elevation
- depreciated structure and contents value

The stage-frequency relationships incorporate the standard deviations can be found in the Engineering Appendix. Based on EM 1110-2-1619 Table 6-5, the first floor elevation standard deviation is approximately 0.6 foot when using topographic mapping using 2-ft contour intervals. The variation in structure value was estimated using a normal distribution with a 10% standard deviation.

Inventory Method

The structure data was obtained through an on-site survey of the area using topographic mapping with a scale of 1 inch = 200 feet with a 2-foot contour interval. The inventory was limited to categorizing structures by type and elevation, and identifying the typical structure value. Structure value is calculated based on RS Means Square Foot Costs manual.

Federal Insurance Administration damage functions for structure and contents damages were applied to the residential and non-residential structures. Public emergency damages were calibrated as a percentage of structure value based on local FEMA damage reports. The damage functions reflect damages as a percent of structural value over a full range of water depths and were applied on a structure-by-structure basis to determine damages at one-tenth-of a foot increments of flood stage. Similarly, depth damage functions developed by Natural Resource Conservation Services were applied to calculate automobile damages.

EXTENT AND SCOPE OF ALTERNATIVES

General

The continuation of the damage potential associated with the conditions described above, there is an opportunity for alternative measures to be taken for storm risk management. The study area requires an effective storm risk management program that would provide adequate levels of risk management against flooding and storm driven waves. Roads and infrastructure are subject to flooding and require risk management to ensure their integrity. These measures could consist of structural and nonstructural measures or combinations thereof.

Structural Alternatives

Six structural alternatives were developed to provide coastal storm risk management along the bayfront. The primary damage mechanism in the area is flooding associated with elevated storm stages and waves. Each structural plan consists of an alignment that would prevent storm surge inundating low-lying developed areas. Each plan was designed to the one percent flood design elevation. Structural Plans S1 through S5 also require drainage improvements to avoid trapping runoff behind the alignment. The alternative screening assumes that a series of small storm water pumps will meet the interior drainage needs. Alternatives S1-S4 also include flood proofing or elevating buildings that lie outside of the alignment. The bayfront alternatives that were considered (which include floodwall/levee tiebacks) include:

Alternative S1: A seawall plan that would provide risk management to the area from Cedar Avenue to Wagner Creek.

Alternative S2: A beach fill plan that would provide risk management to the same area as Alternative S1.

Alternative S3: A combination beach fill and seawall plan that would provide risk management to the same area as Alternatives S1 and S2
.
Alternative S4: Similar to Alternative S3 but would only protect the area from Cedar Avenue to Brevent Avenue.

Alternative S5: A beach fill and seawall plan that would provide risk management to the area from the state marina to Brevent Avenue.

Alternative S6: A road raising plan that would provide risk management to a limited area to the south of Burlington Avenue and Ocean Boulevard.

Alternatives S1, S2 and S3 would be constructed and maintained for 5,850 feet of bayfront shoreline. Alternative S4 would be constructed and maintained for 4,700 ft of bayfront shoreline and Alternative S5 would be constructed and maintained for 2,400 ft of bayfront shoreline. Alternatives S1, S2 and S3 would provide risk management to the entire community of Leonardo from elevated storm surges. Under these alternatives, any areas outside of the alignment would receive nonstructural treatments. Alternative S4 would not provide coastal storm risk management eastward of Brevent Avenue. Alternative S5 would not provide coastal storm risk management to east of Brevent Avenue and to the area west of the state marina.

Alternative S6 would provide risk management to an even more limited area south and west of the intersection of Burlington and Ocean Avenues from large storm events. This alternative would consist solely of raising the intersection of Ocean Boulevard and Burlington Avenue, for approximately 400 ft of roadway. This would prevent higher storm surges from entering low-lying areas landward of the Ocean Boulevard intersection

with Burlington Avenue, while providing for the free flow of traffic at all times. Interior runoff trapped by the raised road would drain out through drop inlets connected to a drain pipe fitted with a flap gate. It was subsequently determined that the flooding problem addressed by this alternative was related to interior drainage rather than costal storms. S6 was not carried further but is included in this discussion to document the study history.

Nonstructural Alternatives

Five nonstructural plans involving flood proofing/building retrofitting of structures were evaluated. The five nonstructural alternative plans considered would provide coastal storm risk management to structures within the 20 percent, four percent and one percent floodplains based on the following criteria:

1) The design elevation of +13.1 ft NAVD88 was used for the first three plans. It consisted of the one percent flood stillwater elevation in 1998 (+10.7 ft NAVD88) plus the historic sea level rise (0.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard.
2) A fourth plan within the 20 percent floodplain was developed for the 10 percent flood design elevation (+9.9 ft NAVD88). The design elevation differed from the one percent flood design elevation only in the Stillwater elevation.
3) A fifth nonstructural plan was developed based on main floor elevation. The fifth nonstructural plan includes managing risk to structures with the main floor less than or equal to +9.4 ft NAVD88 (4 percent flood) to +13.1 ft NAVD88.

Alternative N1: Nonstructural plan for structures in the 20% floodplain. Buildings in the 20% floodplain have a 20% risk of flooding in any given year and have ground elevations below +6.9 ft NAVD88. The structures would be elevated to the design elevation of +13.1 ft NAVD88 was used, which consisted of the one percent flood stillwater elevation in 1998 (+10.7 ft NAVD88) plus the historic sea level rise (.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard. Preliminary assessment indicated that 23 elevations would be required.

Alternative N2: Nonstructural plan for structures in the 4% floodplain. The buildings in this floodplain include structures with ground elevations below +9.4 feet NAVD88. The structures would be elevated to the design elevation of +13.1 ft NAVD88 was used, which consisted of the one percent flood stillwater elevation in 1998 (+10.7 ft NAVD88) plus the historic sea level rise (.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard. Preliminary assessment indicated that 99 elevations would be required.

Alternative N3: Nonstructural plan for structures in the one percent floodplain. The structures would be elevated to the design elevation of +13.1 ft NAVD88 was used, which consisted of the one percent flood stillwater elevation in 1998 (+10.7 ft NAVD88)

plus the historic sea level rise (.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard. This plan includes all structures that have ground elevations below elevation +11.4 feet NAVD88. Preliminary assessment indicated that 1 ring wall and 160 elevations would be required.

Alternative N4: Nonstructural plan. Similar to Alternative N1, Alternative N4 has evaluated a lower flood design elevation for buildings in the 20% floodplain. Instead of designing to the one percent flood (as was the case for Alternative N1), this alternative (N4) would only design to the 10% flood elevation with an added 1 ft of freeboard in addition to the 0.7 ft allowance for sea level rise and 50% of the wave setup contribution (0.7 ft), resulting in +9.9 ft NAVD88 as the design elevation. Preliminary assessment indicated that 18 elevations would be required.

Alternative N5: Alternatives N1 through N4 were developed based on the number of structures within a given floodplain. However, many structures in the project area have elevated main floors such that while they may be located within an area that experiences frequent flooding, the structures themselves do not suffer significant recurring damages. Thus, an alternate approach was taken to identify structures for nonstructural coastal storm risk management: structures were identified for nonstructural improvement by main floor elevation. Alternative N5 is a nonstructural plan that includes structures with the main floor less than or equal to +9.4 ft NAVD88 (4% flood). In order to identify those structures most susceptible to damage, only those structures with a ground elevation less than +7.9 ft NAVD88 were considered. The buildings in this floodplain are designed to the one percent flood design elevation with 1 foot of freeboard and a 0.7-ft allowance for sea level rise and 50% of the wave setup contribution (0.7 ft) to establish a flood proofing design elevation of +13.1 ft NAVD88. Structures with a main floor elevation above +9.4 ft NAVD88 would be expected to experience only limited damage up to the 4% flood event. Preliminary assessment indicated that 25 elevations would be required.

While the nonstructural alternatives avoid impacts to adjacent wetlands, they do not provide 100% flood risk management to flood-prone areas. Nonstructural alternatives would only provide flood risk management for the impacted structures and their contents. Damage to outside property (*i.e.*, landscaping, parking lots, garages, vehicles, etc.) would still occur by the implementation of nonstructural measures. Also, since the area would still continue to be impacted by flood water, the area would continue to incur costs for emergency response associated with roadway closures, emergency transportation, and post-storm debris cleanup. It must be stressed that the various nonstructural plans do not all provide flood risk management to the same number of buildings as did the structural alternatives previously described. If a nonstructural plan were implemented, residents and businesses would still have to evacuate the floodplain during severe storm events.

AVERAGE ANNUAL DAMAGES

Structural Alternatives

Alternatives S1, S2, and S3: These three structural alternatives were designed to the one percent flood design elevation from Cedar Avenue to Wagner Creek. The categories of benefits calculated are 1) structure and content damages prevented. 2) bulkhead/seawall replacement costs prevented, 3) emergency and clean up costs avoided, 4) evacuation and relocation costs avoided, 5) beach recreation benefits, 6) roads and utilities damages prevented, 7) automobile damages prevented, 8) FIA administrative costs avoided, 9) marina damages prevented. Equivalent annual benefits for alternative plan S1 are $901,900 as shown in Table 7. Alternative plan S1 does not have a beach fill component, and therefore recreation benefits are not included. Equivalent annual benefits for alternative S2 are $1,040,800 as shown in Table 8. Equivalent annual benefits for alternative plan S3 are $948,200 as shown in Table 9. Alternative S3's beach fill component is one-third the size of alternative S2 and the recreation benefits have been reduced by two thirds.

1) Structures and Contents Damages Prevented: In order to estimate potential flood damages to structures and contents, properties in Leonardo were inventoried. Replacement costs of structures were estimated using RS Means Square Foot Costs manual. Structure characteristics (elevation, building material, number of floors, basement or no basement) were collected through site visits. The computation of damages for various levels of flooding was accomplished using Flood Insurance Administration depth-damage functions for residential properties. A content-to-structure ratio of 43.5 percent was used for the residences in the analysis. Sea level rise of 0.014 ft per year was incorporated into the stage elevation. Risk and uncertainty was incorporated by using risk distributions to provide confidence intervals around the mean structure value, first floor elevations, and stage elevations. Multiplying the difference in probability by the average damages derived the estimated average annual damages. There are currently 189 structures within the one percent floodplain for this area. The without-project structure and content damages for this plan are $476,000 and the with-project damages are $79,900. Total equivalent annual benefits from a design to the one percent flood design elevation are $396,100.

2) Bulkhead/Seawall Replacement Costs Prevented: Within the first 10 years of without-project life, it is estimated that the existing bulkheads/seawalls will fail from overtopping from a minimum four percent flood. After the tenth year, the bulkheads/seawalls will fail from scour fronting the wall as a result of the effects of long-term erosion. The estimated cost of wall replacement is approximately $1,460,000. Therefore, the equivalent annual replacement costs saved are calculated to be $177,800.

3) Public Emergency and Clean up Costs Avoided: Significant public emergency costs were expended during the 1992 December storm and earlier significant events. With a project in place, it is estimated that $3,750 in equivalent annual emergency and clean-up costs will be avoided.

4) Evacuation and Relocation Costs Avoided: An estimate was made as to emergency evacuations that would be required during significant storm events. Using the government per diem rate for the area of $174 per day per individual, it is estimated that $12,000 in equivalent annual evacuation, relocation and subsistence costs would be avoided.

5) Restoration of Beach Recreation: Currently there is little recreational beach in the project area. With a project, recreational beach use will be restored. It is estimated that with the project the average annual beach recreational usage at Leonardo will be approximately 31,000 a year. The unit day values (UDV) for general recreation for FY 2009 range from $3.59 to $10.77. Using the criteria and judgment factors contained in Economics Guidance Memorandum EGM 09-03, an UDV of $4.48 was derived. Equivalent annual beach recreation benefits to the project are $138,900 (31,000 x $4.48). Alternative plan S1 does not have a beach fill component, and therefore recreation benefits are not included. Alternative S3's beach fill component is one-third the size of alternative S2 and the recreation benefits have been reduced by two thirds.

6) Roads and Utilities Damages Prevented: Infrastructure improvements ranging from gas, water, and electric lines, to sewage and storm water and telephone facilities will suffer damages from storms. The equivalent annual benefits are estimated at $180,600 for with-project conditions.

7) Automobile Damages Prevented: Automobiles are highly susceptible to damage from flooding. Assuming one car valued at an average of $10,000 per floodplain structure, and parked at each house approximately 65% of the time, the equivalent annual automobile damages prevented are $36,200.

8) Marina Facilities Damages Prevented: Based on historical records, damages have been suffered from past storms to Marina facilities and boats. An estimate was made based on these records, yielding an anticipated equivalent annual benefit of $58,000 in damage prevented to Marina facilities with project.

9) FIA Administrative Costs Avoided: FIA administrative costs avoided are based on the number of structures within the 1% annual chance floodplain, which, with project, will no longer need flood insurance. These benefits are calculated to be $36,300 annually.

Table 7. Leonardo, NJ
Alternative S1
Equivalent Annual Benefit
Alignment from Cedar Avenue to Wagner Creek
October 2008 Price Levels and 4 3/8% Interest Rate

Structure and Content Damages Prevented	$396,100
Bulkhead/Seawall Replacement Costs Prevented	$177,800
Emergency and Clean up Costs Avoided	$4,900
Evacuation and Relocation Costs Avoided	$12,000
Roads & Utilities Damages Prevented to	$180,600
Automobiles Damages Prevented	$36,200
Marina Damages Prevented	$58,000
FIA Administrative Costs Avoided	$36,300
TOTAL	**$901,900**

Table 8. Leonardo, NJ
Alternative S2
Equivalent Annual Benefit
Alignment from Cedar Avenue to Wagner Creek
October 2008 Price Levels and 4 3/8% Interest Rate

Structure and Content Damages Prevented	$396,100
Bulkhead/Seawall Replacement Costs Prevented	$177,800
Emergency and Clean up Costs Avoided	$4,900
Evacuation and Relocation Costs Avoided	$12,000
Beach Recreation	$138,900
Roads & Utilities Damages Prevented to	$180,600
Automobiles Damages Prevented	$36,200
Marina Damages Prevented	$58,000
FIA Administrative Costs Avoided	$36,300
TOTAL	**$1,040,800**

Table 9. Leonardo, NJ
Alternative S3
Equivalent Annual Benefit
Alignment from Cedar Avenue to Wagner Creek
October 2008 Price Levels and 4 3/8% Interest Rate

Structure and Content Damages Prevented	$396,100
Bulkhead/Seawall Replacement Costs Prevented	$177,800
Emergency and Clean up Costs Avoided	$4,900
Evacuation and Relocation Costs Avoided	$12,000
Beach Recreation	$46,300
Roads & Utilities Damages Prevented to	$180,600
Automobiles Damages Prevented	$36,200
Marina Damages Prevented	$58,000
FIA Administrative Costs Avoided	$36,300
TOTAL	**$948,200**

Alternative S4: This alternative provides coastal storm risk managment to the structures from Cedar Avenue to Brevent Avenue. The categories of benefits calculated are 1) structure and content damages prevented. 2) bulkhead/seawall replacement costs prevented, 3) emergency and clean up costs avoided, 4) evacuation and relocation costs avoided, 5) beach recreation benefits, 6) roads and utilities damages prevented, 7) automobile damages prevented, 8) FIA administrative costs avoided, 9) marina damages prevented. Estimated equivalent annual benefits for alternative plan S4 are $604,000 as shown in Table 10.

1) Structures and Contents Damages Prevented: There are 154 structures within the one percent floodplain for this area. The without-project structure and content damages for

this plan are $367,900 and the with-project damages are $60,100. Total equivalent annual damages for a design to the one percent design flood elevation are $307,800.
2) Bulkhead/Seawall Replacement Costs Prevented: The length of bulkhead/seawall has been reduced by 2/3. Therefore, the equivalent annual replacement costs saved are calculated to be $59,300.

3) Public Emergency and Clean up Costs Avoided: These equivalent annual benefits were calculated to be $4,100.

4) Evacuation and Relocation Costs Avoided: An estimate was made as to emergency evacuations that would be required during significant storm events. Using the government per diem rate for the area of $174 per day per individual, it is estimated that $9,700 in equivalent annual evacuation, relocation and subsistence costs would be avoided.

5) Restoration of Beach Recreation: Currently there is little recreational beach in the project area. With a project, recreational beach use will be restored. It is estimated that with the project the average annual beach recreational usage at Leonardo will be approximately 10,330 a year. The unit day values (UDV) for general recreation for FY 2009 range from $3.59 to $10.77. Using the criteria and judgment factors contained in Economics Guidance Memorandum EGM 09-03, an UDV of $4.48 was derived. Average annual beach recreation benefits to the project are thus $46,300 (10,330 x $4.48).

6) Roads and Utilities Damages Prevented: The estimated length of road to receive coastal storm risk management is now 1/3 of the full-length plan. The damages prevented are prorated and estimated to be $60,200 for with-project conditions.

7) Automobile Damages Prevented: Automobiles are highly susceptible to damage from flooding. Assuming one car valued at an average of $10,000 per floodplain structure, and parked in front of each house approximately 65% of the time, the equivalent annual automobile damages prevented are $29,000.

8) Marina Facilities Damages Prevented: Based on historical records, damages have been suffered from past storms to Marina facilities and boats. An estimate was made based on these records, yielding an anticipated equivalent annual benefit of $58,000 in damage prevented to Marina facilities with project.

9) FIA Administrative Costs Avoided: FIA administrative costs avoided are based on the number of structures within the one percent floodplain, which, with project, will no longer need flood insurance. These benefits are calculated to be $29,600 annually.

Table 10 - Leonardo, NJ
Alternative S4
Equivalent Annual Benefit
Alignment from Cedar Avenue to Brevent Avenue
October 2008 Price Levels and 4 3/8% Interest Rate

Structure and Content Damages Prevented	$307,800
Bulkhead/Seawall Replacement Costs Prevented	$59,300
Emergency and Clean up Costs Avoided	$4,100
Evacuation and Relocation Costs Avoided	$9,700
Beach Recreation	$46,300
Roads & Utilities Damages Prevented to	$60,200
Automobiles Damages Prevented	$29,000
Marina Damages Prevented	$58,000
FIA Administrative Costs Avoided	$29,600
TOTAL	**$604,000**

Alternative S5: This alternative provides coastal storm risk management to the structures from Benton Avenue to Brevent Avenue. The categories of benefits calculated are 1) structure and content damages prevented. 2) bulkhead/seawall replacement costs prevented, 3) emergency and clean up costs avoided, 4) evacuation and relocation costs avoided, 5) beach recreation benefits, 6) roads and utilities damages prevented, 7) automobile damages prevented, 8) FIA administrative costs avoided. Estimated benefits for alternative S5 are $396,800 annually as shown in Table 11.

1) Structures and Contents Damages Prevented: There are 65 structures within the one percent floodplain for this area. The without-project structure and content damages for

this plan are $227,000 and the with-project damages are $28,200. Total equivalent annual benefits designed to the one percent flood design elevation are $198,800.

2) Bulkhead/Seawall Replacement Costs Prevented: The length of bulkhead/seawall has been reduced by 2/3. Therefore, the equivalent annual benefits have been prorated and estimated to be $59,300.

3) Public Emergency and Clean-up Costs Avoided: These costs were calculated to be $2,800.

4) Evacuation and Relocation Costs Avoided: An estimate was made as to emergency evacuations that would be required during significant storm events. Using the government per diem rate for the area of $174 per day per individual, it is estimated that $4,400 in equivalent annual evacuation, relocation and subsistence costs would be avoided.

5) Restoration of Beach Recreation: Currently there is little recreational beach in the project area. With a project, recreational beach use will be restored. It is estimated that with the project the average annual beach recreational usage at Leonardo will be approximately 10,330 a year. The unit day values (UDV) for general recreation for FY 2009 range from $3.59 to $10.77. Using the criteria and judgment factors contained in Economics Guidance Memorandum EGM 09-03, an UDV of $4.48 was derived. Average annual beach recreation benefits to the project are thus $46,300 (10,330 x $4.48).

6) Roads and Utilities Damages Prevented: The estimated length of road to be receive coastal storm risk management is now 1/3 of the full-length plan. The equivalent annual benefits are prorated and estimated to be $60,200 for with-project conditions.

7. Automobile Damages Prevented: Automobiles are highly susceptible to damage from flooding. Assuming one car valued at an average of $10,000 per floodplain structure, and parked in front of each house approximately 65% of the time, the equivalent annual benefits are $12,500.

8. FIA Administrative Costs Avoided: FIA administrative costs avoided are based on the number of structures within the one percent floodplain, which, with project, will no longer need flood insurance. These benefits are calculated to be $12,500 annually.

Table 11 - Leonardo, NJ
Alternative S5
Equivalent Annual Benefit
Alignment from Cedar Avenue to Brevent Avenue
October 2008 Price Levels and 4 3/8% Interest Rate

Structure and Content Damages Prevented	$198,800
Bulkhead/Seawall Replacement Costs Prevented	$59,300
Emergency and Clean up Costs Avoided	$2,800
Evacuation and Relocation Costs Avoided	$4,400
Beach Recreation	$46,300
Roads & Utilities Damages Prevented to	$60,200
Automobiles Damages Prevented	$12,500
FIA Administrative Costs Avoided	$12,500
TOTAL	**$396,800**

Alternative S6: This alternative is to raise the road at the intersection of Ocean Boulevard and Burlington Avenue to provide flood damage reduction for the 43 structures located in a depression area landward of this street intersection. The categories of benefits calculated are 1) structure and content damages prevented. 2) emergency and clean up costs avoided, 3) evacuation and relocation costs avoided, 4) automobile damages prevented, 5) FIA administrative costs avoided. Equivalent annual benefits for alternative S6 are $21,300 as shown in Table 12.

1. Structures and Contents Damages Prevented: There are 43 structures within the one percent floodplain for this area. The without-project structure and content damages for this plan are $17,200 and the with-project damages are $8,600. Equivalent annual benefits designed to the one percent flood design elevation are $8,600.

2. Public Emergency and Clean-up Costs Saved: These costs were calculated to be $120.

3. Evacuation, Relocation, and Substance Costs Saved: An estimate was made as to emergency evacuations that would be required during significant storm events. Using the government per diem rate for the area of $174 per day per individual, it is estimated that $3,000 in equivalent annual evacuation, relocation and subsistence costs would be saved.

4. Automobile Damages Prevented: Automobiles are highly susceptible to damage from flooding. Assuming one car valued at an average of $10,000 per floodplain structure, and parked in front of each house approximately 65% of the time, the equivalent annual benefits are $1,250.

5. FIA Administrative Costs Saved: FIA administrative costs saved are based on the number of structures within the one percent floodplain, which, with project, will no longer need flood insurance. These benefits are calculated to be $8,300 annually.

Leonardo, NJ
Table 12 - Alternative S6
Equivalent Annual Benefit
Raised Road at Ocean Boulevard and Burlington Avenue
October 2008 Price Levels and 4 3/8% Interest Rate

Structure and Content Damages Prevented	$8,600
Emergency and Clean up Costs Avoided	$120
Evacuation and Relocation Costs Avoided	$3,000
Automobiles Damages Prevented	$1,250
FIA Administrative Costs Avoided	$8,300
TOTAL	**$21,270**

Nonstructural Alternatives

Alternative N1: This is a nonstructural plan to flood proof 23 structures in the 20% floodplain to the one percent flood design elevation with 1 ft of freeboard and a 0.7-ft allowance for sea level rise (design elevation of +13.1 ft NAVD88). The without-project

structure and content damages for this plan are $390,300 and the with-project damages are $245,100. The structure and content damages reduced from this alternative is $145,200 and the FIA administrative costs avoided are $4,400. Equivalent annual benefits for this plan are $149,600.

Alternative N2: This is a nonstructural plan to flood proof 99 structures in the 4% floodplain to the one percent flood design elevation with 1 ft of freeboard and a 0.7-ft allowance for sea level rise (design elevation of +13.1 ft NAVD88). The without-project structure and content damages for this plan are $390,300 and the with-project damages are $75,500. The structure and content damages reduced from this alternative is $314,800 and the FIA administrative costs avoided are $19,000. Equivalent annual benefits for this plan are $333,800.

Alternative N3: This is a nonstructural plan to flood proof 161 structures in the one percent floodplain to the one percent flood design elevation with 1 ft of freeboard and a 0.7-ft allowance for sea level rise (design elevation of +13.1 ft NAVD88). The without-project structure and content damages for this plan are $390,300 and the with-project damages are $45,600. The structure and content damages reduced from this alternative is $344,700 and the FIA administrative costs avoided are $30,900. Equivalent annual benefits for this plan are $375,600.

Alternative N4: This is a nonstructural plan to flood proof 18 structures in the 20% floodplain to the 10% flood design elevation with 1 ft of freeboard and a 0.7-ft allowance for sea level rise (design elevation of +9.9 ft NAVD88). The without-project structure and content damages for this plan are $116,900 and the with-project damages are $52,500. FIA administrative costs avoided are not claimed because main floor elevations are not above the one percent flood. Equivalent annual benefits from this alternative are $64,400.

Alternative N5: This is a nonstructural plan to flood proof 25 structures that have ground elevations less than +7.9 ft NAVD88 with main floor elevations less than or equal to +9.4 ft NAVD88 to the one percent flood design elevation with 1 ft of freeboard and a 0.7-ft allowance for sea level rise (design elevation of +13.1 ft NAVD88). The without-project structure and content damages for this plan are $187,400 and the with-project damages are $6,500. The structure and content damages reduced from this alternative is $180,900 and the FIA administrative costs avoided are $4,800. Equivalent annual benefits for this plan are $185,700.

Summary of Structure and Content Damages

Table 13 summarizes the without-project and with project structure and content annual damage discussed in Structural Alternatives S1-S6 and Nonstructural Alternatives N1-N5 that were discussed in the preceding alternative descriptions.

Table 13 Summary of Structure and Content Equivalent Annual Damages				
Alternative	Description	Without-Project	With-Project	Benefit
S1	Seawall Plan	$476,000	$79,900	$396,100
S2	Beach Fill Plan	$476,000	$79,900	$396,100
S3	Combination Beach Fill & Seawall Plan	$476,000	$79,900	$396,100
S4	Combination Plan West of Brevent Avenue	$367,900	$60,100	$307,800
S5	Limited Structural Plan	$227,000	$28,200	$198,800
S6	Limited Road Raising Plan	$17,200	$8,600	$8,600
N1	20% percent Floodplain Nonstructural (1)	$390,300	$245,100	$145,200
N2	4% percent Floodplain Nonstructural (1)	$390,300	$75,500	$314,800
N3	1% percent Floodplain Nonstructural (1)	$390,300	$45,600	$344,700
N4	20% percent Floodplain Nonstructural (2)	$116,900	$52,500	$64,400
N5	Main Floor at or below +9.4 ft NAVD88 & Ground Elevation below +7.9 ft NAVD88	$187,400	$6,500	$180,900
(1) Designed to the 1% flood design elevation				
(2) Designed to the 10% flood design elevation				
October 2008 price level, 4.375% interest rate				

COMPARISON OF ALTERNATIVE PLANS

The analysis of coastal storm risk management measures for the Leonardo area considered an array of both structural and nonstructural alternatives. The alternatives were compared to the planning objectives to determine which features should be considered for more detailed analysis. Project costs and benefits were evaluated for each alternative and shown in Table 14. Based on the results of the analysis, large and small-scale structural and widespread nonstructural alternatives do not appear to warrant Federal interest. Limited nonstructural alternatives, such as N1 and N5, are recommended for more detailed development, if locally acceptable. The results of the preliminary economic analysis indicate a marginal economic justification for Alternatives N1 and N5. Detailed alternative costs are shown in Table 3 of the main report.

Table 14 Summary of Costs and Benefits for All Alternatives

Alternative	Description	Total Cost	Equivalent Annual Cost (3)	Equivalent Annual Benefit	Net Benefit	BCR
S1	Seawall Plan	$30,097,200	$1,695,000	$901,900	-$793,100	0.53
S2	Beach Fill Plan	$31,507,600	$2,009,000	$1,041,000	-$968,000	0.52
S3	Combination Beach Fill & Seawall Plan	$31,130,700	$1,795,000	$948,200	-$846,800	0.53
S4	Combination Plan West of Brevent Avenue	$23,554,000	$1,389,000	$604,000	-$785,000	0.43
S5	Limited Structural Plan	$14,333,800	$817,000	$396,800	-$420,200	0.49
S6	Limited Road Raising Plan	$499,100	$28,000	$21,000	-$7,000	0.75
N1	20% percent Floodplain Nonstructural (1)	$2,379,000	$118,000	$150,000	$32,000	1.27
N2	4% percent Floodplain Nonstructural (1)	$11,025,600	$547,000	$333,800	-$213,200	0.61
N3	1% percent Floodplain Nonstructural (1)	$16,202,100	$803,000	$375,600	-$427,400	0.47
N4	20% percent Floodplain Nonstructural (2)	$1,570,500	$78,000	$64,000	-$14,000	0.82
N5	Main Floor at or below +9.4 ft NAVD88 & Ground Elevation below +7.9 ft NAVD88	$2,771,900	$137,000	$186,000	$49,000	1.36

(1) Designed to the 1% flood design elevation

(2) Designed to the 10% flood design elevation

(3) Includes Renourishment Cost, OMRR&R Cost

October 2008 price level, 4.375% interest rate

TENTATIVELY SELECTED PLAN

Background

The analysis of coastal storm risk management measures for the Leonardo area presented in the preceding paragraphs considered an array of both structural and nonstructural alternatives. The alternatives were compared to the planning objectives to determine which features should be considered for more detailed analysis. Based on the results of the analysis, it was determined that large-scale structural and widespread nonstructural alternatives do not appear to warrant Federal interest. However, limited nonstructural Alternatives N1 and N5 were found to be marginally cost effective and were recommended for more detailed development.

- Alternative N1 – Nonstructural plan for structures in the 20 percent floodplain where structures have a 20% chance of flooding in any given year. The 20 percent floodplain includes all structures that have ground elevations below +6.9 ft NAVD88. The structures would be elevated to the one percent flood design elevation of +13.1 ft NAVD88, which consisted of the one percent flood stillwater elevation in 2009 (+10.7 ft NAVD88) plus the historic sea level rise (.7 ft) plus 50% of the wave setup contribution (.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard.
- Alternative N5 – Nonstructural plan that includes treating structures with the main floor less than or equal to +9.4 ft NAVD88 (four percent flood). In order to identify those structures most susceptible to damage, only those structures with a ground elevation less than +7.9 feet NAVD88 were considered. The structures included in this alternative would be elevated to manage risk against a one percent flood design elevation (+13.1 ft NAVD88). Structures with a main floor elevation above +9.4 ft NAVD88 would be expected to experience only limited damage up to the four percent flood.

The strategy outlined below describes the process used to determine the scope of a nonstructural plan for Leonardo that would yield favorable National Economic Development benefits. Design criteria were then developed for the selected structures.

Affected Structures

Based on the prior 2009 analysis, 162 structures were identified as potential candidates for nonstructural flood risk management measures from existing topographic maps. It roughly correlated to structures with ground elevations at or below +10.9 ft NAVD88. A field investigation took place to capture any relevant changes to these structures since the 2009 analysis. Investigations revealed that several structures have been damaged or demolished and have not been rebuilt, while other structures have undergone renovations to expand their living space, have been elevated, or have been replaced by a new structure.

The descriptions of alternatives N1 and N5 were modified from the prior analysis to reflect the updated stage-frequency curves from 2014 (see Engineering Appendix) and the two alternatives have been combined to include structures that meet at least one of the following criteria

- All structures within the 20% floodplain, as determined by ground elevation +6.6 ft NAVD88 (2014 data), compared to elevation +6.9 ft NAVD88 for the 20% floodplain from the 1998 stage-frequency curves.
- All structures with a main floor elevation below +9.4 ft NAVD88

This final screening produced a list of 47 structures for further analysis.

Nonstructural Measures Considered

Nonstructural measures considered for the affected buildings included relocation, elevation, rebuild, ring walls/berms, dry flood proofing, and wet flood proofing. The analysis applied a generalized computer algorithm to the structures in the study area. The algorithm combined flood levels along with information about each structure (i.e., ground elevation, main floor elevation, type of construction, etc.) to identify the least cost nonstructural alternative to provide coastal storm risk management measures for each affected structure.

The results of the analysis indicated 25 structures as viable candidates for nonstructural risk management measures. The model used to calculate the benefits is HEC FDA version 1.2.5. The without-project structure dataset reflected existing conditions for each structure including foundation type, main floor elevation, and if a basement existed. The with-project structure dataset reflected each structure's changed conditions including elevation of foundation and elimination of basements. Adjustments to the HEC FDA model were made to change the damage look-up categories and the main floor elevations.

Equivalent Annual Benefits

The benefits of implementing nonstructural treatments represent flood damages avoided by the project. Benefits were calculated as the difference in damages before and after project implementation. Benefits were then amortized over a 50-year period to identify equivalent annual benefits using October 2014 price levels and an interest rate of 3.375%

Net Benefits

Net benefits are calculated by subtracting equivalent annual costs from equivalent annual benefits. Table 15 summarizes the net results of the Tentatively Selected Plan. Net benefits are $59,000 and this plan is economically justified.

Benefit to Cost Ratio

The benefit to cost ratio is calculated by dividing the annual benefits by the annual costs. The benefit to cost ratio for the Tentatively Selected Plan is 1.3.

Table 15 - Leonardo Tentatively Selected Plan October 2014 P.L. 3.375% interest rate							
Structure ID no.	**Ground Elev. (ft NAVD 88)**	**Main Floor Elev (ft NAVD 88)**	**Total First Cost**	**Equivalent Annual Cost**	**Without-Project Equivalent Annual Damages**	**With-Project Equivalent Annual Damages**	**Equivalent Annual Benefit**
4	6.9	8.9	$226,414	$9,436	$4,130	$270	$3,860
13	6.8	6.8	$253,260	$10,555	$6,780	$310	$6,470
14	8.9	8.9	$175,099	$7,298	$1,920	$150	$1,770
22	5.4	8.3	$175,099	$7,298	$16,360	$180	$16,180
23	4.9	8.3	$175,099	$7,298	$3,970	$140	$3,830
27	5.9	11.3	$251,709	$10,491	$1,560	$180	$1,380
38	6.9	12.7	$179,440	$7,479	$18,430	$190	$18,240
93	8.4	8.9	$298,186	$12,428	$7,670	$300	$7,370
149.1	6.9	9.9	$243,384	$10,144	$4,510	$140	$4,370
161	6.9	10.3	$220,448	$9,188	$2,640	$130	$2,510
179	6.4	10.4	$246,925	$10,291	$2,070	$270	$1,800
182	4.9	6.6	$303,233	$12,638	$26,040	$210	$25,830
185	5.4	10.1	$246,925	$10,291	$2,250	$260	$1,990
188	4.9	10.5	$181,947	$7,583	$27,410	$290	$27,120
189	4.9	10.4	$198,238	$8,262	$28,480	$370	$28,110
190	4.9	9.6	$187,676	$7,822	$19,980	$170	$19,810
191	5.9	9.8	$189,539	$7,899	$7,830	$90	$7,740
192	5.9	12.3	$211,387	$8,810	$2,230	$60	$2,170
196	4.9	9.2	$221,335	$9,225	$13,330	$50	$13,280
268	6.9	10.6	$280,354	$11,684	$45,850	$30	$45,820
313	6.9	8.9	$198,442	$8,271	$4,090	$70	$4,020
319	6.9	14	$155,504	$6,481	$3,840	$10	$3,830
337	8.9	8.9	$271,489	$11,315	$4,910	$310	$4,600
343	4.9	6.9	$216,555	$9,025	$21,170	$150	$21,020
345	6.9	13.6	$155,504	$6,481	$13,650	$90	$13,560
		Total	**$5,463,200**	**$227,700**	**$291,100**	**$4,400**	**$286,700**
		Net Benefits					**$59,000**
		Benefit to Cost Ratio					**1.3**