Upper Barataria Basin, Louisiana, Feasibility Study

Appendix B

Economics

Introduction. This appendix presents an economic evaluation of the flood risk reduction alternatives for the Upper Barataria Basin, Louisiana Feasibility Study. It was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies, ER 1110-2-1302 "Civil Works Cost Engineering" and the CSRM NED Manual. The National Economic Development Procedures Manual for Flood Risk Management, prepared by the Water Resources Support Center, Institute for Water Resources, was also used as a reference, along with the User's Manual for the Hydrologic Engineering Center Flood Damage Analysis Model (HEC-FDA).

1. Problem Identification

The headwater flooding from rainfall is intensified by tidal events, resulting in flood damages to industrial, commercial, and agricultural facilities as well as residential structures and critical evacuation routes. Tidal events can create a backwater effect that does not allow rainfall to drain from the basin. The study area has been declared a Federal disaster area nine times in the past 30 years due to flood damages from storms. A coastal storm damage risk management project in the study area will reduce the risk of flooding for residential and commercial structures, major transportation routes, and many other commercially and culturally significant places and activities vital to the economy of the region and nation.

2. DESCRIPTION OF THE STUDY AREA

2.1 Geographic Location. The study area includes communities in the southeast Louisiana parishes of Ascension, Assumption, Jefferson, Lafourche, St. Charles, St. James, and St. John the Baptist. The study area is bounded on the north and east by the Mississippi River Levee, on the west by Bayou Lafourche, and on the south it extends slightly past U.S. Highway 90. The study area covers approximately 800 square miles and is characterized by low, flat terrain with wetlands, numerous navigation channels, drainage canals, and natural bayous that drain into Lake Salvador and eventually the Gulf of Mexico.

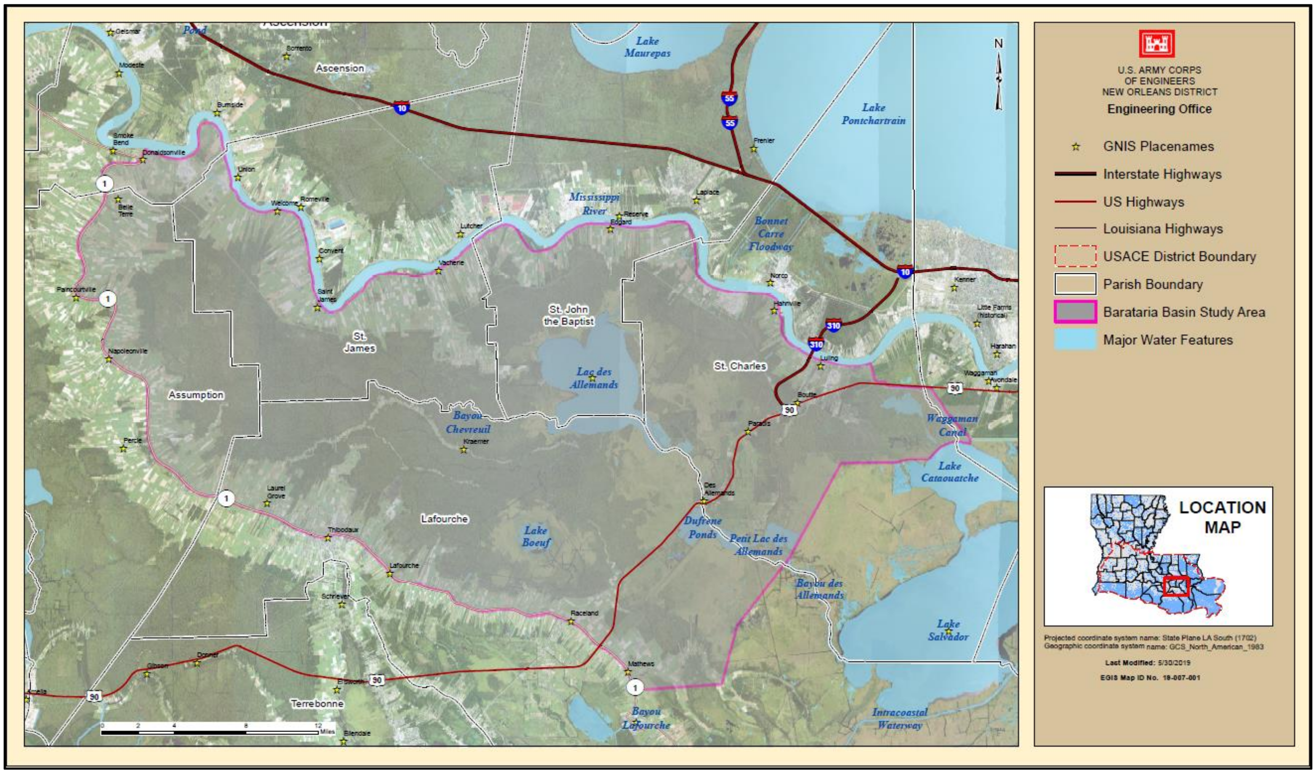


Figure 1 – Study Area Boundary

2.2 Land Use. The total number of acres of developed, agricultural, and undeveloped land in the study area are shown in Table 1. As shown in the table, 8 percent of the total acres in the study area are currently developed land. There are slightly over 500 thousand acres of agricultural land and 1.4 million acres of undeveloped land.

Table 1
Upper Barataria
Land Use in the Study Area

Land Class Name	Acres	Percentage of Total
Developed Land	159,197	8%
Agricultural Land	523,431	25%
Undeveloped Land	1,397,531	67%
Total	2,080,159	100%

Source: USGS National Land Cover Database, 2018

3. SOCIOECONOMIC SETTING

3.1 Population, Number of Households, and Employment. Tables 2, 3, and 4 display the population, number of households, and the employment (number of jobs) for each of the seven parishes for the years 2000, 2010 and 2017, as well as projections for the years 2025 and 2045. The 2000 and 2010 estimates for population and number of households are from the U.S. Census. The 2017 estimates are from Moody's Analytics. The 2000 and 2010 estimates for employment are from the U.S Bureau of Labor Statistics. All projections were developed by Moody's Analytics (ECCA) Forecast, which has projections to the year 2045.

Table 2
Study Area
Historical and Projected Population by Parish

Parish	2000	2010	2017	2025	2045
Ascension	77,335	107,850	123,272	136,988	161,973
Assumption	23,324	23,352	22,775	22,408	21,733
Jefferson	454,936	432,745	440,790	457,149	479,966
Lafourche	89,775	96,681	98,574	98,970	99,479
St. Charles	48,118	52,845	53,359	55,339	58,101
St. James	21,201	22,006	21,790	22,599	23,727
St. John the Baptist	43,248	45,621	44,078	45,713	47,995
Total	757,937	781,101	804,637	839,166	892,975

Sources: 2000, 2010, 2017 from U.S. Census Bureau; 2025, 2045 from Moody's Analytics (ECCA) Forecast

Table 3
Study Area
Existing Condition and Projected Households by Parish

Parish	2000	2010	2017	2025	2045
Ascension	26,995	38,050	44,890	51,815	66,244
Assumption	8,234	8,719	8,776	8,946	9,336
Jefferson	176,405	169,886	179,711	192,879	217,453
Lafourche	32,054	35,654	37,627	39,070	42,122
St. Charles	16,473	18,598	19,586	21,099	23,960

St. James	7,002	7,691	7,945	8,561	9,727
St. John the Baptist	14,381	15,875	16,005	17,249	19,602
Total	281,545	294,473	314,539	339,619	388,444

Sources: 2000, 2010 from U.S. Census Bureau; 2017, 2025, 2045 from Moody's Analytics (ECCA) Forecast

Table 4
Study Area
Existing Condition and Projected Employment by Parish

Parish	2000	2010	2017	2025	2045
Ascension	36,431	49,414	59,670	65,803	82,614
Assumption	9,370	8,902	8,663	8,806	8,958
Jefferson	221,554	200,303	205,796	213,741	240,657
Lafourche	39,295	42,305	41,186	41,195	41,995
St. Charles	22,627	23,594	24,027	24,954	28,096
St. James	8,102	8,949	8,940	9,257	10,448
St. John the Baptist	18,702	19,252	18,794	19,479	21,968
Total	356,080	352,717	367,075	383,236	434,737

Sources: 2000, 2010 from U.S. Bureau of Labor Statistics; 2017, 2025, 2045 from Moody's Analytics (ECCA) Forecast

3.2 Income. Table 5 shows the actual and projected per capita personal income levels for the seven parishes from 2000 to 2025. The 2000 and 2010 estimates are from the U.S Bureau of Economic Analysis while the projection for 2025 are from Moody's Analytics (ECAA) Forecast.

Table 5
Study Area
Per Capita Income ($) by Parish

Parish	2000	2010	2017	2025
Ascension	24,052	39,416	47,628	60,180
Assumption	19,613	32,771	40,543	54,195
Jefferson	28,376	42,033	48,959	63,399
Lafourche	23,485	40,391	46,045	56,959
St. Charles	24,634	39,557	47,618	63,678

St. James	18,722	38,421	45,219	60,576
St. John the Baptist	20,002	33,894	41,505	57,423

Sources: 2000, 2010 from U.S. Bureau of Economic Analysis; 2017, 2025 from Moody's Analytics (ECCA) Forecast

3.3 Compliance with Policy Guidance Letter (PGL) 25, Federal Participation in Land Development at Structural Flood Damage Reduction Projects, 16 October 1990, and ER 1165-2-26 "Implementation of Executive Order 11988 on Floodplain Management". Given continued growth in population, it is expected that development will continue to occur in the study area with or without the flood risk reduction measures in place, and will not conflict with PGL 25 and EO 11988, which state that the primary objective of a flood risk reduction project is to protect existing development, rather than to make undeveloped land available for more valuable uses. However, the overall growth rate is anticipated to be the same with or without the project in place. Thus, the project will not induce development, but would rather reduce the risk of the population being displaced after a major storm event.

4. RECENT FLOOD HISTORY

4.1 Tropical Flood Events. Coastal Louisiana experiences localized flooding from both excessive rainfall events, leading to riverine flooding, and also storm surge events from tropical storms and hurricanes. Table 6 displays the FEMA disaster declarations which involved the seven parishes of the study area. Overall, there were 22 disaster declarations related to hurricane and tropical storm incidents in the study area from 1964 to 2016. During the same timeframe, the seven parishes were included in 19 disaster declarations related to flooding incidents. Since 1851, 62 tropical events have made landfall along the south central portion of the Louisiana coast.

Table 6
Study Area
FEMA Disaster Declarations by Parish
1964-2016

Parish	Hurricane and Tropical Storm Incidents	Flooding Incidents
Ascension	18	16
Assumption	16	8
Jefferson	19	7

Lafourche	20	8
St. Charles	20	8
St. James	16	7
St. John the Baptist	18	6
Total Unique Declarations	22	19

Source: Federal Emergency Management Agency (FEMA)

Table 7
Study Area
Top Tropical Storms by Amount Paid by FEMA

Event	Month & Year	Number of Paid Claims	Total Amount Paid (millions)
2016 Louisiana Floods	August 2016	26,909	$2,455.7
Tropical Storm Lee	September 2011	9,900	$462.2
Hurricane Ike	September 2008	46,684	$2,700.1
Hurricane Gustav	September 2008	4,545	$112.6
Hurricane Rita	September 2005	9,354	$466.2
Hurricane Andrew	August 1992	5,587	$169.1

Source: Federal Emergency Management Agency (FEMA)

Note 1: Total amount paid is at price level at time of the event.
Note 2: Claims and amount paid are for entire event, which may include areas outside of the study area.

4.2 FEMA Flood Claims. The most recent named storms to affect the study area include, Hurricane Ike in 2008, Tropical Storm Lee in 2011, and Hurricane Gustav in 2008. Of the three, Hurricane Gustav brought the most damage to the study area. Hurricane Gustav caused an estimated $2.15 billion in damage to insured property, along with five deaths in Louisiana.

Table 8

Upper Barataria
FEMA Flood Claims by Parish
January 1978-September 2018

Parish	Total Number of Claims	Number of Paid Claims	Total Payments (millions)
Ascension	6,607	5,658	$ 336.89
Assumption	979	785	$ 4.45
Jefferson	129,149	96,712	$ 3,410.58
Lafourche	5,335	3,920	$ 66.93
St. Charles	5,963	4,130	$ 101.05
St. James	249	204	$ 6.19
St. John the Baptist	4,942	3,996	$ 264.24
Total	153,224	115,405	$ 4,190.34

Source: Federal Emergency Management Agency (FEMA)

4.3 FEMA Severe Repetitive Loss Properties. A Repetitive Loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978. A RL property may or may not be currently insured by the NFIP. Table 9 shows the repetitive loss property by parish.

Table 9
Study Area
FEMA Severe Repetitive Loss Properties by Parish
January 1978-December 2018

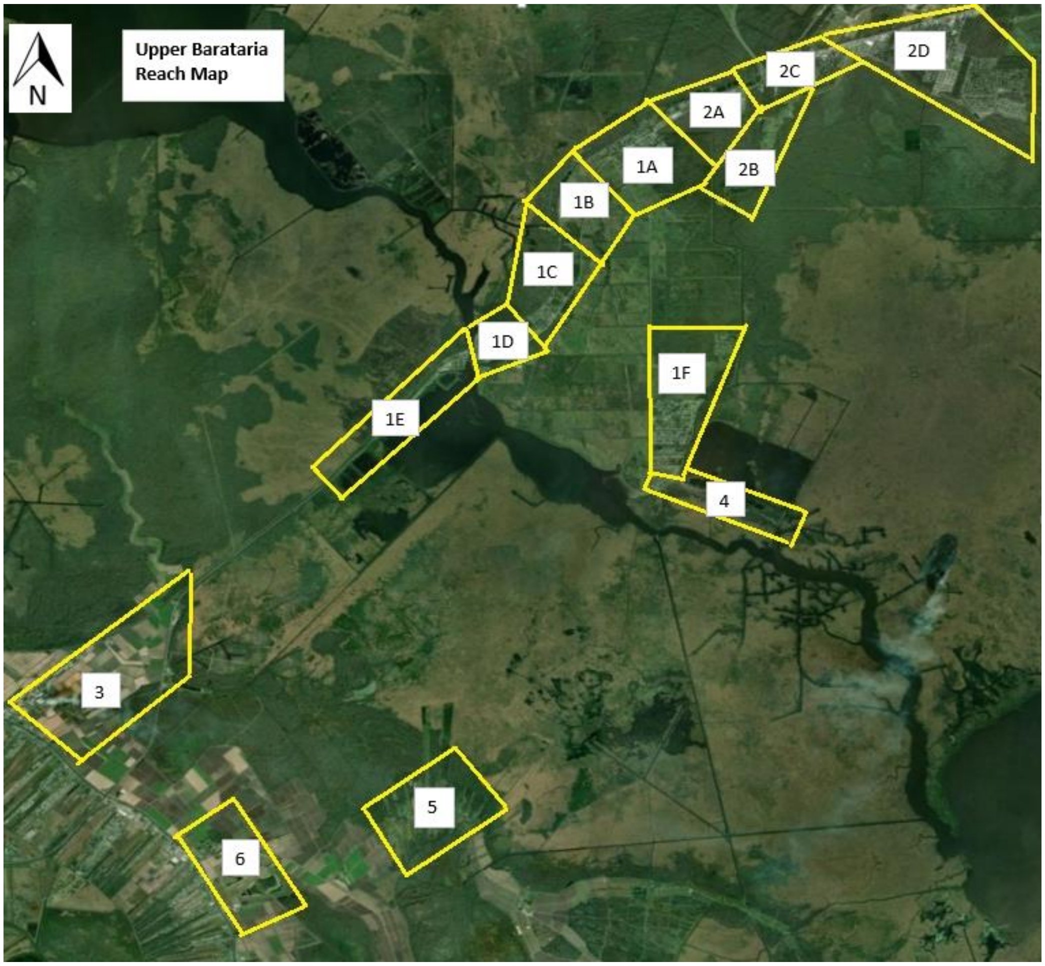
Parish	Number of Structures
Ascension	394
Assumption	84
Jefferson	8,844
Lafourche	450
St. Charles	643
St. James	19
St. John the Baptist	230
Total	153,224

Source: Federal Emergency Management Agency (FEMA)

5. Analysis Overview and Inputs

5.1 Overview. The economic appendix consists of a description of the methodology used to determine National Economic Development (NED) damages, benefits, and projects costs. The sources of damages for this analysis are structures, contents, and vehicles. The project benefits are accrued due to reducing damages to structures through the lowering of stages caused by storm surge. The damages and costs were calculated using FY 2019 price levels. Per EGM, 20-01, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2020, the FY 2020 Federal Discount rate of 2.75% was used to calculate interest during construction from the beginning of construction up to the base year of the project, 2023. This discount rate was also used to discount the future levee lift and O&M costs occurring throughout the 50 year period of analysis back to the project base year. The study area is divided up into 15 reaches that were developed based on hydrologic conditions. Figure 2 shows the reach boundaries overlaid on the study area. They are numbered 1a through 6. Another dummy reach called "Basin" was used to place structures that were not impacted by surge. Intermediate sea-level rise was used in this analysis for the computation of damages and benefits. Hydrologic conditions are expected to change in the future due to sea-level rise and subsidence. As a result, the discount rate is also used to calculate the equivalent annual damages and benefits between the future condition of 2073 and the base year of 2023. No future development was included in the analysis. As per ER 1105-2-101, uncertainty parameters were estimated for all major variables used in the analysis, such as structure value, first floor elevation, content-to-structure value ratios, and depth-damage functions.

Figure 2



5.2 Alternatives. The final array of alternatives consists of three levee alignments, Alternative 1, Alternative 2, Alternative 10, and a nonstructural alternative, Alternative 7.

Alternative 1. This structural alternative would incorporate building up to a 7.5ft levee elevation which connects the southern end of the existing new St. Charles Parish levee to the Lafourche Parish levee across the basin to the natural ridge. CPRA has a structural protection plan in the Master plan following a similar alignment. This alignment would be approximately 18.3 miles in length and incorporate a little over 15.9 miles of earthen levee, 2.3 miles of flood wall, and a 270ft barge gate structure.

Alternative 2. This Highway 90 levee alignment alternative would incorporate a levee connecting the north-east to the south-east side of the basin parallel U.S. Highway 90. The levee elevation would be built to an 8.5 feet elevation, therefore elevating the existing St. Charles Parish levee. This levee would be approximately 30.4 miles in length and incorporate a 270 feet barge gate across Bayou Des Allemands.

Alternative 10. This alignment was developed to reduce the highest concentration of damages around Des Allemands and Paradis. This structural alternative would incorporate a levee from Luling to US Highway 90 just across Bayou Des Allemands. The levee would be built to a 12 feet elevation, therefore elevating the existing St. Charles Parish levee. This levee would be approximately 24 miles in length and incorporate a 270 feet barge gate across Bayou Des Allemands.

5.3 Structure Inventory. There are 22,726 residential structures and 2,200 non-residential structures in the total structure inventory. The source of the inventory is the National Structure Inventory (NSI) version 2. This updated version of the inventory uses Zillow data, ESRI map layer data, and CoreLogic data to improve structure placement and the square footage of structures over the previous version of the NSI. RS Means was used to calculate the depreciated replacement value of structures. The RS Means construction cost index was used to update the depreciated replacement value from FY 2018 to FY 2019. The foundation heights of the structures were updated using the foundation heights from the Donaldsonville to the Gulf study, which were based on samples by occupancy type. Table 10 displays the structure counts by occupancy type. Table 11 displays the structure counts by reach.

Table 10
Study Area
Residential and Non-Residential Structure Inventory

Structure Category	
Residential	*Number*
Single Family 1-Story Slab	8,099
Single Family 1-Story Pier	718
Single Family 2-Story Slab	3,036
Single Family 2-Story Pier	7,564
Mobile Home	3,309
Total	22,726
Total Residential	
Multi-Family	304
Professional	480
Public	272
Repair	220
Restaurants	193
Retail	421
Warehouse	310
Total	2,200
Total Non-Residential	

Table 11
Study Area
Structure Counts and Value by Reach

Reach	Structure Count	Total Value
1A	501	498,460,000
1B	15	4,499,000
1C	315	196,335,000
1D	405	249,724,000
1E	249	116,832,000
1F	623	375,912,000
2A	142	60,503,000
2B	68	38,986,000
2C	844	219,936,000
2D	3,217	1,049,942,000
3	100	25,795,000
4	77	18,315,000
5	174	33,096,000
6	45	11,080,000
Basin	18,151	6,142,461,000
Total	24,926	9,041,876,000

5.4 Structure Value Uncertainty

The uncertainty surrounding the residential structure values was based on the depreciation percentage applied to the average replacement cost per square foot calculated from the four exterior wall types. A triangular probability distribution was used to represent the uncertainty surrounding the residential structure values in each occupancy category. The most-likely depreciated value was based on the average construction class and a 20 percent depreciation rate (consistent with an observed age of a 20-year old structure in average condition), the minimum value was based on the economy construction class and a 45 percent depreciation rate (consistent with an observed age of a 30-year old structure in poor condition), and the maximum value was based on the luxury construction class and a 7 percent depreciation rate (consistent with an observed age of a 10-year old structure in good condition). These values were then converted to a percentage of the most-likely value with the most-likely value equal to 100 percent of the average value for each occupancy category and the economy and luxury class values equal to a percentage of these values. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values in each residential occupancy category.

The uncertainty surrounding the non-residential structure values was based on the depreciation percentage applied to the average replacement cost per square foot calculated from the six exterior wall types. A triangular probability distribution based on the depreciation percentage associated with an observed age (determined using the professional judgment of personnel familiar with the study area) and the type of frame structure was used to represent the uncertainty surrounding the non-residential structure values in each occupancy category. The most-likely depreciated value was based on the depreciation percentage (25 percent) assigned to structures with an observed age of 20 years for masonry and wood construction, the minimum depreciated value was based on the depreciation percentage (40 percent) assigned to structures with an observed age of 30 years for framed construction, and the maximum depreciated value was based on the on the depreciation percentage (8 percent) assigned to structures with an observed age of 10 years for masonry on masonry or steel construction. These values were then converted to a percentage of the most-likely value with the most-likely value being equal to 100 percent and the minimum and maximum values equal to percentages of the most-likely value. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values for each non-residential occupancy category.

5.5 Vehicle Inventory and Values

Based on 2010 Census information for the New Orleans Metropolitan area, there are an average of 2.0 vehicles associated with each household (owner occupied housing or rental unit). According to the Southeast Louisiana Evacuation Behavioral Report published in 2006 following Hurricanes Katrina and Rita, approximately 70 percent of privately owned vehicles are used for evacuation during storm events. The remaining 30 percent of the privately owned vehicles remain parked at the residences and are subject to flood damages. According to Edmunds.Com, the average value of a used car was \$18,800 as of 2nd quarter 2015. The Manheim Used Vehicle Value Index was used to adjust the average value to reflect FY 2019 price levels. According to the Manheim index, the average value of a used car increase 8.0 percent to \$20,000 between the years 2015 and 2019. Since only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of \$12,000 (\$20,000 x 2.0 x 0.30) was assigned to each individual residential automobile structure record in the HEC-FDA model. If an individual structure contained more than one housing unit, then the adjusted vehicle value was assigned to each housing unit in a residential or multi-family structure category. Only vehicles associated with residential structures were included in the analysis. Vehicles associated with non-residential properties were not included in the evaluation. Finally, every apartment building was assumed to contain 50 units so every apartment building has \$600,000 as the average value for vehicles (50 units x \$10.6 thousand).

5.6 Vehicle Value Uncertainty

The uncertainty surrounding the values assigned to the vehicles in the inventory was determined using a triangular probability distribution function. The average value of a used car, \$18,600, was used as the most-likely value. The average value of a new vehicle, \$34,000, before taxes, license, and shipping charges was used as the maximum value, while the average 10-year depreciation value of a vehicle, $3,000 was used as the minimum value. The percentages were developed for the most-likely, minimum, and the maximum values with the most-likely equal to 100 percent, and the minimum and the maximum values as percentages of the most-likely value (minimum=25%, most-likely=100%, maximum=183%). These percentages were entered into the HEC-FDA model as a triangular probability distribution to represent the uncertainty surrounding the vehicle value for both residential and non-residential vehicles.

5.7 First Floor Elevations

Topographical data based on NAVD 88 vertical datum was used to assign ground elevations to structures and vehicles in the study area. The assignment of ground elevations and the placement of structures were based on a digital elevation model (DEM) with a fifteen foot by fifteen foot grid resolution developed by the United States Geological Survey (USGS). The ground elevation was added to the height of the foundation of the structure above the ground in order to obtain the first floor elevation of each structure in the study area. Vehicles were assigned to the ground elevation of the adjacent residential structures.

5.8 Uncertainty surrounding Elevations

There are two sources of uncertainty surrounding the first floor elevations: the use of the LiDAR data for the ground elevations, and the methodology used to determine the structure foundation heights above ground elevation. The error surrounding the LiDAR data was determined to be plus or minus 0.5895 feet at the 95 percent level of confidence. This uncertainty was normally distributed with a mean of zero and a standard deviation of 0.3 feet.

The uncertainty surrounding the foundation heights for the residential structure categories and commercial structures was estimated by calculating the standard deviations surrounding the sampled mean values. An overall weighted average standard deviation for all of the sampled structures was computed for each residential and non-residential structure category and for all of the residential and non-residential structures, regardless of structure category.

Uncertainty can only be applied to structure occupancies in the HEC-FDA model. In order to develop a standard deviation for each structure occupancy, first, the structures in each residential category had to be grouped into the structure occupancies; second, a mean foundation height value was the structures within the structure occupancy; third, the standard deviation as a percentage of the mean foundation height value for all the sampled residential structures was calculated and that percentage was applied to the mean foundation value of the residential and non-residential occupancies; fourth, the calculated standard deviation for each structure occupancy was entered into the HEC-FDA model.

5.9 Depth-Damage Relationships and Content-to-Structure Value Ratio (CSVR)
Depth-damage relationships define the relationship between the depth of flooding and the percent of damage at varying depths that occurs to structures and contents. These mathematical functions are used to quantify the flood damages to a given structure. The content-to-structure value ratio (CSVR) is expressed as a ratio of two values: the depreciated replacement cost of contents and the depreciated replacement cost of the structure. One method to derive these relationships is the "Expert Opinion" method described in the Handbook of Forecasting Techniques, IWR Contract Report 75-7, December 1975 and Handbook of Forecasting Techniques, Part II, Description of 31 Techniques, Supplement to IWR Contract Report 75-7, August 1977. A panel of experts was convened to develop site-specific depth-damage relationships and CSVRS for the Donaldsonville to the Gulf study area. Professionals in the fields of residential and non-residential construction, general contractors, insurance claims adjusters with experience in flood damage, and a certified restoration expert were selected to sit on the panel. The panel was tasked with developing an array of residential and non-residential structure and content types. Residential structure types were divided into one-story on pier, one-story on slab, two-story on pier, two-story on slab and mobile homes. Non-residential structure types were categorized as metal-frame walls, masonry bearing walls, and wood or steel frame walls. Residential contents were evaluated as one-story, two-story, or mobile home. Non-residential content categories included the following types: eating and recreation, groceries and gas stations, multi-family residences, repair and home use, retail and personal services, professional businesses, public and semi-public, and warehouse and contractor services. The results of this panel were published in the report Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios (CSVRS) In Support Of the Donaldsonville to the Gulf Feasibility Study, March 2006 Final Report.

5.10 Debris Removal Costs. Debris removal costs are typically discussed in the Other Benefit Categories section of the Economic Appendix. However, since debris removal costs were included as part of the HEC-FDA structure records for the individual residential and non-residential structures in the SCCL study area, these costs are being treated as an economic input. The HEC-FDA model does not report debris removal costs separately from the total expected annual without-project and with-project damages.

Following Hurricanes Katrina and Rita, interviews were conducted with experts in the fields of debris collection, processing and disposal to estimate the cost of debris removal following a storm event. Information obtained from these interviews was used to assign debris removal costs for each residential and non-residential structure in the SCCL structure inventory. The experts provided a minimum, most likely, and maximum estimate for the cleanup costs associated with the 2 feet, 5 feet, and 12 feet depths of flooding. A prototypical structure size in square feet was used for the residential occupancy categories and for the non-residential occupancy categories. The experts were asked to estimate the percentage of the total cleanup caused by floodwater and to exclude any cleanup that was required by high winds.

In order to account for the cost/damage surrounding debris cleanup, values for debris removal were incorporated into the structure inventory for each record according to its occupancy type. These values were then assigned a corresponding depth-damage function with uncertainty in the HEC-FDA model. For all structure occupancy types, 100% damage was reached at 12 feet of flooding. All values and depth-damage functions were selected according to the long-duration flooding data specified in a report titled "Development of Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes." The debris clean-up values provided in the report were expressed in 2010 price levels for the New Orleans area. These values were converted to 2019 price levels for the SCCL study area using the indexes provided by Gordian's 2019 edition of "Square Foot Costs with RS Means Data." The debris removal costs were included as the "other" category on the HEC-FDA structure records for the individual residential and non-residential structures and used to calculate the expected annual without-project and with-project debris removal and cleanup costs.

5.11 Debris Removal Costs Uncertainty. The uncertainty surrounding debris percentage values at 2 feet, 5 feet and 12 depths of flooding were based on range of values provided by the four experts in the fields of debris collection, processing, and disposal. The questionnaires used in the interview process were designed to elicit information from the experts regarding the cost of each stage of the debris cleanup process by structure occupancy type. The range of responses from the experts were used to calculate a mean value and standard deviation value for the cleanup costs percentages provided at 2 feet, 5 feet, and 12 feet depths of flooding. The mean values and the standard deviation values were entered into the HEC-FDA model as a normal probability distribution to represent the uncertainty surrounding the costs of debris removal for residential and non-residential structures. The depth-damage relationships containing the damage percentages at the various depths of flooding and the corresponding standard deviations representing the uncertainty are shown with in the depth–damage tables.

6. Damages and Benefits Estimation

6.1 Model Overview. The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.4.2 Corps-certified model was used to calculate the damages and benefits for the study. The economic and engineering inputs necessary for the model to calculate damages and benefits include structure inventory, contents-to-structure value ratios, vehicles, first floor elevations, and depth-damage relationships, ground elevations, and without-project stage probability relationships. The uncertainty surrounding each of the economic and engineering variables was also entered into the model. Either a normal probability distribution, with a mean value and a standard deviation, or a triangular probability distribution, with a most likely, a maximum and a minimum value, was entered into the model to quantify the uncertainty associated with the key economic variables. A normal probability distribution was entered into the model to quantify the uncertainty surrounding the ground elevations. The number of years that stages were recorded at a given gage was entered for each study area reach to quantify the hydrologic uncertainty or error surrounding the stage-probability relationships.

6.2 HEC-FDA Model Calculations. The HEC-FDA model was utilized to evaluate flood damages using risk-based analysis. Damages were reported at the index location for each of the 14 study area reaches. A range of possible values, with a maximum and a minimum value for each economic variable (first floor elevation, structure and content values, and depth-damage relationships), was entered into the HEC-FDA model to calculate the uncertainty or error surrounding the elevation-damage, or stage-damage, relationships. The model also used the number of years that stages were recorded at a given gage to determine the hydrologic uncertainty surrounding the stage-probability relationships. The possible occurrences of each variable were derived through the use of Monte Carlo simulation, which used randomly selected numbers to simulate the values of the selected variables from within the established ranges and distributions. For each variable, a sampling technique was used to select from within the range of possible values. With each sample, or iteration, a different value was selected. The number of iterations performed affects the simulation execution time and the quality and accuracy of the results. This process was conducted simultaneously for each economic and hydrologic variable. The resulting mean value and probability distributions formed a comprehensive picture of all possible outcomes. For this analysis, hydrologic data for the alternatives was not available, so the levee module was used to estimate with-project conditions. A top of levee representing the levee elevation of the alternatives was entered for every reach along with an interior-exterior relationship that was provided by the hydrologic engineer.

6.3 Hydraulic and Hydrologic Uncertainty Parameters
HEC-FDA requires the input of the standard deviation of error associated with stages determined by the hydraulic modeling. Additionally, a period of record must be input in order to calculate the distribution for the flow data determined in the hydrologic analysis.

6.4 Stage-Damage Relationships with Uncertainty. The HEC-FDA model used the economic and engineering inputs to generate a stage-damage relationship for each structure category in each study area reach under 2023 and 2073 conditions. The possible occurrences of each economic variable were derived through the use of Monte Carlo simulation. A total of 1,000 iterations were executed by the model for the Upper Barataria evaluation. The sum of all sampled values was divided by the number of samples to yield the expected value for a specific simulation. A mean and standard deviation was automatically calculated for the damages at each stage.

6.5 Stage-Probability Relationships with Uncertainty. The HEC-FDA model used an equivalent record length of 50 years for each study area reach to generate a stage-probability relationship with uncertainty through the use of graphical analysis. The model used eight stage-probability events together with the equivalent record length to define the full range of the stage-probability or stage-probability functions by interpolating between the data points. Confidence bands surrounding the stages for each of the probability events were also provided. Stages were provided for the 0.05, 0.02, 0.01, 0.005, 0.002, and 0.001 AEP events. Place holders were used for the 1.0 and 0.1 AEP events. Table 12 shows the damages by probability event.

Table 12 Study Area Damages by year and probability event $1,000s		
AEP	Damages 2023	Damages 2073
0.05	4,281	85,917
0.02	38,086	1,486,722
0.01	460,706	2,231,887
0.005	670,636	2,634,251
0.002	1,018,760	3,104,190
0.001	1,515,698	3,326,643

6.6 Expected Annual Damages. The model used Monte Carlo simulation to sample from the stage-probability curve with uncertainty. For each of the iterations within the simulation, stages were simultaneously selected for the entire range of probability events. The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships are integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the without-project alternative, the expected annual damages (EAD) were totaled for each study area reach to obtain the total without-project EAD under 2023 and 2073 conditions. Table 13 shows the without-project damages by damage category for 2023 and 2073. Tables 14 and 15 show the without-project damages by reach for 2023 and 2073 respectively. The increase in damages from 2023 to 2073 are due to sea-level rise. No future development was included in this analysis.

Table 13
Study Area
Damages by Damage Category
$1,000s

Year	AUTO	COM	MOBHOME	RES	Total
2023	557	4,467	384	8,483	13,891
2073	2,293	37,105	731	25,596	65,724

Table 14
Study Area
Expected Annual Damages
Without-Project
2023
$1,000s

Reach	EAD
1a	515
1b	26
1c	199
1d	254
1e	614
1f	418
2a	41
2b	342
2c	886
2d	7,561
3	11
4	2,659
5	310
6	54
Total	13,891

Table 15
Study Area
Expected Annual Damages
Without-Project
2073

$1,000s

Reach	EAD
1a	12,049
1b	84
1c	4,326
1d	4,539
1e	2,138
1f	11,007
2a	2,456
2b	879
2c	2,767
2d	24,168
3	167
4	222
5	644
6	278
Total	65,724

6.7 Equivalent Annual Damages. The model uses the discount rate to discount the future damages and benefits occurring in 2073 back to the base year of 2023. Table 16 shows the equivalent annual damages by reach for the without-project condition and the damages reduced for each alternative.

Table 16
Study Area
Equivalent Annual Damages and Benefits by Reach
FY 19 Price Level; FY 20 Discount Rate
$1,000s

	Without	Damages Reduced			
Reach	Project	Alt 1	Alt 2	Alt 10	NS
1a	4,902	4,879	4,881	4,878	1,409
1b	48	48	48	48	25

1c	1,769	1,688	1,704	1,739	405
1d	1,884	1,873	1,875	1,878	385
1e	1,193	1,193	1,193	1,193	881
1f	4,445	3,561	3,739	4,172	857
2a	960	950	953	959	720
2b	546	546	546	546	396
2c	1,602	1,578	1,580	1,587	668
2d	13,877	13,875	13,875	13,876	9,573
3	70	70	70	0	38
4	1,732	0	0	0	1,706
5	437	0	0	0	364
6	139	0	0	0	130
Total	$33,605	30,262	30,466	30,876	17,560

7. **Costs**

7.1 Average Annual Costs. The initial construction cost (first costs), along with the schedule of expenditures, were used to determine the interest during construction and gross investment cost at the end of the installation period (2023). The FY 2020 Federal discount rate of 2.75 percent was used to discount the costs to the base year and then amortize the costs over the 50-year period of analysis. The operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) costs for each alternative were discounted to present value and annualized using the Federal discount rate of 2.75 percent for 50 years. Tables 17 through 20 provide the life cycle costs for each of the project components, the average annual construction costs, the annual operation and maintenance costs, and the total average annual costs for each of the alternatives.

Table 17

Alternative 1

(2019 Price Level; FY 20 Discount Rate)

Year	Years from Base Year	Expenditures	Present Value Factor	Present Value of Expenditures
2020	2	$77,794,500	1.0702	$83,253,686
2021	1	$181,520,500	1.0415	$189,059,465
2022	0	$251,402,732	1.0137	$254,836,075
2023	-1	$720,000	0.9865	$710,300
2024	-2	$720,000	0.9601	$691,289
2025	-3	$720,000	0.9344	$672,788
2026	-4	$720,000	0.9094	$654,781
2027	-5	$720,000	0.8851	$637,256
2028	-6	$720,000	0.8614	$620,201
2029	-7	$720,000	0.8383	$603,602
2030	-8	$720,000	0.8159	$587,447
2031	-9	$720,000	0.7941	$571,725
2032	-10	$720,000	0.7728	$556,423
2033	-11	$720,000	0.7521	$541,531
2034	-12	$720,000	0.7320	$527,037
2035	-13	$720,000	0.7124	$512,932
2036	-14	$720,000	0.6933	$499,204
2037	-15	$720,000	0.6748	$485,843
2038	-16	$720,000	0.6567	$472,840
2039	-17	$720,000	0.6391	$460,185
2040	-18	$720,000	0.6220	$447,868
2041	-19	$720,000	0.6054	$435,882
2042	-20	$720,000	0.5892	$424,216
2043	-21	$720,000	0.5734	$412,862
2044	-22	$720,000	0.5581	$401,812
2045	-23	$720,000	0.5431	$391,058
2046	-24	$720,000	0.5286	$380,592
2047	-25	$720,000	0.5145	$370,406
2048	-26	$720,000	0.5007	$360,492
2049	-27	$720,000	0.4873	$350,844
2050	-28	$720,000	0.4742	$341,454
2051	-29	$720,000	0.4615	$332,315
2052	-30	$720,000	0.4492	$323,421
2053	-31	$720,000	0.4372	$314,765

2054	-32	$720,000	0.4255	$306,341
2055	-33	$720,000	0.4141	$298,142
2056	-34	$720,000	0.4030	$290,162
2057	-35	$720,000	0.3922	$282,397
2058	-36	$720,000	0.3817	$274,838
2059	-37	$720,000	0.3715	$267,483
2060	-38	$720,000	0.3616	$260,324
2061	-39	$720,000	0.3519	$253,356
2062	-40	$720,000	0.3425	$246,576
2063	-41	$720,000	0.3333	$239,976
2064	-42	$720,000	0.3244	$233,554
2065	-43	$720,000	0.3157	$227,303
2066	-44	$720,000	0.3072	$221,219
2067	-45	$720,000	0.2990	$215,299
2068	-46	$720,000	0.2910	$209,536
2069	-47	$720,000	0.2832	$203,928
2070	-48	$720,000	0.2757	$198,470
2071	-49	$720,000	0.2683	$193,158
2072	-50	$720,000	0.2611	$187,989
		$546,717,732		$546,852,648

Interest Rate (%)	2.75
Amortization Factor	0.03704
Average Annual Costs	$19,526,100
Average Annual O&M Costs	$729,800
Total Average Annual Costs	$20,255,900

Table 18

Alternative 2

(2019 Price Level; FY 20 Discount Rate)

Year	Years from Base Year	Expenditures	Present Value Factor	Present Value of Expenditures
2020	2	$100,851,600	1.0702	$107,928,805
2021	1	$235,320,400	1.0415	$245,093,799
2022	0	$325,368,416	1.0137	$329,811,890
2023	-1	$800,000	0.9865	$789,222
2024	-2	$800,000	0.9601	$768,099
2025	-3	$800,000	0.9344	$747,542
2026	-4	$800,000	0.9094	$727,534
2027	-5	$800,000	0.8851	$708,063
2028	-6	$800,000	0.8614	$689,112
2029	-7	$800,000	0.8383	$670,669
2030	-8	$800,000	0.8159	$652,719
2031	-9	$800,000	0.7941	$635,250
2032	-10	$800,000	0.7728	$618,248
2033	-11	$800,000	0.7521	$601,701
2034	-12	$800,000	0.7320	$585,597
2035	-13	$800,000	0.7124	$569,924
2036	-14	$800,000	0.6933	$554,671
2037	-15	$800,000	0.6748	$539,826
2038	-16	$800,000	0.6567	$525,378
2039	-17	$800,000	0.6391	$511,316
2040	-18	$800,000	0.6220	$497,632
2041	-19	$800,000	0.6054	$484,313
2042	-20	$800,000	0.5892	$471,351
2043	-21	$800,000	0.5734	$458,736
2044	-22	$800,000	0.5581	$446,458
2045	-23	$800,000	0.5431	$434,509
2046	-24	$800,000	0.5286	$422,880
2047	-25	$800,000	0.5145	$411,562
2048	-26	$800,000	0.5007	$400,547
2049	-27	$800,000	0.4873	$389,827
2050	-28	$800,000	0.4742	$379,393
2051	-29	$800,000	0.4615	$369,239
2052	-30	$800,000	0.4492	$359,357
2053	-31	$800,000	0.4372	$349,739

2054	-32	$800,000	0.4255	$340,379
2055	-33	$800,000	0.4141	$331,269
2056	-34	$800,000	0.4030	$322,403
2057	-35	$800,000	0.3922	$313,774
2058	-36	$800,000	0.3817	$305,376
2059	-37	$800,000	0.3715	$297,203
2060	-38	$800,000	0.3616	$289,249
2061	-39	$800,000	0.3519	$281,507
2062	-40	$800,000	0.3425	$273,973
2063	-41	$800,000	0.3333	$266,640
2064	-42	$800,000	0.3244	$259,504
2065	-43	$800,000	0.3157	$252,559
2066	-44	$800,000	0.3072	$245,799
2067	-45	$800,000	0.2990	$239,221
2068	-46	$800,000	0.2910	$232,818
2069	-47	$800,000	0.2832	$226,587
2070	-48	$800,000	0.2757	$220,523
2071	-49	$800,000	0.2683	$214,621
2072	-50	$800,000	0.2611	$208,876
		$701,540,416		$704,727,185

Interest Rate (%)	2.75
Amortization Factor	0.03704
Average Annual Costs	$25,292,800
Average Annual O&M Costs	$810,900
Total Average Annual Costs	$26,103,700

Table 19

Alternative 10

(2020 Price Level; FY 19 Discount Rate)

Year	Years from Base Year	Expenditures	Present Value Factor	Present Value of Expenditures
2020	2	$173,322,441	1.0702	$185,485,248
2021	1	$224,628,403	1.0415	$233,957,739
2022	0	$297,082,553	1.0137	$301,139,734
2023	-1	$1,040,000	0.9865	$1,025,988
2024	-2	$1,040,000	0.9601	$998,529
2025	-3	$1,040,000	0.9344	$971,804
2026	-4	$1,040,000	0.9094	$945,795
2027	-5	$1,040,000	0.8851	$920,482
2028	-6	$1,040,000	0.8614	$895,846
2029	-7	$1,040,000	0.8383	$871,869
2030	-8	$1,040,000	0.8159	$848,535
2031	-9	$1,040,000	0.7941	$825,825
2032	-10	$99,607,528	0.7728	$76,977,672
2033	-11	$1,040,000	0.7521	$782,211
2034	-12	$1,040,000	0.7320	$761,276
2035	-13	$1,040,000	0.7124	$740,901
2036	-14	$1,040,000	0.6933	$721,072
2037	-15	$1,040,000	0.6748	$701,773
2038	-16	$1,040,000	0.6567	$682,991
2039	-17	$1,040,000	0.6391	$664,711
2040	-18	$1,040,000	0.6220	$646,921
2041	-19	$1,040,000	0.6054	$629,607
2042	-20	$1,040,000	0.5892	$612,756
2043	-21	$1,040,000	0.5734	$596,356
2044	-22	$1,040,000	0.5581	$580,395
2045	-23	$1,040,000	0.5431	$564,862
2046	-24	$1,040,000	0.5286	$549,744
2047	-25	$78,979,888	0.5145	$40,631,389
2048	-26	$1,040,000	0.5007	$520,711
2049	-27	$1,040,000	0.4873	$506,775
2050	-28	$1,040,000	0.4742	$493,211
2051	-29	$1,040,000	0.4615	$480,011
2052	-30	$1,040,000	0.4492	$467,164
2053	-31	$1,040,000	0.4372	$454,661

2054	-32	$1,040,000	0.4255	$442,492
2055	-33	$1,040,000	0.4141	$430,649
2056	-34	$1,040,000	0.4030	$419,124
2057	-35	$1,040,000	0.3922	$407,906
2058	-36	$1,040,000	0.3817	$396,989
2059	-37	$1,040,000	0.3715	$386,364
2060	-38	$1,040,000	0.3616	$376,023
2061	-39	$1,040,000	0.3519	$365,959
2062	-40	$35,810,013	0.3425	$12,263,718
2063	-41	$1,040,000	0.3333	$346,632
2064	-42	$1,040,000	0.3244	$337,355
2065	-43	$1,040,000	0.3157	$328,326
2066	-44	$1,040,000	0.3072	$319,539
2067	-45	$1,040,000	0.2990	$310,987
2068	-46	$1,040,000	0.2910	$302,663
2069	-47	$1,040,000	0.2832	$294,563
2070	-48	$1,040,000	0.2757	$286,679
2071	-49	$1,040,000	0.2683	$279,007
2072	-50	$1,040,000	0.2611	$271,539
		$958,310,826		$877,221,080

Interest Rate (%)	2.75
Amortization Factor	0.03704
Average Annual Costs	$31,438,900
Average Annual O&M Costs	$1,054,200
Total Average Annual Costs	$32,493,100

Table 20
Nonstructural
(2020 Price Level; FY 19 Discount Rate)

Year	Years from Base Year	Expenditures	Present Value Factor	Present Value of Expenditures
4th Quarter 2022	0	$1,568,912,163	1.0034	$1,574,246,465

Interest Rate (%)	2.75
Amortization Factor	0.03704
Average Annual Costs	$58,311,400
Average Annual O&M Costs	$0
Total Average Annual Costs	$58,311,400

7.2 Nonstructural Implementation Costs

7.2.1 Residential Structures.

Elevation costs were based on the difference in the number of feet between the original first floor elevation and the target elevation (the 100-year future-without project stage) for each structure. The number of feet that each structure was raised was rounded to the closest one-foot increment, with the exception that structures less than one foot below the target elevation were rounded-up to one foot. Elevation costs by structure were summed to yield an estimate of total structure elevation costs. The cost per square foot for raising a structure was based on data obtained during interviews with representatives of three major metropolitan New Orleans area firms that specialize in the structure elevation. Composite costs were derived for residential structures by type: slab and pier foundation, one story and two story configuration, and for mobile homes. These composite unit costs also vary by the number of feet that structures may be elevated. The cost per square foot to raise an individual structure to the target height was multiplied by the footprint square footage of each structure to compute the costs to elevate the structure. A labor estimate of $15,000 per structure to complete required administrative activities by the Federal sponsor in implementing this nonstructural measure was added to the cost of implementation. Additionally, real estate cost of $15,000 per structure was added to the cost of implementation. Also, a contingency of 34.5% was added to the cost of implementation. Table 21 shows the cost per square foot of structure raising by occupancy type and height raised.

7.2.2 Non-Residential Structures.

The dry flood proofing measure was applied to all non-residential structures. Separate cost estimates were developed to flood proof these structures based on their relative square footage. If the square footage was between zero and 20,000, then the total cost equaled $115,255; between 20,000 and 100,000 square feet, then $357,050; and greater than 100,000 square feet, then $899,648. These costs were developed for the Donaldsonville to the Gulf Feasibility Study evaluation by contacting local contractors and were escalated to FY 2019 prices. Also, a labor estimate of $15,000 per structure to complete required administrative activities by the Federal sponsor in accomplishing this nonstructural measure was added to the cost of implementation. Additionally, real estate cost of $15,000 per structure was added to the cost of implementation. Also, a contingency of 34.5% was added to the cost of implementation.

7.2.3 Operations, Maintenance, Relocations, Rehabilitation, and Repair
.

For elevation measures, there are no further resources necessary to ensure that the engineered activity operates as intended. For flood proofing measures, periodic inspection of the work which may be required is expected to be insignificant (approximately $500 per structure over several years). Such inspection costs are an extremely small percentage of the overall cost of implementation and can be considered capitalized in the initial cost of implementation.

Table 21

Cost per square foot of structure raising by occupancy type and number of feet raised

FY 2019 Price Level

	1STY-SLAB			2STY-SLAB			1STY-PIER			2STY-PIER			MOBILE HOME		
Ft. Raised	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max
1	$78	$88	$97	$88	$97	$107	$68	$78	$87	$76	$86	$95	$38	$43	$48
2	$78	$88	$97	$88	$97	$107	$68	$78	$87	$76	$86	$95	$38	$43	$48
3	$80	$90	$99	$90	$99	$109	$71	$81	$90	$79	$89	$99	$38	$43	$48
4	$83	$93	$102	$96	$106	$115	$71	$81	$90	$79	$89	$99	$38	$43	$48
5	$83	$93	$102	$96	$106	$115	$71	$81	$90	$79	$89	$99	$48	$53	$57
6	$85	$95	$104	$98	$107	$117	$73	$83	$92	$81	$91	$100	$48	$53	$57
7	$85	$95	$104	$98	$107	$117	$73	$83	$92	$81	$91	$100	$48	$53	$57
8	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
9	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
10	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
11	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
12	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
13	$92	$101	$111	$107	$117	$127	$77	$86	$96	$85	$95	$104	$48	$53	$57

8. Results

8.1 Net Benefits. The net benefits for the alternatives were calculated by subtracting the average annual costs from the equivalent annual benefits. The net benefits were used to determine the economic justification of the project alternatives. Table 22 summarizes the equivalent annual damages and benefits, total first costs, average annual cost, benefit-to-cost ratio, and equivalent annual net benefits for each project alternative. Alternatives 1 and 2 are both economically justified, meaning their benefit-to-cost ratio is a least 1. Alternative 10 and the nonstructural alternative are both not economically justified. Of the two economically justified alternatives, Alt 1 has the highest net benefits. Since Alternative 1 is the plan that maximizes net benefits, it is the National Economic Development (NED) Plan.

Table 22

Summary of Results
FY 19 Price Level
FY 20 Discount Rate: 2.75%

Alternative	**Alt 1**	**Alt 2**	**Alt 10**	**NS**
Project First Cost	$510,718,000	$661,540,000	$906,310,000	$1,568,912,000
Interest During Construction	$16,431,494	$21,294,078	$25,549,323	$5,329,343
Total Investment Cost	$527,149,494	$682,834,078	$931,859,323	$1,574,241,343
AA Investment Costs	$19,526,100	$25,292,800	$31,438,900	$58,311,400
AA O&M Costs	$729,800	$810,900	$1,054,200	$0
Total AA Costs	$20,255,900	$26,103,700	$32,493,100	$58,311,400
Construction Duration (Years)	3	3	3	1 Quarter
Without Project EAD	$ 33,604,000	$ 33,604,000	$ 33,604,000	$ 33,604,000
EAD Reduced Benefits	$ 30,261,000	$ 30,465,000	$ 30,875,000	$ 17,559,000
Net Benefits	$ 10,005,100	$ 4,361,300	$ (1,618,100)	$ (40,752,400)
B/C Ratio	**1.5**	**1.2**	**0.95**	**0.3**

*Note: The cost for Alt1 do not include armoring. It is likely that some sections of the system will need to be armored to some degree in order to accrue the benefits presented.

8.2 Benefit Exceedance Probability Relationship. The HEC-FDA model used the uncertainty surrounding the economic and engineering inputs to generate results that can be used to assess the performance of project alternatives. Table 23 shows the expected annual benefits at the 75, 50, and 25 percentiles. These percentiles reflect the percentage chance that the benefits will be greater than or equal to the indicated values. The benefit exceedance probability relationship for the NED plan can be compared to the point estimate of its average annual cost. The table indicates the percent chance that the expected annual benefits will exceed the expected annual costs therefore the benefit cost ratio is greater than one and the net benefits are positive.

Table 23
Risk Analysis
Probability that Expected Annual Benefits Exceed Annual Costs

FY 2019 Price Level; FY 2020 Discount Rate
$1,000s

		Probability that Damages Reduced exceed indicated values				
Plan Name	Equivalent Annual Damages Reduced	0.75	0.5	0.25	Average Annual Costs	Probability Benefits Exceed Costs
Alt 1	30,262	13,817	24,600	42,585	20,256	Greater Than 50%

Citations

U.S. Army Corps of Engineers New Orleans District. (2006). *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Report.*

U.S. Army Corps of Engineers New Orleans District. (2010). *Development of Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes.*

Doheny, Matt. (Ed). (2019). *Square Foot Costs with RSMeans Data*. (40th ed.). Rockland: Construction Publishers & Consultants.

United States Census Bureau. "QuickFacts." (2018). <https://www.census.gov/quickfacts/fact/table/>

Moody's Analytics. (2017). *Historical Data and Estimates for the Parishes of Louisiana.* New York: Moody's Corp.

US Bureau of Labor Statistics. "Local Area Unemployment Statistics." (2018). <https://www.bls.gov/lau/#cntyaa>

US Bureau of Economic Analysis. "Regioanl Economic Accounts: Download" https://apps.bea.gov/regional/downloadzip.cfm

FEMA. "Severe Repetitive Loss Data, Louisiana." (2019)

FEMA. "Flood Claims, Louisiana." (2019)

US Geological Survey. "National Geospatial Program, Land Cover." (2018) <https://www.usgs.gov/core-science-systems/national-geospatial-program/land-cover>