

2021

Lake Pontchartrain & Vicinity GRR Appendix J – Economics



**US Army Corps
of Engineers®**
New Orleans District

U.S. Army Corps of Engineers, New Orleans
District

Non-Federal Sponsor: Coastal Protection and
Restoration Authority

February 2021

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LAKE PONTCHARTRAIN & VICINITY GRR

APPENDIX J – ECONOMICS

1 STUDY AREA DESCRIPTION

1.1 INTRODUCTION

This appendix presents an economic evaluation of the Recommended Plan for the Lake Pontchartrain and Vicinity Feasibility Study. It was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, and ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies. 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). The Life Safety analysis will be addressed in its own appendix.

1.2 STUDY AREA

The Lake Pontchartrain and Vicinity study area comprises much of the greater New Orleans area. The delineated sub-basins are St. Charles, Jefferson East Bank, Orleans East Bank, New Orleans East, and the Chalmette Loop. In Figure 1, the sub-basins within the LPV study area are outlined in red. The LPV project includes features in four parishes (St. Charles, Jefferson, Orleans, and St. Bernard) located in the greater New Orleans area on the east bank of the Mississippi River. Currently, LPV contains approximately a total of 126.5 miles of levees and floodwalls (Figure 1-3). There are approximately 83 miles of armored perimeter levees and floodwalls and approximately 43.5 miles of interior levees and floodwalls. The project is in a high-density residential and commercial area. The LPV system is shown in Figure 2.

The Mississippi River and Tributaries' levee (MR&T levees or MRL) along with the Lower Bonnet Carré Guide Levee provides risk reduction from riverine flow flood risks. The LPV project connects to the MRL at both the west and east of the system.

The levees and floodwalls along the Inner Harbor Navigation Canal (IHNC) and Orleans Parish outfall canals were removed from frontline or perimeter risk reduction features and became interior risk reduction features by construction of the Seabrook Gate Closure and the IHNC - Lake Borgne Surge Barrier and Permanent Canal Closures and Pumps. Although these interior levees and floodwalls are not part of the hurricane perimeter defenses, they are an integral part of the LPV hurricane and storm damage reduction system required for reducing the risk of flooding caused by precipitation during a hurricane or tropical storm and over topping of the Lake Borgne Closure Surge Barrier.

Typical operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) activities include mowing levees and ensuring sufficient turf growth, maintaining High Performance Turf Reinforcement mats (armoring), maintaining and repairing spalls in floodwalls and concrete levee transition armoring, maintaining and operating floodgates, and operating and maintaining the complex structures such as IHNC surge barrier, Seabrook Complex, and Permanent Canal Closures and Pumps.

1.3 PROJECT DESCRIPTION

The Recommended Plan includes system levee lifts to the projected 1% AEP event at 2077. Construction of the TSP would generally occur in the same footprint as the existing LPV project and existing MRL levees. Project features consist of 50 miles of levee lifts along the existing levee alignment to be constructed as-needed before the combined effects of consolidation, settlement, subsidence and sea level rise reduce the levee elevations in each levee reach below the required design elevation. In some reaches, levee lifts may need to occur more than once during the period of analysis. Additionally, the plan includes 3 miles of floodwall modifications and replacements along the existing alignment to be constructed as-needed prior to the combined effects causing the design requirements to be exceeded for each structure.



Figure 1. Lake Pontchartrain and Vicinity Sub-Basins (outlined in red)

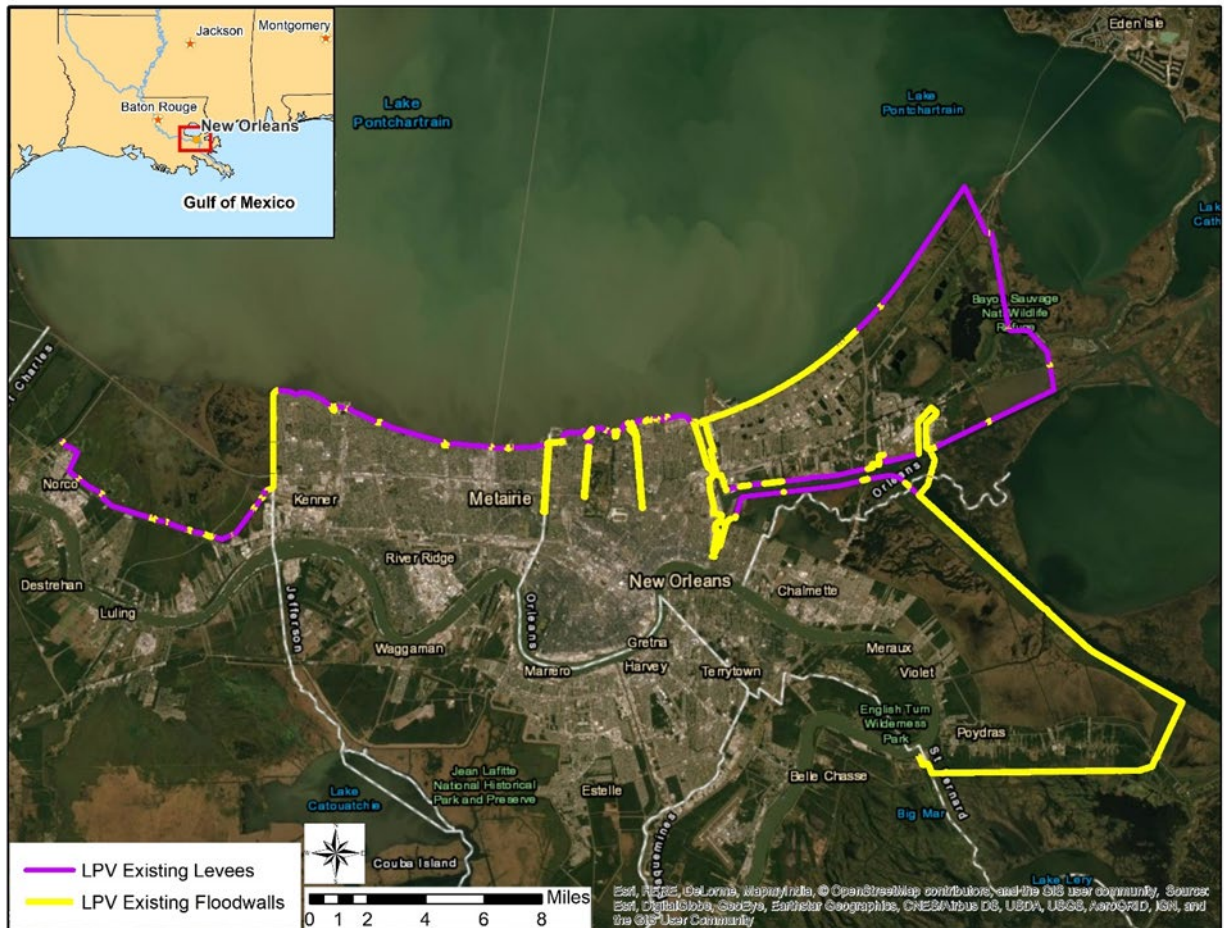


Figure 2. Lake Pontchartrain and Vicinity Existing Levees and Floodwalls

1.4 LAND USE

The total number of acres by sub-basin and type are shown in Table 1-1. Nearly 60 percent of the land in the study area is developed. Most the remaining acres in the study area are comprised of wetlands. Figure 3 shows the distribution across the study area.

Table 1-1. Study Area Historical and Projected Population by Parish

Land Use	St. Charles	Jefferson	Orleans East Bank	New Orleans East	Chalmette Loop	Study Area Total
Open Water	64	72	241	4,375	5,319	10,071 (6.6%)
Developed, Open Space	699	711	1,256	1,318	1,295	5,279 (3.5%)
Developed, Low Intensity	4,397	16,210	13,584	7,459	6,344	47,994 (31.3%)
Developed, Medium Intensity	1,184	6,574	8,110	3,023	2,760	21,651 (14.1%)

Developed, High Intensity	1,258	4,829	4,528	1,926	1,251	13,792 (9.0%)
Barren Land	107	37	0	744	554	1,442 (0.9%)
Deciduous Forest	50	30	23	24	120	247 (0.2%)
Evergreen Forest	22	0	1	0	69	92 (0.1%)
Mixed Forest	20	1	2	0	438	461 (0.3%)
Shrub/Scrub	48	8	6	29	195	286 (0.2%)
Herbaceous	35	9	0	144	99	287 (0.2%)
Hay/Pasture	79	10	3	43	360	495 (0.3%)
Cultivated Crops	123	0	0	116	544	783 (0.5%)
Woody Wetlands	4,358	13	3	6,342	9,594	20,310 (13.3%)
Emergent Herbaceous Wetlands	601	20	0	9,105	20,255	29,981 (19.6%)

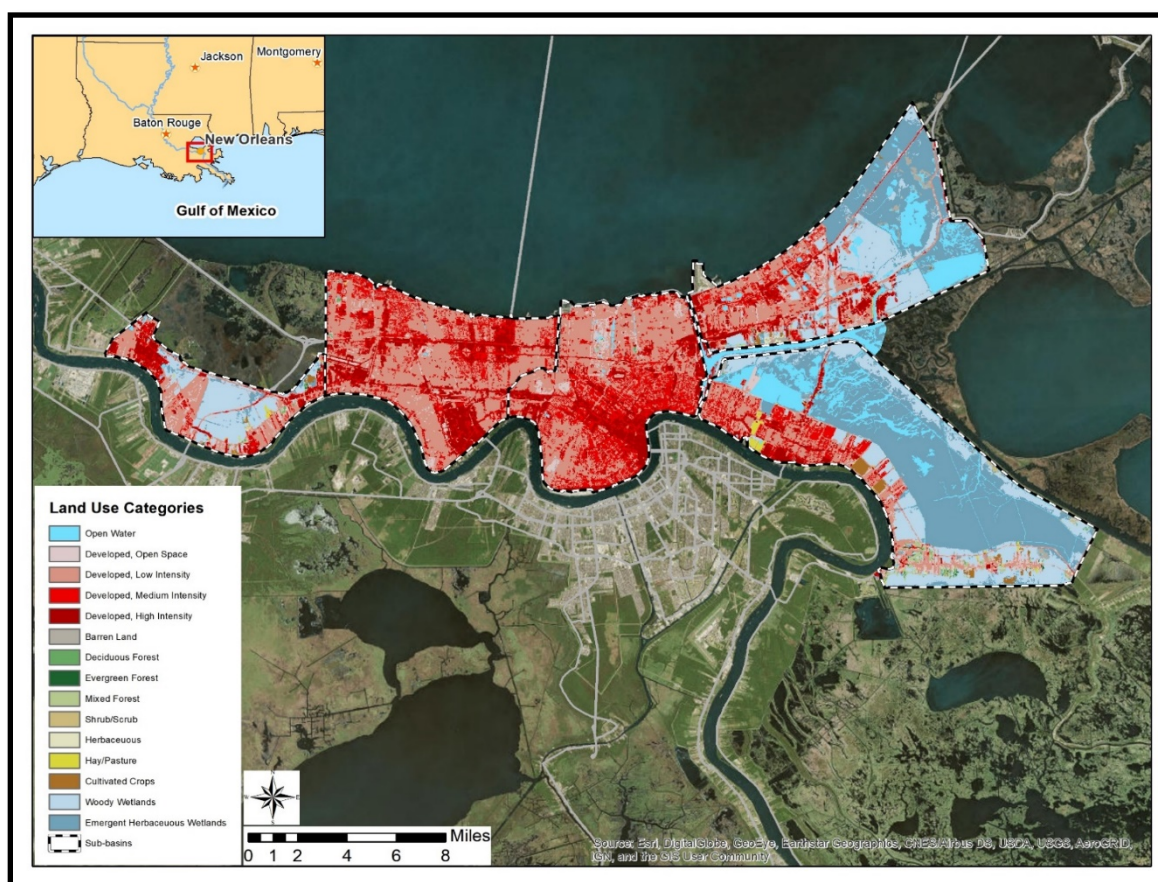


Figure 3. Land Use Distribution

2 SOCIO-ECONOMICS SETTING

2.1 POPULATION, NUMBER OF HOUSEHOLDS, AND EMPLOYMENT

Tables 2-1, 2-2, and 2-3 display the population, number of households, and the employment (number of jobs) for each of the four parishes for the years 2000, 2010, and 2019, as well as projections for the years 2030 and 2045. The 2000, 2010, and 2019 estimates for population and number of households are from the U.S. Census Bureau. The 2001, 2010, and 2019 estimates for employment are from the U.S. Bureau of Economic Analysis. All projections were developed by Moody's Analytics, which has projections to the year 2045.

Table 2-1. Study Area Historical and Projected Population by Parish

Parish	2000	2010	2019	2030	2045
Jefferson	454,940	432,552	432,493	466,710	479,970
Orleans	485,610	343,829	390,144	416,800	428,640
St. Bernard	67,280	35,897	47,244	48,580	49,960
St. Charles	48,118	52,845	53,100	55,339	58,101
Sources: 2000, 2010, 2019 from U.S. Census Bureau; 2030, 2045 from Moody's Analytics Forecast					

Table 2-2. Existing Condition and Projected Households by Parish

Parish	2000	2010	2019	2030	2045
Jefferson	176,410	169,180	168,895	185,170	217,450
Orleans	189,020	143,980	154,036	188,680	203,320
St. Bernard	25,200	13,570	15,029	19,790	21,440
St. Charles	16,473	18,598	18,762	22,080	23,960
Sources: 2000, 2010, 2019 from U.S. Census Bureau; 2025, 2045 from Moody's Analytics Forecast					

Table 2-3. Existing Condition and Projected Employment by Parish

Parish	2001	2010	2019	2030	2045
Jefferson	226,620	207,568	207,150	227,260	251,560
Orleans	288,387	194,416	223,475	223,530	247,440
St. Bernard	17,232	11,753	11,351	12,360	13,690
St. Charles	19,629	23,100	23,615	30,330	34,670
Sources: 2001, 2010, 2019 from U.S. Bureau of Labor Statistics; 2025, 2045 from Moody's Analytics Forecast					

2.2 INCOME

Table 2-4 shows the actual and projected per capita personal income levels for the four parishes from 2000 to 2045. The 2000, 2010, and 2019 estimates are from the U.S Bureau of Economic Analysis and the projections for 2030 and 2045 are from the Moody's Analytics Forecast.

Table 2-4. Per Capita Income (\$) by Parish

Parish	2000	2010	2019	2030	2045
Jefferson	28,638	42,411	52,274	75,450	136,868
Orleans	26,726	42,347	53,923	76,038	137,373
St. Bernard	22,504	30,650	33,556	41,710	72,640
St. Charles	24,634	39,557	49,353	49,660	146,912
Sources: 2000, 2010, 2019 from U.S. Bureau of Economic Analysis; 2030 and 2045 from Moody's Analytics (ECCA) Forecast					

2.3 COMPLIANCE WITH POLICY GUIDANCE LETTER (PGL) 25 AND EO 11988.

Given continued growth in population, it is expected that development will continue to occur in the study area with or without the enhanced 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 would not induce development, but would rather reduce the risk of the population being displaced after a major storm event.

3 FLOOD HISTORY

3.1 MAJOR TROPICAL EVENTS

While the planning area has periodically experienced localized flooding from excessive rainfall events and has experienced two major floods from the Mississippi River in 1927 and 1973 the primary cause of the flood events that have taken place in South Louisiana has been the tidal surges from hurricanes and tropical storms.

Hurricane Juan caused extensive flooding throughout southern Louisiana due to its prolonged 5-day movement back and forth along the Louisiana coast in October 1985. The majority of the flood damage occurred in the Lincolnshire and Westminster subdivisions located on the west bank of Jefferson Parish. Rainfall totals in the area ranged from five inches to almost 17 inches. The storm was responsible for storm surges of five to eight feet and tides of three to six above normal. According to FEMA officials, the estimated value of the residential and commercial damage and public assistance totaled \$112.5 million.

The most significant storm event to affect the Metropolitan New Orleans Area since Hurricane Betsy in 1965 was Hurricane Katrina. Hurricane Katrina made landfall on August 29, 2005, near the town of Buras in Plaquemines Parish as a 0.25% AEP storm with winds in excess of 120

miles per hour and a storm surge of approximately 30 feet. After tracking across the southeastern Louisiana coastline, it made a second landfall near the town of Waveland on the Mississippi Gulf Coast. The surge from Lake Pontchartrain pushed water into the three major outflow canals (London Avenue, Orleans, and 17th Street) of the city of New Orleans, which overwhelmed their adjacent floodwalls. The surge from Lake Borgne overwhelmed the levees protecting St. Bernard Parish, New Orleans East, and the Lower Ninth Ward. Many portions of the metropolitan area were submerged in more than 6 feet of water for more than 3 weeks. Area pump stations were left inoperable or inaccessible, which caused the dewatering process to take approximately 53 days. According to the Department of Health and Hospitals (DHH), approximately 1,400 deaths were reported following Hurricane Katrina. Approximately 1.3 million residents were displaced immediately following the storm. The storm caused more than \$40.6 billion of insured losses to the homes, businesses, and vehicles in six states. Approximately two thirds of these losses, or \$25.3 billion, occurred in Louisiana based on data obtained from the Insurance Information Institute. According to the LRA, approximately 150,000 housing units were damaged, and according to the Department of Environmental Quality (DEQ), 350,000 vehicles, and 60,000 fishing and recreational vessels were damaged.

3.2 FEMA FLOOD CLAIMS

As of the 2019 season, 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. Table 3-1 lists the FEMA flood claims, by parish, from January 1878 through September 2018.

Table 3-1. FEMA Flood Claims by Parish for January 1878-September 2018

Parish	Total Number of Claims	Total Payments (millions)
Jefferson	129,140	\$3,410
Orleans	124,030	\$7,246
St. Bernard	23,626	\$2,238
St. Charles	5,963	\$101
Total	282,759	\$12,995

3.3 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 10-year period, since 1978. A RL property may or may not be currently insured by the NFIP. Table 3-2 shows the repetitive loss property by parish.

Table 3-2. FEMA Severe Repetitive Loss Properties by Parish (January 1978-December 2018)

Parish	Number of Structures
Jefferson	8,844
Orleans	6,544
St. Bernard	1,207
St. Charles	643
Total	17,238
Source: Federal Emergency Management Agency (FEMA)	

4 ANALYSIS OVERVIEW

4.1 STRUCTURE INVENTORY

The structure inventory used for this study is the National Structure Inventory (NSI) version 2. This updated version of the inventory uses open-source building footprints from Microsoft data, ESRI map layer data, and CoreLogic data to improve structure placement over the previous version of the NSI. RS Means was used to calculate the depreciated replacement value of structures. An extensive survey was conducted to estimate foundation heights for different sectors within the Metro New Orleans area. Furthermore, the foundation heights of the inventory were updated using data from a traffic zone survey that was conducted for the Metro New Orleans data. This structure inventory does not include future development. Structure counts by reach along with the total structure and content value are shown in Table 4-1. Structure counts by occupancy types are shown in Table 4-2.

Table 4-1. Structure Counts and Value by Reach (2021 price level)

Reach	Structure Count	Total Value
CL	19,598	7,802,961,000
JEB	86,639	48,018,373,000
NOE	23,959	11,612,588,000
OEB	93,052	63,381,560,000
SC	10,104	4,704,841,000
Total	233,352	135,520,323,000

Table 4-2. Residential and Non-Residential Structure Inventory Counts

Residential	Number
One-Story Slab	73,761
One-Story Pier	67,339
Two-Story Slab	26,600
Two-Story Pier	23,478
Mobile Home	3,420
Total	194,598
Non-Residential	Number
Eating and Recreation	3,718
Professional	12,065
Public and Semi-Public	3,293
Repair and Home Use	4,211
Retail and Personal Services	7,666
Warehouse	5,016
Multi-Family Occupancy	2,795
Total	38,764

4.2 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.

4.3 DEPTH-DAMAGE RELATIONSHIPS AND CONTENT-TO-STRUCTURE VALUE RATIO (CSV)

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 (CSV) 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 feasibility studies associated with Jefferson and Orleans Parishes. 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 Jefferson and Orleans Flood Control Feasibility Studies, June 1996 Final Report. Table 4-3 displays the content-to-structure value ratios and their respective standard deviations used for LPV.

Table 4-3. Content-to-Structure Value Ratios and Standard Deviations

Structure Category		(CSV,SD)
Residential	One-story	(0.69, 0.37)
	Two-story	(0.67, 0.35)
	Mobile home	(1.14, 0.79)
Non-Residential	Eating and Recreation	(1.70, 2.93)
	Groceries and Gas Stations	(1.34, 0.78)
	Professional Buildings	(0.54, 0.54)
	Public and Semi-Public Buildings	(0.55, 0.80)

Structure Category		(CSV,SD)
	Multi-Family Buildings	(0.28, 0.17)
	Repair and Home Use	(2.36, 2.95)
	Retail and Personal Services	(1.19, 1.05)
	Warehouses and Contractor Services	(2.07, 3.25)

4.4 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 2020. Since only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of \$12,000 ($\$20,000 \times 2.0 \times 0.30$) 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 30 units so every apartment building has \$360,000 as the average value for vehicles (30 units x \$12 thousand).

4.5 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, \$18,800, 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.

4.6 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.

4.7 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 DAMAGES AND BENEFITS ESTIMATION

5.1 ECONOMIC MODEL

The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) program version 1.4.2 was utilized to evaluate flood damages using risk-based methods. This program is used to quantify the uncertainty in discharge-exceedance probability, stage-discharge, and stage-damage functions and assimilates it into the economic and engineering performance analyses of alternatives. Monte Carlo simulation is used to compute the expected value of damage while explicitly accounting for the uncertainty in economic and hydraulic parameters used to determine flood inundation damages. The analysis considers a range of possible values for each economic variable used to calculate the elevation- or stage-damage curves, and for each hydrologic/hydraulic variable used to calculate the stage-frequency curves. It also considers a probability distribution for the likely occurrence of any given outcome within the specified range. The key economic inputs for the analysis are the structure inventory, depth-damage functions, content-to-structure value ratios, and the associated quantified risk and uncertainty parameters associated with these inputs.

5.2 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 2028 and 2077 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 LPV

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.

5.3 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. Order statistics are used to define the uncertainty about a graphical frequency function defined by Weibull plotting positions for a specified equivalent record length. A normal distribution is used to define the errors. The model used the eight stage-probability events (1, 0.1, .04, .02, .01, .005, .002, .001) representing water surface elevations from coastal storm surge 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. The model used the 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. False levees were used to control for damages occurring below the stages where inundation begins. Table 5-1 shows the damages by probability event in both 2028 and 2077. The stage probability relationships that were developed for this study reflect inundation resulting from overtopping of the existing system. Levee fragility was not modeled for this study. Although it is common to include levee fragility as part of the estimation of without-project damages for existing local levees, the existing levee system in this study is a FEMA certified Federal levee system that was constructed in accordance with the USACE HSDRRS criteria.

Table 5-1. Study Area Damages by Year and Probability Event (\$1,000s)

AEP	Damages 2028	Damages 2077
0.1	0	0
0.05	0	0
0.02	0	75,000
0.01	18,000	1,525,000
0.005	929,000	32,505,000
0.002	18,651,000	89,972,000
0.001	38,383,000	111,914,000

5.4 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 condition, the expected annual damages (EAD) were totaled for each study area reach to obtain the total without-project EAD under 2028 and 2077 conditions. Table 5-2 shows the without-project damages by damage category for 2028 and 2077. Tables 5-3 and 5-4 show the without-project damages by reach for 2028 and 2077 respectively. The increase in damages from 2028 to 2077 is due to increasing sea-level rise along with increasing subsidence of the existing levee system. No future development was included in this analysis. This process is repeated for the Recommended Plan.

Table 5-2. Study Area Damage by Damage Category (\$1,000s)

Year	Auto	Commercial	Mobile Homes	Residential	Total
2028	3,417	51,974	1,259	40,720	97,370
2077	14,533	258,248	7,097	200,127	480,005

Table 5-3. Study Area Expected Annual Damages Without-Project (2028; \$1,000s)

Reach	EAD
Chalmette Loop	6,353
Jefferson East Bank	68,820
New Orleans East	7,177
Orleans East Bank	7,640
Saint Charles	7,380
Total	97,370

Table 5-4. Study Area Expected Annual Damages Without-Project (2077; \$1,000s)

Reach	EAD
Chalmette Loop	12,150
Jefferson East Bank	249,553
New Orleans East	36,300
Orleans East Bank	160,211
Saint Charles	21,791
Total	480,005

5.5 EQUIVALENT ANNUAL DAMAGES

The model uses the discount rate to discount the future damages and benefits occurring in 2077 back to the base year of 2028. Table 5-5 shows the equivalent annual damages by reach for the without-project condition and the damages reduced for the Recommended Plan. Table 5-6 shows the equivalent annual damages and benefits by category and the percentage that each category contributes to the total.

Table 5-5. Study Area Equivalent Annual Damages and Benefits by Reach (FY 21 Price Level; FY 21 Discount Rate; \$1,000s)

Reach	Without Project Damages	Residual Damages	Damages Reduced
Chalmette Loop	8,612	1,909	6,703
Jefferson East Bank	139,247	17,690	121,558
New Orleans East	18,526	1,964	16,561
Orleans East Bank	67,094	31,171	35,923
Saint Charles	12,995	136	12,860
Total	246,474	52,869	193,605

Table 5-6. Study Area Equivalent Annual Damages and Benefits by Damage Category (FY 21 Price Level; FY 21 Discount Rate; \$1,000s)

Without Project Damages				
Auto	Commercial	Mobile Homes	Residential	Total
7,749	132,354	3,534	102,837	246,474
3%	54%	1%	42%	100%
Damages Reduced				
5,833	107,241	2,789	77,741	193,605
3%	55%	1%	40%	100%

6 PROJECT COSTS

6.1 AVERAGE ANNUAL COSTS

The schedule of initial construction cost, which make up the cost of addressing the existing deficiencies in the system, were used to determine the interest during construction and gross investment cost at the end of the installation period (2028). The FY 2021 Federal discount rate of 2.5 percent was used to discount the costs to the base year and then amortize the costs over the 50-year period of analysis. The incremental operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) costs for the recommended plan was discounted to present value and annualized using the Federal discount rate of 2.5 percent for 50 years. This estimate assumes an average yearly cost of \$1000 per linear foot for minor repairs to concrete, joints, and slope paving, as well as minor mowing. It also assumes an average yearly cost of \$2700 per acre of levee surface for mowing. This estimate of OMRR&R represents the incremental costs associated with the new or improved project features. The total OMRR&R represents approximately 3% of the total project cost. Table 6-1 provides 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 the Recommended Plan.

Table 6-1. Recommended Plan (2021 Price Level; FY 21 Discount Rate)

Year	Years from Base Year	Expenditures	Present Value Factor	Present Value of Expenditures
2025	3	\$36,551,557	1.0637	38,879,041
2026	2	\$36,551,557	1.0377	37,930,772
2027	1	\$36,551,557	1.0124	37,005,631
2028	0	\$0	0.9877	0
2029	-1	\$0	0.9636	0
2030	-2	\$0	0.9401	0
2031	-3	\$0	0.9172	0
2032	-4	\$20,712,363	0.8948	18,534,132
2033	-5	\$20,712,363	0.8730	18,082,080
2034	-6	\$0	0.8517	0
2035	-7	\$32,470,399	0.8309	26,981,037
2036	-8	\$108,572,238	0.8107	88,016,872
2037	-9	\$108,572,238	0.7909	85,870,119
2038	-10	\$18,396,386	0.7716	14,194,886
2039	-11	\$49,300	0.7528	37,113
2040	-12	\$27,476,235	0.7344	20,179,431
2041	-13	\$28,194,235	0.7165	20,201,710
2042	-14	\$43,832,390	0.6990	30,640,730
2043	-15	\$767,300	0.6820	523,293

Year	Years from Base Year	Expenditures	Present Value Factor	Present Value of Expenditures
2044	-16	\$35,092,677	0.6654	23,349,238
2045	-17	\$76,251,961	0.6491	49,497,512
2046	-18	\$72,394,457	0.6333	45,847,304
2047	-19	\$19,163,686	0.6179	11,840,326
2048	-20	\$19,163,686	0.6028	11,551,538
2049	-21	\$19,163,686	0.5881	11,269,793
2050	-22	\$767,300	0.5737	440,229
2051	-23	\$767,300	0.5597	429,491
2052	-24	\$20,836,369	0.5461	11,378,561
2053	-25	\$50,016,020	0.5328	26,647,138
2054	-26	\$29,946,951	0.5198	15,565,755
2055	-27	\$29,946,951	0.5071	15,186,102
2056	-28	\$767,300	0.4947	379,608
2057	-29	\$767,300	0.4827	370,349
2058	-30	\$767,300	0.4709	361,316
2059	-31	\$767,300	0.4594	352,504
2060	-32	\$767,300	0.4482	343,906
2061	-33	\$767,300	0.4373	335,518
2062	-34	\$35,568,039	0.4266	15,173,528
2063	-35	\$39,898,537	0.4162	16,605,798
2064	-36	\$39,898,537	0.4060	16,200,779
2065	-37	\$39,898,537	0.3961	15,805,638
2066	-38	\$767,300	0.3865	296,549
2067	-39	\$767,300	0.3771	289,316
2068	-40	\$767,300	0.3679	282,260
2069	-41	\$24,795,796	0.3589	8,898,927
2070	-42	\$24,795,796	0.3501	8,681,880
2071	-43	\$24,795,796	0.3416	8,470,127
2072	-44	\$767,300	0.3333	255,713
2073	-45	\$767,300	0.3251	249,476
2074	-46	\$767,300	0.3172	243,392
2075	-47	\$767,300	0.3095	237,455
2076	-48	\$767,300	0.3019	231,664

Year	Years from Base Year	Expenditures	Present Value Factor	Present Value of Expenditures
2077	-49	\$767,300	0.2946	226,013
		\$1,134,081,700		\$754,371,549
Interest Rate (%)	2.5			
Amortization Factor	0.03526			
Average Annual Costs	\$26,119,100			
Average Annual O&M Costs	\$478,600			
Total Average Annual Costs	\$26,597,700			

7 RESULTS

7.1 NET BENEFITS

The net benefits for the Recommended Plan 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 Recommended Plan. Table 7-1 displays the equivalent annual damages and benefits, total first costs, average annual cost, benefit-to-cost ratio, and equivalent annual net benefits for the Recommended Plan. The Recommended Plan is economically justified, meaning its benefit-to-cost ratio is at least 1.

Table 7-1. Net Benefits Summary for the Recommended Plan (FY 2021 Price Level; FY 2021 Discount Rate; \$1,000s)

Alternative	Recommended Plan
Project First Cost	\$1,105,593
Interest During Construction	\$4,160
Total Investment Cost	\$1,109,753
AA Investment Costs	\$26,119
AA O&M Costs	\$479
Total AA Costs	\$26,598
Without Project EAD	\$246,474
EAD Reduced Benefits	\$193,605
Net Benefits	\$167,007
B/C Ratio	7.3

7.2 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 the recommended plan. Table 7-2 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 Recommended 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. The net benefits and B/C ratios are also displayed at each of the percentiles.

Table 7-2. Risk Analysis Probability that Expected Annual Benefits Exceed Annual Costs (FY 2021 Price Level; FY 2021 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
Recommended Plan	\$193,605	27,243	73,715	298,131	\$26,598	Greater Than 75%
Net Benefits		645	47,117	271,533		
B/C Ratio		1.0	2.8	11.2		

7.3 RELATIVE SEA LEVEL RISE SCENARIOS

The prior analysis incorporated H&H data that was developed from the intermediate relative sea-level rise scenario, which was determined to be the most likely scenario to occur. H&H data was also developed for low and high relative sea-level rise scenarios. The project benefits, net benefits, and b/c ratios were recalculated under both alternate relative sea-level rise scenarios. These results are displayed in Table 7-3.

Table 7-3. Relative Sea Level Rise Scenarios (FY 2021 Price Level; FY 2021 Discount Rate; \$1,000s)

Scenario	Low RSLR	High RSLR
Total AA Costs	26,598	26,598
Without Project EAD	215,437	394,109
EAD Reduced Benefits	170,066	234,498
Net Benefits	143,468	207,900
B/C Ratio	6.4	8.8

7.4 PROJECT PERFORMANCE

The results from the HEC-FDA model were also used to calculate the long-term annual exceedance probability (AEP) and the conditional non-exceedance probability, or assurance, for various probability storm events. The model provided a target stage to assess project performance for each study area reach for the base year, 2028, and the last year in the 50-year period of analysis under both without-project and with-project conditions. For study area reaches without proposed levees or berms, the target stage was set by default at the elevation where the model calculated five percent residual damages for the 1% AEP (100-year) event.

The HEC-FDA model calculated a target stage AEP with a median and expected value that reflected the likelihood that the target stages will be exceeded in a given year. The median value was calculated using point estimates, while the expected value was calculated using Monte Carlo simulation. The results also show the long-term risk or the probability of a target stage being exceeded over 10-year, 30-year, and 50-year periods. Finally, the model results show the conditional non-exceedance probability or the likelihood that a target stage will not be exceeded by the 10% AEP (10 year), the 4% AEP (25-year), the 2% AEP (50-year), the 1% AEP (100-year), the 0.4% AEP (250-year), and the 0.2% AEP (500-year). Tables 7-4 through B:7-7 display the project performance results for each study area reach for the base year, 2028, and the last year in the 50-year period of analysis, 2077, under without-project and with-project conditions.

Table 7-4. Project Performance by Reach, Without Project 2028

					Long Term Risk (years)				Conditional Non-Exceedance Probability by Events				
Reach	Target Stage	Geo Tech	Median	Expected	10	30	50	0.1	0.04	0.02	0.01	0.004	0.002
CL	-3	L	0.01	0.015	0.1403	0.3645	0.5303	0.9998	0.9797	0.777	0.4499	0	0
JEB	-8	L	0.02	0.037	0.314	0.6772	0.8481	0.9997	0.8068	0.0973	0.0256	0.0117	0.0049
NOE	-6	L	0.01	0.0157	0.1466	0.3784	0.5472	0.9996	0.9784	0.7771	0.4272	0	0
OEB	0.84	L	0.01	0.0151	0.1415	0.3672	0.5336	0.9996	0.9781	0.7738	0.4428	0	0
SC	1.17	L	0.0101	0.0098	0.0938	0.2558	0.3888	0.9998	0.9998	0.8779	0.4975	0.3875	0.3285

Table 7-5. Project Performance by Reach, Without Project 2077

					Long Term Risk (years)				Conditional Non-Exceedance Probability by Events				
Reach	Target Stage	Geo Tech	Median	Expected	10	30	50	0.1	0.04	0.02	0.01	0.004	0.002
CL	-3	L	0.02	0.0352	0.301	0.6584	0.8331	0.9997	0.8068	0.1086	0.0285	0.012	0.0066
JEB	-7	L	0.02	0.0368	0.3124	0.6749	0.8463	0.9997	0.8065	0.049	0.0129	0.009	0.0074
NOE	-5.58	L	0.0198	0.0245	0.2197	0.525	0.7108	0.9997	0.9997	0.1629	0.0423	0.0132	0.0084
OEB	0.85	L	0.0199	0.026	0.2317	0.5465	0.7323	0.9998	0.9993	0.1249	0.0327	0.0162	0.0105
SC	1.17	L	0.0194	0.0216	0.1958	0.48	0.6637	0.9997	0.9997	0.2556	0.0674	0.0463	0.0357

Table 7-6. Project Performance by Reach, Recommended Plan 2028

					Long Term Risk (years)				Conditional Non-Exceedance Probability by Events				
Reach	Target Stage	Geo Tech	Median	Expected	10	30	50	0.1	0.04	0.02	0.01	0.004	0.002
CL	-3	L	0.02	0.0262	0.2336	0.5498	0.7355	0.9995	0.8057	0.4989	0.0521	0	0
JEB	-8	L	0.999	0.999	1	1	1	0	0	0	0	0	0
NOE	-6	L	0.999	0.999	1	1	1	0	0	0	0	0	0
OEB	0.84	L	0.1	0.1237	0.7329	0.9809	0.9986	0.2015	0	0	0	0	0
SC	1.03	L	0.5	0.5921	0.9999	1	1	0	0	0	0	0	0

Table 7-7. Project Performance by Reach, Recommended Plan 2077

					Long Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Reach	Target Stage	Geo Tech	Median	Expected	10	30	50	0.1	0.04	0.02	0.01	0.004	0.002
CL	-3	L	0.02	0.0266	0.236	0.5541	0.7398	0.9996	0.8053	0.4967	0.3016	0	0
JEB	-6.97	L	0.01	0.0145	0.1362	0.3555	0.5191	0.9996	0.9996	0.9887	0.4931	0	0
NOE	-5.58	L	0.0099	0.0144	0.1349	0.3525	0.5154	0.9995	0.9995	0.9884	0.5189	0	0
OEB	0.85	L	0.0199	0.0268	0.2382	0.558	0.7435	0.9998	0.9994	0.1118	0.0294	0.016	0.0112
SC	1.17	L	0.008	0.0082	0.0789	0.2186	0.3371	0.9997	0.9997	0.9997	0.9121	0	0

8 REGIONAL ECONOMIC DEVELOPMENT (RED)

8.1 GENERAL

The Regional Economic Development (RED) account addresses the impacts that the USACE expenditures associated with the construction of a coastal storm risk management system will have on the levels of income, output and employment throughout the region. These impacts are not included in the NED analysis, but can still be used by decision makers as part of their investment decision process.

This Regional Economic Development (RED) analysis employs input-output economic analysis, which measures the interdependence among industries and workers in an economy. This analysis uses a matrix representation of a regional economy to predict the effect that changes in one industry will have on other industries. The greater the interdependence among industry sectors, the larger the multiplier effect on the economy. Changes to government spending drive the input-output model to project new levels of sales (output), value added Gross Regional Product (GRP), employment, and income for each industry.

RECONS Version 2 was the specific input-output model used to estimate the regional economic development impacts of the Recommended Plan. The U.S. Army Corps of Engineers (USACE) Institute for Water Resources, Louis Berger, and Michigan State University developed the regional economic impact modeling tool, RECONS (Regional Economic System), that provides estimates of jobs and other economic measures such as labor income, value added, and sales that are supported by USACE programs, projects, and activities. This modeling tool automates calculations and generates estimates of jobs, labor income, value added, and sales through the use of IMPLAN®'s multipliers and ratios, customized impact areas for USACE project locations, and customized spending profiles for USACE projects, business lines, and work activities. RECONS allows the USACE to evaluate the regional economic impact and contribution associated with USACE expenditures, activities, and infrastructure.

8.2 DESCRIPTION OF METRICS

“Output” is the sum total of transactions that take place as a result of the construction project, including both value added and intermediate goods purchased in the economy. “Labor Income” includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income. “Value Added” or “Gross Regional Product” represents the value-added output of the study regions. This metric captures all final goods and services produced in the study areas because of the existence of the project. It is different from output in the sense that one dollar of a final good or service may have multiple transactions associated with it. “Jobs” is the estimated worker-years of labor required to build the project.

8.3 ASSUMPTIONS

Input-output analysis rests on the following assumptions. The production functions of industries have constant returns to scale, so if output is to increase, inputs will increase in the same proportion. Industries face no supply constraints; they have access to all the materials they can use. Industries have a fixed commodity input structure; they will not substitute any commodities or services used in the production of output in response to price changes. Industries produce their commodities in fixed proportions, so an industry will not increase production of a commodity without increasing production in every other commodity it produces. Furthermore, it

is assumed that industries use the same technology to produce all of their commodities. For this analysis, the Long-Term Impacts and Contributions module was used to account for expenditures occurring throughout the period of analysis. The economic impacts results are presented for the entire period of analysis, aggregated for all 50 years for output, labor income, and value added. The number of jobs is presented as an average across all years included in the period of analysis.

8.4 RESULTS

The construction expenditures associated with the Recommended Plan are estimated to be \$1,105,593,000. Of this total expenditure, \$1,070,309,718 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures of \$1,105,593,000 support a total of 292 average annual, full-time equivalent jobs, \$1,122,511,177 in labor income, \$1,296,667,786 in gross regional product, and \$2,088,615,000 in economic output in the local impact area. More broadly, these expenditures support 379 average annual, full-time equivalent jobs, \$1,506,297,652 in labor income, \$1,867,910,659 in gross regional product, and \$3,096,587,178 in economic output in the nation. Table 8-1 summarizes these results.

Table 8-1. Regional Economic Development (RED) Summary

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	\$1,070,309,718	197	\$788,868,080	\$709,867,871
Secondary Impact	\$1,018,305,281	95	\$333,643,097	\$586,799,915
Total Impact	\$2,088,615,000	292	\$1,122,511,177	\$1,296,667,786
State				
Direct Impact	\$1,074,870,917	203	\$831,590,902	\$717,952,264
Secondary Impact	\$1,059,505,971	101	\$340,238,148	\$601,215,694
Total Impact	\$2,134,376,888	303	\$1,171,829,050	\$1,319,167,958
US				
Direct Impact	\$1,098,810,292	220	\$865,325,430	\$774,817,200
Secondary Impact	\$1,997,776,886	159	\$640,972,222	\$1,093,093,459
Total Impact	\$3,096,587,178	379	\$1,506,297,652	\$1,867,910,659

* Jobs are presented in average annual, full-time equivalence (FTE)

It should be noted that in addition to the regional benefits that would accrue to the study area from the expenditures associated with the construction of the levee lifts, there are additional regional benefits in the form of the avoidance of business losses. Given that the study area is highly developed with a large number of commercial structures, a significant storm event that

would overtop the existing system would cause major disruptions in regional commerce. Maintaining the target level of risk reduction with the levee lifts would reduce the likelihood that the system would overtop, and, in the event that overtopping did occur, would likely result in lower levels of flooding inside of the levee system, mitigating the potential disruption.