Mississippi Valley Division,
Regional Planning and Environment Division South

St. Tammany Parish, Louisiana Feasibility Study

Appendix F – Economics

July 2023

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Introduction

1.1 METHODOLOGY OVERVIEW

After the release of the Draft Integrated Feasibility Report and Environmental Impact Statement (DIFR-EIS) in June 2021, an economic analysis for the Optimized TSP was conducted. Subsequent to the release of the Draft Tentatively Selected Plan (TSP) described in the DIFR-EIS, it was discovered that the clearing and snagging of Bayou Patassat would not be as effective as the Hydraulic and Hydrologic (H&H) modeling originally estimated. An updated analysis of this measure yielded a benefit/cost (b/c) ratio of 0.5. As a result, the measure was not carried forward as part of the Optimized TSP. Furthermore, a new aggregation method was developed for the nonstructural analysis.

This appendix contains the economic evaluation of the Final Array of Alternatives for the St. Tammany Parish, Louisiana Feasibility Study (study). This appendix 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 Coastal Storm Risk Management (CSRM) National Economic Development (NED) Manual. The NED 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).

This appendix consists of a description of the methodology used to determine 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 coastal flooding and rainfall and riverine flooding. The coastal flooding was modeled separately from the rainfall and riverine modeling. The HEC-FDA model was used to calculate these project benefits. The model is described in Section 3. The damages and costs for the Optimized TSP were calculated using FY 2023 price levels. The FY 2023 Federal discount rate of 2.5 percent was used to calculate interest during construction on the Optimized TSP from the beginning of construction up to 2032 which is the base year of the study. This discount rate was also used to discount the future operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs for the Optimized TSP occurring throughout the 50-year period of analysis back to the 2032 (project base year). The annualized costs and interest during construction (IDC) values are shown in Section 4.

The study area is divided up into the sub-basins shown in Figure F:1-1. For modeling purposes, some of the sub-basins shown were subdivided into smaller reaches based on H&H behavior and the study locations. These smaller reaches are shown in Figure F:3-1 and Figure F:3-2. 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 2082 and the base year of 2032. No future development was included in the analysis. In accordance with 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. The development of these uncertainty parameters is described in Section 2.

The evaluation of structural measures is included in Section 5. The evaluation of nonstructural measures is included in Section 6. Section 7 includes the identification of the various measures that comprise the Optimized TSP.

1.2 STUDY AREA

The study area encompasses all of St. Tammany Parish, which is approximately 1,124 square miles and located in southeastern Louisiana (Figure F:1-1). St. Tammany Parish is located on the northeast shore of Lake Pontchartrain and is home to over 258,111 residents. The parish is uniquely located at the crossroads of three interstates, I-10, I-12, and I-59 and transportation waterways to the Gulf of Mexico.

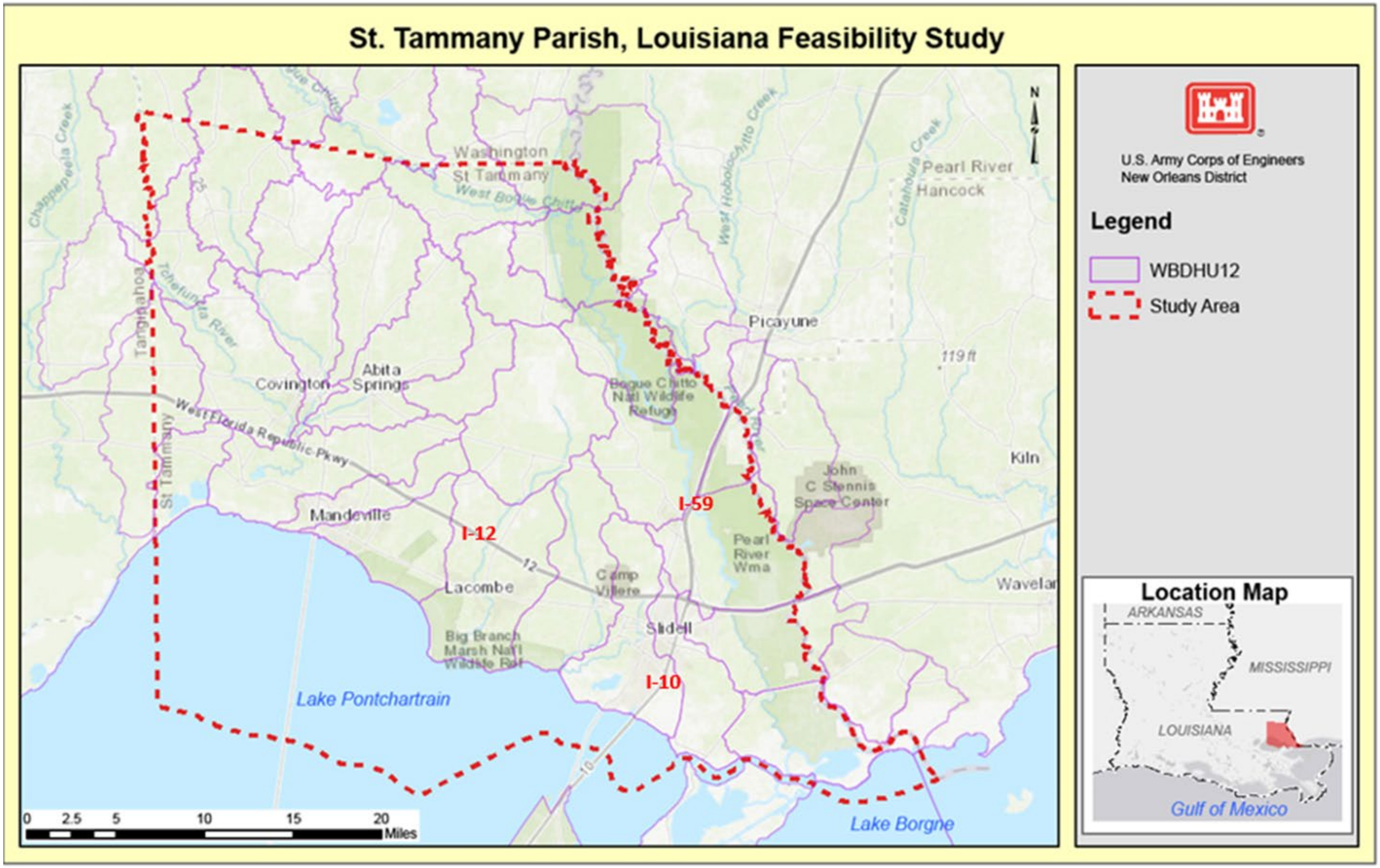


Figure F:1-1. St. Tammany Parish Study Area Boundary

The Pearl River runs along the Mississippi-Louisiana state line and is the eastern boundary of the study area. Lake Pontchartrain, one of the largest estuaries in the United States, serves as the southern border. Tangipahoa Parish is located along the western boundary, and Washington Parish is located along the northern boundary. There are 36 hydrologic sub-basins, as defined by the United States Geological Survey (USGS) 12- digit hydrologic unit delineations (WBDHUC12) within the study area. The majority of St. Tammany Parish's population resides along the edge of Lake Pontchartrain, and many commute into New Orleans. Major communities in the study area include Slidell, Mandeville, Covington, Abita Springs, Pearl River, and Madisonville. St. Tammany Parish is the fastest-growing parish in Louisiana and one of the fastest-growing communities in the nation. Major industries in the study area are health care and social assistance, retail trade, professional, scientific, and technical services, construction, finance, and insurance. The total number of acres by land use of developed agricultural, and undeveloped land in the study area is shown in Table F:1-1.

Table F:1-1. Land Use

Land Class Name	Acres	Percentage of Total
Developed Land	80,190	15%
Agricultural Land	316	0%
Undeveloped Land	455,312	85%
Total	535,817	100%

National Agriculture Statistics Service (NASS), National Cropland Data Layer (CDL), 2020

The significant flood events in the study area are shown in Table F:1-2.

Table F:1-2. St. Tammany Parish Flood Events

Date	Event	Date	Event
Aug-69	Hurricane Camille	Aug-02	Tropical Storm Bertha
Apr-79	Heavy Rainfall	Sep-02	Tropical Storm Isidore
Apr-80	Heavy Rainfall	Oct-02	Hurricane Lili
Dec-82	Heavy Rainfall	Sep-04	Hurricane Ivan
Jan-83	Heavy Rainfall	Aug-05	Hurricane Katrina
Mar-83	Heavy Rainfall	Jan-06	Heavy Rainfall
Apr-83	Heavy Rainfall	Oct-07	Heavy Rainfall

Aug-85	Hurricane Danny	May-08	Heavy Rainfall
Nov-85	Hurricane Juan	Aug-08	Tropical Storm Fay
Feb-88	Heavy Rainfall	Sep-08	Hurricane Ike
Apr-88	Heavy Rainfall	Sep-08	Hurricane Gustav
Jun-89	Heavy Rainfall	Apr-09	Heavy Rainfall
May-91	Heavy Rainfall	Oct-09	Heavy Rainfall
Aug-92	Hurricane Andrew	Nov-09	Heavy Rainfall
Apr-95	Heavy Rainfall	Nov-09	Tropical Storm Ida
May-95	Heavy Rainfall	Dec-09	Heavy Rainfall
Oct-95	Hurricane Opal	Sept-11	Tropical Storm Lee
Aug-96	Heavy Rainfall	Aug-12	Hurricane Isaac
Oct-96	Coastal Flooding	Mar-16	Heavy Rainfall
Jan-98	Heavy Rainfall	Aug-16	Heavy Rainfall
Mar-98	Heavy Rainfall	Dec-18	Heavy Rainfall
Sep-98	Tropical Storm Frances	Feb-20	Pearl River Flooding
Sep-98	Hurricane Georges	Jun-20	Tropical Storm Cristobal
Jun-01	Heavy Rainfall	May -20	Heavy Rainfall
Jun-01	Tropical Storm Allison	Oct-20	Hurricane Zeta

GEC 2012 and Neel Shaffer

1.3 POPULATION, NUMBER OF HOUSEHOLDS, AND EMPLOYMENT

Tables F:1-3, F:1-4, and F:1-5 display the population, number of households, and the employment (number of jobs) for St. Tammany Parish for the years 2000, 2010, 2020, and projections for 2025 and 2045.

Table F:1-3. Historical and Projected Population by Parish

Parish	2000	2010	2020	2025	2045
St. Tammany	192,131	234,567	258,447	262,054	275,133

Sources: 2000, 2010, and 2020 from U.S. Census Bureau; 2025, 2045 from Moody’s Analytics (ECCA) Forecast

Table F:1-4. Historical and Projected Households by Parish

Parish	2000	2010	2020	2025	2045
St. Tammany	69,714	87,915	95,054	105,906	119,757

Sources: 2000, 2010, and 2020 from U.S. Census Bureau; 2025, 2045 from Moody's Analytics (ECCA) Forecast

Table F:1-5. Historical and Projected Employment by Parish

Parish	2000	2010	2020	2025	2045
St. Tammany	59,560	78,379	89,294	96,699	110,549

Sources: 2000, 2010, and 2020 from U.S. Bureau of Labor Statistics; 2025, 2045 from Moody's Analytics (ECCA) Forecast

1.4 INCOME

Table F:1-6 shows the actual and projected per capita personal income levels for St. Tammany Parish from 2000 to 2025.

Table F:1-6. Per Capita Income ($) by Parish

Parish	2000	2010	2020	2025
St. Tammany	29,945	46,995	70,190	96,474

Sources: 2000, 2010, and 2020 from U.S. Bureau of Economic Analysis; 2025 from Moody's Analytics (ECCA) Forecast

1.5 COMPLIANCE WITH POLICY GUIDANCE LETTER 25 AND ER 1165-2-26

Given continued growth in population in the study area, it is expected that development will continue to occur with or without the implementation of the Optimized TSP. The implementation of the Optimized TSP will not conflict with USACE Planning Guidance Letter 25 "Federal Participation in Land Development at Structural Flood Damage Reduction Projects", ER 1165-2-26, "Implementation of Executive Order (EO) 11988 on Floodplain Management", and EO 11988, generally 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 Optimized TSP would not induce development, but would rather reduce the risk of the population being displaced after a major flood event.

SECTION 2

Asset Inventory in Study Area

2.1 STRUCTURE INVENTORY

There are 100,252 residential structures and 11,440 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, Environmental Systems Research Institute (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 data 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 2023. The RS Means Construction Cost Index is a database of current construction cost estimates that includes location factors and a catalogue of historical cost estimates so that costs can be compared over time and escalated when needed. The NSI2 inventory was joined with parcel data to improve structure placement. Table F:2-1 displays the structure counts by occupancy type.

Table F:2-1. Structure Counts by Occupancy Type

Structure Category	
Residential	**Number**
Single Family 1-Story Slab	20,389
Single Family 1-Story Pier	40,374
Single Family 2-Story Slab	28,105
Single Family 2-Story Pier	778
Manufactured, modular and mobile homes	10,606
Total	100,252
Non-Residential	**Number**
Multi-Family	2,181
Professional	2,409
Public	973
Repair	921
Restaurants	726
Retail	1,883
Warehouse	2,347

Total	11,440

The foundation heights of the structures were updated through stratified sampling by study area sub-basin. The strata identified were based on the sub-basin boundaries located within the study area. In cases where sub-basins contained few structures, they were consolidated into a stratum with a neighboring sub-basin. A total of 21 strata were identified. The following formula was used to determine sample size based on foundation height at the 95 percent level of confidence n = ((Z*S)/E)^2.

n = sample size for a Stratum

Z = 1.96 (95 percent level of confidence)

S = (max height - min height)/6

E = allowable error (precision); 0.3 feet is the allowable error for foundations

A total of 30 structures were sampled in each stratum. The selected structures were then located on Google Earth to determine their foundation heights. Table F:2-2 displays the foundation heights by damage category for each sub-basin in the study area.

Table 2:2-2. Foundation Heights by Damage Category and Sub-basin

Sub-basin	**Residential Slab**	**Residential Pier**	**Manufactured, modular and mobile homes**	**Non Residential**
1	1.05	2.75	2.00	1.38
2	0.74	3.00	2.02	1.00
3	0.53	1.33	2.00	1.00
4	0.53	1.33	2.00	1.00
5	0.50	1.67	2.00	1.03
6	0.50	1.00	2.00	1.00
7	0.50	1.00	2.00	1.00
8	0.67	3.80	2.00	1.00
9	0.67	3.80	2.00	1.00
10	0.52	1.83	2.00	1.00
12	0.81	2.14	2.02	1.50
13	0.81	2.14	2.02	1.50
15	0.60	1.20	2.17	1.03
16	0.60	1.20	2.17	1.03

17	0.60	1.20	2.17	1.03
18	0.78	5.00	2.00	1.00
19	0.52	1.00	2.00	1.00
20	0.52	1.00	2.00	1.00
21	0.52	1.00	2.00	1.00
22	0.58	2.25	2.00	1.03
23	0.66	2.75	2.02	1.00
24	0.60	1.45	2.00	1.00
25	0.92	2.50	2.13	0.50
26	0.92	2.50	2.13	0.50
27	0.50	1.33	2.00	1.00
28	0.50	1.33	2.00	1.00
29	0.50	1.33	2.00	1.00
30	0.84	3.25	2.02	1.08
31	0.53	2.22	2.00	1.00
32	0.75	2.60	2.00	1.03
34	0.75	2.60	2.00	1.03
35	0.75	2.60	2.00	1.03
36	0.50	1.40	2.02	1.00

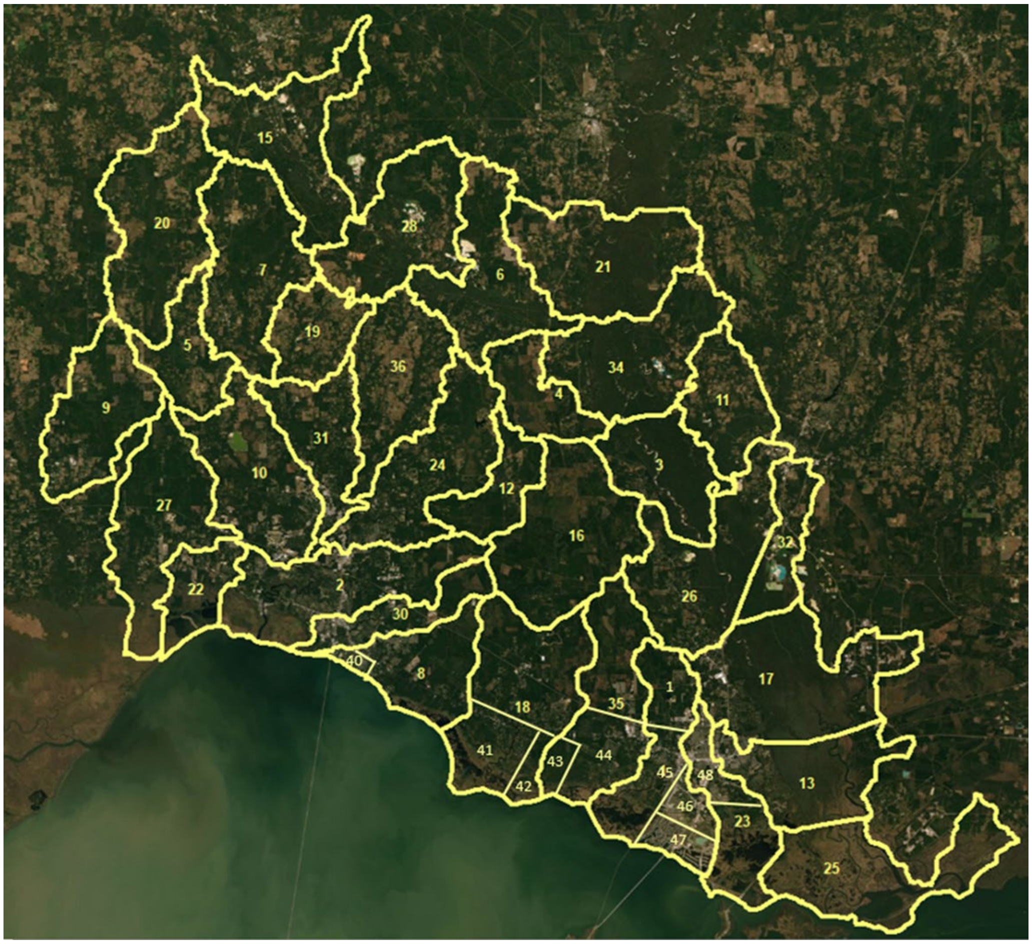


Figure 2:1 Study Area Sub-Basins

2.2 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. The structure value uncertainty values are displayed in Table F:2-2.

Table F:2-2. Structure Value Uncertainty

Maximum and Minimum Structure Value Uncertainty by Occupancy Type		
	Minimum	**Maximum**
1 story Residential	69%	116%
2 story Residential	69%	116%
Manufactured, modular and mobile homes	48%	147%
Multifamily	80%	123%
Public	80%	123%
Retail	80%	123%
Repair	80%	123%
Restaurant	80%	123%
Grocery	80%	123%
Professional	80%	123%
Warehouse	80%	123%

2.3 VEHICLE INVENTORY AND VALUES

Based on 2020 Census information for St. Tammany Parish, there are an average of approximately 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 Kelly Blue Book, the average value of a used car was $27,564 as of October 2022. Since only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of $8,269 ($27,564 x 0.30) was assigned to each individual residential automobile structure record in the HEC-FDA model. Two vehicles were assigned to each single-family residential structure. The number of vehicles assigned to multi-family structures were based on the number of units of each structure. Only vehicles associated with residential and multi-family structures were included in the analysis. Vehicles associated with non-residential properties were not included in the evaluation.

Vehicle Value Uncertainty

The uncertainty surrounding the values assigned to the vehicles in the inventory was determined using a triangular probability distribution function. The most likely value was $8,269, which is the average value of a used vehicle, $27,564, adjusted for the 70 percent evacuation rate. The maximum value used was $14,484, which is the average value of a new vehicle, $48,281, adjusted for the evacuation rate. The minimum value used was $1,448, which is the average 10-year depreciation value of a vehicle, $4,828, adjusted for the evacuation rate. 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=17 percent, most-likely=100 percent, maximum=175 percent). 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.

2.4 FIRST FLOOR ELEVATIONS

Topographical data based on North American Vertical Datum (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 with a 15-feet-by-15 feet 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 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.

2.5 ELEVATION UNCERTAINTY

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. There is also potential uncertainty in the first-floor elevation of a structure that is located on a parcel with a significant slope. In such a case, the first-floor elevation of the structure could vary across its footprint. Such parcels are not common in the study area, so this source of uncertainty is not captured in this analysis.

Uncertainty can only be applied to structure occupancies in the HEC-FDA model. 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.

2.6 DEPTH-DAMAGE RELATIONSHIPS AND CONTENT-TO-STRUCTURE VALUE RATIO

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 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 manufactured, modular 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 manufactured, modular, and mobile homes. 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.” The long duration, saltwater depth-damage functions were used to assess the damages from coastal flooding. The short-duration, freshwater depth-damage functions were used to assess the damages from rainfall and riverine flooding.

2.7 DEBRIS REMOVAL

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 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.

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 percent 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 2023 price levels using the indexes provided by Gordian’s 2023 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.

2.8 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.

2.9 DAMAGES TO STREETS AND HIGHWAYS

The reduction of potential flood damages to streets and highways in an evaluation area can form a significant category of benefits attributable to a project alternative. Major and secondary highways are defined as roadways with four lanes with relatively higher volumes of traffic and access, while streets are defined as roadways with two lanes with relatively lower volumes of traffic and access. The NED costs associated with transportation infrastructure were estimated based on data obtained during interviews with professionals familiar with infrastructure inundation impacts. The information compiled as part of the interview process can be found in the report entitled, “Development of Depth-Emergency Costs and Infrastructure Damage Relationships for Selected South Louisiana Parishes,” dated March 2012.

The professionals interviewed provided costs for three components of streets (street surface, street base, and street curb), three components of major and secondary highways (road surface, road base, and road shoulder, and three components of railroad tracks (electrical interlocking and grade crossings and non-electrical track structures). The experts also provided estimates of the depreciation of the roadways. The value of each mile of roadway and railway component was discounted by the estimated depreciation percentage. Finally, the experts estimated the percentage of the road components that would be damaged at the 2-feet, 5-feet, and 12-feet depths of flooding.

The damage to the highways, streets and railroad tracks per mile was calculated by multiplying the cost of the materials and labor to replace each infrastructural component by the inverse of the depreciation percentage by the percentage damage to each component. The minimum, most likely, and maximum damages for each roadway and railway component were used to develop a range of values for the total cost of the infrastructural damages per mile. Using a normal distribution, a mean value for the damages per mile and a standard deviation were calculated for each of the three depths of flooding. The mean value for the damages per mile in the report were updated from 2010 to 2023 values using the roads, railroads, and bridges index from the Civil Works Construction Cost Index System. An HEC-FDA structure record was created for each roadway or railroad segment within a station. The elevation and value per segment of roadway or railroad in each station were entered on the structure record for the HEC-FDA model. The value was based on the costs of replacing or repairing a roadway or railways segment on a per mile basis.

The depth-damage relationships for major and secondary highways, streets and railroads were converted to percentages and entered into the HEC-FDA model, along with the major and secondary highways, streets, and railroad track structure records. The damage value for each mile of highways, streets, and railroads at 12 feet of flooding was used as the infrastructure value, and the stage-probability relationships for each station within the study area reaches was used to calculate the expected annual without-project and with-project damages to major and secondary highways, streets and railroad tracks.

2.10 DAMAGES TO STREETS AND HIGHWAYS UNCERTAINTY

The uncertainty surrounding the damage percentages for each mile of streets and highways at the three depths of flooding (2 feet, 5 feet, and 12 feet) was represented by a normal probability distribution with mean values and standard deviations. 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 tables for depth–damage relationships.

SECTION 3

Damages and Benefits Estimation

3.1 MODEL OVERVIEW

The HEC-FDA Version 1.4.3 USACE-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.

3.2 HEC-FDA MODEL CALCULATIONS

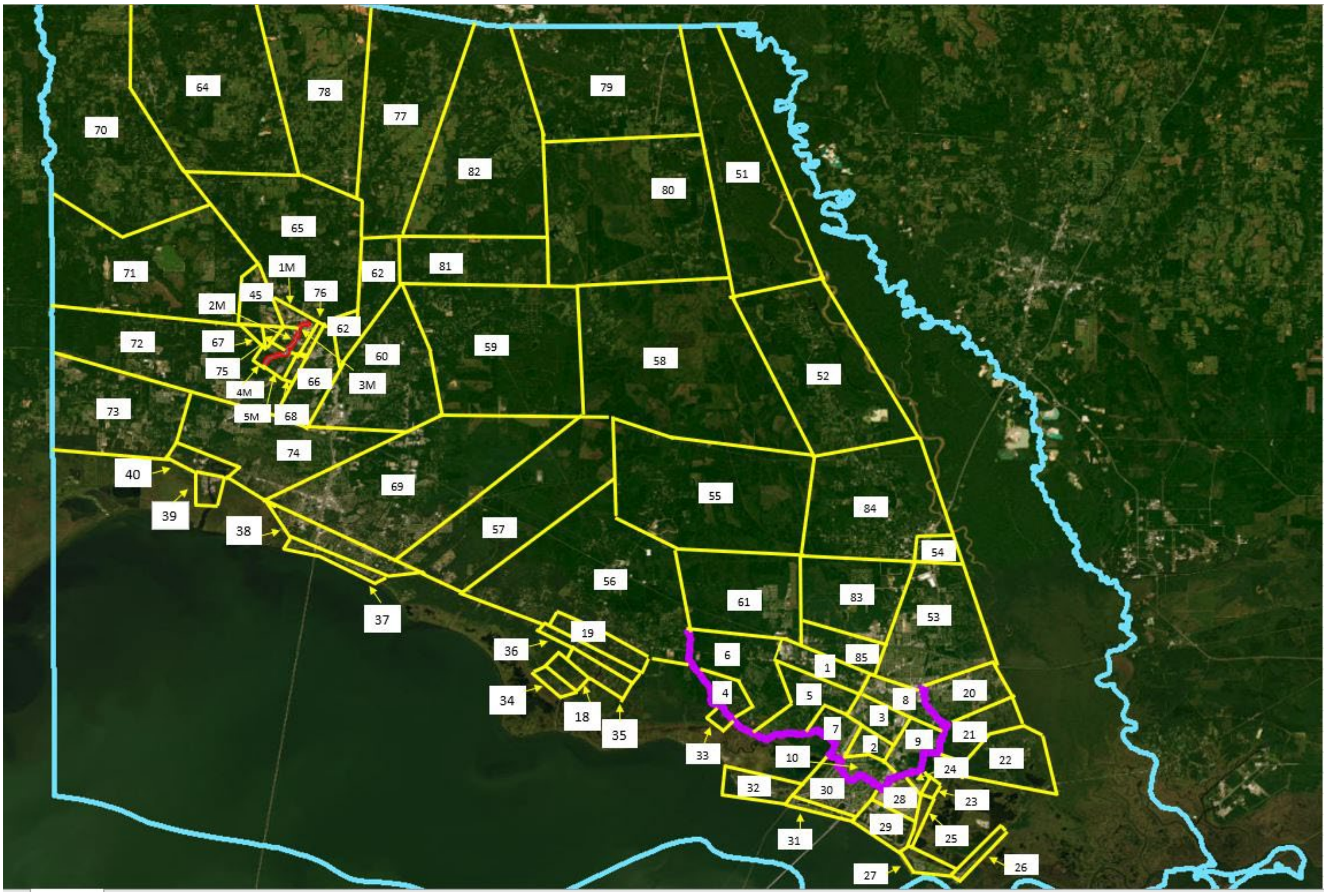
The HEC-FDA model was used to evaluate flood damages using risk-based analysis. Damages were reported at the index location for each of the study area reaches. A range of possible values, with a maximum and a minimum value for each economic variable (first floor elevation, structure and content values, 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 using 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.

The two general types of flooding originate from different sources and were modeled separately. The coastal flooding represents storm surge from the Gulf of Mexico exclusively and was modeled in ADCIRC. The inland flooding was modeled in HEC-River Analysis System (RAS) and represents the overflow from inland streams resulting from rainfall in addition to ponding from rainfall. Four separate HEC-FDA models were used in the analysis, one for the Slidell levee and floodwall, one for the nonstructural aggregates affected by coastal storm surge, one for the Channel Improvements at Mile Branch, and one for nonstructural aggregates affected by rainfall/riverine flooding.

3.3 STUDY AREA REACHES

The study area reaches are shown in figure F:3-1. The reaches were based on the hydrologic unit code 12 sub-basin boundaries. Additional reaches were parsed out of the sub-basin boundaries based on hydrologic behavior and the location and hydraulic influence of the structural measures, and the disadvantaged community delineations.

Figure F:3-1 Study Area reaches



3.4 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 of historic gage data, must be input in order to calculate the distribution for the flow data determined in the hydrologic analysis.

3.5 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 2032 and 2081 conditions. The possible occurrences of each economic variable were derived using Monte Carlo simulation. A total of 1,000 iterations were executed by the model for the St. Tammany Parish 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.

3.6 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 using 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. For the coastal flooding, stages were provided for the 0.1, 0.05, 0.02, 0.01, 0.005, 0.002, and 0.001 annual exceedance probability (AEP) events. Place holders were used for the 1.0 AEP event. For the rainfall and riverine flooding, stages were provided for the 0.5, 0.2, 0.1, 0.04, 0.02, 0.01, 0.005, and 0.002 AEP events.

3.7 EXPECTED ANNUAL DAMAGES

The HEC-FDA model uses 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 HEC-FDA model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the without-project alternative, the EAD were totaled for each study area reach to obtain the total without-project EAD under 2032 and 2081 conditions. Tables F:3-3 and F:3-4 show the without-project damages by damage category for 2032 and 2081. Tables F:3-5 and F:3-6 show the without-project damages by reach for 2032 and 2081 respectively. The increase in damages from 2032 to 2082 are due to sea-level rise and subsidence. No future development was included in this analysis.

Table F:3-3. Expected Annual Damages by Year and Damage Category, Coastal, $1,000s

Year	Auto	Commercial	Highway	Manufactured, modular and mobile homes	Rail	Residential	Street	Total
2032	13,134	49,546	713	1,810	42	145,979	4,116	215,339
2082	40,178	173,211	1,824	4,013	130	361,659	8,992	590,007

Table F:3-4. Expected Annual Damages by Year and Damage Category, Rainfall/Riverine, $1,000s

Year	Auto	Commercial	Manufactured, modular and mobile homes	Residential	Total
2032	13,516	20,230	3,041	150,108	186,895
2082	13,930	20,837	3,058	155,744	193,569

Table F:3-5. Expected Annual Damages by Reach, Coastal, $1,000s

Reach	2032	2082
1	1,400	2,564
2	11,282	31,700
3	11,615	61,686
4	909	1,583
5	16,874	31,215
6	6,231	10,893
7	28,912	59,078
8	552	617
9	24,669	61,314
10	1,229	518
18	451	1,396
19	486	563
20	5,495	10,666
21	12,320	29,491
22	41,224	76,907
23	888	1,619
24	474	1,385
25	1,448	4,288
26	636	1,468

27	414	1,679
28	7,733	19,575
29	1,648	1,733
30	13,545	52,364
31	463	2,019
32	535	2,340
33	204	589
34	247	1,207
35	836	4,807
36	2,049	5,365
37	1,646	5,785
38	8,143	58,650
39	420	1,877
40	10,361	43,065

Table F:3-6. Expected Annual Damages by Reach, Rainfall/Riverine, $1,000s

Reach	2032	2082
45	2,476	2,485
50	0	0
51	461	461
52	2,589	2,595
53	21,307	21,420
54	52	52
55	1,131	1,147
56	3,924	3,951
57	930	931
58	552	553
59	7,814	7,814
60	14,555	14,655
61	1,043	1,043
62	3,625	3,625
63	1,604	1,604
64	2,203	2,203

Reach	2032	2082
65	8,104	8,104
66	14,176	14,989
67	316	316
68	378	381
69	2,965	3,036
70	8,907	8,907
71	17,147	17,147
72	18,667	19,232
73	15,159	15,985
74	19,104	23,223
75	1,044	1,044
76	1,601	1,604
77	1,186	1,186
78	452	452
79	1,143	1,143
80	957	957
81	670	670
82	557	557
83	1,255	1,255
84	2,112	2,112
85	123	125
1M	1,308	1,308
2M	1,009	1,009
3M	1,959	1,959
4M	489	489
5M	1,839	1,839

3.8 EQUIVALENT ANNUAL DAMAGES

The HEC-FDA model uses the discount rate to discount the future damages and benefits occurring in 2082 back to the base year of 2032. Tables F:3-8 and F:3-9 show the equivalent annual damages by reach for the without-project condition and the damages reduced for each structural measure.

Table F:3-7. Equivalent Annual Damages by Reach and Measure, Slidell Levee and Floodwall, FY 2023 Price Level, FY 2023 Discount Rate, $1,000s

Reach	Without Project Damages	With Project Damages	Damages Reduced
1	1,854	73	1,780
2	19,239	177	19,061
3	31,126	20	31,107
4	1,172	5	1,167
5	22,462	340	22,123
6	8,048	105	7,943
7	40,667	93	40,574
8	577	300	278
9	38,948	1,339	37,609
10	952	7	946
Total	165,045	2,458	162,588

Table F:3-8. Equivalent Annual Damages by Reach and Measure, Rainfall and Riverine, FY 2023 Price Level, FY 2023 Discount Rate, $1,000s

Reach	Without Project Damages	With Project Damages	Damages Reduced
1M	1,308	677	631
2M	1,009	268	741
3M	1,959	333	1,626
4M	489	447	42
5M	1,839	1,407	432
Total	6,605	3,133	3,472

SECTION 4

Project Costs

4.1 AVERAGE ANNUAL COSTS

Interest During Construction (IDC) as a requirement when calculating economic costs. Part of the consideration in calculating IDC is the duration of construction. The duration of construction is the length of time funds are committed to an individual structure. This concept is straight forward when looking at a levee, for example. The time from start (no levee) to finish (finished feature) is identified and IDC calculated accordingly. The timing for nonstructural project implementation is less defined. For example, 100 structures may be elevated over the course of a year, but the time to implement a nonstructural measure at a single structure is only 3 months. Thus, the IDC should only be calculated for 3 months. Therefore, when calculating IDC for nonstructural measures or plans, the length of time will be based on construction duration for a specific measure and/or structure, and not the overall duration of construction for the entire project. The initial construction cost, 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 (2032). The FY 2023 Federal discount rate of 2.5 percent was used to discount the costs of the Optimized TSP to the base year and then amortize the costs over the 50-year period of analysis. The operations, maintenance, relocations, rehabilitation, and repair costs for each alternative was discounted to present value and annualized using the Federal discount rate of 2.5 percent for 50 years. Tables F:4-1 and F:4-2 provide the total project 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 structural measures.

Table F:4-1. Average Annual Costs, Slidell Levee and Floodwall, FY 2023 Price Level, FY 2023 Discount Rate of 2.5%

Measure	Slidell Levee and Floodwall
Project First Cost	$2,440,973
Interest During Construction	$105,378
Total Investment Cost	$2,546,351
AA Investment Costs	$86,564
AA O&M Costs	$7,609
Total AA Costs	$94,173
Construction Duration (Years)	5

Table F:4-2. Average Annual Costs, Mile Branch, FY 2023 Price Level, FY 2023 Discount Rate of 2.5%

Measure	Mile Branch Channel Improvements
Project First Cost	$77,002
Interest During Construction	$6,433
Total Investment Cost	$83,435
AA Investment Costs	$2,942
AA O&M Costs	$162
Total AA Costs	$3,104
Construction Duration (Years)	5

SECTION 5

Economic Justification

5.1 NET BENEFITS

The net benefits of the structural measures 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 measures included in the Optimized TSP. Tables F:5-1 and F:5-2 summarize the equivalent annual damages and benefits, total first costs, average annual cost, b/c ratio, and equivalent annual net benefits for the Slidell levee and floodwall, and the Mile Branch channel features of the Optimized TSP.

Table F:5-1. Net Benefit Summary, Slidell Levee and Floodwall, FY 23 Price Level, FY 23 Discount Rate, $1,000s

Measure	Slidell Levee and Floodwall
Project First Cost	$2,440,973
Interest During Construction	$105,378
Total Investment Cost	$2,546,351
AA Investment Costs	$86,564
AA O&M Costs	$7,609
Total AA Costs	$94,173
Without Project EAD	$572,971
EAD Reduced Benefits	$162,588
Net Benefits	$68,415
B/C Ratio	1.7

Table F:5-2. Net Benefit Summary, Mile Branch Channel Improvements, FY 23 Price Level, FY 23 Discount Rate, $1,000s

Measure	Mile Branch Channel Improvements
Project First Cost	$77,002
Interest During Construction	$6,433
Total Investment Cost	$83,435
AA Investment Costs	$2,942
AA O&M Costs	$162
Total AA Costs	$3,104
Without Project EAD	$572,971
EAD Reduced Benefits	$3,472
Net Benefits	$368
B/C Ratio	1.1

SECTION 6

Nonstructural Analysis

6.1 NONSTRUCTURAL OVERVIEW

According to Planning Bulletin 2019-03, nonstructural analyses are to be conducted using a “logical aggregation method.” Rather than the individual structure, this selected aggregate is the unit of analysis, and each such aggregate is a separable element that must be incrementally justified. Aggregates were arranged based on several factors. Since the study area is subject to flooding from a variety of rivers, lakes, and bayous, as well as coastal flooding, aggregates were primarily grouped according to source of flooding. Furthermore, the inland aggregates that were grouped by riverine flood sources were further divided based on whether structures were located either in a rural or urban area where applicable. The coastal aggregates were further subdivided based on geographic boundaries. Using this method, 20 aggregates were identified. The net benefits of each aggregate were optimized based on incremental floodplain. The aggregates are displayed in Figure 6.1. For the nonstructural analysis, structure elevation for residential structures and dry floodproofing for nonresidential structures were the measures considered.

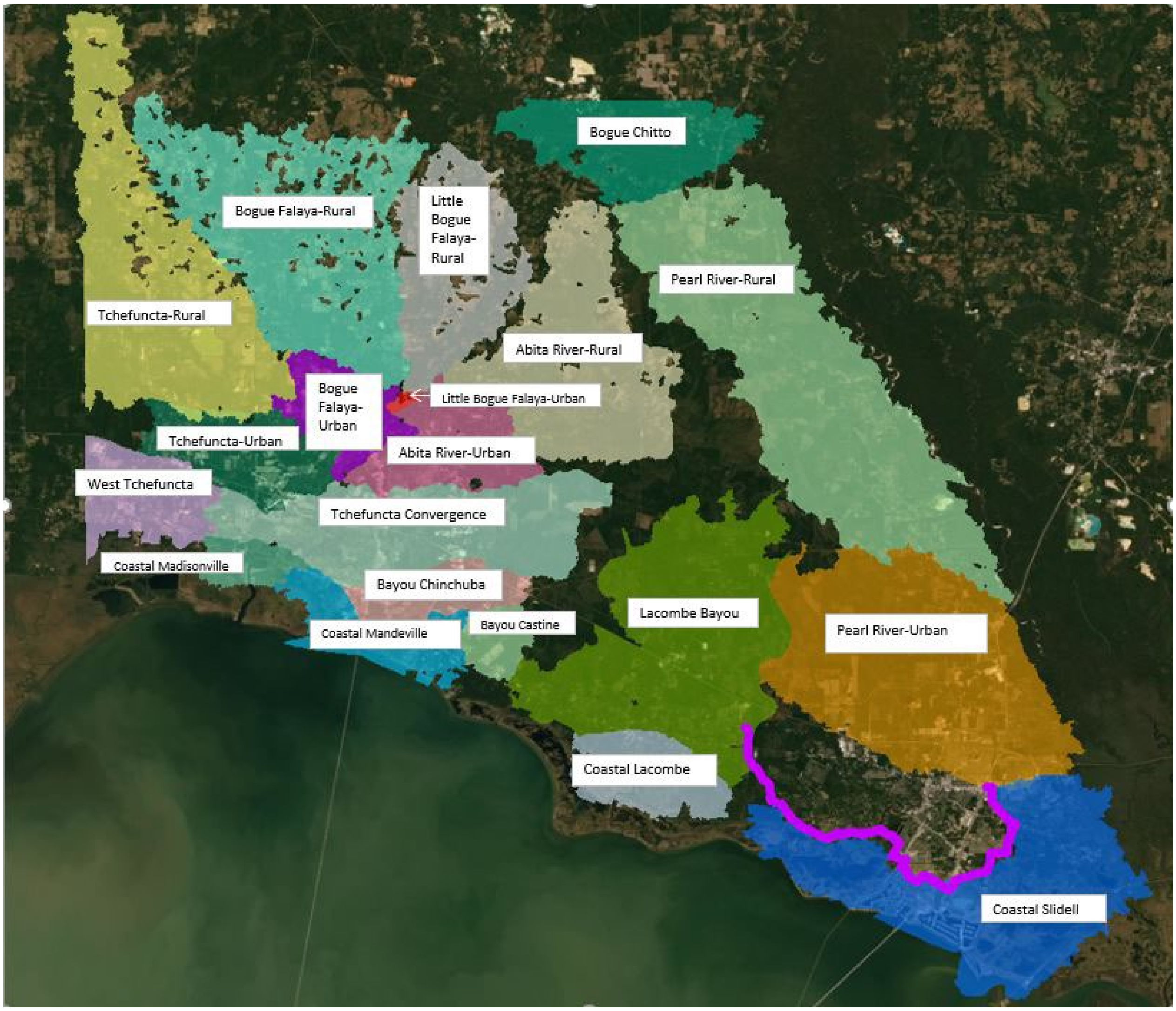


Figure F:6.1 Nonstructural Aggregates

The damages reduced by incremental floodplain for the coastal and riverine aggregates are displayed in Tables F:6-1 and F:6-2.

Table F:6-1. Damages Reduced by Incremental Floodplain, Coastal, $1,000s

Aggregate	Without Project Damages	10% AEP	5% AEP	2% AEP	1% AEP
Coastal Slidell	133,437	38,397	22,290	18,252	5,859
Coastal Lacombe	7,681	1,662	985	324	302
Coastal Mandeville	31,083	1,711	3,693	4,790	5,601
Coastal Madisonville	24,093	8,973	5,451	3,335	641
Total	196,294	50,743	32,419	26,701	12,402

Table F:6-2. Damages Reduced by Incremental Floodplain, Rainfall and Riverine, $1,000's

Reach	Without Project Damages	10% AEP	4% AEP	2% AEP	1% AEP
Bogue Chitto	1,143	500	238	55	39
Rural Pearl River	4,010	1,930	313	191	34
Urban Pearl River	25,937	11,525	3,407	1,491	573
Bayou Lacombe	5,072	2,830	517	147	16
Bayou Castine	930	415	85	32	2
Abita River Rural	9,037	3,539	1,280	700	230
Abita River Urban	14,594	6,159	1,493	631	321
Little Bogue Falaya Rural	5,368	3,241	1,051	271	77
Little Bogue Falaya Urban	1,604	496	391	75	59
Bogue Falaya Rural	13,237	4,421	1,862	1,262	529
Bogue Falaya Urban	17,835	4,167	2,587	1,728	802
Bayou Chinchuba	2,992	1,668	106	63	0
Rural Tchefuncte	26,054	15,192	3,590	1,021	298
Urban Tchefuncte	18,887	6,863	2,392	1,043	317
West Tchefuncte	15,481	4,877	1,874	624	0
Tchefuncte Convergence	20,709	9,562	3,776	1,235	338
Total	182,890	77,385	24,962	10,567	3,635

6.2 NONSTRUCTURAL IMPLEMENTATION COSTS

6.2.1 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 plus one foot) for each structure. Elevation costs by structure were summed to yield an estimate of total structure elevation costs. For screening to the final number of structures included in the nonstructural plan, 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 manufactured, modular and 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 Non-Federal Sponsor in implementing this nonstructural measure was added to the cost of implementation. Additional miscellaneous cost of $15,000 per structure was added to the cost of implementation. Also, a contingency of 34.5 percent was added to the cost of implementation. Table F:6-3 shows the cost per square foot of structure raising by occupancy type and height raised.

Table F:6-3. Cost per Square Foot of Structure Raising by Occupancy Type and Number of Feet raised, FY 2023 Price Level

	1STY-SLAB			2STY-SLAB			1STY-PIER			2STY-PIER			MANUFACTURED, MODULAR & MOBILE HOMES		
Ft. Raised	**Min**	**Most Likely**	**Max**	**Min**	**Most Likely**	**Max**	**Min**	**Most Likely**	**Max**	**Min**	**Most Likely**	**Max**	**Min**	**Most Likely**	**Max**
1	$100	$112	$124	$112	$124	$137	$87	$100	$111	$97	$110	$121	$49	$55	$61
2	$100	$112	$124	$112	$124	$137	$87	$100	$111	$97	$110	$121	$49	$55	$61
3	$102	$115	$126	$115	$126	$139	$91	$103	$115	$101	$114	$126	$49	$55	$61
4	$106	$119	$130	$123	$135	$147	$91	$103	$115	$101	$114	$126	$49	$55	$61
5	$106	$119	$130	$123	$135	$147	$91	$103	$115	$101	$114	$126	$61	$68	$73
6	$109	$121	$133	$125	$137	$149	$93	$106	$118	$103	$116	$128	$61	$68	$73
7	$109	$121	$133	$125	$137	$149	$93	$106	$118	$103	$116	$128	$61	$68	$73
8	$112	$125	$137	$129	$142	$153	$96	$109	$120	$106	$119	$130	$61	$68	$73
9	$112	$125	$137	$129	$142	$153	$96	$109	$120	$106	$119	$130	$61	$68	$73
10	$112	$125	$137	$129	$142	$153	$96	$109	$120	$106	$119	$130	$61	$68	$73
11	$112	$125	$137	$129	$142	$153	$96	$109	$120	$106	$119	$130	$61	$68	$73
12	$112	$125	$137	$129	$142	$153	$96	$109	$120	$106	$119	$130	$61	$68	$73
13	$118	$129	$142	$137	$149	$162	$98	$110	$123	$109	$121	$133	$61	$68	$73

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 0 and 20,000, then the total cost equaled $147,240; between 20,000 and 100,000 square feet equaled $456,137; and greater than 100,000 square feet equaled $1,149,313. These costs were developed by contacting local contractors and were escalated to FY 2023 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. Additional miscellaneous cost of $15,000 per structure was added to the cost of implementation. Also, a contingency of 34.5 percent was added to the cost of implementation.

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.

Average Annual Cost

The cost per structure of elevating and floodproofing is grouped together by aggregate and annualized over the 50-year period of construction at the current Federal Discount Rate. The average annual cost per aggregate is displayed in tables F:6-4 and F:6-5.

Table F:6-4. Average Annual Cost by Aggregate, Coastal, $1,000s

Aggregate	10% AEP	5% AEP	2% AEP	1% AEP
Coastal Slidell	6,380	7,776	17,768	14,881
Coastal Lacombe	300	522	286	230
Coastal Mandeville	655	1,645	2,145	2,220
Coastal Madisonville	1,609	919	1,154	387
Total	8,944	10,862	21,353	17,718

Table F:6-5. Average Annual Cost by Aggregate, Riverine, $1,000s

Aggregate	10% AEP	4% AEP	2% AEP	1% AEP
Bogue Chitto	153	118	59	90
Rural Pearl River	658	252	247	190
Urban Pearl River	3,930	2,817	2,692	1,251
Bayou Lacombe	997	467	297	23
Bayou Castine	176	56	59	18
Abita River Rural	1,165	973	1,083	347
Abita River Urban	2,959	1,069	674	513
Little Bogue Falaya Rural	1,164	1,046	296	164
Little Bogue Falaya Urban	173	207	146	181
Bogue Falaya Rural	1,630	1,397	1,843	1,344
Bogue Falaya Urban	2,013	2,347	2,092	1,744
Bayou Chinchuba	321	100	172	0
Rural Tchefuncte	5,418	2,438	1,473	449
Urban Tchefuncte	3,302	1,974	1,403	895
West Tchefuncte	2,597	1,442	963	0
Tchefuncte Convergence	3,852	3,151	2,120	1,217
Total	30,505	19,853	15,619	8,425

6.3 NONSTRUCTURAL RESULTS

6.3.1 Net Benefits

The net benefits for each aggregate are displayed in Tables F:6-6 and F:6-7. For the coastal aggregates, coastal Slidell yields positive net benefits through the 2 percent AEP event. The other coastal aggregates yield positive net benefits through the 1 percent AEP event. For the riverine aggregates, all yield positive net benefits through the 4 percent AEP event.

Table F:6-6. Net Benefits by Aggregate, Coastal, $1,000s

Aggregate	10% AEP	5% AEP	2% AEP	1% AEP
Coastal Slidell	32,017	14,514	484	-9,022
Coastal Lacombe	1,362	463	38	72
Coastal Mandeville	1,056	2,048	2,645	3,381
Coastal Madisonville	7,364	4,532	2,181	254

Table F:6-7. Net Benefits by Aggregate, Riverine, $1,000s

Aggregate	10% AEP	4% AEP	2% AEP	1% AEP
Bogue Chitto	347	121	-4	-52
Rural Pearl River	1,272	61	-56	-156
Urban Pearl River	7,595	590	-1,201	-678
Bayou Lacombe	1,833	50	-151	-6
Bayou Castine	240	29	-28	-16
Abita River Rural	2,374	307	-383	-117
Abita River Urban	3,200	424	-43	-192
Little Bogue Falaya Rural	2,077	5	-25	-86
Little Bogue Falaya Urban	323	184	-71	-122
Bogue Falaya Rural	2,792	465	-581	-815
Bogue Falaya Urban	2,154	239	-364	-941
Bayou Chinchuba	1,347	7	-109	0
Rural Tchefuncte	9,774	1,153	-452	-151
Urban Tchefuncte	3,562	419	-360	-578
West Tchefuncte	2,280	432	-339	0
Tchefuncte Convergence	5,711	625	-885	-879

6.3.2 Final Nonstructural Results

The nonstructural screening and optimization process yielded a total of 5,583 residential structures and 827 nonresidential structures to be included in the nonstructural component of the Optimized TSP. After the number of structures were identified for inclusion, cost refinements were made, and an updated cost estimate was developed. The summary of results for the nonstructural component of the Optimized TSP are presented in Table F:6-8.

Table F:6-8, Complete Nonstructural Plan, $1,000s

Project First Cost	$1,934,084
Interest During Construction	$5,979
Total Investment Cost	$1,940,063
AA Investment Costs	$68,403
EAD Reduced Benefits	$218,754
Net Benefits	$150,351
B/C Ratio	3.2

SECTION 7

Optimized TSP

7.1 OPTIMIZED TSP COMPONENTS

The Optimized TSP is comprised of the Slidell levee and floodwall, the Mile Branch channel improvements, and the nonstructural plan. The nonstructural plan consists of elevating approximately 5,583 preliminarily eligible residential structures up to 13 feet from ground level and dry floodproofing 827 approximately preliminarily eligible non-residential structures up to 3 feet. Each measure is economically justified and contributes to the overall net benefits of the Optimized TSP, which has an overall b/c ratio of 2.4. Table F:7-1 displays the net benefit summary for the Optimized TSP. Figure F:7-1 contains a map of the structural and nonstructural features included in the Optimized TSP. There was no double counting of benefits between the coastal and rainfall/riverine models. The structural components of the Optimized TSP which are the levee, floodwall, and channel improvements, address different sources of flooding, and are located in different parts of the study area. For the nonstructural measures, structures that are primarily affected by coastal flooding were modeled exclusively in the coastal model, and structures that were primarily affected by rainfall/riverine flooding were modeled exclusively in the rainfall/riverine model.

Table F:7-1. Net Benefit Summary of the Optimized TSP, FY23 Price Level, FY 23 Discount Rate, $1,000s

Measure	Slidell Levee and Floodwall	Mile Branch Channel Improvements	Nonstructural	Optimized TSP
Project First Cost	$2,440,973	$77,002	$1,934,084	$4,452,059
Interest During Construction	$105,378	$6,433	$5,979	$117,790
Total Investment Cost	$2,546,351	$83,435	$1,940,063	$4,569,849
AA Investment Costs	$86,564	$2,942	$68,403	$157,909
AA O&M Costs	$7,609	$162	$0	$7,771
Total AA Costs	$94,173	$3,104	$68,403	$165,680
Without	$572,971	$572,971	$572,971	$572,971

Project EAD				
EAD Reduced Benefits	$162,588	$3,472	$218,754	$384,814
Net Benefits	$68,415	$368	$150,351	$219,134
B/C Ratio	1.7	1.1	3.2	2.3

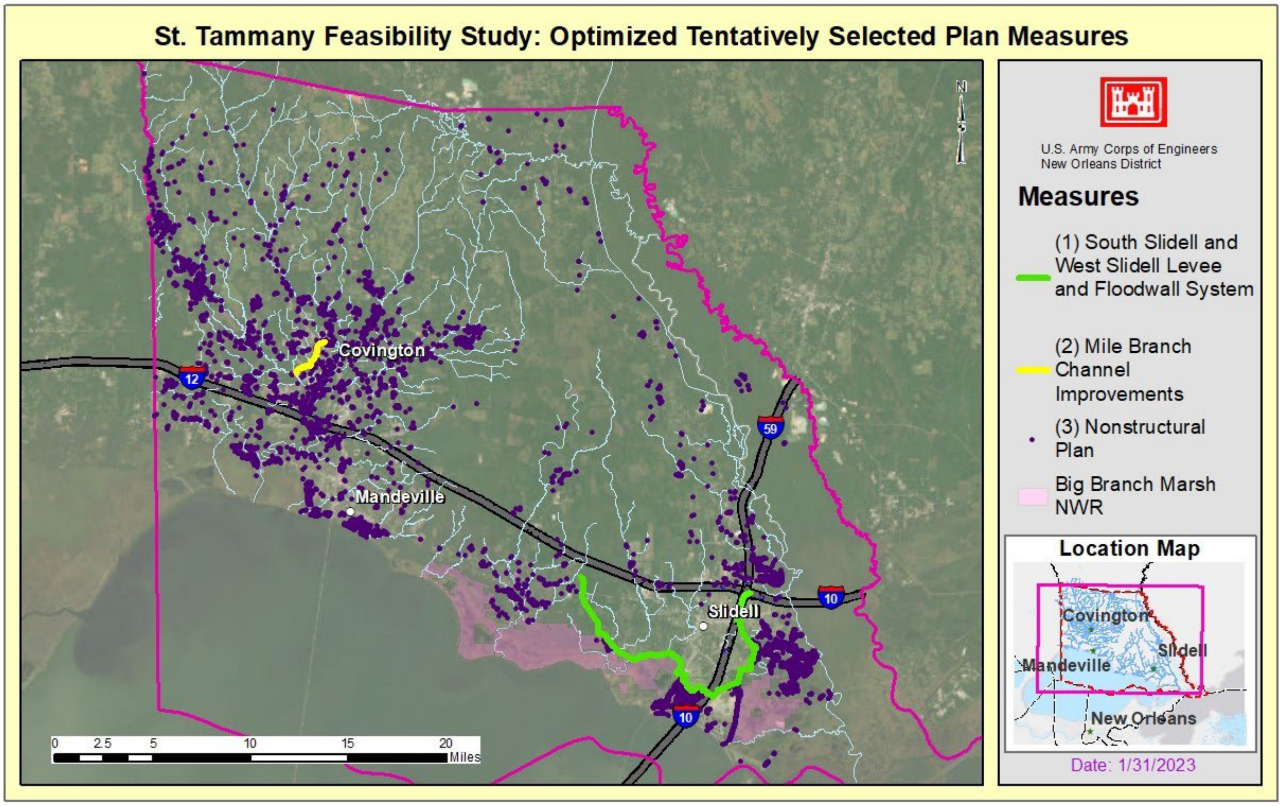


Figure F:7-1. Measures Comprising the Optimized TSP

7.2 RESIDUAL RISK

Of the $573 million in the without project EAD in the study area, about $383 million in estimated annual damages is due to coastal flooding and $190 million in EAD is due to rainfall and riverine flooding. The Optimized TSP is currently estimated to reduce the EAD caused by coastal flooding by about 80 percent and reduce the EAD caused by rainfall and riverine flooding by about 60 percent.

SECTION 8

Regional Economic Development (RED)

8.1 GENERAL

The regional economic development (RED) account addresses the impacts that the U.S. Army Corps of Engineers (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 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.

Regional economic system (RECONS) Version 2 was the specific input-output model used to estimate the regional economic development impacts of the Optimized TSP. The USACE Institute for Water Resources, Louis Berger, and Michigan State University developed the regional economic impact modeling tool, RECONS, 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 using 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 their commodities. 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 Optimized TSP is comprised of three measures, the Slidell levee and floodwall, the Mile Branch channel improvements, and the elevation and floodproofing of structures. Each of the measures is presented separately.

For the Slidell levee and floodwall, expenditures are estimated to be $2,440,973,000. Of this total expenditure, $2,219,412,264 will be captured within the study 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 $2,440,973,000 support a total of 740 average annual, full-time equivalent jobs, $2,232,742,907 in labor income, $2,524,037,966 in value added, and $4,112,532,502 in economic output in the local impact area. More broadly, these expenditures support 1020 average annual, full-time equivalent jobs, $3,310,191,601 in labor income, $4,104,289,101 in value added, and $6,806,716,800 in economic output in the nation. Table F:8-1 summarizes these results.

Table F:8-1. Regional Economic Development (RED) Summary for the Slidell Levee and Floodwall

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$2,219,412,264	505	$1,606,683,533	$1,462,181,013
Secondary Impact	$1,893,120,238	235	$626,059,375	$1,061,856,953
Total Impact	$4,112,532,502	740	$2,232,742,907	$2,524,037,966
State				
Direct Impact	$2,331,560,812	576	$1,826,483,378	$1,602,061,631

Secondary Impact	$2,367,881,842	278	$754,458,665	$1,320,902,540
Total Impact	$4,699,442,654	853	$2,580,942,043	$2,922,964,171
US				
Direct Impact	$2,415,105,510	599	$1,901,147,647	$1,701,368,649
Secondary Impact	$4,391,611,291	422	$1,409,043,954	$2,402,920,452
Total Impact	$6,806,716,800	1020	$3,310,191,601	$4,104,289,101

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

For the Mile Branch channel improvements, expenditures are estimated to be $77,002,000. Of this total expenditure, $67,413,497 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 $77,002,000 support a total of 22 average annual, full-time equivalent jobs, $66,154,528 in labor income, $74,203,702 in value added, and $124,790,106 in economic output in the local impact area. More broadly, these expenditures support 31 average annual, full-time equivalent jobs, $102,080,415 in labor income, $127,564,200 in value added, and $216,530,715 in economic output in the nation. Table F:8-2 summarizes these results.

Table F:8-2. RED Summary for the Mile Branch Channel Improvements

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$67,413,497	15	$47,880,317	$42,275,475
Secondary Impact	$57,376,609	7	$18,274,211	$31,928,227
Total Impact	$124,790,106	22	$66,154,528	$74,203,702
State				
Direct Impact	$70,862,292	17	$54,965,773	$46,301,703
Secondary Impact	$73,027,149	8	$22,402,738	$40,424,843
Total Impact	$143,889,441	26	$77,368,512	$86,726,546
US				
Direct Impact	$75,703,707	18	$57,724,072	$50,907,527
Secondary Impact	$140,827,007	13	$44,356,343	$76,656,673
Total Impact	$216,530,715	31	$102,080,415	$127,564,200

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

For the nonstructural plan, expenditures are estimated to be $1,934,084,000. Of this total expenditure, $1,531,085,009 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 $1,934,084,000 support a total of 430 average annual, full-time equivalent jobs, $1,387,503,061 in labor income, $1,633,118,773 in value added, and $2,759,491,813 in economic output in the local impact area. More broadly, these expenditures support 664 average annual, full-time equivalent jobs, $2,424,878,759 in labor income, $3,097,067,965 in value added, and $5,200,780,639 in economic output in the nation. Table F:8-3 summarizes these results.

Table F:8-3. RED Summary for the Mile Branch Channel Improvements

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$1,531,085,009	276	$996,857,892	$957,565,145
Secondary Impact	$1,228,406,804	154	$390,645,169	$675,553,628
Total Impact	$2,759,491,813	430	$1,387,503,061	$1,633,118,773
State				
Direct Impact	$1,651,881,781	312	$1,191,054,939	$1,107,210,463
Secondary Impact	$1,559,809,227	183	$482,082,740	$861,277,124
Total Impact	$3,211,691,008	495	$1,673,137,679	$1,968,487,587
US				
Direct Impact	$1,861,922,843	350	$1,353,887,980	$1,266,033,975
Secondary Impact	$3,338,857,796	313	$1,070,990,779	$1,831,033,991
Total Impact	$5,200,780,639	664	$2,424,878,759	$3,097,067,965

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

SECTION 9

The Justice 40 Initiative

To assist the Administration in achieving the Justice40 Initiative goals, USACE must use investments as the metric to measure benefits, essentially providing that 40 percent of USACE investments in climate and critical clean water and waste infrastructure would benefit disadvantaged communities. USACE will strive to achieve the 40 percent goal under Justice40 Initiative. In the Interim Implementation Guidance for the Justice40 Initiative, dated 20 July, 2021; and MEMORANDUM FOR COMMANDING GENERAL, U.S. ARMY CORPS OF ENGINEERS SUBJECT: Implementation of Environmental Justice and the Justice40 Initiative (Justice40 Interim Guidance) dated 15 March 2022, the federal government established the goal that 40 percent of the overall benefits of certain Federal investments, flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution.

Climate and Economic Justice Screening Tool (CEJST). The CEQ's recently released CEJST was used to identify disadvantaged communities in the study area. In the CEJST database, the CEQ identifies Census Tracts throughout the nation that meet its definition of a disadvantaged community. The purpose of the tool is to help Federal agencies identify disadvantaged communities that are marginalized, underserved, and overburdened by pollution. The current version of the CEJST provides socioeconomic, environmental, and climate information to identify and inform decisions that may affect these communities. The CEJST identifies disadvantaged communities through publicly available, nationally consistent datasets.

Forty-six percent of the benefits provided by the Slidell levee and floodwall system and sixty-eight percent of the benefits provided by the channel improvements in Mile Branch accrue to these disadvantaged communities. Four percent of the benefits provided by the nonstructural plan accrue to disadvantaged communities. The low percentage of benefits under the non-structural plan is primarily due to community locations. Most of these communities are located either in northern areas of the parish that are not subject to frequent flooding, or they are located in the parts of the parish that would benefit from the levee system in Slidell. The disadvantaged communities where nonstructural measures would be applied are in largely rural areas that are more sparsely developed and have lower flood risk. Overall, approximately 20 percent of the benefits provided by the optimized TSP accrue to disadvantaged communities.

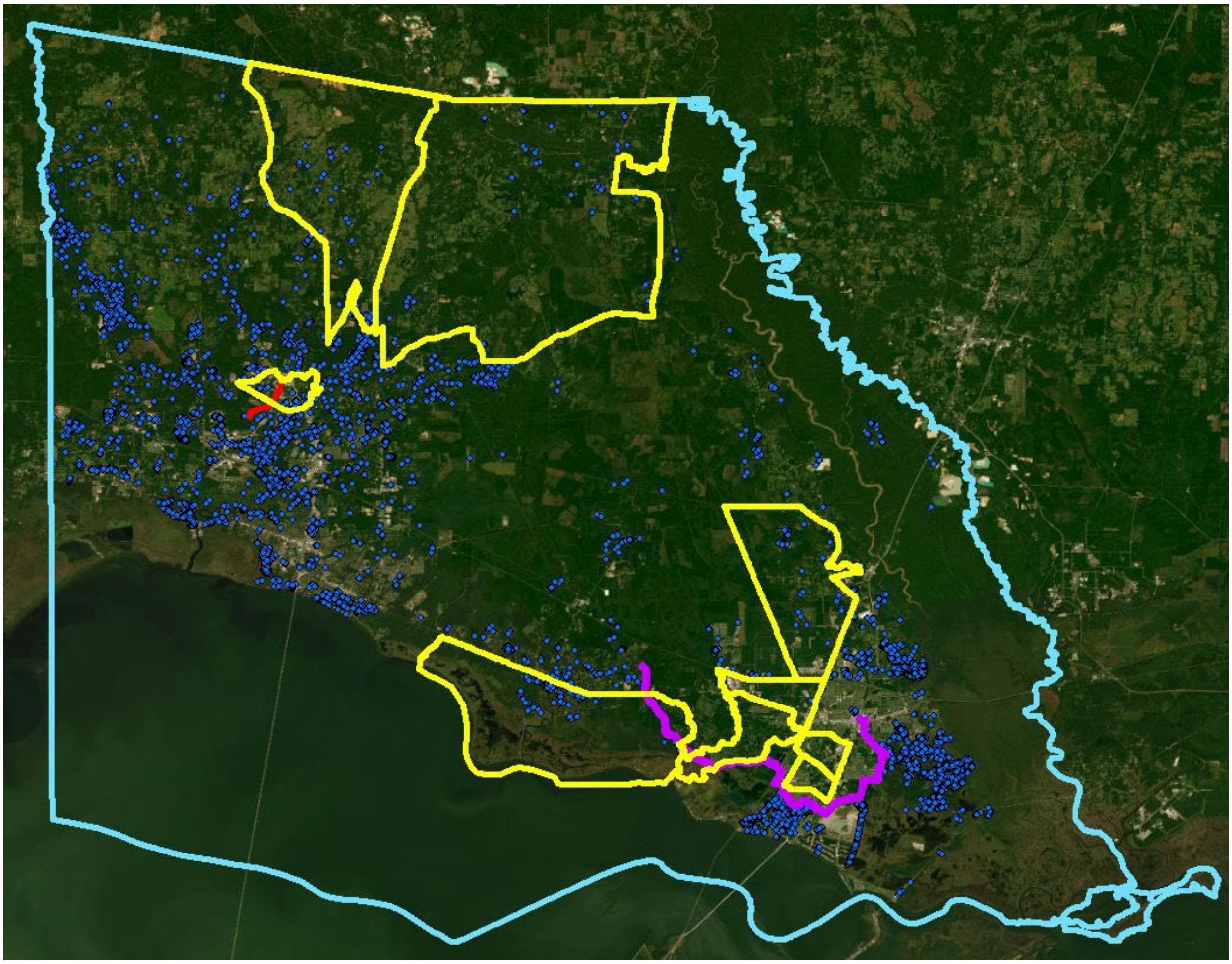


Figure F:9-1. Justice 40 Disadvantaged Communities in St. Tammany Parish and Features of the Optimized TSP

SECTION 10

F-1-Life Safety Annex

In an effort to develop a consistent way to recommend projects that warrant funding based on risk to life safety, USACE has developed the Life Safety Risk Indicator (LSRI) tool, which provides a screening-level, relative representation of the life risk (average annual life loss) that would be reduced if a given structural or non-structural flood damage reduction project was constructed. The LSRI is intended to serve as a budget tool to prioritize studies and projects starting with the FY25 budget development process. (For more information on the USACE budget development process, see the latest Budget Engineer Circular and Program Development Manuals). The LSRI builds off of and replaces the Life Safety Hazard Index (LSHI) tool by incorporating not just consequence information, but also likelihood of the consequences.

For the study, the Slidell levee feature of the Optimized TSP was modeled using the LSRI software. The results of which show an LSRI value of 6.682 meaning if this project were not built, then this area would experience an average annual life loss of 6.682 people per year. Additionally, the cost per statistical life saved (CSSL) for St. Tammany is $10,623,109 annually. To arrive at these values, the maximum storm surge event the levee is designed to protect against, 14 feet, was used. The LifeSim model allowed for 8 to 24 hours of warning time before the first structure got wet. The population of the study area was developed using the default NSI 2022 values.

The inputs used in modelling the LSRI for the Slidell levee and floodwall feature of the Optimized TSP are discussed in more detail in the Sections below.

10.0 INTRODUCTION

The software itself requires three different types of inputs in order to create a life-safety risk indicator value: a study area with structure inventory, a flood scenario with H&H inputs, and life-risk inputs such as hazard advance notice. Each input will be discussed further in subsequent Sections.

11.0 STUDY AREA AND STRUCTURE INVENTORY

The area protected by the Slidell levee and floodwall feature of the Optimized TSP is the study area.

For the Optimized TSP:

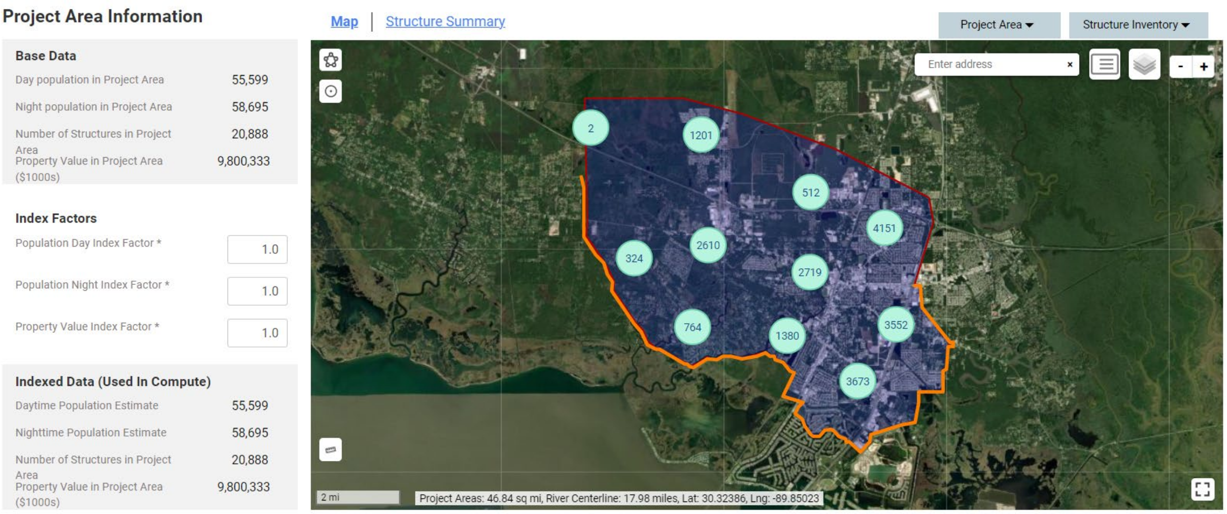
Day Population: 55,599

Night Population: 58,695

Number of Structures: 20,888

Total Property Value ($1000s): 9,800,333

These values are pulled directly from NSI 2022 and aggregated. The circles on the map of the study area are just structures that the software automatically groups based on proximity.



Project Area Information

Base Data

Day population in Project Area	55,599
Night population in Project Area	58,695
Number of Structures in Project Area	20,888
Property Value in Project Area ($1000s)	9,800,333

Index Factors

Population Day Index Factor *	1.0
Population Night Index Factor *	1.0
Property Value Index Factor *	1.0

Indexed Data (Used In Compute)

Daytime Population Estimate	55,599
Nighttime Population Estimate	58,695
Number of Structures in Project Area	20,888
Property Value in Project Area ($1000s)	9,800,333

Project Areas: 46.84 sq mi, River Centerline: 17.98 miles, Lat: 30.32386, Lng: -89.85023

Figure F:1-1, Population Summary

12.0 INUNDATION AND H&H INPUTS

The second input is a flood scenario. For the coastal areas within the study area, a coastal surge event equal to the proposed design of the levee was chosen (15 feet) as the PDT was trying to find the life-risk reduction benefits should the levee be built. The model runs a simplified version of 2D HEC-RAS. The orange line, shown in the 2nd picture in this Section, represents where the water is coming from. Since it is a coastal model, the model assumes that water will come perpendicular from the orange line. The river width and floodplain multiplier boxes are greyed out as they are specific to riverine models.

Once the line is drawn, the model then imports 10-meter USGS elevation data and processes it. After that, a simple hydrograph is created by the user using inputs from H&H.

For a coastal storm surge event:

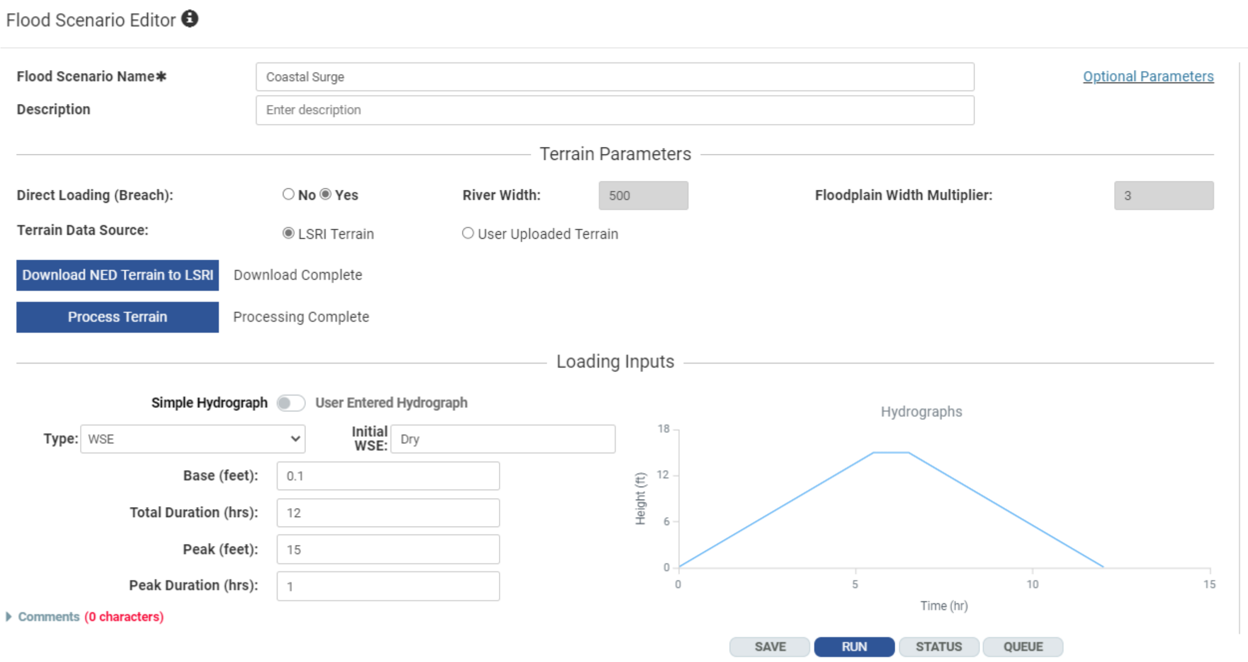
Base (feet):0.1

Total Duration (hrs.): 12

Peak (feet): 15

Peak Duration (hrs.): 1

The resulting inundation is also shown in the 2nd picture in this Section.



Flood Scenario Editor

Flood Scenario Name✱: Coastal Surge
Description: Enter description

Terrain Parameters

Direct Loading (Breach): ○ No ● Yes
River Width: 500
Floodplain Width Multiplier: 3
Terrain Data Source: ● LSRI Terrain ○ User Uploaded Terrain

Download NED Terrain to LSRI: Download Complete
Process Terrain: Processing Complete

Loading Inputs

Simple Hydrograph / User Entered Hydrograph
Type: WSE
Initial WSE: Dry
Base (feet): 0.1
Total Duration (hrs): 12
Peak (feet): 15
Peak Duration (hrs): 1

Comments (0 characters)

Below is the inundation map produced from the simplified RAS model. The deep red the color, the deeper the depths.

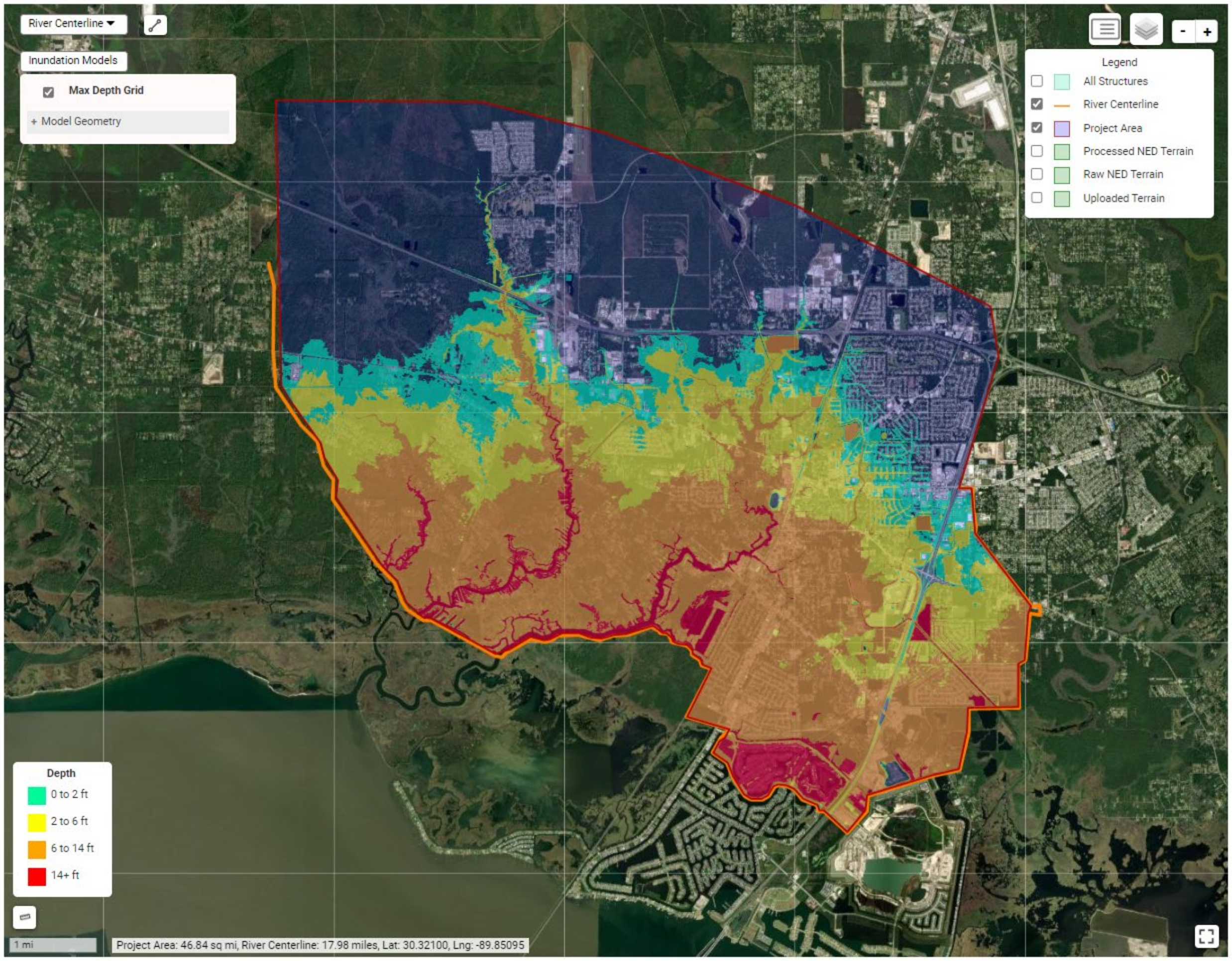


Figure F:1-2, Inundation Map

13.0 SIMPLIFIED LIFESIM INPUTS

The final set of inputs for LSRI are the LifeSim Compute inputs.

For the study, the final set of inputs are listed as:

Evacuation Planning: Flood Specific

Community Awareness: Generally Aware

Flood Warning Effectiveness: Fast

Hazard Advanced Warning: Long

Below are the different input selections and their corresponding definition.

Evacuation Planning

- Flood Specific – The local EMA maintains a warning and/or evacuation plan for the community that contains specific information about the content of a message that would be provided in the case of a flood emergency. That content includes a description of the flood threat, specific information on the locations at risk, what actions the public should take and how to take them (which evacuation routes to take), when the at-risk population should start and complete those actions, and why taking those actions is a good idea. Also, a successful recent evacuation regardless of evacuation plan detail could lead to an acceptable rating.

- All Hazards – The local EMA maintains a warning or evacuation plan for the threatened community, but it does not have message templates or directions that would suggest the information defined under the Acceptable rating would be provided to the public in a timely manner.

- None or Outdated – An evacuation plan does not exist for the threatened community.

- Unknown

Community Awareness

- Very Aware – The community is very aware that it could be impacted by flooding. It has either happened recently or it is often a topic in local media. Local flood agencies routinely provide public education opportunities related to flooding, and they strive to increase awareness and preparedness in the community.

- Generally Aware – The community is generally aware that it is vulnerable to flooding, but there is no ongoing public awareness or education effort to improve flood awareness.

- Unaware – The community is generally unaware that it could be impacted by a flood event.

- Unknown (must be unknown if Evacuation Planning is “Unknown” and vice-versa)

Flood Warning Effectiveness

- Fast – The community’s EMA has a written warning plan and standard operating procedures for issuing warnings. Responsibility for issuing a warning is clearly defined, warning thresholds are in place that relate the flood threat to the recommended public protective action, and SOP drills are regularly conducted. Additionally, the EMA has access to multiple warning systems or channels (e.g., auto-dial telephones, Wireless Emergency Alert, sirens, etc.) that would be use in the case of a major flood event.

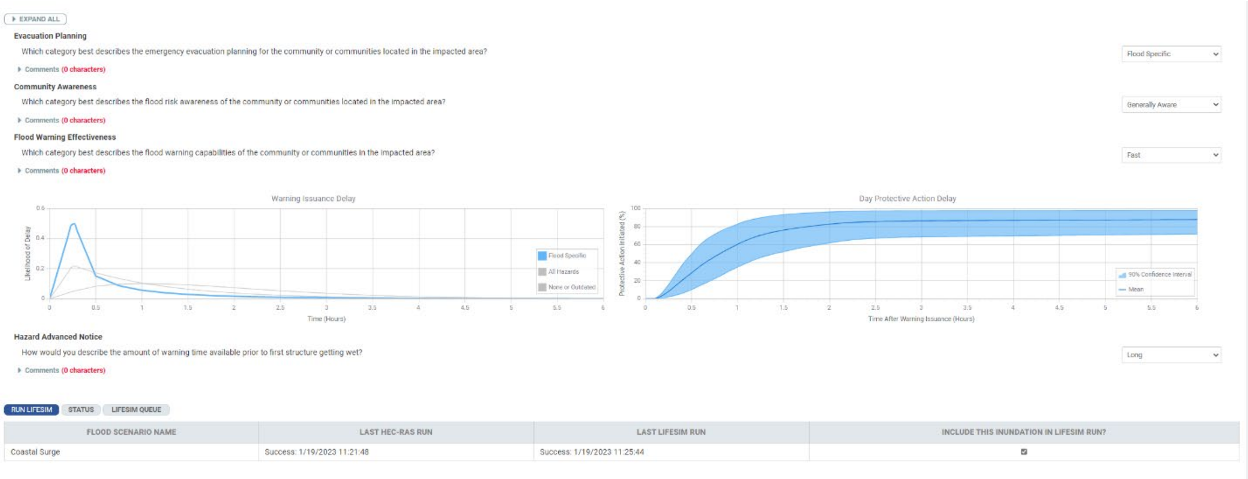
- Medium – The community’s EMA has an emergency evacuation plan with general guidance on warning procedures. However, roles are not clearly defined, and SOP drills are not conducted regularly. The warning process relies primarily on emergency responders to spread the warning. The procedures are reviewed and updated at regular intervals.

- Slow – An emergency action plan does not exist or has not been updated at regular intervals. Flood warning procedures do not exist or are outdated.

Hazard Advanced Notice

- Very Short – 0 to 2 hours
- Short – 2 to 4 hours
- Moderate – Moderate 4 to 8 hours
- Long – 8 to 24 hours
- Very Long – 24-48 hours

Once these inputs are selected and run, it will run 1000 iterations of LifeSim with uncertainty sampling. Below are the inputs selected for the study area.



Evacuation Planning

Which category best describes the emergency evacuation planning for the community or communities located in the impacted area? Flood Specific

Comments (0 characters)

Community Awareness

Which category best describes the flood risk awareness of the community or communities located in the impacted area? Generally Aware

Comments (0 characters)

Flood Warning Effectiveness

Which category best describes the flood warning capabilities of the community or communities in the impacted area? Fast

Comments (0 characters)

Hazard Advanced Notice

How would you describe the amount of warning time available prior to first structure getting wet? Long

Comments (0 characters)

FLOOD SCENARIO NAME	LAST HEC-RAS RUN	LAST LIFESIM RUN	INCLUDE THIS INUNDATION IN LIFESIM RUN?
Coastal Surge	Success: 1/19/2023 11:21:48	Success: 1/19/2023 11:25:44	☑

FIGURE F:1-3, LIFESIM INPUTS

14.0 CONSEQUENCE RESULTS

The consequence results for the Slidell levee feature of the Optimized TSP are as follows:

Parameter	**Day**	**Night**
PAR	39,416	39,416
Exposed Population	2,602	2,595
% of PAR Exposed	6.60%	6.58%

Median Life Loss	123	123
Fatality Rate	4.73%	4.74%
Mean Life Loss (Exposure Weighted)	136.37	
Mean Life Loss as % of PAR	0.35%	
Weighted Fatality Rate (% of Exposed PAR)	4.66%	
Property Damages	$3.22B	
# Structures Inundated	14,094	

Table F:1-1, Consequence Results

Below is a map of the study area with each hexagon representing an area of life-risk during the day ranging from zero, which is the green color, to one or more. The areas of deep red are areas with at least one simulated life-loss event. The deeper the red, the more life-risk.

Essentially what the software is doing is assigning a life-loss value to a specific structure based on the results of the LifeSim model. Within each hexagon there are many structures, and their aggregate value of life-loss determines what color the hexagon will be. The greater the life-loss, the deeper red the color.

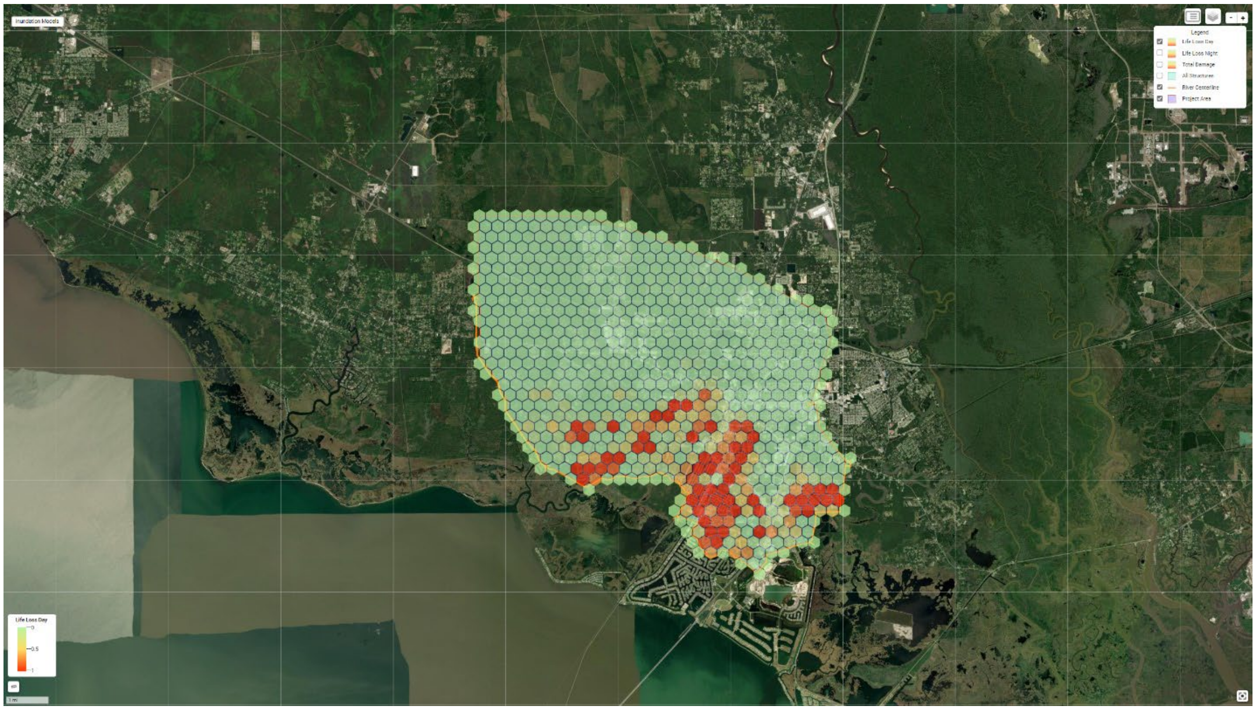


Figure F:1-4, Areas of Life Risk During the Day

Below is a map of the study area with each hexagon representing an area of life-risk during the night ranging from zero, which is the green color, to one or more. The areas of deep red are areas with at least one simulated life-loss event. The deeper the red, the more life-risk.

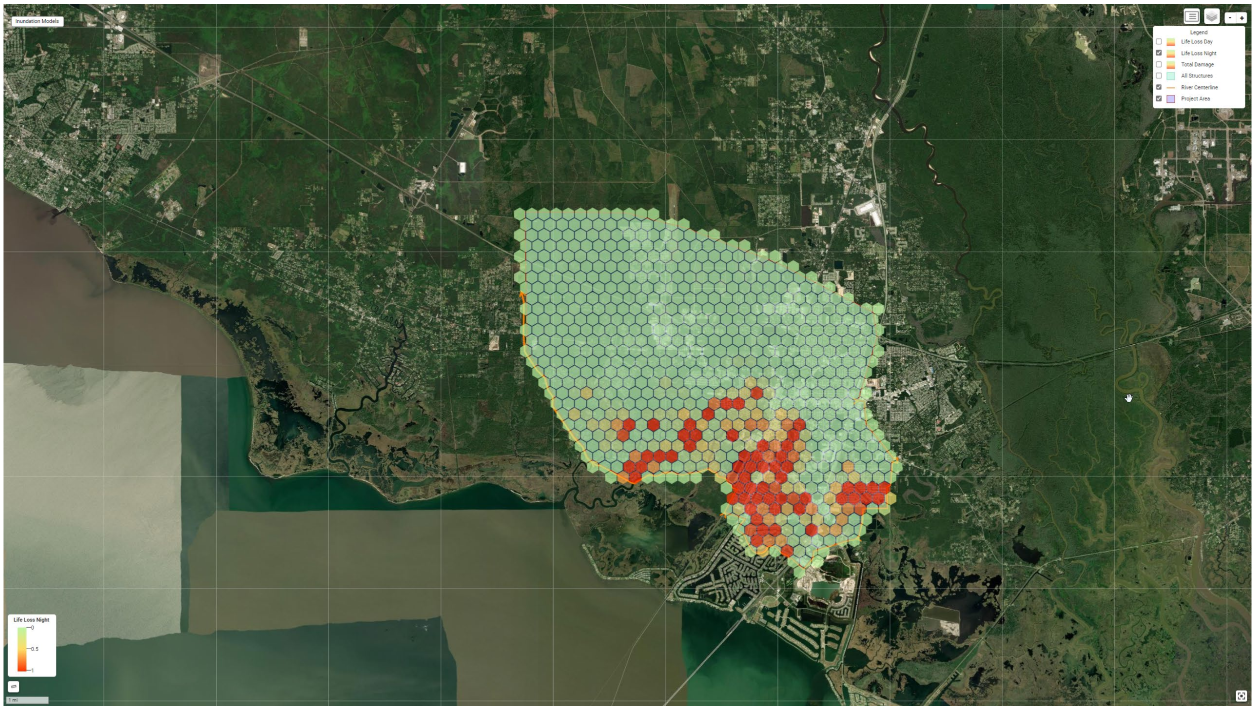


Figure F:1-5, Areas of Life Risk during the Night