Mississippi River Valley Division,
Regional Planning and Environment Division South

South Central Coast Louisiana

Hurricane Ike flooding in Delcambre, Louisiana.

Appendix D - Economics

May 2022

CONTENTS

LIST OF TABLES

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

Section 1
Background Information

1.1 INTRODUCTION

1.1.1 General

This appendix presents an economic evaluation of the coastal storm surge flood risk reduction measures for the South Central Coastal Louisiana Feasibility Study. The evaluation area includes portions of three south central parishes that include Iberia, St. Mary, and St. Martin. The report 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 and Coastal Storm 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 economic appendix consists of a description of the methodology used to determine National Economic Development (NED) damages and benefits under existing conditions and the projects costs. The damages and costs were calculated using FY 2021 price levels. Costs were annualized using the FY 2021 Federal discount rate of 2.5 percent and a period of analysis of 50 years with the year 2025 as the base year. The expected annual damage and benefit estimates were compared to the annual construction costs and the associated OMRR&R costs for each of the project measures.

For the Recommended Plan (post TSP), benefits and costs were shown using FY 2022 price levels and the FY 2022 interest rate of 2.25 percent. All tables and figures associated with the TSP-level analysis, sensitivity analysis, or optimization are in FY2021 price level and interest rates.

1.1.2 National Economic Development Benefit Categories Considered

The NED procedure manuals for coastal and urban areas recognize four primary categories of benefits for flood risk management measures: inundation reduction, intensification, location, and employment benefits. The majority of the benefits attributable to a project measure generally result from the reduction of actual or potential damages caused by inundation. Inundation reduction includes the reduction of physical damages to structures, contents, and vehicles and indirect losses to the national economy.

1.1.3 Physical Flood Damage Reduction

Physical flood damage reduction benefits include the decrease in potential damages to residential, commercial, public, and industrial structures, their contents, and the privately owned vehicles associated with these structures.

1.1.4 Emergency Cost Reduction Benefits

Emergency costs are those costs incurred by a community during and immediately following a major storm. The cost of debris removal from inundated residential and non-residential structures was the only emergency cost reduction benefit considered for this analysis.

1.1.5 NED Benefit Categories NOT Considered

The following NED benefit categories were not addressed in this economic appendix. These categories were excluded from the NED analysis because other regionally specific or nationally specific studies and reports were not available to source the assumptions to calculate them, or the NED category was not determined to either provide more than 1-3 percent of overall existing condition damages or qualify as a NED benefit.

- Costs associated with evacuation and reoccupation activities before, during and following a flood event incurred by property owners and governments;
- Indirect losses to the national economy as a result of disruptions in the production of goods and services by industries affected by the storm or riverine flooding
- Increased cost of operations for industrial facilities following a flood event relative to normal business operations
- Physical loss of agricultural crops grown to be sold for commercial profit

1.1.6 Regional Economic Development

When the economic activity lost in a flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the RED account. The input-output macroeconomic model RECONS can be used to address the impacts of the construction spending associated with the project alternatives.

1.1.7 Other Social Effects

The other social effects (OSE) account includes impacts to life safety, vulnerable populations, local economic vitality, and community optimism. Impacts on these topics are a natural outcome of civil works projects and are most commonly qualitatively discussed in the OSE account. Life loss modeling software such as HEC-FIA and HEC-LifeSim have the ability to quantify loss of life for a given alternative to determine if life safety risk decreases or is induced as a result of federal investment. This study examines topics that relate to life safety, such as analyzing evacuation routes for floodprone segments and studying existing evacuation procedures to determine if the study area is prepared for and ready to respond to a coastal storm event.

1.2 DESCRIPTION OF THE STUDY AREA

1.2.1 Geographic Location

The South Central Coastal Louisiana (SCCL) study area includes three parishes (Iberia, St. Martin, St. Mary) and extends from the City of Lafayette south to the coastal portions of the study area bordering the Gulf of Mexico. The SCCL measures for the study area will be analyzed in this part of the Economics Appendix. An inventory of residential and non-residential structures was developed using the National Structure Inventory (NSI) version 2.0 for the portions of the three parishes impacted by storm surge associated with the future without project condition. Additional structures were initially added at the beginning of the study to address riverine flooding conditions, but were later sidelined when riverine flooding stopped being an objective of the study during the TSP milestone. Figure D:1-1 shows the structure inventory and the boundaries of the parishes for the full structure inventory.

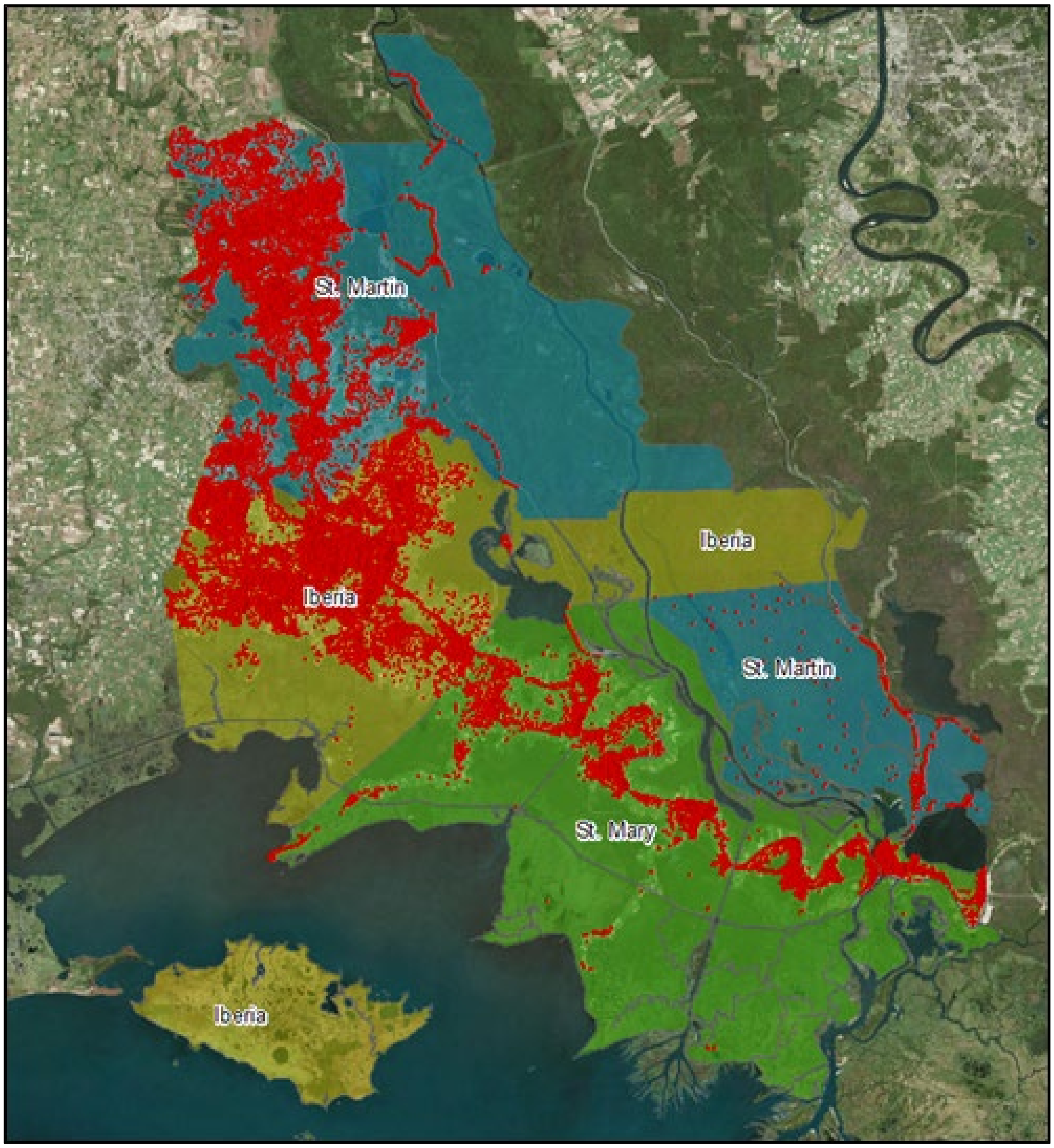

Figure D:1-1. Parish Boundaries and Structure Inventory

The study area was further divided into 158 study area subunits that were designed by the hydraulic engineer to contain areas that experienced similar hydraulic conditions. Some groups of subunits are small, designating highly variable hydraulic conditions across the study area. Other clusters of subunits are larger, designating more consistent water surface profiles. Structures located within each subunit were assigned that area, which is classified as a reach in HEC-FDA. Figure D:1-2 shows the study area subunit/reach boundaries for the SCCL area. Table D:1-1 shows a structure count by reach, split by the structure being either residential or non-residential, which includes commercial, industrial, and public structures. The study area has a total of 63,720 structures located across the 158 study area subunits.

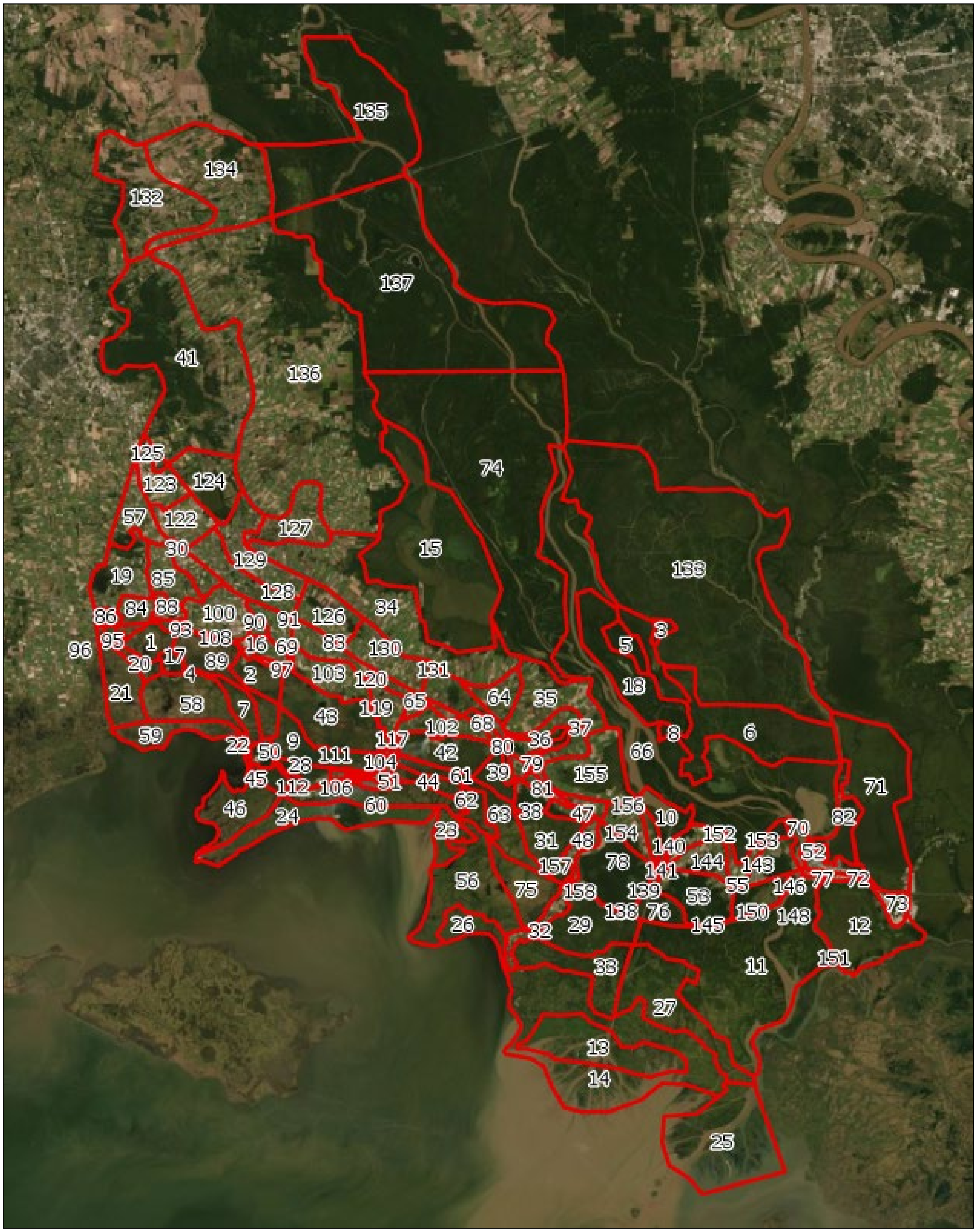

Figure D:1-2. Study Subunits (Reaches)

Table D:1-1. Structure Count by Reach

Reach	Residential	Non-Residential	Total Structures
1	1	0	1
2	1	0	1
3	0	0	0
4	2	0	2
5	10	0	10
6	0	0	0
7	0	0	0
8	3	0	3
9	4	1	5
10	0	6	6
11	0	5	5
12	4	0	4
13	2	3	5
14	40	5	45
15	162	9	171
16	68	8	76
17	2	0	2
18	371	42	413
19	2	1	3
20	0	0	0
21	0	0	0
22	1	0	1
23	218	5	223
24	0	0	0
25	0	0	0
26	0	0	0
27	0	1	1
28	0	0	0
29	293	52	345
30	0	0	0
31	37	5	42
32	0	0	0
33	4,120	404	4,524
34	122	23	145

35	70	35	105
36	2,019	311	2,330
37	8	7	15
38	3	2	5
39	14	5	19
40	4,378	785	5,163
41	0	0	0
42	0	0	0
43	0	0	0
44	0	0	0
45	136	4	140
46	0	0	0
47	17	8	25
48	2	1	3
49	0	2	2
50	1	1	2
51	4,497	1,066	5,563
52	814	105	919
53	8	0	8
54	35	1	36
55	1	0	1
56	923	206	1,129
57	6	0	6
58	0	0	0
59	24	9	33
60	0	0	0
61	0	0	0
62	1	0	1
63	843	96	939
64	177	16	193
65	28	1	29
66	0	0	0
67	72	5	77
68	107	5	112
69	9	21	30
70	615	42	657

71	12	37	49
72	249	184	433
73	6	2	8
74	0	0	0
75	1	0	1
76	157	45	202
77	64	7	71
78	419	53	472
79	602	77	679
80	465	32	497
81	288	36	324
82	308	50	358
83	88	5	93
84	763	61	824
85	47	9	56
86	70	29	99
87	197	17	214
88	1	2	3
89	25	1	26
90	577	62	639
91	0	0	0
92	25	5	30
93	5	0	5
94	1	0	1
95	0	0	0
96	0	0	0
97	0	0	0
98	0	2	2
99	502	209	711
100	0	0	0
101	189	7	196
102	44	7	51
103	1	0	1
104	0	0	0
105	4	0	4
106	0	2	2

107	1	0	1
108	0	0	0
109	0	0	0
110	0	0	0
111	0	1	1
112	1	0	1
113	0	0	0
114	0	0	0
115	0	0	0
116	2	2	4
117	0	0	0
118	41	4	45
119	19	6	25
120	51	1	52
121	302	119	421
122	301	113	414
123	338	49	387
124	142	30	172
125	368	52	420
126	1,311	81	1,392
127	1,430	463	1,893
128	5,756	1522	7,278
129	1,913	254	2,167
130	430	75	505
131	1,470	72	1,542
132	186	23	209
133	2,584	158	2,742
134	14	2	16
135	6,950	789	7,739
136	378	22	400
137	0	0	0
138	0	0	0
139	0	0	0
140	4	2	6
141	0	0	0
142	2,368	328	2,696

143	1,906	224	2,130
144	0	0	0
145	436	60	496
146	0	0	0
147	0	0	0
148	10	6	16
149	2	13	15
150	0	0	0
151	13	1	14
152	13	1	14
153	34	2	36
154	202	10	212
155	600	33	633
156	0	0	0
157	0	0	0
158	0	0	0

1.2.2 Existing Flood Damage Reduction Infrastructure

The South Central Coastal Louisiana (SCCL) study area includes significant investment in flood risk management infrastructure, including 10 pump stations, multiple floodgates, and levee systems. The levee systems include Bayou Sale, levees West of Berwick, Morgan City Backwater levees, Wax Lake outlet levees, West Atchafalaya Protection Levee, and East Atchafalaya Protection Levee. Each levee system reduces flood risk from either riverine or coastal storm events and are concentrated in the southeastern reaches of the study area from Franklin to Morgan City.

The levee systems within the SCCL study area are well maintained and do not have any known design deficiencies and therefore the HEC-FDA model did not incorporate the probability of failure of the levee systems in the form of fragility curves. The existing condition hydraulics incorporate all existing flood damage reduction infrastructure, including the levee systems. Figure D:1-3 shows the levee systems within the SCCL study area.

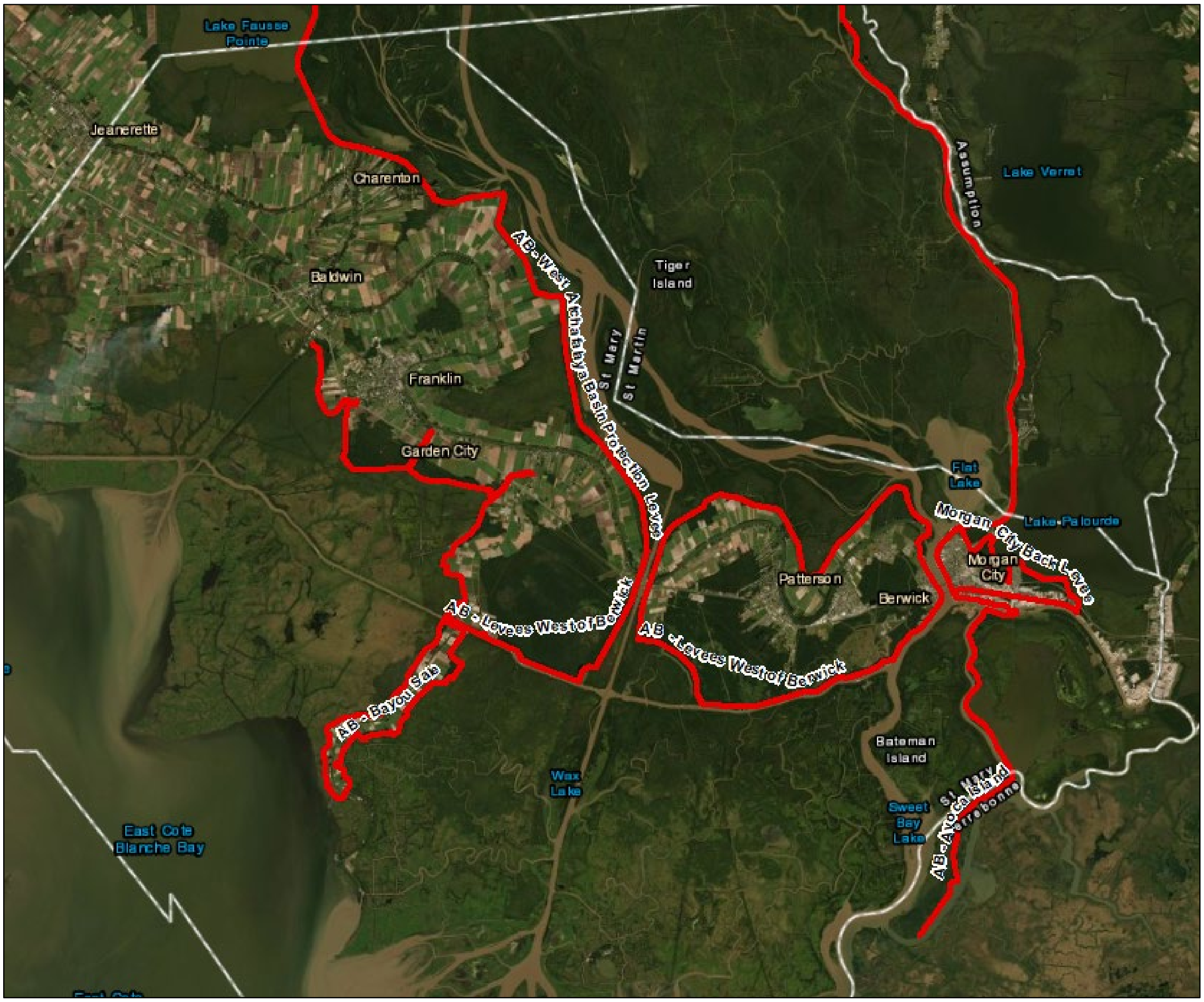

Figure D:1-3. SCCL Levee Systems

1.2.3 Land Use

The total number of acres of developed, agricultural, and undeveloped land in Iberia, St. Martin, and St. Mary Parishes are shown in Table D:1-2. As shown in the table, 7 percent of the total acres in the study area are currently developed land. There are slightly over 1.2 million acres of agricultural land and 3.9 million acres of undeveloped land.

Table D:1-2. Land Use in the Study Area

Land Class Name	**Acres**	**Percentage of Total**
Developed Land	364,094	7%
Agricultural Land	1,278,535	23%
Undeveloped Land	3,913,174	70%
Total	5,555,803	100%

Source: USGS National Land Cover Database
Note: Sugarcane accounts for the majority of the agricultural land and pasture/hay the remainder.

1.3 SOCIOECONOMIC SETTING

1.3.1 Population, Number of Household, and Employment

Tables D:1-3, D:1-4, and D:1-5 display the population, number of households, and the employment (number of jobs) for each of the three parishes for the years 2000 and 2010, as well as projections for the years 2017, 2025, and 2045. The 2000 and 2010 estimates for population, number of households and employment are from the U.S. Census and the projections were developed by Moody's Analytics (ECCA) Forecast, which has projections to the year 2045.

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

Parish	**2000**	**2010**	**2017**	**2025**	**2045**
Iberia	73,266	73,240	72,176	71,052	63,087
St. Martin	48,583	52,160	54,171	53,771	51,598
St. Mary	53,500	54,650	50,973	52,136	50,551
Total	175,349	180,050	177,320	176,959	165,237

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

Table D:1-4. Existing Condition and Projected Households by Parish

Parish	2000	2010	2017	2025	2045
Iberia	25,381	26,770	28,028	27,800	26,530
St. Martin	17,164	19,216	20,674	21,188	21,841
St. Mary	19,317	20,457	20,390	20,883	21,784
Total	61,862	66,443	69,092	69,871	70,155

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

Table D:1-5. Existing Condition and Projected Employment by Parish

Parish	2000	2010	2017	2025	2045
Iberia	28,760	29,464	27,627	26,613	25,531
St. Martin	20,192	22,137	21,104	21,010	21,761
St. Mary	20,866	22,815	20,763	21,233	21,602
Total	69,818	74,416	69,494	68,857	68,895

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

1.3.2 Income

Table D:1-6 shows the actual and projected per capita personal income levels for the three parishes from 2000 to 2025.

Table D:1-6. Per Capita Income ($)

Parish	2000	2010	2017	2025
Iberia	20,423	34,986	39,421	50,937
St. Martin	17,912	32,060	39,979	56,565
St. Mary	21,602	35,400	39,784	51,010

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

1.3.3 Compliance with Policy Guidance Letter (PGL) 25 and Executive Order 11988

Given continued growth in employment and/or income, it is expected that development will continue to occur in the study area with or without additional storm surge risk reduction, and will not conflict with PGL 25 and EO 11988, which state that the primary objective of a flood risk reduction project is to protect existing development, rather than to make undeveloped land available for more valuable uses. However, the overall growth rate is anticipated to be the same with or without the project in place. Thus, the project will not induce development, but would rather reduce the risk of the population being displaced after a major storm event.

1.4 RECENT FLOOD HISTORY

1.4.1 Tropical Events

Coastal Louisiana experiences localized flooding from both excessive rainfall events, leading to riverine flooding, and also storm surge events from tropical storms and hurricanes. Since 1851, the paths of 30 tropical events have crossed the study area. The paths and intensities of these storms are shown in Figure D:1-4.

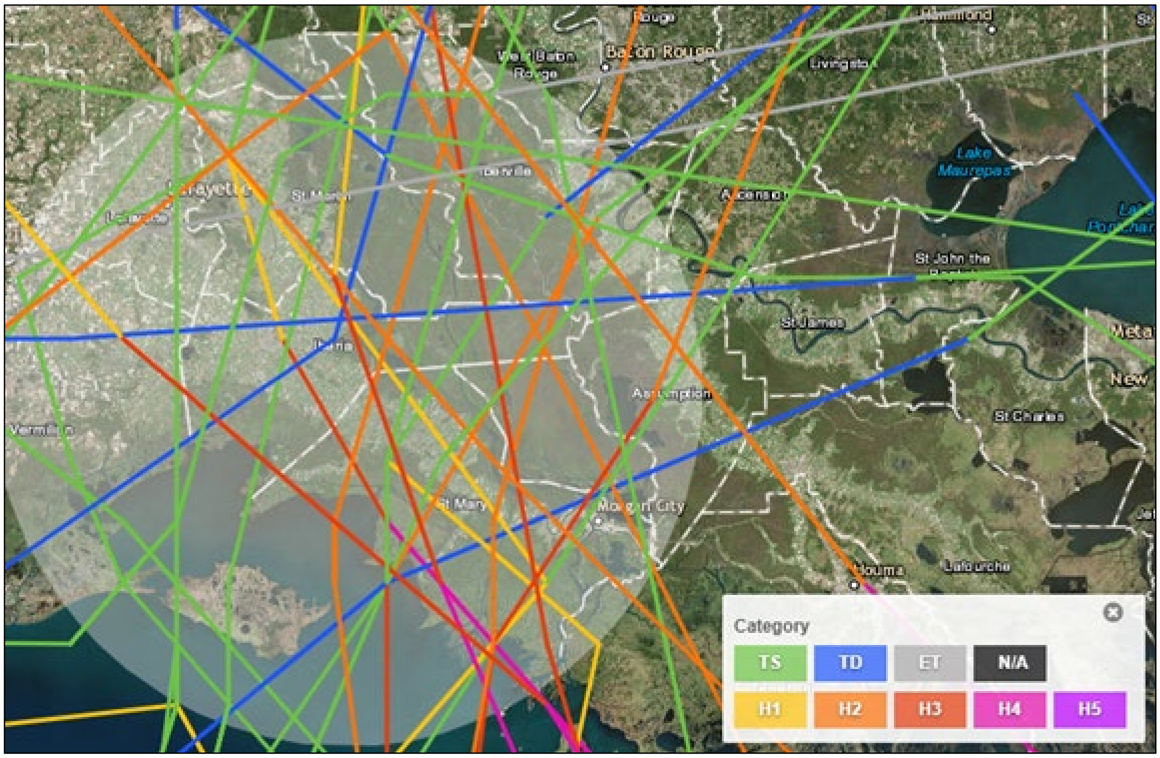

Figure D:1-4. Hurricane and Tropical Storm Paths Since 1851

1.4.2 FEMA Flood Claims

The most recent named storms to affect the SCCL study area include Tropical Storm Lee in 2011, Hurricane Ike in 2008, Hurricane Gustav in 2008, and Hurricane Rita in 2005. With that said, the 2016 flooding across Louisiana, including the SCCL study area, was the single worst event by amount paid per flood insurance claim. The FEMA flood claims for these events, including the 2016 storms, are shown Table D:1-7. The flood events listed in Table D:1-7 includes damages to structures both inside and out of the study area, and the exact impact to the SCCL study area is not known. Table D:1-8 shows the flood claims paid between 1978 and January 2018 for the three parishes within study area. The table includes the number of paid losses, the total amount paid, and the average amount paid on each loss in the dollar value at the time of the storm. The table excludes losses that were not covered by flood insurance. While there have been events that have damaged portions of the study area, there has never been a major named hurricane that has directly impacted the study area over the last 20 years.

Table D:1-7. Top Tropical Storms by Amount Paid by FEMA

Event	Month & Year	Number of Paid Claims	Total Amount Paid (millions)
2016 Louisiana Floods	Aug-16	26,909	$2,610
Tropical Storm Lee	Sep-11	9,900	$550
Hurricane Ike	Sep-08	46,684	$3,580
Hurricane Gustav	Sep-08	4,545	$150
Hurricane Rita	Sep-05	9,354	$740
Hurricane Andrew	Aug-92	5,587	$380

Source: Federal Emergency Management Agency (FEMA)
Note 1: Total amount paid has been indexed to 2020 price level using RS Means Cost Index
Note 2: Claims and amount paid are for entire event, which include areas outside of the study area.

Table D:1-8. FEMA Flood Claims by Parish (Jan 1978 – Sept 2018)

Parish	Total Number of Claims	Number of Paid Claims	Total Payments (millions)
Iberia	3,085	2,683	$94.70
St. Martin	1,323	1,093	$19.10
St. Mary	2,346	1,794	$31.50
Total	6,754	5,570	$145.20

Source: Federal Emergency Management Agency (FEMA)

1.4.3 FEMA Flood Insurance Rate Maps (FIRMS)

Flood insurance rate maps from FEMA were utilized in this study to help evaluate flood risk in coastal areas. The FIRM maps for all three parishes in the study area and each had a different effective date:

- Iberia Parish – effective 12/02/2011
- St. Mary Parish – effective 4/19/2017

- St. Martin Parish – effective 12/21/2018

The maps provided furthermore helped the study team address concerns by the public regarding flood insurance rates. The effective base flood elevations were utilized when formulating the nonstructural methodology regarding elevating residential structures to ensure that mitigation investment will reduce future flood insurance requirements for residential homeowners. Figure D:1-5 shows the effective coastal floodplains for the study area in each of the three parishes. The numbers in the figure represent the base flood elevation, also known as the 0.01 AEP expected flood stage.

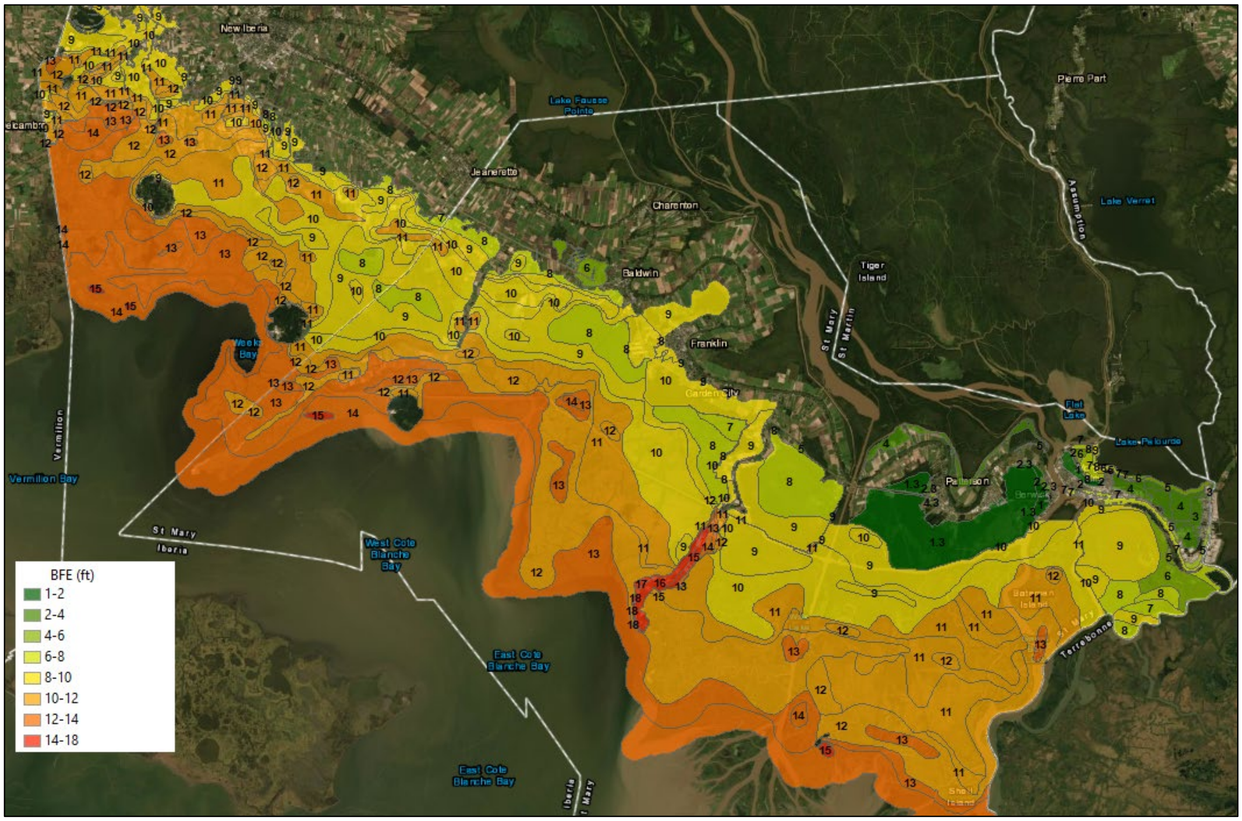

Figure D:1-5. FEMA Effective Base Flood Elevations

1.5 CRITICAL INFRASTRUCTURE

The critical infrastructure identified within the SCCL study area is comparable to other study areas of similar economic characteristics. Critical infrastructure unique to the study area is the amount of petroleum terminals and electric power generation facilities present, as the oil and gas industry makes up a large portion of economic activity within the region. A significant portion of the existing condition critical infrastructure is currently protected by structural flood risk reduction measures, such as levees along Morgan City and Franklin, or is on high ground, such as around Iberia.

The structure inventory developed for the SCCL study area included all applicable critical infrastructure that has a damageable footprint with an associated depth-damage curve available. Critical infrastructure within the structure inventory included hospitals, schools, police, fire, EMS, and power generation facilities. Excluded critical infrastructure from the structure inventory included petroleum terminals, electric substations, and some wastewater treatment plants. This study assumed the excluded critical infrastructure was either already mitigated or would not be structurally damaged by a coastal storm event, such as in the case of a petroleum terminal. Figure D:1-6 shows the critical infrastructure inventory for the entire study area with the 0.04 AEP (25-Year) floodplain overlaid. Figure D:1-7 shows the expected depths of flooding on critical infrastructure during a 0.04 AEP (25-Year) storm event.

Figure D:1-8 shows the expected depths of flooding during a 0.01 AEP (100-Year) storm event. All critical infrastructure was sourced from Homeland Security Infrastructure Program (HSIP) Gold database.

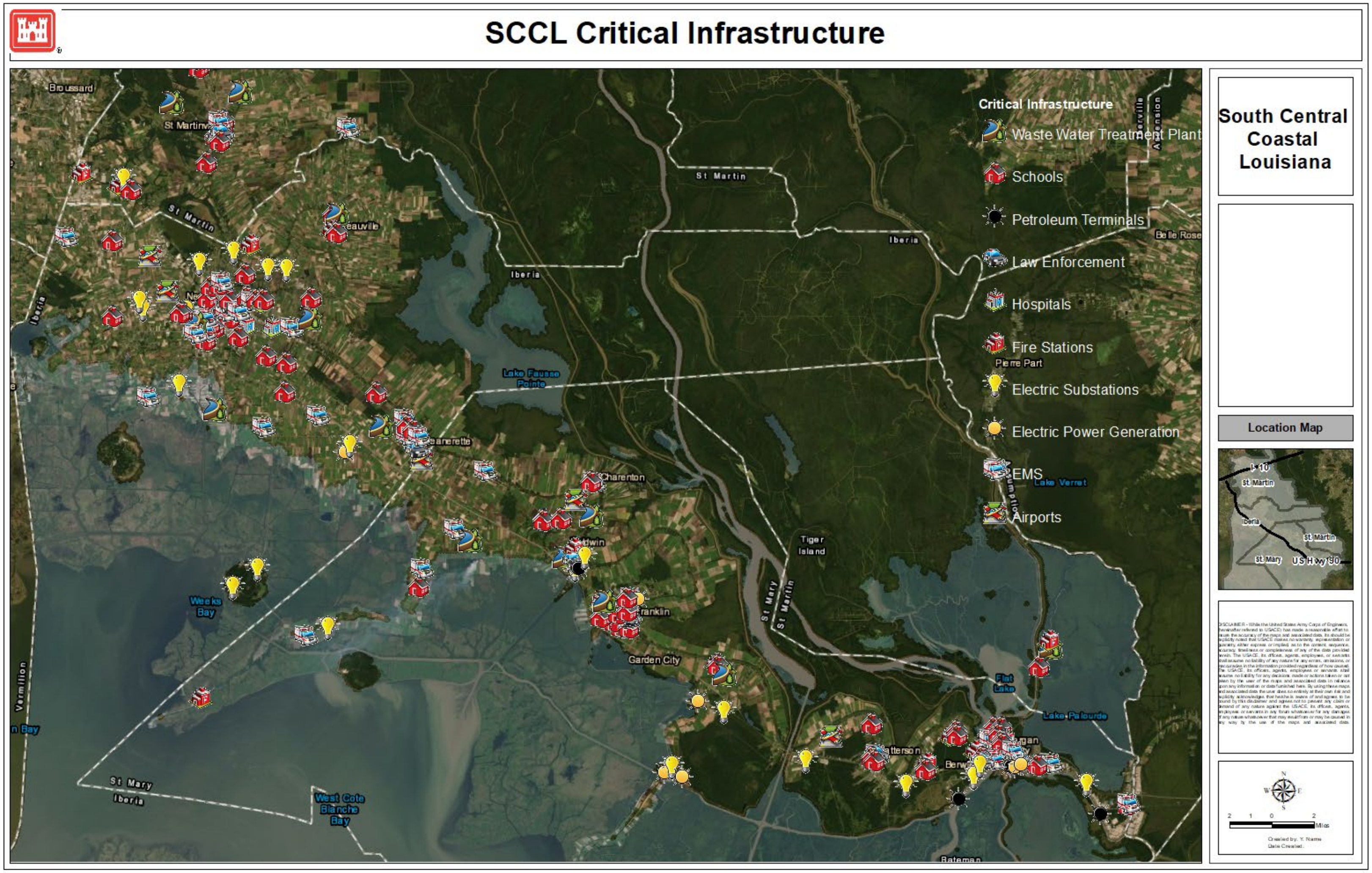

Figure D:1-6. SCCL Critical Infrastructure with 0.04 AEP Overlay

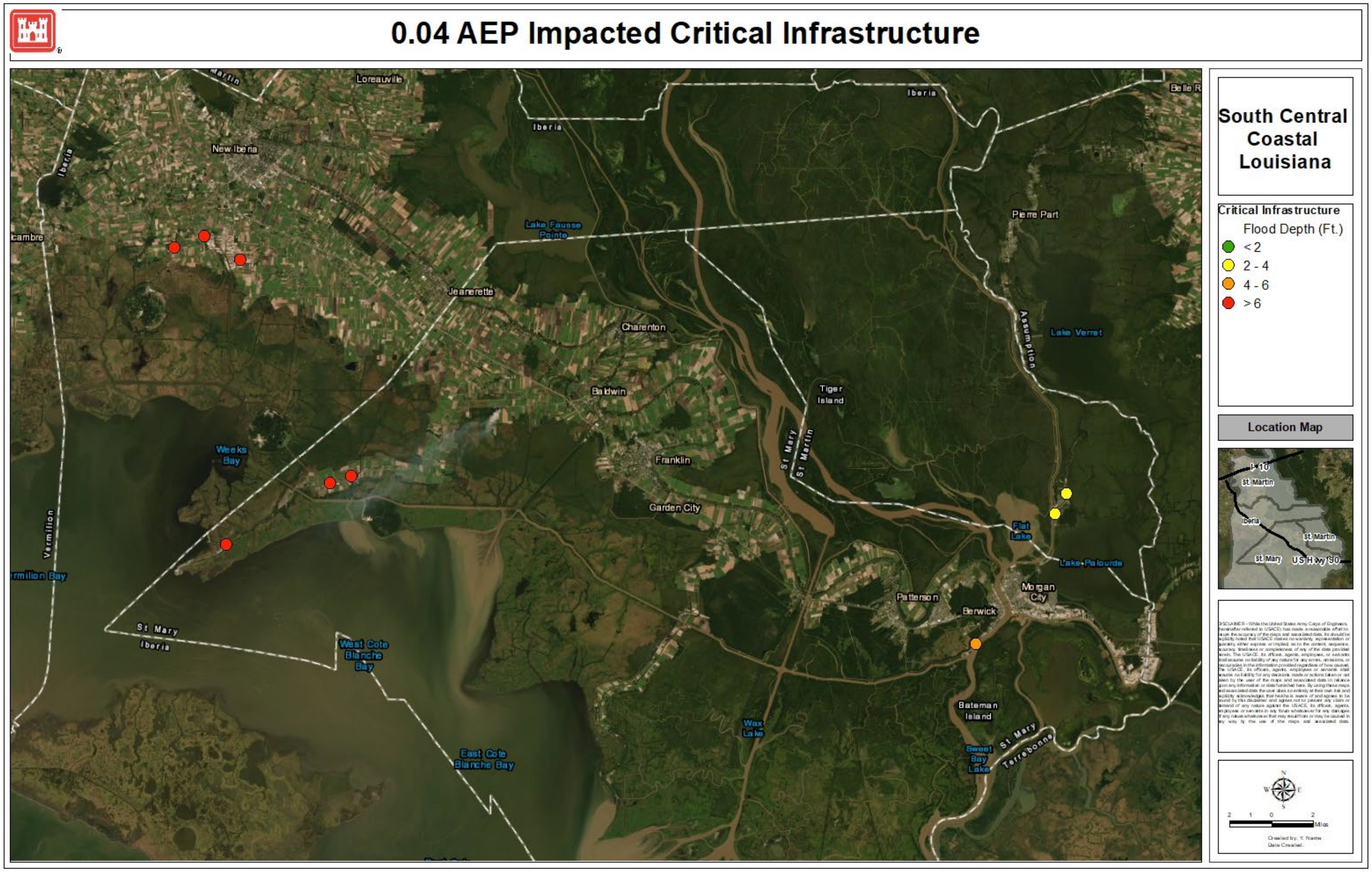

Figure D:1-7. 0.04 AEP Impacted Critical Infrastructure with Flood Depths

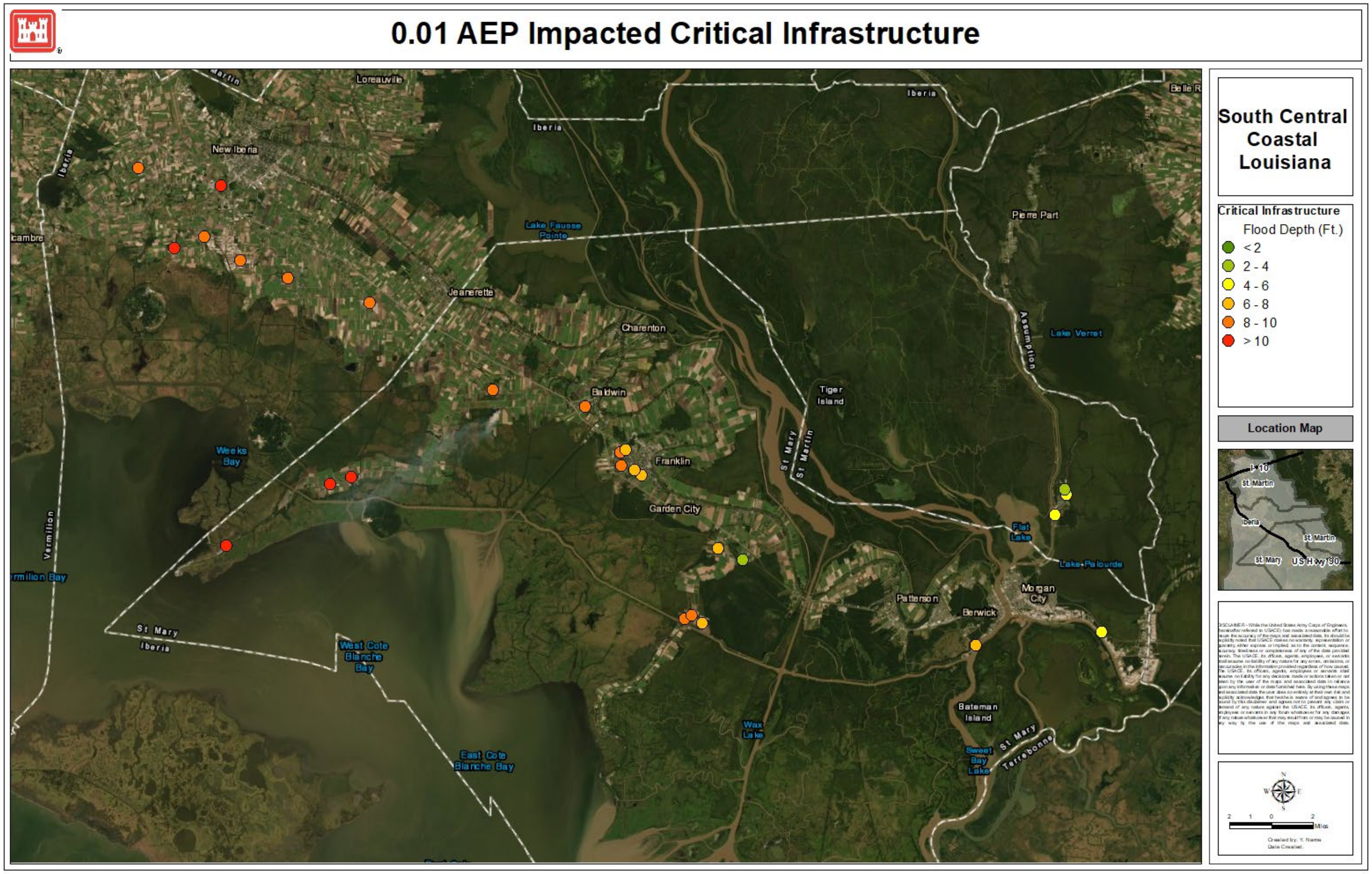

Figure D:1-8. 0.01 AEP Impacted Critical Infrastructure with Flood Depths

1.6 SCOPE OF THE STUDY

1.6.1 Problem Description

The study area is characterized by low, flat terrain, which makes the area highly susceptible to flooding from the tidal surges of hurricanes and tropical storms, as well as riverine flooding from excess precipitation. Exacerbating the flooding is the phenomenon of relative sea level rise (RSLR), which is the combination of the water level rising and the land subsiding. The highest rates of RSLR of all North America coastal communities are found in the SCCL study area.

The exposure of the study area to coastal storm surge was made apparent by Hurricane Gustav in 2008, which made landfall around Cocodrie, which is near Houma and the study area extents in Morgan City (see Figure D:1-9). Hurricane Gustav shut down the primary highway leading from southern Louisiana to New Orleans and required thousands of residents to either evacuate or shelter in place.

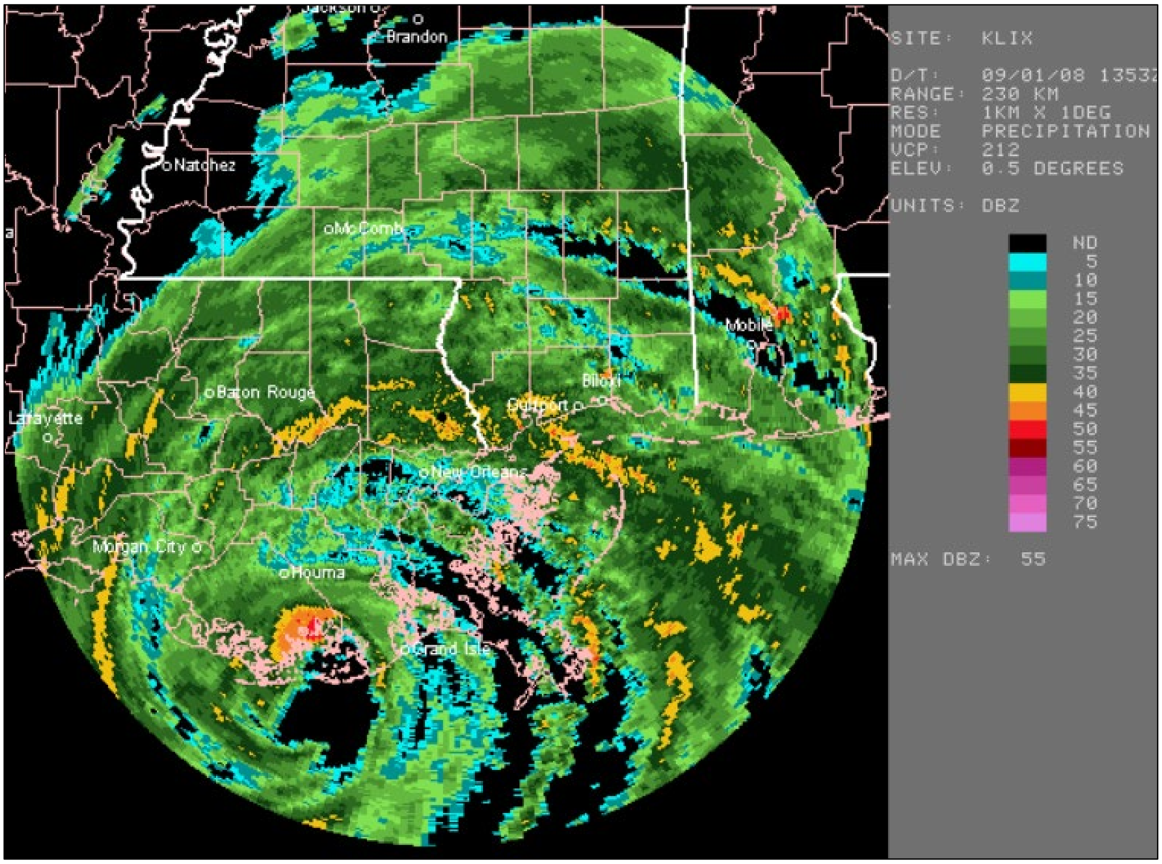

Figure D:1-9. Satellite View of Hurricane Ike

1.6.2 Project Measures

The suite of measures carried through to the final array included:

- Raising Levees West of Berwick (Ex -1)
- Construction of new Ring Levees 1+2, or 2,
- Raising levees surrounding Morgan City
- Nonstructural elevations and floodproofing at the 0.04 AEP, 0.02 AEP and 0.01 AEP floodplain
- Nonstructural acquisitions and relocation at the 0.04 AEP floodplain

The economic appendix only includes basic descriptions of measures carried through to the final array (4th planning iteration). A full description of measures included in the focused array (3rd planning iteration) and final array can be found in Chapter 3. Furthermore, after the Agency Decision Milestone (ADM), it was decided that the 0.04 AEP aggregation nonstructural alternative would be the Recommended Plan. Descriptions of the screened out measures and Recommended Plan are provided in the subsections that follow.

Raising Levees West of Berwick

Economic assessments of all levee segments within Levees West of Berwick, were not justified during the third planning iteration. However, coordination with the non-Federal sponsor highlighted the importance of these reaches due to presence of critical infrastructure and economic hot spot identification. The hot spot analysis showed geographic areas where existing condition damages to infrastructure are expected to be experienced during future coastal storm hazard events. The PDT refined the Levee West of Berwick measure to include only the levee sub-segment (Ex-1) near Franklin, Louisiana that had the highest probability of meeting economic justification. Figure D:1-10 shows the existing levee system near Franklin that was identified as being raised to mitigate future damages to floodprone structures (colored).

Figure D:1-10. Levees West of Berwick with Floodprone Structures

Construction of New Ring Levees

Analysis during the third iteration resulted in the screening of Ring levees 1 and 3 individually. Due to the Port of Iberia being an economic hot spot, the PDT determined evaluation of Ring levee 1 combined with Ring Levee 2 may result in a justified project. Ring Levee 1 in conjunction with Ring Levee 2 was carried forward. The areas identified by the ring levees are currently unprotected by any flood reduction system. Figure D:1-11 shows the proposed ring levee alignments for each of the identified areas with floodprone structures (colored).

Figure D:1-11. Delcambre/Port of Iberia Ring Levees with Floodprone Structures

Raising Levees Surrounding Morgan City

There are two portions of the Morgan City Back Levees not currently completed to represent 0.01 AEP storm surge risk reduction elevation, known as Lakeside Gap (Ex-21) and Young's Rd (Ex-19). Young's Road Levee Gap levee elevation would be raised over a 3,054 linear foot length. Lakeside Gap I-wall with barge gate at Lakeside Subdivision, is 2,143 feet long. An I-wall is a line of steel sheet piling similar to adjacent levee segments that would be installed in these identified areas. This feature also included replacing an existing barge gate on the eastern edge. Figure D:1-12 shows the completed and uncompleted levee segments within Morgan City, as labeled by EX-21 and EX-19. The existing levee system was constructed prior to current Hurricane & Storm Damage Risk Reduction System (HSDRRS) design criteria, and therefore the entire system potentially would have to be reconstructed if this alternative was selected.

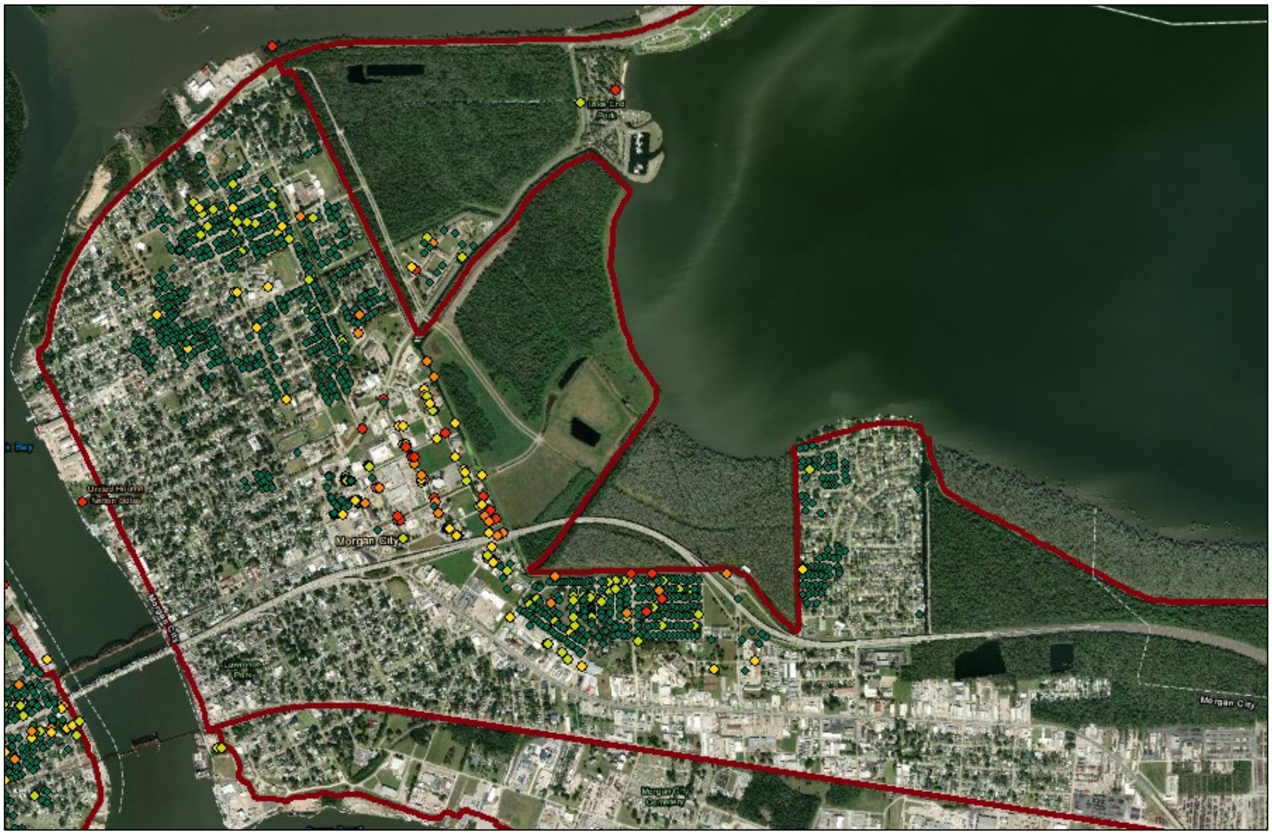

Figure D:1-12. Morgan City Levee System with Floodprone Structures

Nonstructural – Final Array

Two nonstructural measures have been carried forward to the final array and include elevating residential structures with floodproofing non-residential structures, and acquiring and relocating both residential and non-residential structures. Elevating residential structures for the Final Array relied on a target elevation of the future 0.01 AEP stage, not to exceed 13 feet and floodproofing non-residential structures up to 3 feet using dry floodproofing strategies.

For both nonstructural measures, a floodplain aggregation methodology was utilized that grouped structures together based on their flood depth relative to first floor elevation during various coastal storm surge events: (0.04 AEP (25-Year), 0.02 AEP (50-Year), and 0.01 AEP (100-Year)). For example, all structures with flood depths greater than the first floor elevation during the 0.04 AEP event would be grouped together into a “0.04 AEP Aggregation” nonstructural plan. The logic of this aggregation technique is that evaluating a group of structures together instead of individually helps remove bias related to structure values, building type, social status, or any other contributing factor besides the combination of flood frequency and magnitude. The 0.04 AEP aggregation was determined to be the most efficient plan and therefore the acquisition and relocation measure was limited to that aggregation size.

Nonstructural – Recommended Plan

After presenting the various nonstructural alternatives within the Final Array for the TSP and ADM milestones, the analysis found the elevation of residential structures to the future 0.01 AEP stage and dry floodproofing non-residential structures as being the plan that reasonably maximized net benefits. The acquisition and relocation alternative was not carried forward. After the ADM milestone, the TSP (0.04 AEP nonstructural aggregation) was optimized by calibrating the following factors:

- Further refined the geospatial locations of structures within the 0.002 (500-year) AEP floodplain
- Further refined structure inventory attributes (occupancy type, square footage, foundation height, depreciated replacement value, etc.)
- Removed structures being damaged inside areas of high risk reduction (0.002 AEP leveed areas for example)
- Incorporated revised hydraulics that included higher stages due to wave action
- Refined the nonstructural cost estimate by using cost per occupancy type estimates instead of cost per construction category estimates
- Refined cost estimates to be based on square footage instead of a max cost
- Optimized the size of the nonstructural aggregation
- Optimized the height of residential elevations
- Reduced non-residential residual risk by developing costs and benefits associated with wet floodproofing (rather than dry floodproofing) industrial structures
- Identified and removed structures built after July 1, 1991 within the 0.01 AEP floodplain to be in compliance with Section 308 of the Water Resource Development Act (WRDA) 1990

Once each of these factors were incorporated into the nonstructural TSP Plan, it was determined to be the Recommended Plan. More information on each of these optimizing and calibration factors can be found throughout the Economic Appendix.

Section 2

Economic and Engineering Inputs to the HEC-FDA Model

2.1 HEC-FDA MODEL OVERVIEW

The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.4.3 Corps-certified model was used to calculate the damages and benefits for the South Central Coastal Louisiana evaluation. The economic and engineering inputs necessary for the model to calculate damages for the project base year (2025) include the existing condition structure inventory, contents-to-structure value ratios, vehicles, first floor and ground elevations, depth-damage relationships, and without-project and with-project stage-probability relationships for the existing (2025) and future year (2075) conditions.

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. The inputs and uncertainties associated with the HEC-FDA model are explained in subsequent sections.

2.2 ECONOMIC INPUTS TO THE HEC-FDA MODEL

2.2.1 Structure Inventory

A structure inventory of residential and non-residential structures for the SCCL study area was obtained using the National Structure Inventory (NSI), version 2.0. NSI was originally created by USACE to simplify the GIS pre-processing workflow for the Modeling Mapping and Consequence center (MMC) and was recently upgraded to version 2 using upgraded data sources and algorithms. The NSI 2.0 database was significantly improved through various techniques further described in subsequent sections.

NSI 2.0 sources its structural attribute data from tax assessed parcel data (available through CoreLogic), business location data available through Esri/Infogroup, and HAZUS (where other datasets were unavailable). NSI 2.0 data is not an exact representation of reality, but rather contains many county-level, state-level, or regional assumptions applied to individual structures, often by random assignment. As such, while county or other large aggregations of structures will be accurate on average, individual structure characteristics may not be accurate. Although these and other accuracy issues exist, the NSI 2.0 dataset functions as an available common and consistent standard for the United States. The chief advantage of NSI 2.0 over other national datasets is its spatial accuracy, which is a significant improvement over the census block level accuracy that NSI 1.0 relied on.

Based on the conclusions of the socioeconomic analysis, this study assumes the human population will slightly decrease and the household formulation is predicted to show minor increases, but no changes to a future condition structure inventory were incorporated.

Occupancy Types

The NSI 2.0 database comes with its own list of occupancy types, which describes the type of structure more than simply residential or non-residential. Occupancy types are important because they eventually are used to assign depth-damage relationships to determine the rate at which a structure is damaged given a depth of water. The SCCL study utilized these three different occupancy types:

1. **NSI 2.0** – these occupancy type descriptions came with the original NSI 2.0 data and were the starting point for the study. The NSI 2.0 occupancy types were verified during sampling that was performed, especially in areas where one kind of occupancy dominated others, such as in the Port of Iberia with industrial warehouse buildings.
2. **RS Means** – to estimate costs per square foot for structures, the NSI 2.0 occupancy types were converted to RS Means occupancy types. In general, there was a unique RS Means occupancy type to match to each NSI 2.0 occupancy type, but certain structures were generalized, such as multi-occupancy apartment buildings. Professional judgment was used when combining occupancy types based on how the structure would be damaged.
3. **Depth-Damage Relationships** – Neither the NSI 2.0 nor RS Means occupancy types matched the occupancy types required to use for the depth-damage relationships that were selected for the local flooding conditions found in the SCCL study area. Professional judgment was used again to sort each structure type into the most representative occupancy type that the depth damage relationships offered.

Table D:2-1 shows the conversion process of moving structures through the three different occupancy types. Further descriptions of each occupancy type can be found in subsequent sections of the report.

Table D:2-1. RS Means Structure Inventory Statistics

RS Means OccType	NSI 2.0 OccType	Depth-Damage OccType
Post Frame Barn	AGR1	WARE
Store, Retail	COM1	RETA
Warehouse	COM2	WARE
Garage, Service Station	COM3	REPA
Office, 1 Story	COM4	PROF
Bank	COM5	PROF
Hospital, 2-3 Story	COM6	PUBL
Medical Office, 1 Story	COM7	PROF
Restaurant	COM8	EAT
School, Elementary	EDU1	PUBL
Office, 1 Story	GOV1	PUBL
Police Station	GOV2	PUBL
Factory, 1 Story	IND1	WARE
Factory, 1 Story	IND2	WARE
Factory, 1 Story	IND3	WARE
Factory, 1 Story	IND4	WARE
Office, 1 Story	IND6	WARE
Church	REL1	PUBL
1 Story Residential	RES1-1SNB	1STY-PIER / 1STY-SLAB
2 Story Residential	RES1-2SNB	2STY-PIER / 2STY-SLAB
Mobile Home	RES2	MOBHOM
1 Story Residential	RES3A	MULT
Apartment, 1-3 Story	RES3B	MULT
Apartment, 1-3 Story	RES3C	MULT
Apartment, 1-3 Story	RES3D	MULT
Apartment, 1-3 Story	RES3E	MULT
Motel, 1 Story	RES4	MULT
Jail	RES5	MULT
Nursing Home	RES6	MULT

Structure Values

As previously identified in the description of NSI 2.0, the national database has limitations and oversimplifications that lead to unacceptable levels of uncertainty for a feasibility level study. To overcome the limitations and reduce uncertainty, RS Means was used to reevaluate the depreciated replacement values and multiple statistically significant samples were performed to ensure an accurate representation of structural attributes. This process is further described in the "*Sample Structural Attributes*" section.

Application of RS Means – Residential Structures

The 2020 RS Means Square Foot Costs Data catalog was used to assign a depreciated replacement cost per square foot value to residential structures. The RS Means system of valuation provides the user to customize the following primary items: exterior wall type, build quality, additions, depreciation, and regional factors.

- Exterior Wall Type - Replacement costs per square foot were provided for four exterior walls types (wood frame, brick veneer, stucco, or masonry) and an **average** cost per square foot for the **four exterior wall types** was computed since there was not enough information to determine the exact wall types per structure.
- Build Quality – Build quality of a structure helps determine how high the starting cost per square foot should be for structures. Based on windshield surveys (using Google Street View), it was determined that the characteristics of the structures in the area were consistent with those of the **average build quality** (economy and luxury/custom homes existed, but were in the minority).
- Depreciation – Depreciation of a structure is based on the observed condition (effective age) of the structure and can be described as the structures wear and tear since it was constructed or last rehabilitated. Based on windshield surveys (using Google Street View), it was determined that the average condition of residential structures in the area was **20 years old**, and therefore structure values were **depreciated on average 20 percent** based on RS Means depreciation schedule. See the "Structure Value Uncertainty" on how uncertainty in observed condition impacts the uncertainty surrounding structure values.
- Region - A regional adjustment factor was applied to the cost per square foot to account for construction costs (**0.86 for residential**) consistent with the **Lafayette, Louisiana area**. Lafayette was the closest adjustment factor to the SCCL study area. was applied to the depreciated cost per square foot.
- Additions – RS Means allows for users to enter additional structural features that may be present beyond the default features. Based on windshield surveys (using Google Street View), it was determined that a half-bath and attached one-car garage was appropriate to add for both one-story and two-story residential structures. This adjustment represented approximately a 10% increase in the base cost per square foot estimate.

Application of RS Means – Non-residential Structures

The 2020 RS Means Square Foot Costs Data catalog was used to assign a depreciated replacement cost per square foot value to non-residential structures. The RS Means system of valuation provides the user to customize the following primary items: exterior wall type, build quality, additions, depreciation, and regional factors.

- Exterior Wall Type - Replacement costs per square foot were provided for six exterior wall types (decorative concrete with steel frame and with bearing walls frame, face brick with concrete block back-up with steel frame and with bearing walls frame, metal sandwich panel with steel frame, and precast concrete panel with bearing walls frame), and an **average** cost per square foot for the **six exterior wall types** was computed since there was not enough information to determine the exact wall types per structure.

- Build Quality – Build quality of a structure helps determine how high the starting cost per square foot should be for structures. Based on windshield surveys (using Google Street View), it was determined that the characteristics of the structures in the area were consistent with those of the **average build quality**, which is the only option for non-residential structures.

- Depreciation – Depreciation of a structure is based on the observed condition (effective age) of the structure and can be described as the structures wear and tear since it was constructed or last rehabilitated. Based on windshield surveys (using Google Street View), it was determined that the average condition of non-residential structures in the area was **20 years old**, and therefore structure values were **depreciated on average 25 percent** based on RS Means depreciation schedule. See the “Structure Value Uncertainty” on how uncertainty in observed condition impacts the uncertainty surrounding structure values.

- Region - A regional adjustment factor was applied to the cost per square foot to account for construction costs (**0.84 for non-residential**) consistent with the **Lafayette, Louisiana area**. Lafayette was the closest adjustment factor to the SCCL study area. was applied to the depreciated cost per square foot.

- Additions – RS Means allows for users to enter additional structural features that may be present beyond the default features. No additional features were added to non-residential structures.

The formula to determine depreciated replacement value for structures is simplified as follows:

$$Avg. Cost\ per\ sq\ ft * Avg.\ depreciation\ factor * \ Regional\ adjustment\ factor$$

The mean final cost per square foot by occupancy type was then applied to every structure in the inventory to determine depreciated replacement values. The square footage for each of the individual residential structures was multiplied by the size-specific depreciated cost per square for the average construction class to obtain a total depreciated cost. Finally, the Marshall and Swift Valuation Service was used to calculate a depreciated replacement cost per square foot for the manufactured or mobile homes in the Southern Louisiana area since mobile homes are not included in the RS Means catalog.

Square Foot Estimation

During the TSP phase of the study, the square footage for each occupancy type was averaged based on NSI 2.0 attributes, and the average at that time was based on the entire inventory of 63,720 structures. After the TSP, square foot estimates were resampled using only the structures within the 0.02 AEP aggregation. The only difference was that Microsoft Building Footprints were utilized to improve the data source of the square foot estimate.

Microsoft Building Footprints is a GIS outline of each structure generated from an algorithm that recognizes building pixels on aerial imagery and converts the building pixels into polygons. While Microsoft estimates that the error of such estimates is only 1.15%, the pixels detected include the overhang of the roof, and therefore overestimate the square footage for buildings with eaves. Historical USACE studies using Microsoft Building Footprints have used GIS measurement techniques to determine that the overestimation is approximately 10% to 20%. Square foot estimates for SCCL were reduced by 20% to account for roof overhang. Additional adjustments using professional judgement were made to account for occupancy types with more than one story since the footprints only measure a single floor.

Final square footage estimates per building footprint were spatially joined to the underlying structure points in GIS. Each occupancy type received an average square footage estimate based on the individual structures included within that occupancy type. Average square footage estimates by occupancy types were compared with the structure inventory for the Morganza to the Gulf PAC Study, which represents regionally similar inventory attributes. The comparison found that the square footages for single-story residential structures in the SCCL inventory was 5 percent less and two-story residential structures in the SCCL inventory was 22 percent less than those surveyed by URS for the Morganza study, which was performed in December 2008. This amount could be explained by the sampling technique, or the conversion of a single-story footprint to a two-story footprint.

Table D:2-2 shows the structure count and distribution of square foot estimates for each of the RS Means and NSI 2.0 occupancy types. The total structure count in Table D:2-2 reflects the amount of structures within the 0.02 AEP aggregation at the time of the TSP milestone. It does not reflect the total amount of structures within the study area, or the amount of structures within the Recommended Plan’s 0.04 AEP aggregation.

Furthermore, Table D:2-2 shows the average square foot by occupancy type for newly constructed buildings with an average build quality at the national level, according to the 2020 RS Means Square Foot Costs Data catalog. This column helps show deviations from the national average for the SCCL study area. Larger deviations could be explained by the average age of structures in the inventory verses newly constructed averages.

Table D:2-3 shows the results of the RS Means valuation analysis, which is the triangular distribution of cost per square foot by occupancy type. More information on RS Means triangular distribution is provided in the next section.

Table D:2-2. RS Means Square Foot Statistics by Occupancy Type

Occupancy Type (NSI 2, RS Means)	Structure Count	SCCL Avg. Sq. Ft.	National Avg. Sq. Ft
AGR1, Post Frame Barn	10	5,280	N/A
COM1, Store, Retail	80	8,707	8,000
COM2, Warehouse	101	18,043	30,000
COM3, Garage, Service Station	66	2,885	1,400
COM4, Office, 1 Story	141	9,597	7,000
COM5, Bank	16	4,915	4,100
COM6, Hospital, 2-3 Story	1	15,779	55,000
COM7, Medical Office, 1 Story	36	11,314	7,000
COM8, Restaurant	35	7,613	5,000
EDU1, School, Elementary	4	9,934	45,000
GOV1, Office, 1 Story	14	7,858	7,000
GOV2, Police Station	5	4,718	11,000
IND1, Factory, 1 Story	26	14,542	30,000
IND2, Factory, 1 Story	12	11,597	30,000
IND3, Factory, 1 Story	4	11,390	30,000
IND4, Factory, 1 Story	26	20,193	30,000
IND6, Office, 1 Story	74	14,444	11,000
REL1, Church	27	9,093	17,000
RES1-1SNB 1 Story	2,597	1,866	2,000
RES1-2SNB 2 Story	758	2,239	2,400
RES2 Mobile Home	72	900	N/A
RES3A 1 Story	25	2,041	3,200
RES3B, Apartment, 1-3 Story	32	3,822	22,500
RES3C, Apartment, 1-3 Story	32	6,622	22,500
RES3D, Apartment, 1-3 Story	24	9,269	22,500
RES3E, Apartment, 1-3 Story	1	13,116	22,500
RES4, Motel, 1 Story	4	12,980	8,000
RES5, Jail	4	28,122	40,000
RES6, Nursing Home	1	36,548	25,000

Table D:2-3. RS Means Cost per Square Foot Statistics by Occupancy Type

			RS Means Cost per Sq. Ft		
Occupancy Type (NSI 2, RS Means)	**Structure Count**	**Avg. Sq. Ft.**	**Minimum**	**Most Likely**	**Maximum**
AGR1, Post Frame Barn	10	5,280	33.7	42.2	51.7
COM1, Store, Retail	80	8,707	89.0	111.3	136.5
COM2, Warehouse	101	18,043	83.9	104.9	128.7
COM3, Garage, Service Station	66	2,885	135.2	169.0	207.3
COM4, Office, 1 Story	141	9,597	112.5	140.6	172.5
COM5, Bank	16	4,915	155.7	194.6	238.7
COM6, Hospital, 2-3 Story	1	15,779	223.1	278.9	342.1
COM7, Medical Office, 1 Story	36	11,314	116.8	146.0	179.1
COM8, Restaurant	35	7,613	132.6	165.7	203.3
EDU1, School, Elementary	4	9,934	100.7	125.9	154.5
GOV1, Office, 1 Story	14	7,858	112.5	140.6	172.5
GOV2, Police Station	5	4,718	180.7	225.9	277.1
IND1, Factory, 1 Story	26	14,542	91.9	114.9	140.9
IND2, Factory, 1 Story	12	11,597	91.9	114.9	140.9
IND3, Factory, 1 Story	4	11,390	91.9	114.9	140.9
IND4, Factory, 1 Story	26	20,193	91.9	114.9	140.9
IND6, Office, 1 Story	74	14,444	91.9	114.9	140.9
REL1, Church	27	9,093	136.7	170.8	209.6
RES1-1SNB 1 Story	2,597	1,866	59.8	86.9	101.1
RES1-2SNB 2 Story	758	2,239	57.7	84.0	97.6
RES2 Mobile Home	72	900	24.1	50.0	73.3
RES3A 1 Story	25	2,041	117.4	146.7	180.0
RES3B, Apartment, 1-3 Story	32	3,822	117.4	146.7	180.0
RES3C, Apartment, 1-3 Story	32	6,622	117.4	146.7	180.0
RES3D, Apartment, 1-3 Story	24	9,269	117.4	146.7	180.0
RES3E, Apartment, 1-3 Story	1	13,116	117.4	146.7	180.0
RES4, Motel, 1 Story	4	12,980	90.7	113.3	139.0
RES5, Jail	4	28,122	219.8	274.8	337.1
RES6, Nursing Home	1	36,548	129.3	161.6	198.3

Structure Value Uncertainty

The uncertainty surrounding the residential structure values includes the depreciation percentage applied based on the effective age (observed condition) of the structures as well as the four exterior wall types. The uncertainty factors were applied to the previously computed depreciated replacement value per square foot. A triangular probability distribution was developed for residential structures using the following RS Means information:

- Minimum Depreciation – Effective Age: 10 Years & Good Condition
- Most Likely Depreciation – Effective Age: 20 Years & Average Condition
- Maximum Depreciation – Effective Age: 30 Years & Poor Condition

Effective age for this uncertainty analysis was defined as the average observed condition of a structure as recorded during the windshield survey. 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 exterior wall type and occupancy category. 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 calculated from the six exterior wall types. A triangular probability distribution was developed for non-residential structures using the following RS Means information:

- Minimum Depreciation – Effective Age: 10 Years & Masonry on Masonry/Steel
- Most Likely Depreciation – Effective Age: 20 Years & Masonry on Wood
- Maximum Depreciation – Effective Age: 30 Years & Frame

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. Table D:2-4 shows the minimum and maximum percentages of the most-likely structure values assigned to the various structure categories.

Table D:2-4. RS Means Structure Value Uncertainty Factors

	RS Means Cost per Sq. Ft Factor		
RS Means Occupancy Type	Minimum	Most Likely	Maximum
Non-Residential	0.80	1.00	1.23
1 Story Res	0.69	1.00	1.16
2 Story Res	0.69	1.00	1.16
Mobile Home	0.48	1.00	1.47

Residential and Non-Residential Content-to-Structure Value Ratios

Based on Economic Guidance Memorandum (EGM), 04-01, dated 10 October 2003, a content-to-structure value ratio (CSVR) of 100 percent was applied to all of the residential structures in the structure inventory and the error associated with CSVR was set to zero. The EGM states that the 100 percent CSVR is to be used with the generic depth-damage relationships developed for residential structures, which were also used for this study.

The content-to-structure value ratios (CSVRs) applied to the non-residential structure occupancies were taken from an extensive survey of business owners in coastal Louisiana for three large coastal storm risk management evaluations. These interviews included a sampling from the eight non-residential content categories from each of the three evaluation areas. A total of 210 non-residential structures were used to develop CSVRs for each of the non-residential categories.

Since only a limited number of property owners participated in the field surveys and the participants were not randomly selected, statistical bootstrapping was performed to address the potential sampling error in estimating the mean and standard deviation of the CSVR values. Statistical bootstrapping uses re-sampling with replacement to improve the estimate of a population statistic when the sample size is insufficient for straightforward statistical inference. The bootstrapping method has the effect of increasing the sample size and accounts for distortions caused by a specific sample that may not be fully representative of the population.

Content-to-Structure Value Ratio Uncertainty

For each of the occupancy types, a mean CSVR and a standard deviation was calculated and entered into the HEC-FDA model using the information gathered from the survey performed for the three large coastal storm risk management evaluations. A normal probability density function was used to describe the uncertainty surrounding the CSVR for each content category. The expected CSVR percentage values and standard deviations for each of the occupancy types are shown in Table D:2-5.

Table D:2-5. Content-to-Structure Value Ratios and Uncertainty

	Average	Standard Deviation
1-Story Res	100%	0%
2-Story Res	100%	0%
Mobile Home	114%	79%
EAT	168%	127%
GROC	134%	80%
MULT	28%	17%
PROF	54%	59%
PUBL	57%	90%
REPA	239%	120%
RETA	124%	111%
WARE	207%	366%

2.2.2 Vehicle Inventory and Values

Based on 2017 Census information for the Louisiana area, there are an average of 1.76 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 Edmund, the average value of a used car was $19,700 as of June 2018. Since only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of $10,400 ($19,657 x 1.76 x 0.30) was assigned to each individual residential automobile structure record in the HEC-FDA model. The figure was indexed to 2021 price levels using the USACE CWCCIS composite index.

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.

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, $19,700, was used as the most-likely value. The average value of a new vehicle, $33,560, 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=16 percent, most-likely=100 percent, maximum=180 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.

2.3 DEBRIS REMOVAL COSTS

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

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

In order to account for the cost/damage surrounding debris cleanup, values for debris removal were incorporated into the structure inventory for each record according to its occupancy type. These values were then assigned a corresponding depth-damage function with uncertainty in the HEC-FDA model. For all structure occupancy types, 100 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 2020 price levels for the SCCL study area using the 2020 RS Means Square Foot Costs Data catalog. 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.

2.3.1 Debris Removal Costs Uncertainty

The uncertainty surrounding debris percentage values at 2 foot, 5 foot and 12 foot 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.

2.4 ELEVATION DATA AND SAMPLING ATTRIBUTES

Elevation data associated with the ground surface, foundation heights, and first floors of structures are critical to the economic analysis and feasibility of studies. Given the low-resolution of elevation data provided with the NSI 2.0 database, a statistically significant sample was calculated to inform a windshield survey to improve the estimates associated with foundation and first floor elevations.

2.4.1 Sampling Structural Attributes

A geo-stratified sample was applied to the SCCL study area to split the structure inventory into separable elements that do not naturally share similar attributes, such as foundation height. For the SCCL study, the sample was geospatially stratified between the coastal and inland areas using coastal storm surge data provided by the H&H Branch. Figure D:2-1 shows how the SCCL study area was stratified between coastal and inland using storm surge flood depth break lines at approximately the 9.8 feet level.

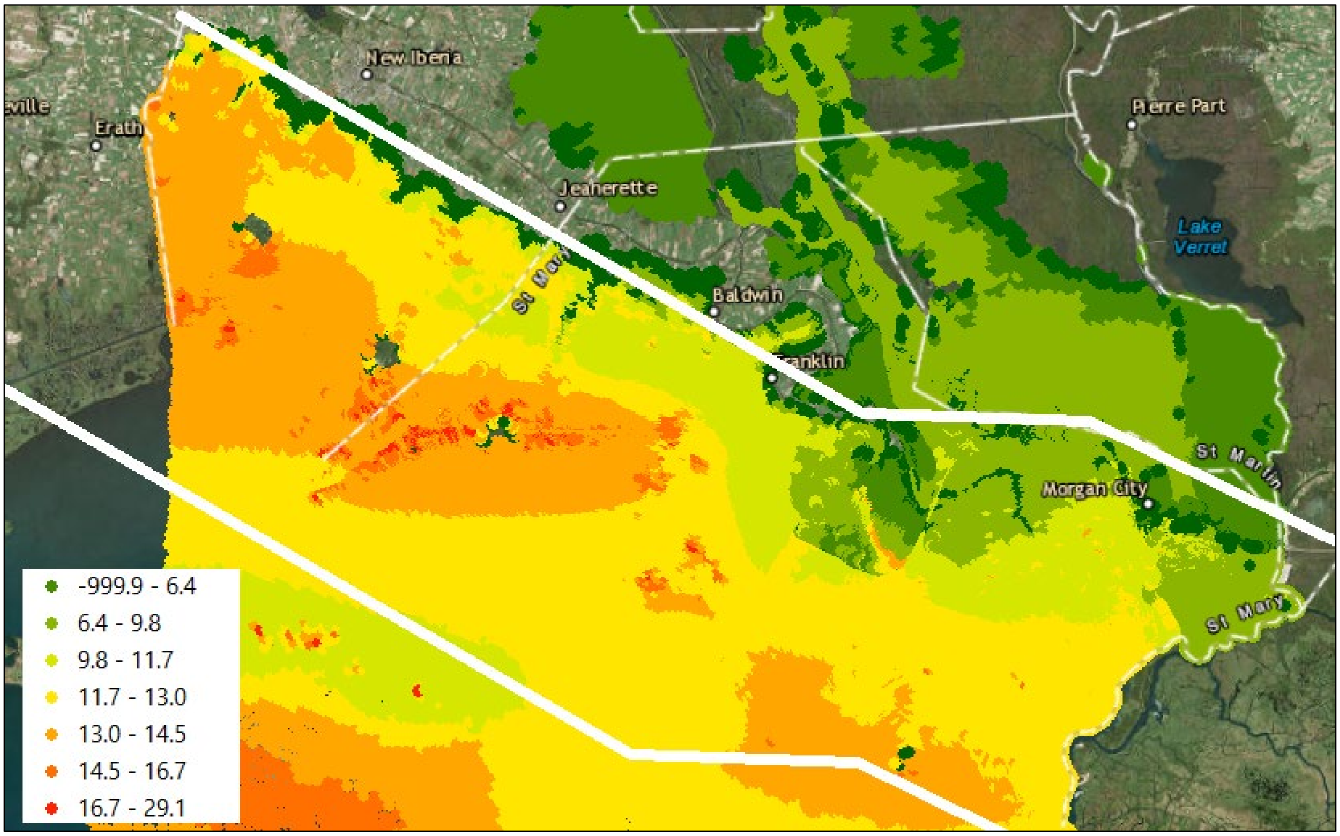

Figure D:2-1. Pre-TSP Geo-stratified Break Lines using Coastal Storm Flood Depths

A GIS-based sampling design tool developed by the National Oceanic and Atmospheric Administration (NOAA) was used to generate a geographically random sample of structures split between inland and coastal structures. Within either the coastal or inland stratification, structures were sampled using construction categories (either residential or commercial). The amount of structures to sample was computed using the statistically significant sample size formula in Figure D:2-2. The allowable error within the formula deviated from 0.20 feet but was limited to 20 percent to 30 percent of the standard deviation of the foundation height to reduce the amount of uncertainty in the structural attributes being sampled.

$$n = \left(\frac{Z*S}{E}\right)^2 \text{, where}$$

n = Sample size

Z = Z-Value (1.96)

$$S = \frac{Foundation\ Height_{High} - Foundation\ Height_{Low}}{6}$$

E = Allowable error (0.20 feet)

Figure D:2-2. Statistically Significant Sample Size Formula

A total of three Google Street View windshield surveys were conducted. The final two windshield survey samples were completed using the geo-stratified formulation previously described. The primary differences between the Pre-TSP and Post-TSP samples were the area where the sample was concentrated and the specific geo-stratification strategy. In addition to the three Google Street View windshield surveys conducted, an initial vehicle-based in-person drive was conducted through the study area to characterize different areas.

1. **Pre-TSP** - The first was a preliminarily survey completed prior to calculating the formula in Figure D:1-9 to determine the standard deviation of the average residential and commercial structures foundation height (S).
2. **Pre-TSP** - Once the foundation height standard deviation was estimated, it was entered into the formula in Figure D:1-9 to determine how many structures to sample based on the designated geo-stratification across the entire study area. The second windshield survey used two geo-stratifications: inland and coastal.
3. **Post-TSP** - The third survey sampled the 0.02 AEP floodplain aggregation to ensure the structural attributes and associated uncertainties were focused on the structures with the potential to impact the results of the economic analysis. The third windshield survey used three geo-stratification areas: inland, semi-coastal, and coastal.

2.4.2 Pre-TSP Windshield Survey

Prior to the ADM milestone, the economic team used the sampling formula (Figure D:1-6) to sample the entire study area, which resulted in sampling 84 residential coastal, 21 commercial coastal, 43 residential inland, and 35 commercial inland structures. This amount was exceeded in all categories by at least 30 percent. The variables sampled included:

- Foundation height – measured from the bottom of the front door to adjacent ground, each step was assumed to be 8 inches
- Foundation type – designated as either slab on grade, pier/pile, or crawlspace
- Story count – measured as either one or two or more story height
- Existing condition – qualitative judgment of the condition of the exterior of the structure condition
- Verification of occupancy type – confirmation of the occupancy being one of the 10 occupancy types

The results of the SCCL sample were compared with the results from the significantly larger 2012 Morganza to the Gulf sample and it was determined at the time of the TSP milestone to adopt the foundation heights and associated uncertainties of that study given similar results and regional factors.

2.4.3 Post-TSP Windshield Survey

Post-TSP milestone, the economics team performed a third sample focused on the 0.02 (50-year) AEP floodplain aggregation since the results of the TSP milestone recommended a full nonstructural alternative. The 0.04 (25-year) AEP floodplain aggregation was not selected for the sample because at the time of the sampling, it was not yet known what the optimized aggregation would result in. The post-TSP sample focused on the attributes with the largest impact on the net benefits, which were the foundation heights (presented in Table D:2-6) and square footage of the structures (presented previously in Table D:1-10). The post-TSP sample split the previous geo-stratified coastal area into two revised separable segments: coastal and semi-coastal, shown in Figure D:2-3. The segments were separated given the expectation that semi-coastal structural attributes could be considerably different given the greater exposure to coastal storms. The inland classification for structures was used to separate structures outside of the 0.02 AEP floodplain.

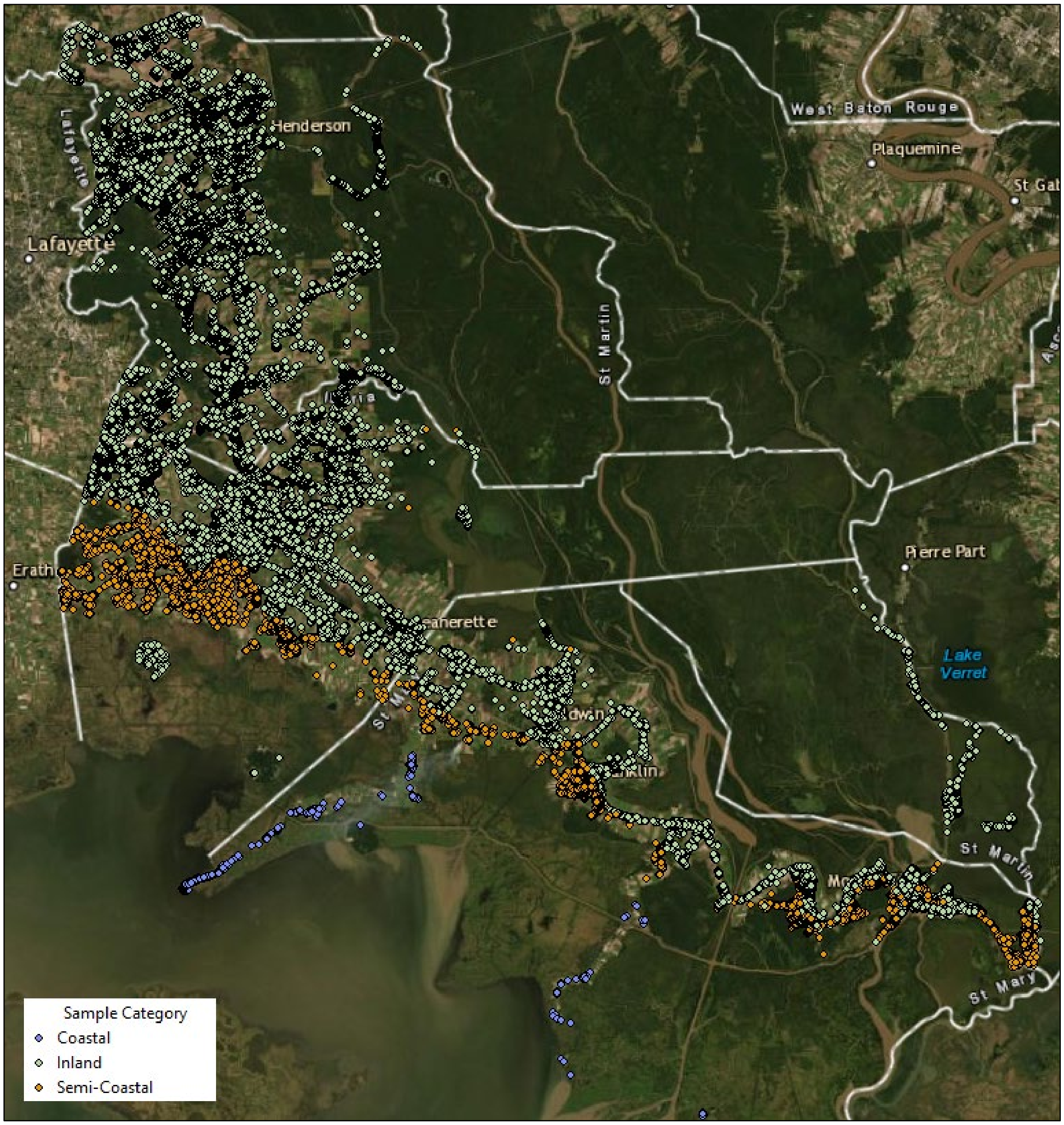

Figure D:2-3. Post-TSP Geo-stratified Sample Break Lines

The statistically significant sample size equation (Figure D:1-6) was utilized again for coastal and semi-coastal areas. The amount was exceeded in all categories, and in the case of coastal structures, a sample of greater than 90 percent was completed due to the high variability in foundations of residential structures on piers. A total of 594 semi-coastal structures were surveyed, which represented 14 percent of the structures located within the 0.02 AEP floodplain, again exceeding the amount computed in the formula in Figure D:1-6. Table D:2-6 shows the results of the post-TSP sample. All occupancy types rolled up into the commercial construction category received the foundation heights associated with its construction category.

Table D:2-6. Post-TSP Windshield Survey Foundation Height Results

	Coastal		Semi-Coastal	
	Avg. Foundation (ft.)	Standard Deviation (ft.)	Avg. Foundation (ft.)	Standard Deviation (ft.)
1STY-PIER	7.42	2.30	2.82	1.68
1STY-SLAB	N/A	N/A	0.83	0.45
2STY-PIER	5.36	2.35	2.86	1.46
2STY-SLAB	N/A	N/A	1.00	0.96
COMMERCIAL	0.63	0.49	0.84	0.82
INDUSTRIAL	0.56	0.22	0.34	0.29

2.4.4 Ground Surface Elevations

Topographical data based on Light Detection and Ranging (LiDAR) data using NAVD 1988 vertical datum was processed by the United States Geological Survey (USGS) and provided in a 3-meter resolution raster format. The 3-meter LiDAR data were used to assign ground elevations to structures and vehicles in the study area. The LiDAR dataset was verified to match the terrain data utilized by the hydraulic engineer perform hydraulic modeling using ADCIRC.

2.4.5 First Floor Elevations

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 and did not include adjustments for foundation heights.

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 survey technique used to determine the structure foundation heights above ground elevation. The error surrounding the LiDAR data was determined by the post-processed metadata 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 0.30 feet. The metadata associated with the LiDAR data was utilized over estimates within EM 1110-2-1619 given the age of the engineering manual and how estimating techniques regarding ground surface have changed.

The uncertainty surrounding the foundation heights for the residential and non-residential structures was estimated by calculating the standard deviations surrounding the sampled mean values. An overall weighted average standard deviation for the structure groups was computed for each structure category. Table D:2-6 previously showed the distribution of the foundation height uncertainty for each occupancy type sampled during the post-TSP windshield survey.

A Google Street View windshield survey was conducted using the stair counting method. The uncertainty surrounding the instrumentation (stair counting using street view) of measuring foundation heights was also not quantified for this report. The study did not complete any validations or verifications to determine how far off estimates could be by relying on a stair-counting method to measure foundation heights. Given the potential for uncertainty inherent with stair counting using street view, a sensitivity analysis was conducted to determine the impact on equivalent annual damages reduced. The sensitivity analysis is presented in Section 7.2, and examines the impact of increasing foundation heights by an additional 0.5 feet for all structures.

The standard deviations for the ground elevations and foundation heights were combined for three different construction categories, and for both the coastal and semi-coastal geo-stratified areas. Table D:2-7 displays the calculations used to combine the uncertainty surrounding the ground elevations with uncertainty surrounding the foundation height to derive the uncertainty surrounding the first floor elevations of residential, commercial and industrial structures.

Table D:2-7. First Floor Stage Uncertainty Standard Deviation (SD) Calculation

Ground - LiDAR (conversion cm to inches to feet)	
+/- 18 cm @ 95% confidence	18cm
	x 0.393
z = (x - u)/ std. dev.	7.074in
	÷ 12
1.96 = (0.5895 - 0)/ std.dev.	0.5895ft
0.3007 = std.dev.	

Foundation Height (shown in feet)

RES - Semi-Coastal				RES - Coastal		COM		IND	
1Sty-Pier	1Sty-Slab	2Sty-Pier	2Sty-Slab	1Sty-Pier	2Sty-Pier	Coastal	Semi-Coast	Coastal	Semi-Coast
2.82	0.83	2.86	1.00	7.42	5.36	0.63	0.84	0.56	0.34

Combined First Floor (shown in feet)

RES - Semi-Coastal				RES - Coastal		COM		IND		
1Sty-Pier	1Sty-Slab	2Sty-Pier	2Sty-Slab	1Sty-Pier	2Sty-Pier	Coastal	Semi-Coast	Coastal	Semi-Coast	
0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	ground std. dev.
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	ground std. dev. Squared
1.68	0.45	1.46	0.96	2.3	2.35	0.49	0.82	0.22	0.29	1st floor std. dev.
2.82	0.20	2.13	0.92	5.29	5.52	0.24	0.67	0.05	0.08	1st floor std. dev. squared
2.91	0.29	2.22	1.01	5.38	5.61	0.33	0.76	0.14	0.17	Sum of Squared
1.71	**0.54**	**1.49**	**1.01**	**2.32**	**2.37**	**0.57**	**0.87**	**0.37**	**0.42**	**Square Root of Sum of Squared = Combined Std. Dev.**

2.6 DEPTH DAMAGE RELATIONSHIPS

The USACE generic depth-damage relationships for one-story and two-story residential structures with no basement from EGM, 01-03, dated 4 December 2000, were used in the analysis. The mobile home depth-damage relationships were based on the relationships developed by a panel of insurance experts as part of the 2012 Morganza to the Gulf Feasibility Study. The vehicle depth-damage functions were based on the generic depth-damage curves from EGM, 09-04, generic depth-damage relationships for vehicles, dated 22 June 2009. The generic vehicle curves for sedans were used for vehicles associated with residential structures.

Since site-specific non-residential depth-damage relationships were not available for the SCCL study area, the saltwater, long duration (greater than 1 day of inundation) depth-damage relationships, developed by a panel of building and construction experts for the Lower Atchafalaya and Morganza to the Gulf, Louisiana feasibility study, were used in the economic analysis. These relationships were deemed appropriate because the adjacent study area has similar coastal topography and hydrology and similar structure categories and occupancies. Both study areas are characterized by low, flat terrain and are highly susceptible to flooding from the tidal surges associated with hurricanes and tropical storms due to their proximity to the Gulf of Mexico. The majority of the residential structures in the inventory are either wood frame construction with pier foundation or masonry construction with slab foundation. The areas have similar types of retail, eating and recreation non-residential structures and warehouse facilities.

Since the major source of flooding in both study areas is related to tropical storm surges from the Gulf of Mexico, saltwater depth-damage relationships were used in the analysis. Water is pushed into the area during a tropical event must flow over land features such as beaches, agricultural land, roads and highways, ridges along waterways and localized flood risk management systems. After the storm system moves through the area, there are no mechanisms to push the water back over these land features, and the saltwater could remain inside of inundated structures for several days. Evacuated residents may not be able to return to their homes until the roads are safely passable and electrical power has been restored. According to a panel of experts, when water remains inside of structures located in a warm, humid climate for several days, mold will quickly develop, and additional damages will occur.

Depth-damage relationships indicate the percentage of the total structure value that would be damaged at various depths of flooding. For residential structures, damage percentages were provided at each one-foot increment from 2 feet below the first floor elevation to 16 feet above the first floor elevation for the structural components and the content components. For non-residential structures, damage percentages were determined for each 0.50 foot increment from 0.50 foot below first floor elevation to 2 feet above first floor, and for each 1-foot increment from 2 feet to 15 feet above first floor elevation. Vehicle damage relationships were provided from one-half foot above the ground to 10 feet above the ground.

2.6.1 Uncertainty Surrounding Depth-Damage Relationships

A normal distribution with a standard deviation for each damage percentage provided at the various increments of flooding was used to determine the uncertainty surrounding the generic depth-damage relationships used for residential structures and vehicles. For non-residential structures and mobile homes, a triangular probability density function was used to determine the uncertainty surrounding the damage percentage associated with each depth of flooding. A minimum, maximum and most-likely damage estimate was provided by a panel of experts for each depth of flooding. The specific range of values regarding probability distributions for the depth-damage curves can be found in the final report dated May 1997 entitled Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies. The specific range of values regarding probability distributions for the debris depth-damage curves can be found in the final report dated March 2012 entitled Development of Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes. This report was also used as the basis for the depth-damage relationships developed for transportation infrastructure, which will be discussed more fully in the Other Benefits section of the economic appendix.

2.7 SUMMARY OF THE HEC-FDA MODEL UNCERTAINTY

Section 10 of this appendix (supplemental tables) shows the damage relationships for structures, contents, vehicles, and debris removal. The tables contains the damage percentages at each depth of flooding along with the uncertainty surrounding the damage percentages.

Table D:2-8 shows a summary of all of the variables included within the HEC-FDA model that have uncertainty associated with them. The foundation height and first floor stages have ranges due to the post-TSP sampling that occurred for coastal and semi-coastal regions. The other value column does not have uncertainty since it is built into the uncertainty in the depth-damage functions that represent debris damages.

Table D:2-8. Summary of HEC-FDA Model Uncertainty

South Central Coastal Louisiana Uncertainty Summary											
Occupancy Type	Foundation Height Error*	LiDAR Error	First Floor Stage Error*	Structure Value			Content Value	Vehicle Value			Other Value (Debris)
				Triangular				Triangular			
	Normal (ft.)	Normal (ft.)	Normal (ft.)	Min	Most Likely	Max	Normal	Min	Most Likely	Max	Normal
1STY-PIER	1.68 - 2.30	0.30	1.71 - 2.32	69%	100%	116%	0%	16%	100%	180%	0%
1STY-SLAB	0.45	0.30	0.54	69%	100%	116%	0%	16%	100%	180%	0%
2STY-PIER	1.46 - 2.35	0.30	1.49 - 2.37	69%	100%	116%	0%	16%	100%	180%	0%
2STY-SLAB	0.96	0.30	1.01	69%	100%	116%	0%	16%	100%	180%	0%
MOBHOM	0.00	0.30	0.30	48%	100%	147%	79%	16%	100%	180%	0%
MULT	0.49 - 0.82	0.30	0.57 - 0.87	80%	100%	123%	17%	16%	100%	180%	0%
WARE	0.22 - 0.29	0.30	0.37 - 0.42	80%	100%	123%	366%	N/A			0%
RETA	0.49 - 0.82	0.30	0.57 - 0.87	80%	100%	123%	111%				0%
REPA	0.49 - 0.83	0.30	0.57 - 0.88	80%	100%	123%	120%				0%
PROF	0.49 - 0.84	0.30	0.57 - 0.89	80%	100%	123%	59%				0%
PUBL	0.69	0.30	0.79	80%	100%	123%	90%				0%
EAT	0.49 - 0.84	0.30	0.57 - 0.89	80%	100%	123%	127%				0%

Note*: The foundation height and first floor stages have ranges due to the post-TSP sampling that occurred for coastal and semi-coastal regions.

2.8 ENGINEERING INPUTS TO THE HEC-FDA MODEL

2.8.1 Stage-Probability Relationships

Stage-probability relationships were provided for the existing without-project condition (2025) and future without-project condition (2075). Because the Recommended Plan is a nonstructural alternative, there is no with-project condition hydraulic modeling required. At the TSP milestone, with project condition hydraulics were not provided for the screened structural measures, and as a result, benefits were computed using the HEC-FDA structure detail .out file. Damages associated with this method can be found in Supplemental Table 7 at the end of the economic appendix.

The ADCIRC model provided water surface profiles for six annual exceedance probability (AEP) events ranging from the 0.02 (50-year) to the 0.001 (1000-year) events. The H&H and GIS branches interpolated the results to provide water surface profiles for eight AEP events: 0.50 (2-year), 0.20 (5-year), 0.10 (10-year), 0.04 (25-year), 0.02 (50-year), 0.01 (100-year), 0.004 (250-year), and 0.002 (500-year). The ADCIRC model results were summarized in a geospatial format through the designation of hydraulic subunits, as previously shown in Figure D:1-2.

The existing and future without-project water surface profiles were based on storm surge and incorporated heavy rainfall events and wave action. The future without-project condition (2075) is based on an intermediate sea level rise (SLR) forecast that assumes an approximate raise in sea level of 1.8 feet across all frequencies. More information on how the intermediate SLR forecast was determined can be found in the Hydraulics and Hydrology appendix.

2.8.2 Uncertainty Surrounding the Stage-Probability Relationships

A 50-year equivalent record length was used to quantify the uncertainty surrounding the stage-probability relationships for each study area reach. Based on this equivalent record length, the HEC-FDA model calculated the confidence limits surrounding the stage-probability functions.

Section 3
National Economic Development Flood Damage Calculations

3.1 HEC-FDA MODEL CALCULATIONS

The HEC-FDA model was utilized to evaluate flood damages using risk-based analysis. Damages were reported at the index location for each of the 158 study area reaches for which a structure inventory had been created. A range of possible values, with a maximum and a minimum value for each economic variable (first floor elevation, structure and content values, and depth-damage relationships), was entered into the HEC-FDA model to calculate the uncertainty or error surrounding the elevation-damage, or stage-damage, relationships. The model also used the number of years that stages were recorded at a given gage to determine the hydrologic uncertainty surrounding the stage-probability relationships.

The possible occurrences of each variable were derived through the use of Monte Carlo simulation, which used randomly selected numbers to simulate the values of the selected variables from within the established ranges and distributions. For each variable, a sampling technique was used to select from within the range of possible values. With each sample, or iteration, a different value was selected. The number of iterations performed affects the simulation execution time and the quality and accuracy of the results. This process was conducted simultaneously for each economic and hydrologic variable. The resulting mean value and probability distributions formed a comprehensive picture of all possible outcomes.

3.2 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 the existing (2025) and future (2075) condition. The possible occurrences of each economic variable were derived through the use of Monte Carlo simulation. A total of 1,000 iterations were executed in the model for the stage-damage relationships. 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.

3.3 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 for the without-project condition under base year (2025) conditions through the use of graphical analysis. The hydraulic engineer selected 50 years to represent the length of records analyzed during the calibration process that the hydraulic model underwent. The model used the eight stage-probability events together with the equivalent record length to define the full range of the stage-probability functions by interpolating between the data points. Confidence bands surrounding the stages for each of the probability events were also provided.

3.4 WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES

The model used Monte Carlo simulation to sample from the stage-probability curve with uncertainty. For each of the iterations sampled 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) and are shown in Table D:3-1 for the existing (2025) and future (2075) condition. From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the without-project alternative, the expected annual damages (EAD) were totaled for each study area reach to obtain the total without-project EAD under base year (2025) and future (2075) conditions.

Table D:3-1. Recommended Plan Existing & Future Condition Economic Damage by Probability Events (FY22, $1,000s)

Annual Exceedance Probability (AEP)	**Existing Condition (2025) Damage by Damage Categories**					
	AUTO	COM	IND	PUBL	RES	Total Damage
0.5 (2 yr.)	3	45	43	4	70	167
0.2 (5 yr.)	23	370	757	27	451	1,627
0.1 (10 yr.)	1,092	15,638	32,894	1,194	17,077	67,895
0.04 (25 yr.)	7,990	155,628	366,317	11,946	146,813	688,694
0.02 (50 yr.)	25,773	409,852	937,012	47,304	555,063	1,975,004
0.01 (100 yr.)	60,201	852,276	1,783,604	120,676	1,358,479	4,175,235
0.004 (250 yr.)	128,963	2,016,037	3,568,313	322,541	3,210,924	9,246,778
0.002 (500 yr.)	204,867	3,396,618	5,337,143	534,567	5,462,961	14,936,171

Annual Exceedance Probability (AEP)	**Future Condition (2075) Damage by Damage Categories**					
	AUTO	COM	IND	PUBL	RES	Total Damage
0.5 (2 yr.)	13	219	173	21	331	756
0.2 (5 yr.)	34	482	534	44	785	1,880
0.1 (10 yr.)	4,467	90,535	189,060	7,051	92,829	383,941
0.04 (25 yr.)	25,809	548,901	1,114,325	59,523	640,265	2,388,824
0.02 (50 yr.)	67,563	1,362,415	2,378,106	181,529	1,829,537	5,819,149
0.01 (100 yr.)	118,701	2,327,511	3,846,407	326,581	3,231,668	9,850,875
0.004 (250 yr.)	207,197	4,022,496	6,157,872	600,501	5,835,119	16,823,192
0.002 (500 yr.)	284,243	5,670,551	8,121,245	824,331	8,087,262	22,987,637

3.5 STRUCTURE INVENTORY ADJUSTMENTS FOR HIGH FREQUENCY INUNDATION

Adjustments were made to the structure inventory to more accurately reflect the most-likely future without-project and with-project conditions. Under without-project and with-project conditions, residential and non-residential structures that were identified as being inundated above the first floor elevation from the 0.50 (2-year) and 0.20 (5-year) AEP events were modified to have the 2-year and 5-year stages below the ground surface elevation by at least seven feet to ensure high frequency damages were mitigated in the existing and future without-project conditions. This adjustment is consistent with the FEMA floodplain regulations that require residents to rebuild above the base flood elevation after a structure receives greater than 50 percent damage to the structural components as a result of a flood. This modification ensures project justification cannot be attributable to a limited amount of structures continuously being damaged by high frequency flood events.

3.6 WITH-PROJECT EXPECTED ANNUAL DAMAGES

Similarly to other sections of this report, the with-project expected annual damages figures for the final array were computed during the TSP milestone differently than post-TSP, when the Recommended Plan was identified. As a result, this section shows two different expected annual damage tables to document how measures were screened, and display the NED recommended plan that was refined, resulting in the Recommended Plan tables in subsequent pages.

3.6.1 TSP-Level with Project Expected Annual Damages

Table D:3-2 shows the without project condition expected annual damages for the final array of measures presented during the TSP milestone. Table D:3-3 shows the expected annual damage reduced for the final array of measures presented during the TSP milestone.

Table D:3-2. TSP-Level Expected Annual Damages by Damage Category (FY21, $1,000's)

Plan	**AUTO**	**COM**	**IND**	**PUBL**	**RES**	**Total**
Without Project	4,398	100,074	47,626	7,046	61,102	220,246
0.04 AEP Elev/Flood proof	4,398	64,076	30,494	4,511	41,938	145,417
0.02 AEP Elev/Flood proof	4,398	59,958	28,534	4,221	39,243	136,354
0.01 AEP Elev/Flood proof	4,398	55,353	26,343	3,897	36,229	126,220
0.04 AEP Acquisitions	2,336	53,164	25,301	3,743	32,460	117,005
Berwick Levee Raises	4,333	98,599	46,924	6,942	60,201	216,999
Ring Levees 1+2	4,049	91,105	78,957	2,025	26,319	202,455
Ring Levee 2	4,170	93,822	81,312	2,085	27,104	208,493
Morgan City Levee Raises	4,345	97,760	84,725	2,172	28,242	217,244

Table D:3-3. TSP-Level Expected Annual Damages Reduced by Measure (FY21, $1,000's)

Plan	**Total Without Project**	**Total With Project**	**Damages Reduced**
Without Project	220,246	220,246	0
0.04 AEP Elev/Flood proof	220,246	145,417	74,829
0.02 AEP Elev/Flood proof	220,246	136,354	83,892
0.01 AEP Elev/Flood proof	220,246	126,220	94,026
0.04 AEP Acquisitions	220,246	117,005	103,241
Berwick Levee Raises	220,246	216,999	3,247
Ring Levees 1+2	220,246	202,455	17,791
Ring Levee 2	220,246	208,493	11,753
Morgan City Levee Raises	220,246	217,244	3,002

3.6.2 Recommended Plan With-Project Expected Annual Damages

Tables D:3-4 shows the final without project condition expected annual damages for the Recommended Plan. A summary of changes made to the TSP-level to reach the Recommended Plan can be found in Section 1.6 of this appendix. Table D:3-4 shows the expected annual damage reduced for the Recommended Plan. Table D:3-4 includes both expected annual and equivalent annual damages for the 0.04 AEP aggregation nonstructural plan.

Table D:3-4. Recommended Plan Expected/Equivalent Annual Damages and Damages Reduced by Damage Category (FY22, $1,000's)

Year 2025 Expected Annual Damages						
Plan	AUTO	COM	IND	PUBL	RES	Total EAD
Without	2,337	38,080	71,176	5,010	54,694	171,296
0.04 AEP Elev/Flood proof	2,337	29,536	63,290	4,413	35,843	135,421
Damages Reduced (Expected)	-	8,544	7,885	597	18,850	35,876
Year 2075 Expected Annual Damages						
Plan	AUTO	COM	IND	PUBL	RES	Total EAD
Without	4,705	93,194	161,109	12,141	124,681	395,830
0.04 AEP Elev/Flood proof	4,705	80,593	147,421	11,102	92,951	336,771
Damages Reduced (Expected)	-	12,601	13,689	1,039	31,730	59,058
Equivalent Annual Damages (2.25%, 50 years)						
Plan	AUTO	COM	IND	PUBL	RES	Total EAD
Without	3,282	60,080	107,075	7,856	82,631	260,924
0.04 AEP Elev/Flood proof	3,282	49,917	96,874	7,083	58,639	215,795
Damages Reduced (Equivalent)	-	10,163	10,201	773	23,992	45,129

3.7 EXCLUSION OF AGRICULTURAL BENEFITS

An economic analysis of the agricultural lands in the study area was conducted to determine the number of acres impacted in the study area. The National Agricultural Statistical Service (NASS) geo-spatial information system for the year 2019 data were used to identify the agricultural land and crop distribution within the study area. Agricultural activity was found to be predominately sugar cane crops. Using GIS software, it was determined that there is currently more than 50,000 acres of sugar cane crops that are not receiving flood risk reduction from coastal flood hazards. Hydraulic depth grids showing depth of flooding were overlaid with the sugar cane crops to estimate the amount of acres of sugar cane that would be flooded for each of the eight flood frequencies analyzed. The analysis assumed that each acre of sugar cane would be completely destroyed given more than two feet of depths, and that when incorporating hydraulic frequencies, the average annual damage per acre for sugar cane would be $430. Agricultural damages to sugar cane were left out of the economic analysis because measures to protect the crops would be vastly greater than the potential damages reduced to crops. Thus, estimates of agricultural benefits were not included in the net benefit computations.

Section 4
Project Costs

4.1 CONSTRUCTION SCHEDULE

For the purposes of computing interest during construction (IDC), construction of the project alternatives is expected to begin in the year 2025 and will continue for a period of 3 months. The construction period of 3 months is based on the expected length of construction to construct, install, and complete each of the nonstructural mitigation measures, and is not a complete construction schedule required to fully implement the Recommended Plan.

For the structural measures analyzed during the TSP milestone that were later screened, a one year construction period was utilized to compute interest during construction.

4.2 STRUCTURAL COSTS

Structural cost estimates for the final array were developed by the New Orleans District Cost Engineering Branch and were commensurate with a level 4 cost estimate. An abbreviated cost risk analysis was completed to determine the 36.5 percent contingency used for all structural measures analyzed during the TSP milestone. A second detailed cost risk analysis was completed to determine the 31.7 percent contingency used for the Recommended Plan analyzed to support the final report.

Interest during constructed was calculated for each of the structural alternatives and assumed the construction period lasted one year. Interest during construction was calculated using an end of year payment schedule and 2.25 percent discount rate (FY22).

4.3 NONSTRUCTURAL COSTS – ELEVATION AND FLOODPROOFING

Nonstructural cost estimates for the final array were developed through a joint effort between the New Orleans District Economics, Real Estate, Cultural Resources and Cost Engineering Branches. A 36.5 percent contingency was applied to all nonstructural cost estimates during the TSP milestone phase of the study, and a 31.7 percent contingency used during the Recommended Plan phase of the study. The contingency represents the uncertainty regarding the cost and schedule risk of these measures. The contingency amount was computed during an abbreviated cost risk analysis using some of the most significant factors impacting cost associated with the Southwest Coastal Feasibility Study.

Interest during constructed was calculated for each of the nonstructural alternatives and assumed the construction period lasted 3 months for any of the nonstructural mitigation measures. Interest during construction was calculated on a mid-period quarterly basis payment schedule and 2.25 percent discount rate (FY22).

Real estate costs were included in the nonstructural analysis, which included relocation assistance costs for tenants, and administrative costs. A 25 percent contingency was applied to the real estate costs, which is separate from the contingency applied to the square foot cost estimates for elevation and floodproofing. A detailed cost analysis can be found in Section 10 of the Real Estate Plan.

Cultural Resources costs were included in the nonstructural analysis, which included architectural and archeological surveys, archaeological mitigation, and architectural mitigation.

4.3.1 Residential Structures

The estimate of the cost to elevate all residential structures was computed once model execution was completed. Elevation costs were based on the difference in the number of feet between the original first floor elevation and the target elevation (the future condition optimized stage, including sea level rise) for each structure in the HEC-FDA module. The number of feet that each structure was raised was rounded to next highest 1-foot increment. Elevation costs by structure were summed to yield an estimate of total structure elevation costs.

The cost per square foot for raising a structure was based on data obtained during interviews in 2008 with representatives of three major metropolitan New Orleans area firms that specialize in the structure elevation. Composite costs were derived for residential structures by type: slab and pier foundation, one story and two story configuration, and for mobile homes. These composite unit costs also vary by the number of feet that structures may be elevated. Table D:4-1 displays the costs for each of the five residential categories analyzed and by the number of feet elevated. The costs in this table do not include contingency, or any other supporting cost such as construction management or PED.

The cost per square foot to raise an individual structure to the target height was multiplied by the average footprint square footage of each structure's occupancy type to compute the costs to elevate the structure. The total costs for all elevated structures were annualized over the 50-year period of analysis of the project using the FY22 federal discount rate of 2.25 percent. The square foot costs for elevation was price indexed to FY22 price levels by the New Orleans District Cost Engineering Branch.

Table D:4-1. Nonstructural Elevation Costs for Residential Structures (FY22, $/Sq. Ft.)

Height	1STY-PIER	1STY-SLAB	2STY-PIER	2STY-SLAB	MOBILE
[ft.]	[$]	[$]	[$]	[$]	[$]
N/A	0	0	0	0	0
1	78	88	86	97	43
2	78	88	86	97	43
3	81	90	89	99	43
4	81	93	89	106	53
5	81	93	89	106	53
6	83	95	91	107	53
7	83	95	91	107	53
8	85	98	93	111	53
9	85	98	93	111	53
10	85	98	93	111	53
11	85	98	93	111	53
12	85	98	93	111	53
13	86	101	95	117	53
14	86	101	95	117	53
15	86	101	95	117	53
16	86	101	95	117	53

4.3.2 Non-residential Structures – Dry Floodproofing

The dry floodproofing costs were applied to all non-warehouse, non-residential structures. Separate cost estimates were developed to flood proof non-residential structures based on their square footage. Table D:4-2 shows a summary of square footage costs for dry floodproofing and excludes contingency. These costs were developed for the Draft Nonstructural Alternatives Feasibility Study, Donaldsonville LA to the Gulf evaluation (September 14, 2012) by contacting a local contractor (Arcadis) and were adopted for this study due to the similarity in the structure types between the two study areas. Again, final cost estimates are expressed in FY 2022 prices. As shown in Table D:2-3 (RS Means Cost per Square Foot Statistics by Occupancy Type), nearly all of the structures eligible for dry floodproofing were applied a cost estimate of $121,938 since the average square footage by occupancy type was less than 30,000. Average square footage of an occupancy type would have had to exceed 30,000 square feet to increase to a cost estimate of $268,800. The square foot costs for dry floodproofing was price indexed to FY22 price levels by the New Orleans District Cost Engineering Branch.

Table D:4-2. Nonstructural Dry Floodproofing Costs for Non-residential Structures (FY22,$)

Square Footage	**Cost**
1,000	121,938
10,000	121,938
20,000	121,938
30,000	268,800
40,000	268,800
50,000	268,800
60,000	268,800
70,000	268,800
80,000	268,800
90,000	268,800
100,000	268,800
>= 110,000	664,476

4.3.3 Non-residential Structures – Wet Floodproofing

The wet floodproofing costs were applied to all non-residential, warehouse structures. For the SCCL study area, it was determined that given the Port of Iberia and other industrial areas, the overall percentage of warehouse structures was proportionally higher than comparable projects. The residual damage analysis post-TSP also found that given high existing condition flood depths, dry floodproofing was ineffective at reducing damages for warehouse structures. Additionally, the dry floodproofing methodology requires gates, barriers, and floodproofing veneer to prevent water intrusion. Industrial warehouse structures typically do not allow for dry floodproofing given the larger hanger style entrances and fabricated steel walls prone to hydrostatic loadings. As a result of dry floodproofing being incompatible with warehouse structures, the study partnered with the Association of State Floodplain Management (ASFPM) and the Flood Mitigation Industry (FMI) to develop generic cost estimates for wet floodproofing of warehouse structures.

Wet floodproofing the envelope of the structure included installing engineered flood vents, tearing out existing sheetrock, batt insulation, electrical outlets, and installing rigid foam wall insulation, hardy dry board, and elevating electric outlets. Costs for wet floodproofing also included blasting existing coatings and rust and applying two coats of epoxy coating. The effectiveness of wet floodproofing was determined to be 12 feet for the structure. More information about the development of wet floodproofing costs can be found in Appendix L. Wet floodproofing costs were developed specifically for the South Central Coastal Louisiana study area and are in FY22 price levels.

4.4 NONSTRUCTURAL COSTS – ACQUISITION AND RELOCATION

4.4.1 Acquisition

The estimate of the cost of acquiring structures was computed once model execution was completed and was only used to compare alternatives for the TSP milestone. Acquisition costs are based on the cost of acquiring the parcel of land, the structure(s) built on the land, an architectural survey, and miscellaneous costs associated with the acquisition process. The depreciated replacement value of the structure (excluding any contents) was used to represent the cost of the structure, which was previously described as being sourced from RS Means Square Foot Cost data. The cost of acquiring the parcel was provided by the New Orleans Real Estate Branch, and was $2 per square foot for residential structures and $3 per square foot for non-residential structures. This square foot estimate was applied to the size of the parcel of land and not the size of the structure. Added to the acquisition cost was the cost of performing an architectural survey, which is associated with cultural resources concerns. Finally, a cost of $47,000 for residential structures and $141,000 for non-residential structures was added to represent the cost of demolition, deed changes, legal fees, and regarding the surface. These miscellaneous costs associated with acquisition were sourced from the 2010 USACE Cedar Rapids, Iowa Feasibility Report. The prices derived from the 2010 report were price indexed to 2020 price levels. Acquisition costs by structure were summed to yield an estimate of total structure acquisition cost. The acquisition and relocation alternative was not carried forward.

4.4.2 Relocation

Relocation costs are based on the cost of relocating the occupant, as required per Uniform Relocation Assistance and Real Property Acquisition Act of 1970 (URA), that has been removed from the acquired parcel. Relocation costs include purchasing a suitably located piece of property commensurate with the acquired parcel and the costs associated with the URA. Costs associated with URA include assisting the occupant with moving costs and incidentals for residential structures and moving costs, searching expenses, and re-establishing costs for non-residential structures. The URA costs amount to $38,000 per residential structure and $50,000 per non-residential structure. Relocation costs by structure were summed to yield an estimate of total structure relocation cost.

The total acquisition and relocation costs were added together and applied on a per structure basis to determine the full cost of acquisition and relocation.

4.5 TSP-LEVEL ANNUAL PROJECT COSTS

Life cycle cost estimates were provided for the nonstructural measures in FY20 price levels. The initial construction costs (first costs) and the schedule of expenditures were used to determine the interest during construction over a one year construction period. The FY 2021 Federal interest 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.

Operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) costs associated with the final array of measures was not computed due to an initial screening without it that showed negative net benefits. At the time of the TSP, the nonstructural alternatives did not have OMRR&R in the with-project condition. Residential structures are recommended to be elevated to the future year (2075) stage associated with the intermediate sea level rise and therefore it is assumed that future sea level rise will not require future elevations. Table D:4-3 and Table D:4-4 display cost summaries for both the structural and nonstructural measures studied during the TSP-level analysis.

Table D:4-3. Summary of TSP-Level Costs for Structural Measures (FY21, $)

	Berwick Levee Raises	Ring Levees 1+2	Ring Levee 2	Morgan City Levee Raises
Construction First Cost	131,798,000	1,311,479,000	738,204,000	80,701,000
Wetland Mitigation Cost	923,000	16,309,000	19,450,000	-
Real Estate Cost	1,560,000	33,546,000	9,416,000	841,000
Cultural Cost	100,000	114,675,000	520,000	195,000
Interest During Construction	1,846,000	18,718,000	10,547,000	2,316,000
Total Cost	136,227,000	1,494,727,000	778,137,000	84,053,000
Average Annual Cost	5,046,000	55,366,000	28,823,000	3,113,000

Table D:4-4. Summary of TSP-Level Costs for Nonstructural Measures (FY21, $)

	0.04 AEP Elev/Flood proof	0.02 AEP Elev/Flood proof	0.01 AEP Elev/Flood proof	0.04 AEP Acquisitions
Construction First Cost	1,411,000,000	1,901,000,000	3,137,000,000	2,999,758,000
Wetland Mitigation Cost	-	-	-	-
Real Estate Cost	-	-	-	-
Cultural Cost	5,307,000	8,845,000	13,142,000	5,307,000
Interest During Construction	4,793,000	6,457,000	10,656,000	4,793,000
Total Cost	1,421,100,000	1,916,302,000	3,160,798,000	3,009,858,000
Average Annual Cost	52,639,000	70,982,000	117,079,000	111,488,000

4.6 RECOMMENDED PLAN ANNUAL PROJECT COSTS

Life cycle cost estimates were provided for the nonstructural measures in FY22 price levels. The initial construction costs (first costs) and the schedule of expenditures were used to determine the interest during construction and gross investment cost at the end of the installation period (2025). The FY 2022 Federal interest rate of 2.25 percent was used to discount the costs to the base year and then amortize the costs over the 50-year period of analysis.

The Recommended Plan is only expected to have OMRR&R associated with the wet floodproofing component of the with-project condition. Wet floodproofing OMRR&R costs included inspections, paint, lubrication, and maintenance of the flood vents. Residential structures are recommended to be elevated to the future year (2075) stage associated with the intermediate sea level rise and therefore it is assumed that future sea level rise will not require future elevations. The Recommended Plan consists of elevations and floodproofing and does not include any structural acquisition or relocations. Table D:4-5 shows the cost summary for the Recommended Plan.

Table D:4-5. Summary of Recommended Plan Costs (FY22, $)

	2.25%
Elevation Cost	373,096,000
Dry Floodproofing Cost	35,281,000
Wet Floodproofing Cost	102,905,000
Total Nonstructural Cost	511,282,000
Contingency (31.7%)	162,076,000
Cultural Resource Preservation	14,723,000
Real Estate	41,145,000
Planning, Engineering and Design	117,972,000
Construction Management	65,540,000
Interest During Construction	2,031,000
Total Cost	914,769,000
Annual Operations and Maintenance	386,000
Total Average Annual Cost	$ 31,048,000

Section 5
Optimization

To ensure that the economic damages reduced reasonably maximize net benefits, all factors that could be optimized in support of the TSP were analyzed. These factors include the nonstructural aggregation, residential elevation height, and non-residential floodproofing effectiveness. It is important to note that the figures and tables utilized in this section of the report were accurate at the time the optimization occurred, and therefore the figures (such as expected annual damages reduced) and structure counts will be inconsistent with the Recommended Plan tables reported in Section 5.2.

5.1 AGGREGATION

In compliance with Planning Bulletin 2019-03, all nonstructural analyses will formulate and evaluate measures and plans using a logical aggregation method. The logical aggregation method utilized for the SCCL study was flood depths relative to first floor elevation. This method was determined to be logical because it excludes previous criticisms of economic analysis, namely prioritizing high property value structures and excluding low-income populations that typically reside in smaller homes with less structure value. The logical aggregation method utilized for the SCCL study is not biased to structure size, value, or any other economic attribute. Instead, it is based on being floodprone, and therefore treats the study area more equitably relative to studies that use a logical aggregation focused on maximizing individual structures net benefits. The aggregation method selected was not perfect, as it resulted in some fringe situations where neighborhoods or streets were split between structures included and excluded within the aggregation.

Once the logical aggregation method was determined (using flood depths relative to first floor), the planning guidance notebook specifies that net benefits must be reasonably maximized, meaning the aggregation method must also be optimized. The aggregation method sorted all structures within the study area by existing condition depth of flooding, which was sourced from the hydraulic ADCIRC model. Three different depth of flooding thresholds were utilized to determine which aggregation method maximized net benefits. These depth thresholds were the 0.1 AEP (10YR), 0.04 AEP (25YR), and 0.02 AEP (50YR) flood frequencies. Every structure with a depth of flooding greater than zero for each depth threshold was included in the aggregation. The aggregation optimization analysis followed all of the same assumptions previously described in the economic appendix and the HEC-FDA model was re-run to reflect the nonstructural mitigation for each of the aggregations. The aggregation optimization analysis results are shown in Table D:5-1.

The results in Table D:5-1 show that the net benefits are optimized in the 0.04 AEP (25YR) aggregation. Since neither bracket (0.1 AEP or 0.02 AEP) of the optimization exceeded the net benefits of the 0.04 AEP aggregation, it was determined that the 0.04 AEP aggregation was optimized and would be utilized going forward. The aggregation optimization was the first task completed post-TSP and therefore the economic damages reduced were reported as expected annual damages instead of equivalent annual damages, which take into account changes in future condition hydraulics. Given the large incremental drop from the 0.04 AEP aggregation to either the 0.1 AEP or 0.02 AEP aggregation, this study assumed that the results would not change by incorporating future condition hydraulics.

Table D:5-1. Summary of the Aggregation Optimization (FY21)

	Aggregation Optimization		
	0.1 AEP (10YR)	0.04 AEP (25YR)	0.02 AEP (50YR)
Residential Count	454	1,943	3,948
Non-Residential Count	196	542	802
Total Structure Count	650	2,485	4,750
Elevation Cost	79,244,000	343,219,000	689,599,000
Floodproofing Cost	43,767,000	116,106,000	170,107,000
Nonstructural Cost	123,011,000	459,325,000	859,706,000
Contingency	44,899,000	167,654,000	313,793,000
Cultural Resource Preservation	560,000	2,091,000	3,914,000
Planning, Engineering and Design	6,151,000	22,966,000	42,985,000
Real Estate	9,616,000	37,592,000	72,792,000
Construction Management	2,460,000	9,187,000	17,194,000
Interest During Construction	570,000	2,130,000	3,986,000
Total Cost	187,267,000	700,945,000	1,314,370,000
Average Annual Cost	6,937,000	25,964,000	48,685,000
Average Annual Damages Reduced	28,426,920	55,888,090	68,308,850
Net Benefits	21,489,920	29,924,090	19,623,850
BCR	4.10	2.15	1.40

The 0.04 AEP aggregation was not further sub-aggregated once optimized. Sub-aggregation is the analysis of determining if any portions, or combinations of portions of the larger aggregation can be further broken down into smaller areas that further maximize net benefits. Based on the analysis performed to sample structure attributes, there were logical sub-aggregations that could have occurred, such as coastal verses inland geographic areas, or sub-aggregating based on mitigation type or construction category. This study did not sub-aggregate, but Section 7.10 of this appendix does provide some analysis related to how benefits and costs change for the recommended plan by mitigation type and construction type.

5.2 NON-RESIDENTIAL NONSTRUCTURAL MITIGATION

Non-residential structures for the SCCL study were categorized by occupancy type as falling into one of two categories: non-warehouse or warehouse. Non-warehouse structures will be mitigated using dry floodproofing techniques and warehouse structures will be mitigated using wet floodproofing techniques. These techniques were previously described in Section 4.0 (Project Costs). The cost estimates utilized for this study only offer one kind of mitigation for dry and wet floodproofing and therefore non-residential damages reduced could not be optimized by having a measure that provides more or less mitigation for dry and wet floodproofing. This report assumes that damages reduced for non-residential structures are optimized since the maximum mitigation for these methods is currently being utilized.

5.3 RESIDENTIAL NONSTRUCTURAL MITIGATION

The residential optimization required determining the height to elevate residential structures that reasonably maximized net benefits. The elevation optimization analysis was performed for single-occupancy residential structures, including mobile homes, but excluding multi-occupant buildings, such as apartment buildings with three or more units that were assumed too large to cost effectively elevate. To run the optimization analysis, future condition depth of flooding values for each of the frequencies tested was utilized in the with-project condition and ran through HEC-FDA.

The elevation optimization analysis found that the elevation required to mitigate future frequency flood depths significantly changed between the frequencies tested. The average height required to elevate residential structures for the 0.02 AEP (50YR) frequency was 6.7 feet for one-story structures, 6.3 feet for two-story structures, and 5.8 feet for mobile homes. This figure dramatically increased when attempting to mitigate up to the 0.01 AEP (100YR) frequency. At this frequency, one-story structures required 10.4 feet of mitigation and two-story structures and mobile homes both required 10.7 feet of mitigation. The final frequency tested was mitigating up to the 0.4 percent (250YR) frequency. For this frequency, the required mitigation elevation again increased (albeit diminishing), with one-story structures requiring 11.6 feet of mitigation, two-story structures requiring 10.8 feet and mobile homes requiring 10.4 feet of elevation to mitigate the 0.04 AEP (250YR) frequency.

During the elevation optimization analysis, it was discovered that a significant portion of the residential structures being optimized were identified as requiring more than 13 feet of elevation. While the cost estimate utilized allowed up to 16 feet of elevation, a detailed literature review was conducted by the engineering branch to determine a maximum allowable elevation that residential structures could be elevated to relative to ground surface elevation. The literature review cited FEMA P-550, FEMA P-762, international building codes, local development ordinances, local development codes, and the CPRA Master Plan to conclude that residential structures could safely be elevated between 10 and 15 feet relative to ground surface. This study used the median value and decided not to recommend elevating residential structures any higher than 13 feet.

The number of structures requiring more than 13 feet in elevation to clear the 2075 flood were as follows: 10 (0.02 AEP), 218 (0.01 AEP), and 420 (0.004 AEP). In the event that a structure required more than 13 feet of mitigation to meet the future flood frequency flood depth, the mitigation elevation was changed to 13 feet. The first phase of the elevation optimization analysis is shown in Table D:5-2. This table shows that the future 0.01 AEP (100YR) threshold used in the TSP was not optimized, as the 0.004 AEP (250YR) elevation threshold reasonably maximizes net benefits relative to the other two frequencies tested.

Costs and damages reduced do not change significantly between the 0.01 AEP and 0.004 AEP elevation thresholds, but the analysis did show that there potentially could be additional net benefits if structures were elevated higher to a mitigate a less frequent future flood, such as the 0.002 AEP (500YR) event. As a result, the SCCL team decided to run a maximum elevation mitigation optimization event to determine if every residential structure was elevated as high as it could without moving into a higher cost bracket within the cost estimate table. As a result, the required mitigation elevation for the maximum optimization event was 12.9 feet for one-story and two-story structures, and 12.8 feet for mobile homes.

The theory of the maximum elevation optimization analysis was that the cost estimate table for elevating residential structures increases at a very small incremental rate ($1/sq. ft.) to elevate a structure from the 8-12 range to the 13 foot range, and therefore any structure currently being elevated to 8 feet could receive an additional 4-5 feet of mitigation for only a $1/sq. ft. more. The phase 2 elevation optimization analysis tested if this rate of cost increase outpaced the diminishing returns that this elevation would correlate to as the marginal elevation gain only becomes advantageous for very infrequent flood events. Table D:5-3 shows the comparison results of the phase 1 elevation analysis with the phase 2 elevation optimization analysis.

Phase 2 of the optimization analysis shows that the marginal benefits (equivalent annual damages reduced) outpaced the additional cost of elevating residential structures to the next higher cost bracket (generally 13 feet). The SCCL study concluded that the elevation heights could not be further optimized than what was highlighted by the maximum elevation threshold.

The decision to optimize using a maximum elevation height has other benefits not identified by net benefits. The first benefit deals with the long-term performance that any nonstructural alternative selected will be effective for at least 50 years. A significant portion of the cost to elevate residential structures is based on mobilization, and therefore to the extent possible, the elevation recommendations will be high enough to limit the likelihood that a structure would have to be re-elevated prior to the 50 year project life being concluded. The recommendation of 13 feet for most residential structure will ensure that, pending major technological improvements, it would be infeasible to further elevate the structure in the future. The second benefit deals with feedback from the public about the ability to afford to live in the study area given high flood insurance premiums. By ensuring that structures are raised to an elevation that exceeds the base flood elevation, the study is assisting locals with the ability to maintain affordable housing and neighborhood cohesion. The recommendation of 13 feet will raise some homes 3-5 feet above the BFE, and therefore insurance costs will see a large decrease at the on-set of the mitigation reflecting the additional freeboard provided.

Table D:5-2. Summary of the Elevation Optimization (FY21, Phase 1)

	Elevation Optimization		
	0.02 AEP (50YR) Elevation	0.01 AEP (100YR) Elevation	0.004 (250YR) Elevation
Elevation Count	1,790	1,790	1,790
Floodproofing Count	450	450	450
Total Structure Count	2,240	2,240	2,240
Elevation Cost	315,285,000	324,479,000	325,232,000
Floodproofing Cost	95,556,000	95,556,000	95,556,000
Nonstructural Cost	410,841,000	420,035,000	420,788,000
Contingency	149,957,000	153,313,000	153,588,000
Cultural Resource Preservation	1,870,000	1,912,000	1,916,000
Planning, Engineering and Design	20,542,000	21,002,000	21,039,000
Real Estate	34,168,000	34,168,000	34,168,000
Construction Management	8,217,000	8,401,000	8,416,000
IDC	1,905,000	1,947,000	1,951,000
Total Cost	627,500,000	640,778,000	641,866,000
Average Annual Cost	23,243,000	23,735,000	23,775,000
Equivalent Annual Damage Reduced	43,550,000	48,719,000	48,900,000
Net Benefits	20,307,000	24,984,000	25,125,000
BCR	1.87	2.05	2.06

Table D:5-3. Summary of the Elevation Optimization (FY21, Phase 2)

	0.004 AEP Elevation Phase 1	**Max Elevation Phase 2**
Elevation Count	1,790	1,790
Floodproofing Count	450	450
Total Structure Count	2,240	2,240
Elevation Cost	325,232,000	332,047,000
Floodproofing Cost	95,556,000	95,556,000
Nonstructural Cost	420,788,000	427,603,000
Contingency	153,588,000	156,075,000
Cultural Resource Preservation	1,916,000	1,947,000
Planning, Engineering and Design	21,039,000	21,380,000
Real Estate	34,168,000	34,168,000
Construction Management	8,416,000	8,552,000
IDC	1,951,000	1,982,000
Total Cost	641,866,000	651,707,000
Average Annual Cost	23,775,000	24,140,000
Equivalent Annual Damage Reduced	48,900,000	50,366,000
Net Benefits	25,125,000	26,226,000
BCR	2.06	2.09

Section 6

Results of the Economic Analysis

6.1 TSP-LEVEL NET BENEFIT ANALYSIS

6.1.1 Calculation of TSP Net Benefits

The *expected* annual benefits attributable to the final array of measures were compared to the annual costs to develop a benefit-to-cost ratio for the measures. The net benefits for the measures were calculated by subtracting the annual costs from the expected annual benefits. The net benefits were used to determine the economic justification of the project measures during the TSP phase of the study and were included in the final report to document how measures were screened.

As previously mentioned in Section 2.3, with-project hydraulic and future with-project hydraulic conditions were not available for the TSP-level milestone of the study. During the TSP phase of the study, net benefit calculations for the with-project condition were computed using the HEC-FDA structuredetail.out summary file that contains the stage frequency-damage relationships for the study. For the structural measures, two tables were made from the stage frequency-damage relationships that showed the damage by frequency for both the with and without project condition to determine the average annual damages reduced. These tables can be found in Supplemental Table 6. Table D:6-1 shows the net benefits for the structural measures and Table D:6-2 shows the net benefits for the nonstructural measures.

Table D:6-1. Summary of TSP-Level Structural Economic Benefits (FY21,Damages Reduced, $)

Damage Category	**Berwick Levee Raises**	**Ring Levees 1+2**	**Ring Levee 2**	**Morgan City Levee Raises**
Structural	1,022,000	5,426,000	3,585,000	946,000
Contents	2,111,000	11,743,000	7,758,000	1,951,000
Vehicle	49,000	267,000	176,000	45,000
Debris Removal	65,000	356,000	235,000	60,000
Total Average Annual Benefits	3,247,000	17,792,000	11,754,000	3,002,000
Total Average Annual Cost	5,046,000	55,366,000	28,823,000	3,113,000
Net Benefits	(1,799,000)	(37,574,000)	(17,069,000)	(111,000)
BCR	0.64	0.32	0.41	0.96

Table D:6-2. Summary of TSP-Level Nonstructural Economic Benefits, (FY21, Damages Reduced, $)

Damage Category	**0.04 AEP Elev/Flood proof**	**0.02 AEP Elev/Flood proof**	**0.01 AEP Elev/Flood proof**	**0.04 AEP Acquisitions**
Structural	24,694,000	27,684,000	31,029,000	32,521,000
Contents	47,891,000	53,691,000	60,177,000	66,074,000
Vehicle	-	-	-	1,549,000
Debris Removal	2,245,000	2,517,000	2,821,000	3,097,000
Total Average Annual Benefits	74,830,000	83,892,000	94,027,000	103,241,000
Total Average Annual Cost	52,639,000	70,982,000	117,079,000	111,488,000
Net Benefits	22,191,000	12,910,000	(23,052,000)	(8,247,000)
BCR	1.42	1.18	0.80	0.93

6.2 RECOMMENDED PLAN NET BENEFIT ANALYSIS

6.2.1 Calculation of Final Net Benefits

The *equivalent* annual benefits attributable to the final array of measures were compared to the annual costs to develop a benefit-to-cost ratio for the Recommended Plan. The net benefits were calculated by subtracting the annual costs from the expected annual benefits. The net benefits were used to determine the economic justification of the project measures. With-project (2025) and future with-project hydraulic conditions (2075) were used to compute equivalent annual benefits over a 50 year project life using an FY22 interest rate of 2.25 percent. Table D:6-3 shows the equivalent annual net benefits for the Recommended Plan and Table D:6-5 shows the nonstructural mitigation activity required to realize the net benefits. A participation rate sensitivity analysis was performed to describe the uncertainty of a voluntary mitigation program's effects on the net benefits and is documented in the Risk Analysis section of this report.

Table D:6-4 shows the damages reduced by frequency for the Recommended Plan, for both the existing (2025) and future (2075) condition. Damages reduced begin to diminish as the frequency of flood event decreases for commercial and public structures due to the dry floodproofing method applied. Dry floodproofing is only effective up to 3 feet, so higher depths from lower frequency flood events lead to the effectiveness of floodproofing to be exceeded during approximately the 0.01 AEP flood event. The Recommended Plan did not reduce any damages to vehicles. The recommended plan would reduce flood damage for a total of 2,240 structures, of which 1,790 are residential and 450 are non-residential. For more information about the statistical distribution of net benefits of the Recommended Plan, see Section 7.1.

Table D:6-3. Summary of Recommended Plan Benefits (FY 22 Damages Reduced, $1000's)

Damage Category	**Recommended Plan 2.25%**
Structural	17,871
Contents	26,386
Vehicle	0
Debris Removal	854
Total Average Annual Benefits	45,130
Total Average Annual Cost	31,048
Net Benefits	14,082
BCR	1.45

Table D:6-4. Damages Reduced by Frequency for the Recommended Plan (FY22, $1,000)

Annual Exceedance Probability (AEP)	**0.04 AEP Elevations / Floodproofing (2025) Damage Reduced**					
	AUTO	COM	IND	PUBL	RES	Total Damage Reduced
0.5 (2 yr)	-	30	14	3	60	108
0.2 (5 yr)	-	287	288	19	378	973
0.1 (10 yr)	-	14,952	13,611	1,115	15,028	44,706
0.04 (25 yr)	-	123,000	145,718	7,352	133,207	409,276
0.02 (50 yr)	-	216,691	326,148	26,938	441,065	1,010,843
0.01 (100 yr)	-	124,060	470,967	11,923	554,069	1,161,019
0.004 (250 yr)	-	624	620,948	2,077	569,841	1,193,490
0.002 (500 yr)	-	-	706,796	-	602,322	1,309,118
Annual Exceedance Probability (AEP)	**0.04 AEP Elevations / Floodproofing (2075) Damage Reduced**					
	AUTO	COM	IND	PUBL	RES	Total Damage Reduced
0.5 (2 yr)	-	122	36	7	210	376
0.2 (5 yr)	-	295	152	18	562	1,027
0.1 (10 yr)	-	60,642	57,935	4,085	67,650	190,313
0.04 (25 yr)	-	209,930	286,686	22,933	354,255	873,804
0.02 (50 yr)	-	163,324	436,123	17,804	540,479	1,157,730
0.01 (100 yr)	-	43,251	532,335	1,885	556,107	1,133,578
0.004 (250 yr)	-	-	659,500	-	575,315	1,234,815
0.002 (500 yr)	-	-	773,111	-	629,205	1,402,316

Table D:6-5. Summary of Recommended Plan Nonstructural Mitigation (Structure Count)

Residential Elevation Count by Range					
Range (ft.)	1STY-PIER	1STY-SLAB	2STY-PIER	2STY-SLAB	MOBHOM
1.5 -2.5	0	0	0	0	0
2.6 -3.5	0	0	0	0	2
3.6 - 4.5	0	0	0	0	0
4.6 - 5.5	0	0	0	0	0
5.6 -6.5	0	0	0	0	0
6.6 - 7.5	0	7	0	1	0
7.6 - 8.5	0	0	0	0	0
8.6 - 9.5	0	0	0	0	0
9.6 - 10.5	0	0	0	0	0
10.6 -11.5	0	0	0	0	0
11.6 -12.5	0	0	0	0	0
12.6 - 13.5	422	965	203	97	93
13.6 - 17.0	0	0	0	0	0
				Residential Elevation Count	1,790
				Wet Floodproofing Count	185
				Dry Floodproofing Count	265
				Total 0.04 AEP Mitigation Count	2,240

6.3 CONSTRUCTION CATEGORY BENEFIT ANALYSIS

The benefit-cost analysis previously analyzed in Section 6.2 was performed for the entire study in aggregate. When analyzing the Recommended Plan, the nonstructural methods can further be sub-analyzed by construction category: elevated residential structures, dry floodproofed commercial/public structures, and wet floodproofed industrial warehouse structures. Table D:6-6 below shows the average annual costs and equivalent annual damages prevented for each construction category and mitigation type. The table shows that every mitigation type and construction is incrementally justified, and no portion of the recommended plan is being carried by another.

Table D:6-6. Construction Category Mitigation Benefit Analysis (FY22, Recommended Plan)

Construction Category	**Mitigation Type**	**Average Annual Costs**	**Equivalent Annual Benefits**	**BCR**
Residential	Elevation	22,375,000	24,746,000	1.11
Commercial & Public	Dry Floodproofing	2,116,000	10,182,000	4.81
Industrial	Wet Floodproofing	6,557,000	10,202,000	1.56
Total		31,048,000	45,130,000	1.45

Section 7
Risk Analysis

The risk analysis section of the report discusses the risk and uncertainty associated with the HEC-FDA model and the economic benefits. The HEC-FDA model was utilized for the existing condition and with project alternatives and therefore all risk analysis was completed using the model.

7.1 BENEFIT EXCEEDANCE PROBABILITY RELATIONSHIP

All of the TSP-level structural measures were screened out at the TSP due to various factors, including negative net benefits. The negative net benefits of the structural measures were not likely to increase any further than what was presented in this economic appendix due to HSRDDS design criteria. The costs for the structural measures are based on standard design criteria, and not HSRDDS design criteria. Incorporation of HSRDDS design criteria would increase the cost estimates by at least 30 percent, further decreasing net benefits for the structural alternatives. The TSP-level nonstructural measures have been reanalyzed as shown in Section 6.0 (Optimization) of this appendix, and it is assumed that each nonstructural measure cannot independently be improved relative to any other aggregation boundary.

The Recommended Plan (0.04 AEP nonstructural aggregation) was computed with uncertainty within HEC-FDA, and therefore the model can compute upper and lower bounds to show the uncertainty associated with damages reduced. Table D:7-1 shows the mean estimate (Damage Reduced), as well as the likelihood of benefits exceeding three different thresholds 75 percent, 50 percent, and 25 percent. The 25 percent threshold could be interpreted as “there is a 25 percent chance that benefits would exceed $49.1 million equivalent annual damages” or “there is a 75 percent chance that benefits would exceed $20.4 million equivalent annual damages.”

Table D:7-1. Probability HEC-FDA Damages Reduced Exceed Indicated Values (FY22, $1,000's)

Year 2025 Expected Annual Damages						
Plan Name	Total Without Project	Total With Project	Damage Reduced	0.75	0.5	0.25
Without	171,316	171,316	-	-	-	-
0.04 AEP Elev/Flood proof	171,316	135,441	35,875	20,467	34,201	49,125
Year 2075 Expected Annual Damages						
Plan Name	Total Without Project	Total With Project	Damage Reduced	0.75	0.5	0.25
Without	395,844	395,844	-	-	-	-
0.04 AEP Elev/Flood proof	395,844	336,786	59,058	37,800	56,660	78,109
Equivalent Annual Damages (2.25%, 50 years)						
Plan Name	Total Without Project	Total With Project	Damage Reduced	0.75	0.5	0.25
Without	260,944	260,944	-	-	-	-
0.04 AEP Elev/Flood proof	260,944	215,814	45,130	26,741	43,167	61,268

7.2 WINDSHIELD SURVEY INSTRUMENTATION RISK ANALYSIS

The "Elevation Data and Sampling Attributes" Section of this report previously described the methodology of measuring foundation heights for structures as being a Google Street View windshield survey. Given the size of the study area, the quality of the Google Street View images varied, as the date of imagery ranged from 2008 to 2019, and the resolution of the data varied from 360p to 1080p (HD). While the majority of the 0.04 AEP aggregation structures were located in areas with high resolution street imagery, the Google Street View windshield survey instrumentation approach carries inherent uncertainty in its estimate of foundation heights.

To determine the impact of the uncertainty of using Google Street View for foundation heights, the existing condition and with project condition were run through HEC-FDA with a boundary condition. To ensure that the study was not justified as a result of foundation heights being estimated too low, the HEC-FDA model was re-run using an additional 0.5 feet of foundation for all structures. Table D:7-2 shows the mean estimate (Damage Reduced), as well as the likelihood of benefits exceeding three different thresholds 75 percent, 50 percent, and 25 percent for the boundary condition of setting all foundation heights higher by 0.5 feet. The table helps show that the without project condition equivalent annual damages decreased by 12 percent, the with project condition (0.04 AEP nonstructural aggregation) EAD decreased by 13 percent, and the EAD reduced decreased by 10 percent. All else held constant, increasing foundation heights by 0.5 feet decreases the BCR from a 2.8 to 2.6.

As typical, not everything can be held constant, and increasing foundation heights by 0.5 feet has the potential to exclude additional structures from the 0.04 AEP nonstructural aggregation. Additional analysis was performed to conclude that increasing foundation heights by 0.5 would remove 307 structures from the 0.04 AEP aggregation because they would no longer experience damages during the 0.04 AEP coastal storm event. An additional analysis was not conducted as a result of this finding. It can be concluded that the

433 structures identified to be on the margin experience the least amount of flooding at the more frequent flood events and therefore would likely contribute less to the overall computed EAD reduced. A removal of the 433 structures would also decrease cost, leading to a remote likelihood that project justification would be impacted. The analysis resulting in Table D:7-2 was ran prior to the final recommended plan and therefore is inconsistent with the final results of this appendix.

Table D:7-2. Probability HEC-FDA Damages Reduced Exceed Indicated Values (Instrumentation Risk Analysis, FY21, $1,000's)

Year 2025 Expected Annual Damages (0.5 Ft Increase in Foundation Heights)						
Plan Name	Total Without Project	Total With Project	Damage Reduced	0.75	0.5	0.25
Without	152,745	152,745	-	-	-	-
0.04 AEP Elev. / Floodproof	152,745	90,335	62,410	30,964	55,826	86,576
Year 2075 Expected Annual Damages (0.5 Ft Increase in Foundation Heights)						
Plan Name	Total Without Project	Total With Project	Damage Reduced	0.75	0.5	0.25
Without	347,641	347,641	-	-	-	-
0.04 AEP Elev. / Floodproof	347,641	244,194	103,447	58,678	94,276	139,263
Equivalent Annual Damages (2.5%, 50 years) (0.5 Ft Increase in Foundation Heights)						
Plan Name	Total Without Project	Total With Project	Damage Reduced	0.75	0.5	0.25
Without	226,870	226,870	-	-	-	-
0.04 AEP Elev. / Floodproof	226,870	148,852	78,018	41,401	70,445	106,668

7.3 RESIDUAL RISK & RISK REDUCTION

Post-TSP, the study team further examined the plan that reasonably maximized net benefits at that time, which was the 0.04 AEP nonstructural measure that elevated residential structures and dry floodproofed non-residential structures. At this time in the study, the TSP reduced existing condition damages by less than 20 percent, meaning more than 80 percent of the existing condition damages would remain, even after spending over a billion dollars of investment. Despite having the highest net benefits, this level of residual damages was unacceptable. After analyzing where damages remained during the more frequent AEP events (0.02 AEP events and more frequent), it was clear that dry floodproofing was only a marginally effective mitigation strategy for non-residential structures. This was due to the addition of wave action to existing stillwater flood elevations that were added to the hydraulic model post-TSP. This change increased flood depths to three feet during frequent flood events in high commercial/industrial areas, impacting the effectiveness and benefit of dry floodproofing.

During a flood event, unequal rates of rise and fall of water height on the inside and outside of a structure cause hydrostatic and hydrodynamic forces on the foundation wall as shown in Figure 4-1. For the average steel frame / steel corrugated siding warehouse structure within the study area, dry floodproofing presents numerous technical challenges and is not recommended without accounting for the structural vulnerabilities. The steel framing used in these industrial warehouse structures is not designed to withstand hydrostatic loading. In the event that an unreinforced steel frame warehouse becomes loaded, a partial structural collapse could occur in addition to water seeping through the steel frame into the interior of the building. The industrial warehouses are designed using continuous or floating slab concrete floors, meaning dry floodproofing could lead to uplift in the building or leakage through floor joints. The steel frame warehouse structures were not constructed to be water tight buildings or withstand hydraulic pressures, and would require, in some cases, significant external alterations. Therefore, dry floodproofing industrial structure types were determined to not be feasible for broad implementation due to the fact that site-by-site it would be either not technically feasible at some sites or it would be cost prohibitive at others due to the need for substantial external improvements.

The SCCL study area was also particularly unique given the Port of Iberia and other highly industrial areas that were present. This existing condition led to the idea of exploring the possibility of wet floodproofing warehouse structures and determining its effectiveness relative to dry floodproofing. Appendix L details how wet floodproofing effectiveness was determined, but the end result was that wet floodproofing warehouse structures could mitigate up to 12 feet of flooding to the structure envelope. The risk reduction from this provided warehouse structures with less than a 0.04 AEP level of risk reduction using dry floodproofing to near a 0.02 AEP level of risk reduction with wet floodproofing. This statistic varies by location, but provides an approximate risk reduction measure.

When examined as a whole, optimizing the nonstructural aggregation, elevation heights, and wet floodproofing for warehouse structures reduced equivalent annual residual risk for the entire study area by 17 percent. This figure is for the entire study area, which encompasses thousands of additional structures that are not included within the 2,240 structures in the 0.04 AEP nonstructural aggregation. When calculating residual risk for just the nonstructural aggregation, the Recommended Plan reduces equivalent annual damages by 28 percent, meaning 72 percent of the existing condition damages will remain within the 0.04 AEP floodplain.

After optimizing the nonstructural aggregation and its components, it became clear that of the residual damages, warehouse contents represented a relatively large portion of the damages remaining with only floodproofing the structural envelope component of industrial structures, as shown in Table D:7-3 & D:7-4. The significant conclusion of Table D:7-4 is the highest industrial content damage associated with the 0.1 (10-year) AEP and 0.04 (25-year) AEP hydraulic events, which could lead to relatively large reductions in equivalent annual damages reduced.

Table D:7-3. Content Damage by Frequency and Construction Category ($1,000's) Recommended Plan Condition (2025)

	Annual Exceedance Probability (AEP)							
	0.5 (2 yr)	0.2 (5 yr)	0.1 (10 yr)	0.04 (25 yr)	0.02 (50 yr)	0.01 (100 yr)	0.004 (250 yr)	0.002 (500 yr)
Residential	-	-	-	-	246,388	871,925	1,624,175	2,077,482

Public	-	-	541	541	43,891	93,149	159,303	203,050
Commercial	-	-	-	1,931	84,940	357,194	1,035,377	1,768,298
Industrial	**-**	**9,793**	**98,114**	**270,563**	**469,381**	**778,329**	**1,285,900**	**1,716,319**
Total	-	9,793	98,655	273,035	844,600	2,100,598	4,104,755	5,765,149

Table D:7-4. Content Damage Reduced (%) by Frequency and Construction Category Recommended Plan Condition (2025)

Annual Exceedance Probability (AEP)								
	0.5 (2 yr)	0.2 (5 yr)	0.1 (10 yr)	0.04 (25 yr)	0.02 (50 yr)	0.01 (100 yr)	0.004 (250 yr)	0.002 (500 yr)
Residential	100%	100%	100%	100%	59%	30%	19%	16%
Public	100%	100%	92%	98%	0%	0%	0%	0%
Commercial	100%	100%	100%	99%	76%	42%	17%	10%
Industrial	**100%**	**100%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Total	100%	100%	61%	67%	42%	23%	13%	9%

When residual risk is examined across flood frequencies, the analysis naturally can shift into the concept of a projects level of risk reduction. According to the previous two tables, there is high residual risk associated with warehouse content damage, and consequently a low level of risk reduction for those contents given that wet floodproofing allows water to enter the structure to reduce hydrostatic loads. To test the effectiveness of industrial warehouse content mitigation, the study applied a sensitivity analysis to a level of 6 feet of content risk reduction to determine how damages could change. Table D:7-5 & D:7-6 illustrate that including 6 feet of content mitigation for industrial warehouses would increase the level of risk reduction from damages occurring at a 0.10 (10-year) AEP event, to not until a 0.02 AEP event, with strong risk reduction until the 0.004 AEP event, where 51% of content damages are still mitigated.

Table D:7-5. Content Damage by Frequency and Construction Category ($1,000's) Recommended Plan With 6 Ft of Industrial Content Mitigation (2025)

Annual Exceedance Probability (AEP)								
	0.5 (2 yr)	0.2 (5 yr)	0.1 (10 yr)	0.04 (25 yr)	0.02 (50 yr)	0.01 (100 yr)	0.004 (250 yr)	0.002 (500 yr)
Residential	-	-	-	-	246,388	871,925	1,624,175	2,077,482
Public	-	-	541	541	43,891	93,149	159,303	203,050
Commercial	-	-	-	1,931	84,940	357,194	1,035,377	1,768,298
Industrial	**-**	**-**	**-**	**-**	**51,218**	**218,096**	**630,454**	**1,038,091**
Total	-	-	541	2,472	426,437	1,540,364	3,449,309	5,086,921

Table D:7-6. Content Damage Reduced (%) by Frequency and Construction Category Recommended Plan With 6 Ft of Industrial Content Mitigation (2025)

	Annual Exceedance Probability (AEP)							
	0.5 (2 yr)	0.2 (5 yr)	0.1 (10 yr)	0.04 (25 yr)	0.02 (50 yr)	0.01 (100 yr)	0.004 (250 yr)	0.002 (500 yr)
Residential	100%	100%	100%	100%	59%	30%	19%	16%
Public	100%	100%	92%	98%	0%	0%	0%	0%
Commercial	100%	100%	100%	99%	76%	42%	17%	10%
Industrial	**100%**	**100%**	**100%**	**100%**	**89%**	**72%**	**51%**	**40%**
Total	100%	100%	100%	100%	71%	43%	27%	20%

Given the effectiveness of 6 feet of content mitigation for industrial warehouses, the final step in analyzing residual risk and risk reduction was to run the full economic analysis to determine its impact on equivalent annual damages, which are shown in Table D:7-7. This table shows that equivalent annual damages reduced increases by 93% by including 6 feet of content mitigation for industrial warehouses. Therefore, leaving the contents unmitigated drastically increases the residual risk associated with the recommended plan.

Currently there is no known nonstructural technique or measure that is policy compliant with USACE guidance and regulations and therefore content risk mitigation alternatives may be implemented by other federal, state, or local entities, or the owners of the warehouses. For reasons why, see Section 7 of the main report for a full discussion on policy compliant nonstructural measures regarding the contents of industrial warehouse facilities. Some examples of floodproofing measures for warehouse contents include hoists or shelving systems to elevate contents above the flood hazard.

Table D:7-7. Content Damage Reduced (%) by Frequency and Construction Category Recommended Plan With 6 Ft of Industrial Content Mitigation (2025)

Recommended Plan *Equivalent Annual Damages (2.25%, 50 years)*						
Plan Name	Total Without Project	Total With Project	Damage Reduced	0.75	0.5	0.25
Without Project	260,944	260,944	-	-	-	-
Recommended Plan	260,944	215,814	45,130	26,741	43,167	61,268

Recommended Plan with 6 Ft of Industrial Warehouse Content Mitigation *Equivalent Annual Damages (2.25%, 50 years)*						
Plan Name	Total Without Project	Total With Project	Damage Reduced	0.75	0.5	0.25
Without Project	260,944	260,944	-	-	-	-
Revised Recommended Plan	260,944	173,758	87,186	48,542	79,889	118,591

7.4 PROJECT PERFORMANCE

ER 1105-2-101, Risk Assessment for Flood Risk Management Studies, provides the requirement to describe project performance by annual exceedance probability (AEP), assurance (conditional non-exceedance probability), and long-term exceedance probability (LTEP). Project performance describing these attributes is computed within HEC-FDA, and is based on a target stage (traditionally the 0.01 AEP). Table D:7-6 and Table D:7-7 show the project performance table consistent with ER 1105-2-101 for the existing and future without project conditions. The with project condition (nonstructural 0.04 AEP) was not shown in this appendix because it did not impact the stages of the study. Without a change in hydraulic stages, Table D:7-6 will not show a benefit in project performance. As a result, project performance for the Recommended Plan (with project condition) can be interpreted from the discussion in Section 7.1 and Section 7.2.

Regardless of no change to stages, Table D:7-6 does help show existing condition project performance for the reaches where equivalent annual damage HEC-FDA computations resulted in more than $5 million in equivalent average annual damages per reach. These included 9 different reaches that are highlighted in the table. Reaches 37 and 73 currently have existing structural risk reduction features (levees, pumps, canals, etc.) and the existing condition results in the table reflect this reduced long-term risk as a result of existing infrastructure. Reaches 52, 60, 80, 85, 100, and 128, on the other hand do not have existing structural risk reduction features and show more flood risk. While the reaches were formed to represent consistent stages across structures within, some reaches contain areas outside of the leveed area, and therefore the existing condition analysis has uncertainty in its results. The reaches were not developed for this specific analysis.

Table D:7-8. SCCL Project Performance (2025 Existing Condition)

Reach	Target Stage AEP		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
	Median	**Expected**	**10**	**30**	**50**	**10%**	**4%**	**2%**	**1%**	**0.40%**	**0.20%**
1	18%	20%	89%	100%	100%	10%	20%	5%	1%	0%	0%
9	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
10	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
11	6%	6%	47%	85%	96%	92%	31%	14%	5%	1%	0%
12	2%	2%	20%	48%	67%	100%	86%	49%	27%	6%	1%
13	18%	22%	91%	100%	100%	0%	0%	1%	1%	0%	0%
14	13%	14%	77%	99%	100%	15%	0%	0%	0%	0%	0%
15	10%	10%	67%	96%	100%	46%	8%	6%	3%	0%	0%
16	8%	8%	56%	92%	98%	71%	19%	8%	3%	0%	0%
17	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
19	7%	7%	51%	88%	97%	82%	25%	8%	2%	0%	0%
20	18%	20%	89%	100%	100%	11%	18%	5%	1%	0%	0%
24	11%	12%	72%	98%	100%	30%	1%	1%	1%	0%	0%
28	3%	2%	22%	52%	71%	51%	81%	42%	22%	7%	3%
30	2%	2%	14%	37%	54%	51%	100%	60%	30%	8%	3%
32	6%	6%	46%	84%	95%	97%	34%	9%	1%	0%	0%
34	**2%**	**1%**	**13%**	**33%**	**49%**	**50%**	**50%**	**66%**	**34%**	**25%**	**21%**
35	2%	2%	21%	50%	68%	50%	85%	46%	24%	10%	5%
36	2%	2%	17%	43%	60%	50%	94%	56%	32%	14%	7%
37	**2%**	**2%**	**20%**	**48%**	**67%**	**50%**	**88%**	**47%**	**24%**	**9%**	**5%**
38	3%	3%	26%	60%	78%	51%	62%	28%	11%	4%	3%
39	8%	7%	50%	88%	97%	87%	21%	10%	4%	1%	0%
40	13%	13%	75%	99%	100%	22%	2%	2%	1%	0%	0%
41	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
46	12%	13%	75%	98%	100%	20%	0%	0%	0%	0%	0%
48	3%	3%	25%	58%	76%	51%	71%	32%	14%	3%	1%
49	7%	6%	47%	85%	96%	95%	30%	15%	5%	1%	0%
50	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
51	6%	6%	45%	84%	95%	97%	33%	16%	6%	1%	0%
52	**18%**	**22%**	**91%**	**100%**	**100%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
53	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
54	3%	3%	27%	61%	79%	50%	62%	28%	12%	2%	1%
55	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
57	1%	1%	12%	33%	48%	51%	51%	78%	42%	9%	2%
58	18%	21%	91%	100%	100%	0%	0%	0%	0%	0%	0%
60	**10%**	**10%**	**66%**	**96%**	**100%**	**48%**	**9%**	**4%**	**1%**	**0%**	**0%**
64	3%	3%	24%	55%	74%	100%	75%	40%	19%	6%	3%
65	1%	1%	13%	34%	50%	51%	51%	72%	38%	11%	3%
66	18%	21%	91%	100%	100%	0%	3%	6%	9%	0%	0%
68	2%	2%	18%	45%	63%	51%	93%	53%	29%	11%	5%
69	3%	3%	26%	59%	77%	100%	69%	34%	16%	3%	1%
70	4%	5%	40%	78%	92%	87%	49%	21%	8%	1%	0%
71	10%	11%	68%	97%	100%	43%	4%	3%	1%	0%	0%
72	6%	6%	45%	83%	95%	97%	35%	16%	8%	0%	0%
73	**3%**	**3%**	**25%**	**57%**	**75%**	**99%**	**74%**	**40%**	**22%**	**1%**	**0%**
74	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
76	1%	1%	11%	29%	44%	50%	100%	83%	50%	19%	8%

77	13%	12%	72%	98%	100%	37%	6%	6%	2%	0%	0%
78	3%	2%	22%	53%	72%	50%	80%	41%	21%	7%	2%
79	1%	1%	13%	34%	50%	51%	51%	69%	36%	14%	8%
80	**3%**	**3%**	**27%**	**61%**	**79%**	**100%**	**66%**	**27%**	**10%**	**2%**	**1%**
81	3%	3%	23%	54%	72%	51%	80%	38%	19%	4%	2%
82	6%	7%	51%	88%	97%	74%	34%	12%	3%	0%	0%
83	1%	1%	13%	34%	50%	51%	51%	70%	36%	14%	6%
84	8%	8%	57%	92%	99%	68%	20%	7%	2%	0%	0%
85	**3%**	**3%**	**25%**	**57%**	**75%**	**100%**	**72%**	**36%**	**18%**	**4%**	**1%**
86	9%	9%	60%	94%	99%	62%	15%	6%	2%	0%	0%
87	12%	12%	71%	98%	100%	35%	5%	3%	1%	0%	0%
88	5%	6%	45%	84%	95%	85%	37%	14%	5%	1%	0%
89	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
90	2%	2%	21%	52%	70%	51%	82%	43%	23%	7%	3%
91	2%	2%	18%	45%	63%	50%	92%	52%	29%	12%	6%
93	10%	10%	66%	96%	100%	49%	9%	3%	1%	0%	0%
94	13%	13%	74%	98%	100%	29%	4%	4%	1%	0%	0%
95	8%	7%	53%	89%	98%	82%	19%	10%	3%	0%	0%
100	**9%**	**9%**	**61%**	**94%**	**99%**	**57%**	**15%**	**7%**	**2%**	**0%**	**0%**
102	4%	4%	32%	69%	86%	100%	55%	26%	11%	3%	1%
103	4%	4%	33%	70%	86%	100%	54%	23%	9%	1%	0%
106	11%	11%	68%	97%	100%	44%	8%	5%	1%	0%	0%
113	3%	3%	26%	60%	78%	100%	67%	29%	12%	2%	0%
114	1%	1%	13%	34%	50%	51%	51%	71%	38%	13%	6%
117	1%	1%	13%	33%	49%	51%	51%	76%	41%	9%	2%
119	2%	2%	22%	52%	70%	51%	83%	41%	21%	6%	2%
120	2%	1%	13%	35%	51%	50%	50%	66%	35%	14%	6%
121	2%	2%	16%	41%	58%	51%	51%	55%	14%	2%	0%
122	1%	1%	12%	33%	49%	50%	50%	77%	41%	9%	2%
123	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
124	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
125	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
126	18%	20%	89%	100%	100%	11%	18%	5%	1%	0%	0%
127	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
128	**2%**	**2%**	**21%**	**50%**	**69%**	**50%**	**85%**	**44%**	**24%**	**7%**	**2%**
129	18%	20%	89%	100%	100%	11%	19%	5%	1%	0%	0%
130	18%	20%	89%	100%	100%	11%	18%	5%	1%	0%	0%
131	3%	2%	21%	51%	70%	50%	81%	45%	25%	8%	4%
132	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
133	3%	3%	30%	65%	83%	99%	61%	30%	13%	5%	1%
134	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
135	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
136	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
137	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
141	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
143	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
144	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
146	2%	2%	20%	50%	68%	100%	85%	46%	25%	6%	2%
149	13%	13%	76%	99%	100%	15%	0%	0%	0%	0%	0%
150	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
152	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
153	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%

154	18%	20%	89%	100%	100%	10%	19%	6%	1%	0%	0%
155	18%	20%	89%	100%	100%	10%	19%	6%	1%	0%	0%
156	18%	22%	91%	100%	100%	0%	0%	0%	0%	0%	0%
157	3%	3%	24%	56%	74%	50%	76%	34%	15%	4%	2%

Table D:7-9. SCCL Project Performance (2075 Future Without Project Condition

Reach	Target Stage AEP		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
	Median	**Expected**	**10**	**30**	**50**	**10%**	**4%**	**2%**	**1%**	**0.40%**	**0.20%**
1	0.0	18%	20%	89%	100%	100%	10%	20%	5%	1%	0%
9	-1	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
10	-1	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
11	1.5	13%	13%	76%	99%	100%	20%	1%	1%	1%	0%
12	2.6	8%	8%	57%	92%	99%	66%	20%	11%	4%	0%
13	0.0	3%	11%	67%	96%	100%	49%	19%	2%	2%	0%
14	5.4	14%	15%	79%	99%	100%	6%	0%	0%	0%	0%
15	1.6	13%	13%	77%	99%	100%	15%	0%	0%	0%	0%
16	3.1	12%	12%	73%	98%	100%	27%	2%	2%	1%	0%
17	-0.1	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
19	3.6	11%	11%	69%	97%	100%	41%	6%	3%	1%	0%
20	0.0	18%	20%	89%	100%	100%	10%	19%	5%	1%	0%
24	8.1	13%	13%	76%	99%	100%	15%	0%	0%	0%	0%
28	2.8	3%	3%	29%	64%	81%	100%	61%	28%	12%	3%
30	1.7	3%	3%	23%	54%	73%	51%	77%	38%	18%	6%
32	4.0	11%	11%	68%	97%	100%	41%	7%	3%	0%	0%
34	**2.2**	**2%**	**1%**	**13%**	**34%**	**49%**	**50%**	**50%**	**65%**	**33%**	**26%**
35	1.0	3%	3%	24%	57%	75%	50%	73%	34%	16%	5%
36	3.9	2%	2%	22%	53%	72%	100%	79%	40%	19%	7%
37	**2.7**	**2%**	**2%**	**19%**	**47%**	**66%**	**50%**	**89%**	**48%**	**26%**	**10%**
38	0.4	18%	17%	84%	100%	100%	3%	0%	0%	0%	0%
39	1.0	8%	7%	54%	90%	98%	77%	19%	11%	4%	0%
40	2.2	15%	15%	79%	99%	100%	9%	0%	0%	0%	0%
41	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
46	6.4	14%	14%	78%	99%	100%	10%	0%	0%	0%	0%
48	0.7	13%	13%	75%	98%	100%	23%	2%	2%	1%	0%
49	0.2	15%	13%	76%	99%	100%	30%	4%	1%	0%	0%
50	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
51	0.2	10%	10%	64%	95%	99%	54%	5%	2%	1%	0%
52	**1.3**	**6%**	**6%**	**44%**	**82%**	**94%**	**97%**	**38%**	**8%**	**1%**	**0%**
53	-0.5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
54	1.1	6%	5%	42%	81%	94%	99%	39%	17%	7%	1%
55	0.0	18%	20%	89%	100%	100%	0%	19%	5%	1%	0%
57	1.9	2%	2%	17%	43%	61%	50%	95%	55%	30%	11%
58	0.0	18%	21%	91%	100%	100%	0%	0%	0%	0%	0%
60	**4.7**	**12%**	**13%**	**74%**	**98%**	**100%**	**23%**	**1%**	**1%**	**0%**	**0%**
64	7.3	3%	4%	30%	66%	84%	96%	62%	29%	12%	4%
65	1.3	3%	2%	22%	53%	71%	51%	80%	42%	22%	8%
66	0.1	4%	5%	41%	79%	93%	50%	57%	18%	7%	2%
68	2.4	3%	3%	24%	56%	74%	51%	77%	34%	13%	4%
69	4.0	4%	4%	35%	72%	88%	100%	50%	21%	8%	1%

70	5.5	10%	10%	65%	96%	99%	49%	9%	7%	2%	0%
71	4.3	13%	13%	76%	99%	100%	15%	0%	0%	0%	0%
72	3.0	8%	8%	57%	92%	98%	66%	22%	11%	4%	0%
73	**4.3**	**11%**	**12%**	**72%**	**98%**	**100%**	**31%**	**1%**	**1%**	**1%**	**0%**
74	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
76	2.1	2%	2%	20%	49%	67%	100%	86%	47%	25%	7%
77	4.2	4%	4%	37%	75%	90%	92%	51%	23%	10%	2%
78	1.3	3%	3%	26%	60%	78%	51%	67%	26%	9%	1%
79	2.0	2%	2%	21%	50%	68%	51%	85%	45%	24%	10%
80	**3.1**	**7%**	**8%**	**56%**	**91%**	**98%**	**68%**	**23%**	**10%**	**1%**	**0%**
81	2.4	5%	5%	40%	78%	92%	100%	44%	15%	4%	1%
82	3.7	11%	12%	71%	98%	100%	33%	1%	1%	0%	0%
83	2.0	2%	2%	21%	51%	70%	51%	83%	43%	22%	7%
84	5.4	11%	12%	71%	98%	100%	34%	3%	2%	1%	0%
85	**4.0**	**4%**	**4%**	**34%**	**72%**	**88%**	**100%**	**52%**	**22%**	**8%**	**1%**
86	3.3	12%	13%	74%	98%	100%	25%	2%	1%	0%	0%
87	2.4	15%	15%	79%	99%	100%	10%	0%	0%	0%	0%
88	6.5	8%	9%	61%	94%	99%	60%	17%	6%	2%	0%
89	-1.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
90	1.2	3%	3%	27%	61%	79%	100%	65%	27%	10%	2%
91	5.4	2%	2%	22%	52%	71%	51%	84%	40%	16%	5%
93	3.1	14%	14%	78%	99%	100%	14%	0%	0%	0%	0%
94	1.5	16%	15%	81%	99%	100%	8%	0%	0%	0%	0%
95	0.3	17%	16%	81%	99%	100%	19%	3%	1%	0%	0%
100	**6.2**	**12%**	**12%**	**72%**	**98%**	**100%**	**29%**	**1%**	**1%**	**1%**	**0%**
102	4.1	8%	8%	57%	92%	99%	67%	21%	11%	4%	1%
103	3.0	7%	7%	50%	87%	97%	87%	25%	8%	2%	0%
106	1.6	15%	14%	79%	99%	100%	13%	1%	1%	0%	0%
113	1.2	5%	5%	40%	79%	92%	99%	43%	17%	6%	1%
114	1.2	3%	2%	22%	53%	72%	51%	79%	41%	21%	7%
117	2.1	2%	2%	15%	38%	55%	51%	99%	63%	35%	13%
119	2.1	5%	5%	39%	77%	91%	100%	44%	18%	6%	1%
120	1.6	3%	3%	24%	56%	74%	51%	75%	36%	17%	5%
121	0.3	3%	3%	23%	54%	72%	51%	73%	29%	9%	4%
122	1.2	2%	2%	21%	52%	70%	50%	82%	44%	24%	6%
123	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
124	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
125	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
126	0.0	18%	20%	89%	100%	100%	11%	19%	5%	1%	0%
127	0.0	18%	20%	89%	100%	100%	10%	18%	5%	1%	0%
128	**2.6**	**3%**	**2%**	**22%**	**53%**	**72%**	**50%**	**81%**	**39%**	**18%**	**5%**
129	0.0	18%	22%	91%	100%	100%	0%	0%	0%	0%	0%
130	0.0	18%	22%	91%	100%	100%	0%	0%	0%	0%	0%
131	0.4	3%	3%	27%	61%	79%	50%	61%	30%	12%	3%
132	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
133	2.6	12%	12%	73%	98%	100%	25%	0%	0%	0%	0%
134	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
135	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
136	1.5	3%	3%	28%	62%	80%	51%	67%	17%	0%	0%
137	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
141	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
143	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%

144	0.0	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
146	3.1	4%	4%	33%	70%	87%	99%	54%	24%	10%	2%
149	3.4	15%	15%	80%	99%	100%	3%	0%	0%	0%	0%
150	0.0	18%	20%	89%	100%	100%	0%	19%	6%	1%	0%
152	-0.5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
153	0.0	18%	20%	89%	100%	100%	10%	18%	5%	1%	0%
154	0.0	18%	22%	91%	100%	100%	0%	0%	0%	0%	0%
155	0.0	18%	22%	91%	100%	100%	0%	0%	0%	0%	0%
156	1.2	3%	3%	23%	55%	73%	51%	78%	37%	21%	1%
157	2.0	5%	5%	39%	78%	92%	100%	44%	16%	4%	1%

7.5 COMPLIANCE WITH SECTION 308 OF WRDA 1990

Section 308 of the Water Resource Development Act (WRDA) 1990 limits structures built or substantially improved after July 1, 1991 in designated floodplains not elevated to the 0.01 AEP flood elevation from being included in the benefit base of the economic analysis.

7.5.1 CRS/NFIP Analysis

To ensure compliance with the act, the Community Rating System (CRS) and National Flood Insurance Program (NFIP) databases were queried for communities and unincorporated parishes within the study area to determine the level of enforcement or exceedance of NFIP program regulations. The NFIP database shows communities that have been suspended or withdrawn from the program due to non-compliance. Table D:7-10 shows the list of communities and unincorporated parishes within the study area, and includes the dates of when the NFIP was adopted and when the first flood insurance rate map (FIRM) went into effect. These are key dates in the analysis because they show which communities would be expected to have enforced NFIP regulations from July 1, 1991 to present. All of the communities and unincorporated parishes are active participants of the NFIP and have been enforcing NFIP regulations prior to July 1, 1991. Prior to subsequent sections, the study team was not aware of any communities that developed portions of the floodplain without following NFIP regulations. Based on this analysis, it is the determination that there is no evidence that there are any structures built or substantially improved after July 1, 1991 within the study that were not properly elevated to the 0.01 AEP flood elevation. This is not to say that there have not been structures still built within the study area since July 1, 1991, which is why this study also examined aerial imagery, as presented in the next section.

Table D:7-10. CRS/NFIP Status

Community Name	Parish	CRS Community	NFIP Issue	Initial Compliance Date	Initial FIRM
Unincorporated Iberia	Iberia	No	No	1978	1978
Unincorporated St. Martin	St. Martin	No	No	1982	1982
Unincorporated St. Mary	St. Mary	No	No	1980	1980
Delcambre	Iberia	No	No	1983	1983
New Iberia	Iberia	No	No	1978	1978
Morgan City	St. Mary	Yes	No	1978	1978
Jeanerette	Iberia	No	No	1976	1976
Franklin	St. Mary	No	No	1978	1978
Berwick	St. Mary	No	No	1980	1980
Baldwin	St. Mary	No	No	1978	1978
Patterson	St. Mary	No	No	1978	1978

7.5.2 Aerial Imagery Analysis

To further determine if any structure within the 0.04 AEP aggregation has been built since July 1991, historical and contemporary aerial imagery was compared using Google Earth for areas with high existing condition damages. Areas analyzed included Morgan City, Franklin, Delcambre, Berwick, Port of Iberia, and coastal hubs of structures. During the aerial imagery analysis, there were three primary results:

1. **Structures built after July 1991, but excluded from the 0.04 AEP aggregation** – these structures were found to be recently constructed, but they were not included within the 0.04 AEP aggregation, which means they are represented within the existing condition damages, but are not counted towards the benefit base by qualifying as damage reduced within the with-project condition. An example of this scenario can be found near Morgan City in Figure D:7-19 and Figure D:7-20.
2. **Structures built after July 1991, and included in the 0.04 AEP aggregation** – these structures were found to be recently constructed and also included within the 0.04 AEP aggregation. These structures were removed from the benefit base. An example of this scenario can be found near Cypremort Point in the coastal area in Figure D:7-21 and Figure D:7-22.
3. **Structures built after July 1991, and have a dependent use** - The Port of Iberia has significantly expanded since July 1991, and it is clear within the imagery that structures have been built since then without proper mitigation. During the process of determining if these structures should be removed from the benefit base of the economic analysis, the local floodplain manager for Iberia Parish was contacted and said that structures within the Port of Iberia are classified as "dependent use structures." Dependent use structures have some exemptions from NFIP regulations and can be built below the base flood elevation.

Section 308 of WRDA 1990 has one exemption to the rule, which states "any new or substantially improved structure (other than a structure necessary for conducting a water-dependent activity) built in…" With this said, Figure D:7-23 and Figure D:7-24 show a few examples of the expansion of the port. After discussing this topic with the MVD division economist, it was determined that structures associated with the Port of Iberia would be classified as conducting water-dependent activities as justified by its dependent use criteria in the NFIP. As a result, no structures within the Port of Iberia inside the 0.04 AEP aggregation were removed from the benefit base.

The Figures D:7-19 through D:7:24 provide examples of the aerial imagery analysis. Red boxes highlight areas of development that have occurred after 1991, and the three examples below show the three different cases that were applied as a result of the aerial imagery analysis.

Figure D:7-19. Morgan City 1990 Aerial Imagery – Structures Outside 0.04 AEP Aggregation

Figure D:7-20. Morgan City 2019 Aerial Imagery – Structures Outside 0.04 AEP Aggregation

Figure D:7-21. Coastal Area (Cypremort Point) 1990 Aerial Imagery – Structures Removed

Figure D:7-22. Coastal Area (Cypremort Point) 1990 Aerial Imagery – Structures Removed

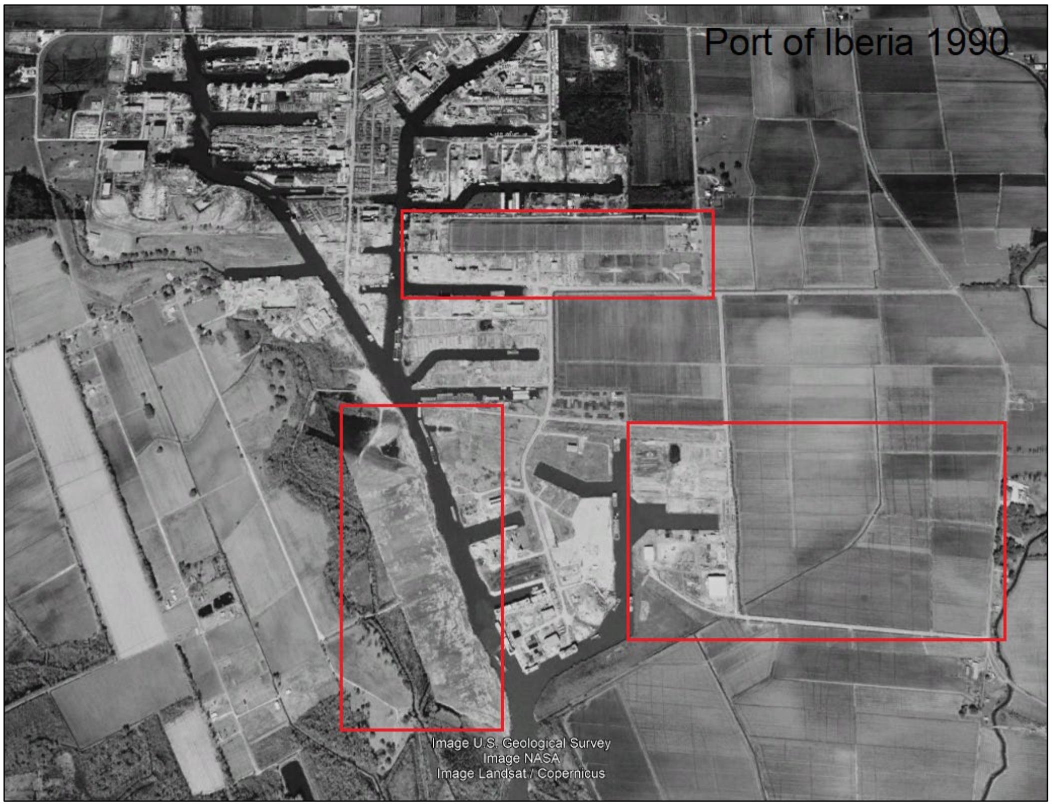

Figure D:7-23. Port of Iberia 1990 Aerial Imagery – Dependent Use Structures

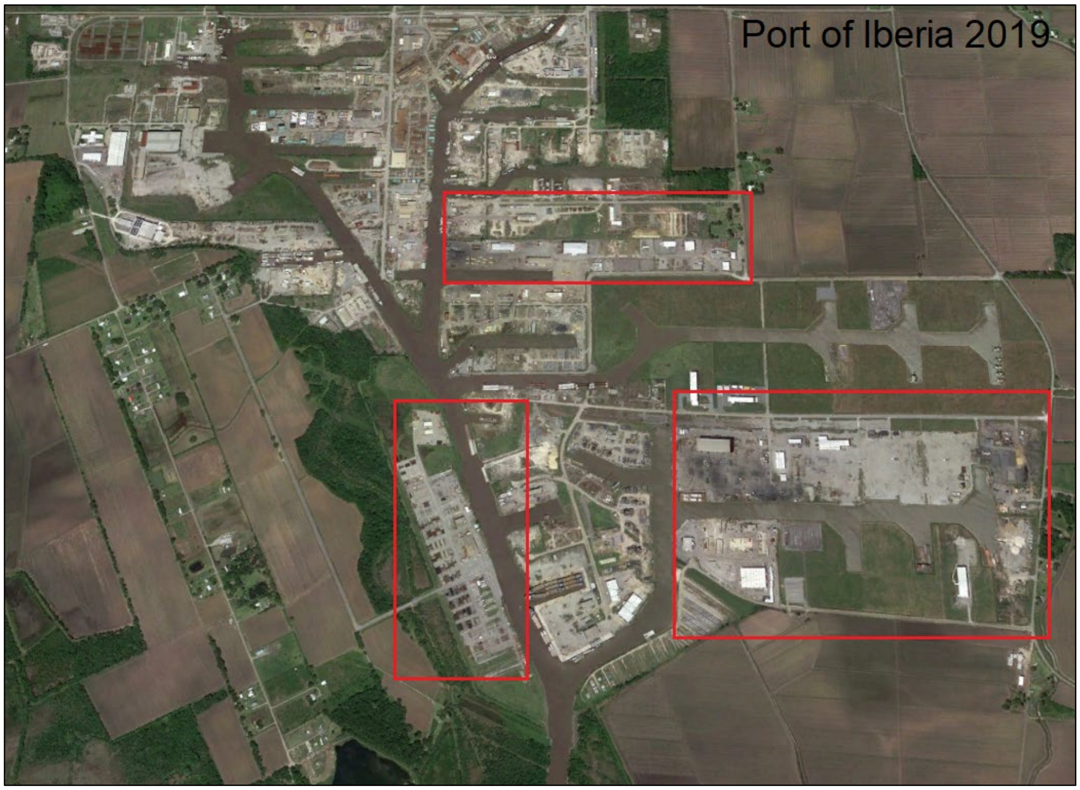

Figure D:7-24. Port of Iberia 2019 Aerial Imagery – Dependent Use Structures

7.6 NONSTRUCTURAL PARTICIPATION RATE ESTIMATION

In July 2020, the SCCL study team conducted a participation rate sensitivity discussion that included the involvement of the USACE National Nonstructural Committee. This group will hereby be referred to as the “discussion team.” The discussion followed the five factors that have been identified as significant contributors to participation within Best Practice Guide 02 (BBG 2020-02).

Each of the factors were discussed for St. Martin, St. Mary, and Iberia Parish, but the conclusions made were shared among all three parishes, and therefore the participation rates resulting from the discussion team will be treated equally for all structures within the study area. These factors and its impact on participation rates are described below. Each factor was qualitatively ranked either slight, moderate, or large, depending on the perceived influence of impact on participation.

- **Temporal Proximity of Severe Flood Damage** – the discussion team used the data provided in Table D:1-7 and Table D:1-8 of this report to help illustrate how often the study area experiences coastal storm events that have the potential to cause structural damages. The sponsor of the study (CPRA) and PDT members that know specifically of the study area all spoke to the frequency of storm events that occur within the study area. The conclusion of the discussion was that the proximity of severe flood damages will cause a **moderate increase** in participation for this study area.

- **Decent, Safe, and Sanitary (DSS) Living Conditions** – the discussion team utilized year built data provided by the Census Bureau, which was displayed at the National, state, and parish level. The year built data showed that 49.8 percent of structures within the study area were built prior to 1980, meaning there is not the potential for widespread violations of state and local health, sanitary, and safety codes. A large portion of the structure inventory was built in the 1970s and 1980s during the regional oil boom. The Iberia Parish assessor's office was contacted to get more information about DSS, but a response was not provided in time for the discussion with the team. The conclusion of the discussion was that the DSS living conditions would cause a **slight increase** in participation for this study area.

- **Free of Hazardous, Toxic, Radioactive Waste (HTRW)** – the discussion team utilized year built data provided by the Census Bureau, which was displayed at the National, state, and parish level. The year built data showed that 49.8 percent of structures within the study area were built prior to 1980. A higher rate of structures constructed prior to 1980 is correlated with higher rates of remediation, but structures built in the study area are actually on average, newer than the national average, likely due to the previously referenced oil boom in the region. The Iberia Parish assessor's office was contacted to get more information about HTRW, but a response was not provided in time for the discussion with the team. The conclusion of the discussion was that a marginally lesser amount of HTRW would cause a **slight increase** in participation for this study area.

- **Ability to be Temporarily Relocated** – The discussion team examined three separate items specific to relocation criteria. The first considered the available places that displaced homeowners or tenants could be relocated to. The study area that contains the 0.04 AEP nonstructural aggregation is predominately rural and the structures are located on larger than average parcels, leading to the ability of a homeowner to be able to rent a mobile trailer to reside in while the mitigation activity takes place on their primary residence. Contrasting with this fact is that the rural density of structures also leads to limited availability of nearby hotels, motels, extended stay residences, and other multi-residence facilities that a homeowner or tenant could temporarily reside in. The discussion team concluded these two factors canceled each other out, leading to no change in participation for this study area.

  The second item contributing to participation is that on average, the rate of homeownership within the study area is greater than both state and national averages, leading to more out of pocket costs. A higher rental ratio would lead to higher participation rates because tenants relocation costs are paid by the government. The discussion team determined a higher ownership rate will decrease participation for this study area.

The third item contributing to participation is household economic circumstances. All three parishes within the study area have higher unemployment, lower median household incomes, and a higher percentage of household poverty relative to both the state and national levels. The discussion team concluded that homeowners with significantly less financial resources will lead to a decrease in participation for this study area.

Overall, the discussion team concluded that the factors discussed contributing to the ability to relocate will cause a **large decrease** in participation for this study area.

- **Physical Disability Requirements** – The discussion team utilized disability data from the Census Bureau, which was displayed at the national, state, and parish level. The disability data showed that the three parishes analyzed all exceed the state and national statistics when it comes to the amount of people under age 65 with a disability and the total age population with a disability. These factors are significant for those that cannot find short-term housing that is ADA accessible and therefore would decrease participation. With this said, the Census Bureau data only reported total disabilities and it was unknown if the data was a physical disability or not. The discussion team concluded that the disability factors would lead to a **slight decrease** in participation for this study area.

- **Other Demographic Statistics** – The discussion team looked beyond the five factors outlined in BBG 2020-02 and analyzed all available Census Bureau data to determine if there were any other significant factors impacting participation rates. The only Census Bureau statistic not utilized by other factors was education. The statistics show that each of the three parishes have a lower obtainment rate of both high school diplomas and bachelor's degrees relative to State and National statistics. The discussion team agreed that having a population with lower education may lead to some residents deciding not to participate due to not fully understanding how climate change, sea level rise, and subsidence lead to increases in future flood risk in the area. The discussion team concluded that having lower education will also impact outreach efforts and therefore lead to a **slight decrease** in participation for this study area.

- **Other Local Factors** – After concluding the discussions regarding the five BBG factors, and other demographic statistics, the discussion team identified a few more items related to local factors that play a role in the mindset of residents when determining if to participate in a voluntary program. The local factors considered included:

  - Coastal Culture – this factor goes beyond the *Temporal Proximity of Severe Flood* Damage factor by surmising that the local populace has traditionally lived in this area for an extensive period of time and have family connections within the region dating back centuries. This investment of time and resources in the region lead to an unwillingness to relocate, and therefore an increase in willingness to mitigate structures to maintain residency within the area.

- Mitigation Magnitude – this factor deals with the elevation height optimization analysis previously presented in Section 6.3, which concluded that the level of risk reduction for a residential structure after implementing the Recommended Plan will on average exceed 0.01 AEP. Knowing a structure is elevated multiple feet above the existing freeboard requirement will lead to homeowners to be more willing to participate in the mitigation program since they will have a level of assurance that they will not have to elevate a second next within the next 30 to 50 years given current SLR forecasts.

- Flood Insurance – given the same logic as Mitigation Magnitude, it would be expected that all else held constant, elevating a residential structure higher than the local floodplain ordinance by multiple feet could lead to reductions in flood insurance premiums. Reductions in flood insurance premiums would expect to increase in voluntary mitigation given long-term affordability as flood insurance rates continue to increase to actuarial rates.

- Home Value/Tax Value – investing in flood mitigation to reduce future risk can have multiple impacts on the structures economic value. All else held constant, reducing the potential for flood damage to a structure has the potential to increase the market value of a structure. Competing with this is that the tax assessor's office may determine the structure to be worth more and consequently require the homeowner to pay additional property taxes. These competing impacts are not expected to have an impact on overall participation rates. Negotiating with local tax assessor offices to forgo increasing the values of properties for those who willingly elevate could be a strategy to increase participation.

The combination of these four local factors were determined by the discussion team to add a **moderate increase** to participation rates.

When examining the participation rate sensitivity analysis as a whole, the discussion team concluded that the SCCL study area would likely have a marginally higher participation rate than other study areas across the country. This decision was made in light of the largest item detracting property owners from participating being the considerable poverty and education deficiencies of those living in the area that are expected to be offered mitigation opportunities. In reality, these property owners and communities are the ones that need these mitigation opportunities the most, as they are the ones that take the longest to recover after a storm, and as a result, become dependent on social programs. This study will need to have a strong public outreach component to help educate these communities on the long-term benefits of flood risk mitigation to be successful and live up the expected participation rate presented below:

Best Case Scenario – 85%
Most Likely Case Scenario – 65%
Worst Case Scenario – 50%

The two tables below provide supporting and concluding summaries of the participation rate sensitivity analysis. Table D:7-11 shows the overall conclusions for the factors impacting participation rates. Table D:7-12 displays the Census Bureau statistics used to help inform decisions regarding each of the factors.

Table D:7-11. Factors Impacting Participation Rates

Attribute	St. Martin	St. Mary	Iberia
Proximity to Flood Damage	Moderate Increase	Moderate Increase	Moderate Increase
DSS	Slight Increase	Slight Increase	Slight Increase
HTRW	Slight Increase	Slight Increase	Slight Increase
Temp Relocation	Large Decrease	Large Decrease	Large Decrease
Disability	Slight Decrease	Slight Decrease	Slight Decrease
Education Obtainment	Slight Decrease	Slight Decrease	Slight Decrease
Local Factors	Moderate Increase	Moderate Increase	Moderate Increase

Table D:7-12. Census Bureau Statistics (2018)

	St. Martin	St. Mary	Iberia	Louisiana	United States
Population, Total	53,431	49,348	69,830	4,648,794	328,239,523
Population, O65, %	15.7%	17.0%	15.7%	15.9%	16.5%
Population, U65, %	84.3%	83.0%	84.3%	84.1%	83.5%
Housing, Owned	78.0%	61.0%	66.5%	65.3%	63.8%
Housing, Rented	22.0%	39.0%	33.5%	34.7%	36.2%
Housing, Same house 1 yr. ago	92.8%	86.6%	85.7%	87.0%	85.5%
Education, High School	80.9%	81.3%	78.7%	84.8%	87.7%
Education, Bachelor's	14.4%	10.6%	12.7%	23.7%	31.5%
Health, Disability, U65, %	10.4%	13.7%	12.8%	11.0%	8.6%
Health, Disability, All, %	N/A	N/A	16.9%	15.4%	12.6%
Civilian Labor Force, %	59.7%	54.5%	61.0%	59.3%	62.9%
Median Household Income	47,974	40,485	45,274	47,942	60,293
Household Poverty, %	19.3%	21.0%	24.1%	18.6%	11.8%

7.7 NONSTRUCTURAL PARTICIPATION RATE SENSITIVITY ANALYSIS

Once the participation rates were agreed upon by the discussion team, the economics team utilized the National Nonstructural Committee's Best Practice Guide 03 (BBG 2020-03), which provides guidance on how to compute various participation rates once the team has a triangular distribution. For this analysis, the final HEC-FDA model was utilized that included all sensitivity and optimization analyses and is consistent with the figures presented in the Recommended Plan. A 100 percent participation rate was included in addition to the three other sensitivities to show how the Recommended Plan compares with different participation rates.

The logical structure selection method utilized for this study was the random approach, which randomly selects structure records based on how many structures were computed to not be participating. This approach does not bracket the potential for highest or lowest benefits, but rather provides a more realistic expectation of the randomness of human behavior despite the fact that a structure with high average annual benefits generally correlates with being highly floodprone, and therefore very willing to participate. The random approach also fits the aggregation technique, which is that the structures within the aggregation are selected based on being damaged during the 0.04 AEP flood event, and not selected based on having individual positive net benefits. In fact, it is assumed that a large portion of the aggregation would not be individually justified without being part of an aggregation as a whole. This phenomenon of individual structures within the aggregation having random magnitudes of positive or negative net benefits is in-line with the theory of the random structure selection approach, in which the structures selected to be excluded could be either positive or negative.

The NOAA Sampling Design Tool, previously used to sample structural attributes, was again utilized to select random structures that would not voluntarily participate in the mitigation program. The sample selected structures at random and was unbiased to construction category, occupancy type, or geographic location. The only sampling tool utilized was a buffer to ensure that structures sampled were at least 2,500 feet apart to confirm structures were selected from the entire study area, and not concentrated within any given neighborhood or hub.

Table D:7-13 shows the results of the HEC-FDA modeling for each of the participation rate sensitivity runs. The table illustrates a decrease in damages reduced for the existing (2025), future (2075), and equivalent annual for each of the decreasing participation rates.

Table D:7-13. HEC-FDA Participation Rate Damages Reduced Results (FY21, $1,000's)

Year 2025 Expected Annual Damages			
Plan Name	**Total Without Project**	**Total With Project**	**Damage Reduced**
Without	171,057	171,057	-
100% Participation	171,057	101,256	69,801
85% Participation	171,057	114,447	56,610
65% Participation	171,057	130,318	40,739
50% Participation	171,057	138,465	32,592
Year 2075 Expected Annual Damages			
Plan Name	**Total Without Project**	**Total With Project**	**Damage Reduced**
Without	396,148	396,148	-
100% Participation	396,148	282,796	113,352
85% Participation	396,148	305,072	91,076
65% Participation	396,148	330,987	65,161
50% Participation	396,148	344,651	51,497
Equivalent Annual Damages (2.5%, 50 years)			
Plan Name	**Total Without Project**	**Total With Project**	**Damage Reduced**
Without	256,666	256,666	-
100% Participation	256,666	170,301	86,365
85% Participation	256,666	186,947	69,719
65% Participation	256,666	206,638	50,028
50% Participation	256,666	216,884	39,782

A unique cost estimate was provided for each of the participation rates utilized in the analysis, and it was assumed the Recommended Plan to represent the 100 percent participation rate. The results of the participation rate sensitivity analysis show that since a random selection method was utilized in combination with a floodplain aggregation, both structures with individual positive and negative net benefits were randomly selected to be removed. This results in no significant change to the overall benefit cost ratio since both benefits and costs decreased proportionally. While the overall BCR does not change, the net benefits decrease significantly as the participation rates decrease, and thereby also increasing residual damages. Table D:7-14 shows the results of the participation rate analysis.

Table D:7-14. Participation Rate Analysis Results (FY21, $)

	100% Participation	85% Participation	65% Participation	50% Participation
Elevation Count	1,790	1,557	1,171	897
Dry Floodproofing Count	265	200	175	139
Wet Floodproofing Count	185	154	116	88
Total Structure Count	2,240	1,911	1,462	1,124
Elevation Cost	346,521,000	301,391,000	226,672,000	173,634,000
Dry Floodproofing Cost	24,659,000	15,221,000	13,319,000	10,579,000
Wet Floodproofing Cost	164,772,000	154,020,000	116,015,000	88,012,000
Total Nonstructural Cost	535,953,000	470,632,539	356,006,000	272,224,000
Contingency (31.7%)	169,423,000	156,721,000	118,550,000	90,651,000
Cultural Resources	12,999,000	3,848,000	2,943,000	2,264,000
Real Estate	37,959,000	32,265,000	24,673,000	18,980,000
PED	129,038,000	23,532,000	17,800,000	13,611,000
Construction Mgmt.	71,688,000	9,413,000	7,120,000	5,444,000
IDC	2,954,000	2,273,000	1,720,000	1,315,000
Total Cost	958,518,000	698,684,539	528,812,241	404,489,106
Average Annual Cost	33,795,000	25,880,000	19,588,000	14,983,000
EAD Reduced	86,365,000	69,719,000	50,027,710	39,782,400
Net Benefits	52,570,000	43,839,000	30,439,710	24,799,400
BCR	2.56	2.69	2.55	2.66

7.8 RELATIVE SEA LEVEL RISE (RSLR) SENSITIVITY ANALYSIS

The ADCIRC model provided water surface profiles for six annual exceedance probability (AEP) events ranging from the 0.02 (50-year) to the 0.001 (1000-year) events. The H&H and GIS branches interpolated the results to provide water surface profiles for eight AEP events: 0.50 (2-year), 0.20 (5-year), 0.10 (10-year), 0.04 (25-year), 0.02 (50-year), 0.01 (100-year), 0.004 (250-year), and 0.002 (500-year). The ADCIRC model results were summarized in a geospatial format through the designation of hydraulic subunits, as previously shown in Figure D:1-2.

The three eustatic sea level rise rates for USACE are 0.3 foot, 0.8 foot, and 2.4 feet over the course of 50 years for low, intermediate, and high. To estimate these scenarios using the existing and future (+1.5 feet) simulations, a linear interpolation/extrapolation was applied to approximate the +0.3 foot, +0.8 foot, and +2.4 feet cases for the entire coast. For the relative sea level rise in the SCCL project area, the local subsidence rate was combined with the eustatic to produce the RSLR. The average subsidence rate of the project area is 1 foot over the 50 year period. This resulted in an estimated RSLR of +1.3, +1.8, and +3.4 for the low, intermediate, and high cases.

The existing and future without-project water surface profiles were based on storm surge and incorporated heavy rainfall events and wave action. The future without-project condition (2075) is based on an intermediate sea level rise (SLR) forecast that assumes an approximate raise in sea level of 1.8 feet across all frequencies.

A formal sensitivity analysis was not completed to model how the equivalent annual damages would change as a result of moving to the low or high SLR conditions. With this said, the nonstructural mitigation within the recommended plan reflects an optimization that elevates the vast majority of residential structures to 13 feet and applies the maximum dry or wet floodproofing available for non-residential structures, and therefore equivalent annual damages would not increase as a result of a high (+3.4) SLR condition. With this said, an increase in stages would increase the equivalent annual damages, and also residual risks since the with project mitigation with nonstructural is fixed. The only remaining option for nonstructural mitigation in a high SLR condition would be to reconsider acquisition and relocations of residential structures. It would still be assumed that acquiring non-residential structures would be cost-prohibitive or be opposed by local residents.

For the low SLR condition, Section 7.2 describes a sensitivity analysis conducted related to uncertainty in the foundation height and found that if foundation heights were 0.5 feet higher than what was sampled, equivalent annual damages would decrease from $86M to $78M, resulting in a BCR decrease from 2.56 to 2.3 all else held constant. Given that the difference between the intermediate (used in recommended plan) and low SLR is 0.5 feet, it can be assumed that all else held constant, a low SLR condition would result in a decrease in net benefits of the same amount of $8M equivalent annual damages.

The conclusions of the RSLR sensitivity discussion is that the justification of the South Central Coastal Louisiana study is not sensitive to changes in relative sea level rise.

Section 8
Life Safety

As explained in Section 1.4, 30 tropical events have crossed the study area since 1851. According to the National Oceanic and Atmospheric Administration (NOAA), there have been zero direct life loss in the area associated with coastal storms. This figure is not comprehensive and does not include indirect life loss, but it does show that the area has not experienced a major hurricane to the effect of Hurricane Katina. As a result, while the population at risk is aware of coastal storms, they may not be prepared for serious life-threatening hurricanes.

8.1 US-90 GEOSPATIAL ANALYSIS

The study area has one primary evacuation route headed inland, which is Interstate US-90. US-90 splits the study area between the coastal floodprone area and the higher elevated inland area, which is less floodprone. This statement is supported by the fact that close to 75 percent of the structures identified within the 25YR nonstructural aggregation are located on the coastal side (south) of US-90. To determine where risk to life safety was the greatest as it relates to an inability to evacuate, a GIS analysis was completed for US-90.

Within ArcGIS, US-90 was broken into 2,000 points spaced 50 meters apart. Each of these points represented a 50 meter segment of the road, and was used to extract other GIS data to each of the points. Data extracted to each road point included ground surface elevation, bathymetry, and flood stages for various frequency events. The points were organized and classified with nearby communities to provide a sense of location of the segments.

The ground surface elevation and bathymetry data both showed similar trends in rising and falling elevations that are affected by infrastructure such as bridges, berms, and levees. These items allow for false positive readings that were corrected where appropriate to best determine where floodprone areas of US-90 are located. Figure D:8-1 through Figure D:8-4 show the profile of US-90 from a ground surface elevation and bathymetry perspective overlaid with the depth of flooding profile of various frequencies. The figures show that during the 0.04 AEP (25YR) event, there could be the possibility of flooded road segments around Amelia, which is east of Morgan City near the extents of the study area. During the 0.04 AEP event, the depths are shallow enough that it would be expected that cars could still evacuate. On more infrequent events such as the 0.02 AEP (50YR) or 0.01 AEP (100YR), the depths are high enough to impede evacuation efforts.

The most floodprone stretch of US-90 can be found near Franklin, where depths of flooding during the 0.04 AEP event exceed the elevation of the road by 3 to 5 feet. As shown in the subsequent figures, the Franklin area continues to be the most floodprone area up to the 0.01 AEP (100YR) flood event, where other road segments of US-90 also become inundated. During a 0.04 (25YR) or 0.02 (50YR) event, low-clearance vehicles driving along US-90 toward Franklin, or originating in Franklin, would likely have to detour further inland to one or two-lane roads, slowing evacuation egress. Estimates of floodwater velocities are uncertain for the SCCL study area, and therefore it is unknown if cars caught by floodwaters on US-90 near Franklin would be swept off the road. Given flood depths exceeding 3-5 feet, velocities of at least 0.66-1 feet per second would be enough to lead to the potential for life loss for low-clearance vehicles evacuating through Franklin.

In the case of Amelia, the structures comprising the area are primarily commercial and industrial, and therefore a large storm event would likely provided enough lead time for operations to send workers home ahead of time, and therefore not pose a significant risk to life safety. Conversely, the constraint at Franklin could be an issue for the communities of Franklin, Centerville, Calumet, Bayou Visa, and portions of Morgan City, especially if the inundated roads were not made aware to evacuees until arriving at a detour.

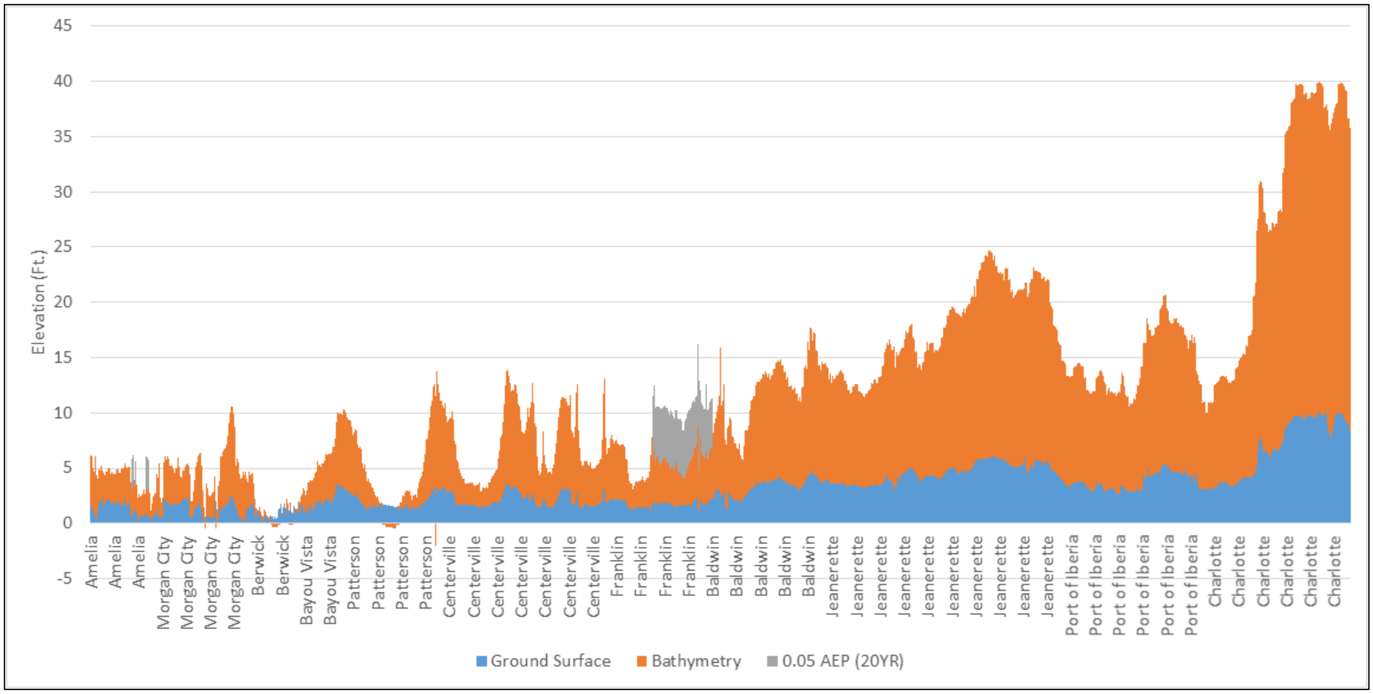

Figure D:8-1. HWY-90 Elevation Profile with 0.05 AEP (20YR) Flood Depths

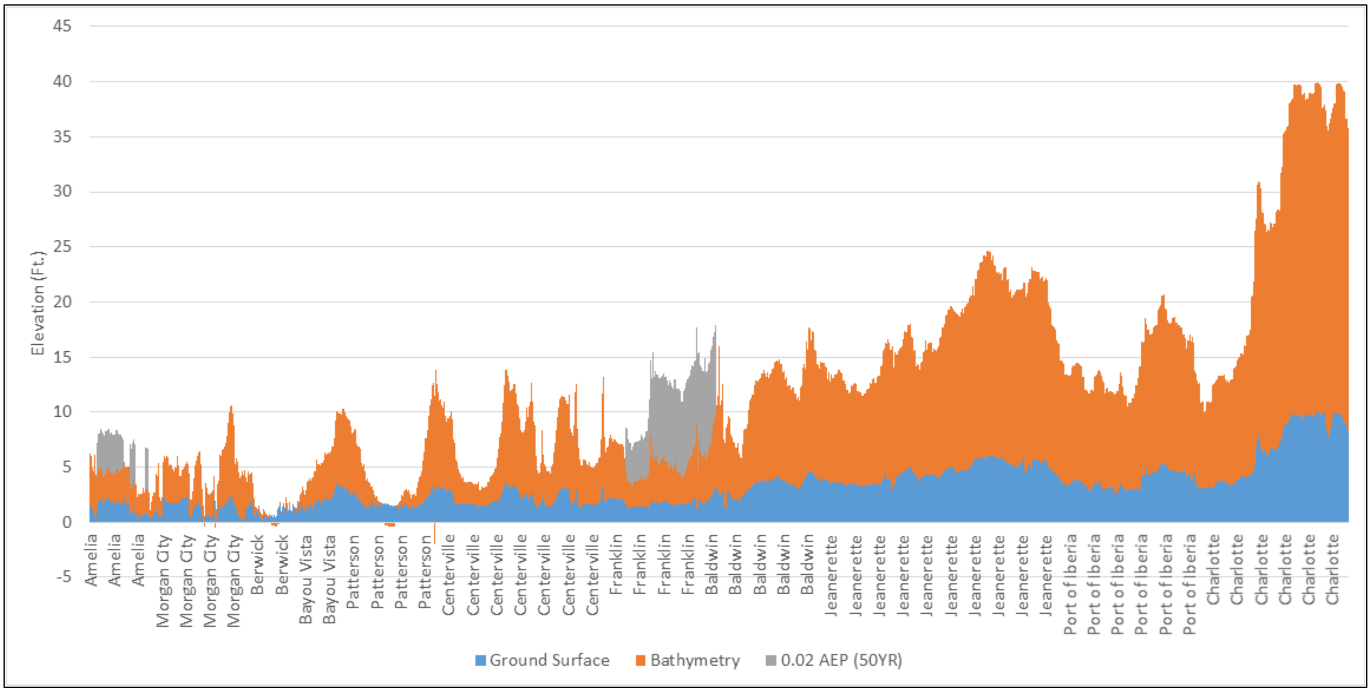

Figure D:8-2. HWY-90 Elevation Profile with 0.02 AEP (50YR) Flood Depths

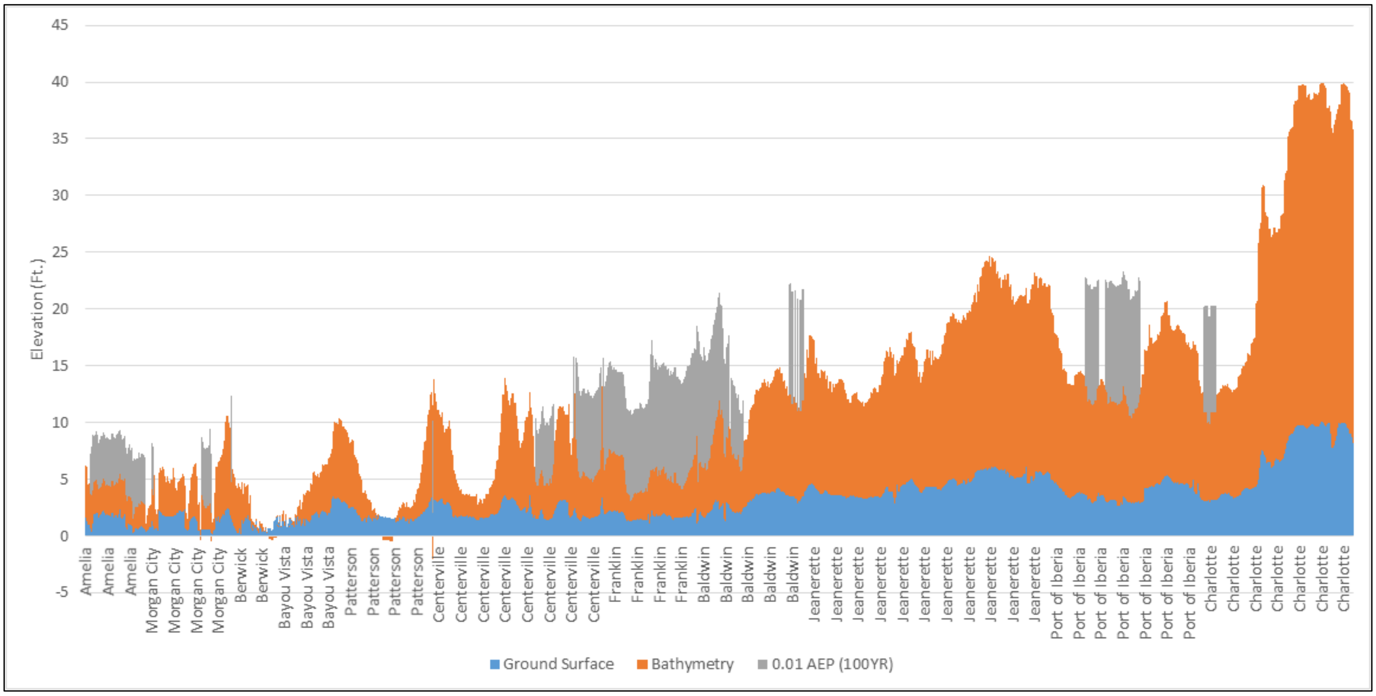

Figure D:8-3. HWY-90 Elevation Profile with 0.01 AEP (100YR) Flood Depths

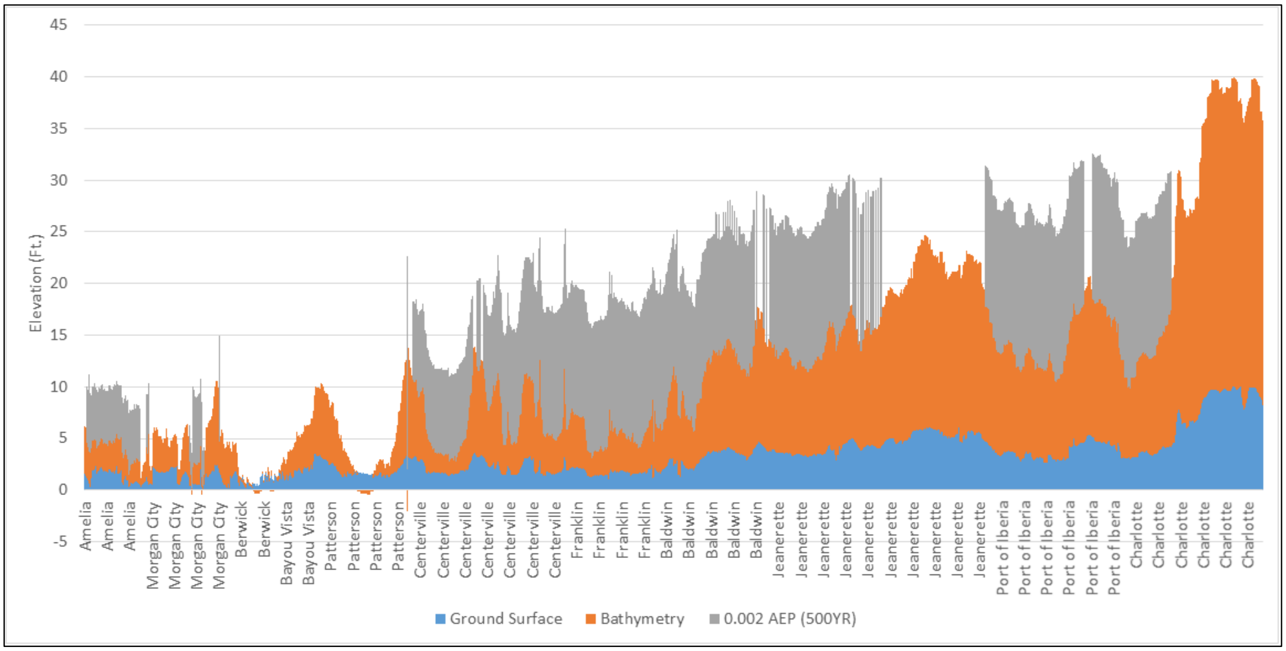

Figure D:8-4. HWY-90 Elevation Profile with 0.002 AEP (500YR) Flood Depths

8.2 IMACTS TO LIFE SAFTEY – RESIDENTIAL

The NED Plan does not reduce flood depths on HWY-90, and does not provide any additional risk reduction for those evacuating. With that said, the average post-mitigation elevation of residential structures within the Recommended Plan is 13 feet above ground surface elevation. For residents choosing to or unable to evacuate during a storm event, the additional elevation will reduce the likelihood of loss of life given the reduction of flood depths on the structure. According to stability criteria relationships within HEC-LifeSim, being caught in a vehicle during a storm event relative to a wood-frame house significantly increases the likelihood of the individual sampling a high fatality rate. While this report is not recommending sheltering in place, the Recommended Plan has the potential to reduce life safety if that is the last resort. This qualitative analysis assumes that structures being elevated will be designed to endure hurricane force winds without failing. As a result, raising structures will help reduce the risk that a structure would be inundated with life-threating flood depths, thereby marginally improving life safety.

8.3 IMPACTS TO LIFE SAFTEY – NON-RESIDENTIAL

For non-residential structures receiving either dry or wet floodproofing, the impacts of the Recommended Plan to life safety will not change from the existing condition. Floodproofing changes the frequency of when water begins to damage the structure, but it does not remove the risk of life safety in the event of a high magnitude coastal storm. Any person in dry or wet floodproofed non-residential structure should follow local evacuation orders and evacuate the floodplain prior to any coastal storm event arriving. Those that remain in a non-residential structure will not have the benefit of being elevated and will be exposed to flood hazards and life safety risk.

8.4 IMPACTS TO LIFE SAFETY – CYPREMONT POINT

The ADCIRC hydraulic model utilized for the SCCL study output depths of flooding, which was previously summarized in the economic appendix. Velocities of flooding were not analyzed by the ADCIRC hydraulic model and therefore the life safety risk to coastal structures is uncertain. Despite unavailability of coastal velocities, FEMA FIRM's with VE zones were available and examined. FEMA defines the VE zone as a coastal high hazard area where areas are subject to high velocity water, including waves of 3 feet or greater. Figure D:8-5 shows the only coastal VE zone of concern related to velocities, which is Cypremont Point. Unfortunately, the VE zone data from FEMA did not include velocity estimates, and quantifiable velocities remain uncertain.

Figure D:8-5. Cypremont Point VE Zone Flood Depths

As previously mentioned in Section 8.2, residential structures will be elevated to 13 feet, but as coastal storm events increase in magnitude, this level of risk reduction leads to some structures within Cypremont Point to experience flood depths, and potentially wave action, above the first floor, leading to the potential for structures to collapse. The foundations that residential structures within Cypremont Point are being elevated on are expected to be hurricane resistant, and not be prone to collapsing from depth x velocity forces prior to flood waters reaching the first floor. Non-residential structures located within Cypremont Point receiving floodproofing are expected to be impacted by high depth x velocity forces. The structure inventory assumes 95 percent of the structures within Cypremont Point are residential, and seasonally occupied. In general, the life safety risk in Cypremont Point exists, but is not expected to be significant given ample warning times, seasonal occupation, elevated structures, and the frequency at which depth x velocity forces much reach to lead to life safety concerns.

Section 9
Regional Economic Development (RED)

When the economic activity lost in a flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the RED account. The input-output macroeconomic model RECONS can be used to address the impacts of the construction spending associated with the project alternatives. The RECONS model utilizes a total construction cost of a project that is attributable to contracts being awarded to complete the construction of the project. This cost excludes USACE labor associated with planning, engineering, and design, as well as economic costs like interest during construction. The costs also include real estate and cultural resources costs since these disbursement of federal funds are expected to be spent within the region of the study area. An example of this would be using Uniform Relocation Act funding to pay a tenant to temporarily relocate to a hotel while their home is being elevated.

The total cost input into the RECONS model for the Recommended Plan was $871,344,000 which again excludes PED, CM, and IDC. Since there was no nonstructural option within RECONS to classify the construction activity, the spending profile was modified to put more weight on the rehabilitation of structures and less weight on water resource infrastructure. Of this the total expenditures identified, 79 percent will be captured within the local study area. The remainder of the expenditures will be captured within the state or national level. 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 Table D:9-1. The regional economic effects are shown for the local, state, and national impact areas. In summary, the nonstructural expenditures of $871,344,000 support a total of 9,975 full-time equivalent jobs, $549,844,110 in labor income, $648,709,975 in the gross regional product, and $1,074,837,864 in economic output in the local impact area. More broadly, these expenditures support 15,648.8 full-time equivalent jobs, $1,013,182,652 in labor income, $1,365,481,104 in the gross regional product, and $2,296,339,206 in economic output in the nation due to the multiplier effect. Table D:9-2 shows specific regional impacts to specific industries that are related to nonstructural activities.

Table D:9-1. RECONS Impacts to Local, State, and National Economy's ($1,000)

Area	Local Capture ($000)	Output ($000)	Jobs	Labor Income ($000)	Value Added ($000)
Local					
Direct Impact		$692,664	7,432	$437,166	$434,148
Secondary Impact		$382,173	2,543	$112,678	$214,561
Total Impact	$692,664	$1,074,837	9,975	$549,844	$648,70
State					
Direct Impact		$770,049	8,120	$508,644	$509,373
Secondary Impact		$671,710	4,001	$207,067	$374,620
Total Impact	$770,049	$1,441,759	12,122	$715,711	$883,993
National					
Direct Impact		$843,838	8,652	$549,043	$571,595
Secondary Impact		$1,452,500	6,996	$464,139	$793,885
Total Impact	$843,838	$2,296,339	15,648	$1,013,182	$1,365,481

Table D:9-2. RECONS Impacts to Specific Industries ($1,000)

		Output ($000)	Jobs	Labor Income ($000)	Value Added ($000)
	Direct Impacts				
29	Sand and gravel mining	$10	0.2	$0	$0
54	Construction of new highways and streets	$8,713	47	$2,338	$3,596
55	Construction of new commercial structures, including farm structures	$87,134	744	$35,194	$40,387
56	Construction of other new nonresidential structures	$87,134	1387	$66,153	$16,372
57	Construction of new single-family residential structures	$104,561	829	$39,295	$49,713
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$0	0.0	$0	$0
269	All other industrial machinery manufacturing	$7	0.0	$1	$2,445
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$481	1	$133	$272
400	Wholesale - Other nondurable goods merchant wholesalers	$2,246	7	$457	$1,120

401	Wholesale - Wholesale electronic markets and agents and brokers	$460	7	$736	$392
414	Air transportation	$69	0.2	$16	$43
415	Rail transportation	$350	0.7	$10	$165
416	Water transportation	$78	0.1	$9	$15
417	Truck transportation	$6,896	42	$1,996	$2,707
444	Insurance carriers, except direct life	$699	0.9	$59	$328
453	Commercial and industrial machinery and equipment rental and leasing	$34,694	74	$7,388	$24,972
457	Architectural, engineering, and related services	$65,275	430	$22,501	$25,957
463	Environmental and other technical consulting services	$8,575	135	$3,714	$3,580
470	Office administrative services	$41,294	473	$32,714	$20,542
544	Employment and payroll of federal govt, non-military	$95,848	613	$76,225	$95,848
5001	Private Labor	$148,129	2,635	$148,129	$148,129
	Direct Impact	**$692,664**	**7,432**	**$437,166**	**$434,148**
	Secondary Impact	**$382,173**	**2,543**	**$112,678**	**$214,561**
	Total Impact	**$1,074,837**	**9,975**	**$549,844**	**$648,709**

Section 10
Supplemental Tables

Supplemental Table 1
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal
Source: Morganza to the Gulf Long Duration Salt Water Curves

Residential 1-Story on Pier (1STY-PIER)				**Residential 1-Story on Slab (1STY-SLAB)**				**Residential 2-Story on Pier (2STY-PIER)**				**Residential 2-Story on Slab (2STY-SLAB)**			
Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.1	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	-1.1	0.0	0.0	0.0	-1.0	0.0	0.0	0.0
-1.0	1.1	1.0	1.7	-0.5	1.1	1.0	1.7	-1.0	1.4	1.2	2.1	-0.5	1.2	1.1	1.8
-0.5	12.2	11.9	18.3	0.0	1.1	1.0	1.7	-0.5	2.2	2.0	3.3	0.0	1.2	1.1	1.8
0.0	15.2	13.7	22.8	0.5	23.3	21.0	35.0	0.0	6.4	5.8	9.6	0.5	16.1	14.5	24.2
0.5	49.4	44.4	74.0	1.0	23.3	21.0	35.0	0.5	19.0	17.1	28.5	1.0	16.1	14.5	24.2
1.0	50.1	45.1	75.1	1.5	37.2	35.5	55.9	1.0	19.0	17.1	28.5	1.5	26.1	23.5	39.1
1.5	66.7	60.0	100.0	2.0	41.9	37.7	62.9	1.5	31.9	28.7	47.9	2.0	27.1	24.4	40.7
2.0	70.2	63.2	100.0	3.0	45.3	40.8	68.0	2.0	32.6	29.3	48.9	3.0	28.5	25.7	42.8
3.0	71.2	64.1	100.0	4.0	92.0	82.8	100.0	3.0	33.3	30.0	49.9	4.0	80.0	72.0	100.0
4.0	97.5	87.7	100.0	5.0	92.0	82.8	100.0	4.0	93.4	84.0	100.0	5.0	80.0	72.0	100.0
5.0	97.5	87.7	100.0	6.0	92.0	82.8	100.0	5.0	93.4	84.0	100.0	6.0	80.0	72.0	100.0
6.0	97.5	87.7	100.0	7.0	92.0	82.8	100.0	6.0	93.4	84.0	100.0	7.0	80.0	72.0	100.0
7.0	97.5	87.7	100.0	8.0	92.0	82.8	100.0	7.0	93.4	84.0	100.0	8.0	80.0	72.0	100.0
8.0	97.5	87.7	100.0	9.0	92.0	82.8	100.0	8.0	93.4	84.0	100.0	9.0	80.0	72.0	100.0
9.0	97.5	87.7	100.0	10.0	92.0	82.8	100.0	9.0	93.4	84.0	100.0	10.0	80.3	72.0	100.0
10.0	97.5	87.7	100.0	11.0	92.0	82.8	100.0	10.0	93.6	84.0	100.0	11.0	80.3	72.0	100.0
11.0	97.5	87.7	100.0	12.0	92.0	82.8	100.0	11.0	93.6	84.0	100.0	12.0	80.3	72.0	100.0
12.0	97.5	87.7	100.0	13.0	92.0	82.8	100.0	12.0	93.6	84.0	100.0	13.0	83.2	72.0	100.0
13.0	97.5	87.7	100.0	14.0	92.0	82.8	100.0	13.0	93.6	84.0	100.0	14.0	83.2	72.0	100.0
14	97.5	87.7	100	15	92	82.8	100	14	93.6	84	100	15	83.2	72	100
15	97.5	87.7	100												

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent	Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent	Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent	Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	95.0	90.0	98.0	0.5	95.0	90.0	98.0	0.5	69.6	66.2	73.1	0.5	69.6	66.2	73.1
1.0	95.0	90.0	98.0	1.0	95.0	90.0	98.0	1.0	69.6	66.2	73.1	1.0	69.6	66.2	73.1
1.5	95.0	90.0	98.0	1.5	95.0	90.0	98.0	1.5	74.7	70.9	78.4	1.5	74.7	70.9	78.4
2.0	95.0	95.0	98.0	2.0	95.0	95.0	98.0	2.0	74.7	70.9	78.4	2.0	74.7	70.9	78.4
3.0	95.0	95.0	98.0	3.0	95.0	95.0	98.0	3.0	78.5	74.6	82.5	3.0	78.5	74.6	82.5
4.0	98.0	98.0	100.0	4.0	98.0	98.0	100.0	4.0	79.9	75.9	83.9	4.0	79.9	75.9	83.9
5.0	98.0	98.0	100.0	5.0	98.0	98.0	100.0	5.0	83.2	79.0	87.3	5.0	83.2	79.0	87.3
6.0	98.0	98.0	100.0	6.0	98.0	98.0	100.0	6.0	83.2	79.0	87.3	6.0	83.2	79.0	87.3
7.0	98.0	98.0	100.0	7.0	98.0	98.0	100.0	7.0	83.2	79.0	87.3	7.0	83.2	79.0	87.3
8.0	98.0	98.0	100.0	8.0	98.0	98.0	100.0	8.0	83.2	79.0	87.3	8.0	83.2	79.0	87.3
9.0	98.0	98.0	100.0	9.0	98.0	98.0	100.0	9.0	83.2	79.0	87.3	9.0	83.2	79.0	87.3
10.0	98.0	98.0	100.0	10.0	98.0	98.0	100.0	10.0	83.2	79.0	87.3	10.0	83.2	79.0	87.3
11.0	98.0	98.0	100.0	11.0	98.0	98.0	100.0	11.0	97.5	92.6	100.0	11.0	97.5	92.6	100.0
12.0	98.0	98.0	100.0	12.0	98.0	98.0	100.0	12.0	97.8	92.9	100.0	12.0	97.8	92.9	100.0
13.0	98.0	98.0	100.0	13.0	98.0	98.0	100.0	13.0	98.5	93.6	100.0	13.0	98.5	93.6	100.0
14.0	98.0	98.0	100.0	14.0	98.0	98.0	100.0	14.0	98.5	93.6	100.0	14.0	98.5	93.6	100.0
15.0	98.0	98.0	100.0	15.0	98.0	98.0	100.0	15.0	98.5	93.6	100.0	15.0	98.5	93.6	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	82.0	11.0	2.0	82.0	11.0	2.0	82.0	11.0	2.0	82.0	11.0
5.0	90.0	12.0	5.0	90.0	12.0	5.0	90.0	12.0	5.0	90.0	12.0
12.0	100.0	12.0	12.0	100.0	12.0	12.0	100.0	12.0	12.0	100.0	12.0

Supplemental Table 2
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal
Source: Morganza to the Gulf Long Duration Salt Water Curves

Mobile Home
Mobile Home (MOBHOME)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.1	0.0	0.0	0.0
-1.0	6.1	6.4	7.7
-0.5	6.9	7.3	8.8
0.0	9.4	9.9	11.9
0.5	41.2	43.4	52.1
1.0	42.5	44.7	53.6
2.0	43.6	45.9	55.1
3.0	44.3	46.6	55.9
4.0	44.5	46.8	56.2
5.0	48.5	51.0	61.2
6.0	63.5	66.9	80.2
7.0	63.5	66.9	80.2
8.0	64.0	67.3	80.8
9.0	64.0	67.3	80.8
10.0	64.0	67.3	80.8
11.0	64.0	67.3	80.8
12.0	64.0	67.3	80.8
13.0	64.0	67.3	80.8
14.0	64.0	67.3	80.8

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	90.0	95.0	100.0
1.0	92.0	96.0	100.0
1.5	94.0	97.0	100.0
2.0	96.0	98.0	100.0
3.0	98.0	99.0	100.0
4.0	100.0	100.0	100.0
5.0	100.0	100.0	100.0
6.0	100.0	100.0	100.0
7.0	100.0	100.0	100.0
8.0	100.0	100.0	100.0
9.0	100.0	100.0	100.0
10.0	100.0	100.0	100.0
11.0	100.0	100.0	100.0
12.0	100.0	100.0	100.0
13.0	100.0	100.0	100.0
14.0	100.0	100.0	100.0
15.0	100.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	82.0	14.0
5.0	90.0	14.0
12.0	100.0	15.0

Industrial
Industrial Warehouse (WARE)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.1	1.1	1.3
0.5	22.3	20.8	25.7
1.0	23.7	22.1	27.3
1.5	25.8	24.0	29.7
2.0	32.7	29.5	39.3
3.0	34.4	31.0	43.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15	80.5	72.4	100

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	17.6	16.8	22.0
1.0	22.1	21.0	27.7
1.5	22.1	21.0	27.7
2.0	29.2	27.8	36.6
3.0	34.0	32.3	42.5
4.0	42.8	40.7	53.6
5.0	50.8	48.3	63.5
6.0	58.7	55.8	73.4
7.0	66.7	63.4	83.4
8.0	74.6	70.9	93.3
9.0	79.7	75.7	99.6
10.0	79.7	75.7	99.6
11.0	79.7	75.7	99.6
12.0	79.7	75.7	99.6
13.0	79.7	75.7	99.6
14.0	79.7	75.7	99.6
15.0	79.7	75.7	99.6

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	76.0	13.0
5.0	87.0	14.0
12.0	100.0	14.0

Commercial
Multi-Family Residence, over 5 units (MULT)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	6.6	6.2	7.6
0.5	19.8	18.4	22.8
1.0	19.8	18.4	22.8
1.5	24.5	22.8	28.2
2.0	24.5	22.8	28.2
3.0	29.6	26.6	37.0
4.0	34.7	31.2	43.4
5.0	37.9	34.1	47.4
6.0	37.9	34.1	47.4
7.0	37.9	34.1	47.4
8.0	63.3	57.0	79.2
9.0	63.3	57.0	79.2
10.0	63.3	57.0	79.2
11.0	63.3	57.0	79.2
12.0	63.3	57.0	79.2
13.0	63.3	57.0	79.2
14.0	63.3	57.0	79.2
15.0	63.3	57.0	79.2

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	20.1	15.8	22.2
1.0	26.2	22.4	28.7
1.5	33.5	31.2	35.2
2.0	42.4	40.5	46.2
3.0	49.8	46.6	51.4
4.0	51.7	50.3	53.0
5.0	51.7	50.3	53.1
6.0	51.7	50.3	54.6
7.0	51.7	50.3	54.6
8.0	51.7	50.3	54.6
9.0	51.7	50.3	54.6
10.0	71.8	56.4	79.3
11.0	85.2	79.6	89.5
12.0	100.0	93.5	100.0
13.0	100.0	97.1	100.0
14.0	100.0	97.1	100.0
15.0	100.0	97.1	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	77.0	7.0
5.0	83.0	7.0
12.0	100.0	10.0

Supplemental Table 3
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal
Source: Morganza to the Gulf Long Duration Salt Water Curves

Commercial Groceries & Gas Station (GROC)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.0	1.1	1.3
0.5	18.7	20.2	24.1
1.0	18.7	20.2	24.1
1.5	23.2	25.8	31.0
2.0	26.9	29.9	36.7
3.0	29.9	34.0	40.8
4.0	34.6	40.7	50.9
5.0	41.7	49.0	61.3
6.0	41.7	49.0	61.3
7.0	43.2	50.8	63.6
8.0	44.5	52.4	65.5
9.0	48.7	57.3	71.6
10.0	48.7	57.3	71.6
11.0	48.7	57.3	71.6
12.0	51.3	60.4	75.4
13.0	51.3	60.4	75.4
14.0	51.3	60.4	75.4

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	8.9	9.9	11.9
1.0	26.6	29.6	35.5
1.5	67.9	75.4	90.5
2.0	78.5	87.2	100.0
3.0	85.7	95.2	100.0
4.0	88.9	98.8	100.0
5.0	90.0	100.0	100.0
6.0	90.0	100.0	100.0
7.0	90.0	100.0	100.0
8.0	90.0	100.0	100.0
9.0	90.0	100.0	100.0
10.0	90.0	100.0	100.0
11.0	90.0	100.0	100.0
12.0	90.0	100.0	100.0
13.0	90.0	100.0	100.0
14.0	90.0	100.0	100.0
15.0	90.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	95.0	21.0
5.0	97.0	21.0
12.0	100.0	21.0

Commercial Repairs & Home Use (REPA)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.0	1.1	1.3
0.5	18.7	20.2	24.1
1.0	18.7	20.2	24.1
1.5	23.2	25.8	31.0
2.0	26.9	29.9	36.7
3.0	29.9	34.0	40.8
4.0	34.6	40.7	50.9
5.0	41.7	49.0	61.3
6.0	41.7	49.0	61.3
7.0	43.2	50.8	63.6
8.0	44.5	52.4	65.5
9.0	48.7	57.3	71.6
10.0	48.7	57.3	71.6
11.0	48.7	57.3	71.6
12.0	51.3	60.4	75.4
13.0	51.3	60.4	75.4
14.0	51.3	60.4	75.4

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	13.1	14.6	17.5
1.0	18.5	20.6	24.7
1.5	28.6	31.8	38.2
2.0	29.5	32.8	39.3
3.0	59.4	66.0	79.2
4.0	60.7	67.4	80.9
5.0	62.0	68.8	82.6
6.0	69.3	76.9	92.3
7.0	71.9	79.9	95.9
8.0	71.9	79.9	95.9
9.0	71.9	79.9	95.9
10.0	71.9	79.9	95.9
11.0	71.9	79.9	95.9
12.0	71.9	79.9	95.9
13.0	71.9	79.9	95.9
14.0	71.9	79.9	95.9
15.0	71.9	79.9	95.9

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	95.0	21.0
5.0	97.0	21.0
12.0	100.0	21.0

Commercial Retail and Personal Services (RETA)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.5	1.6	1.9
0.5	11.2	12.0	14.4
1.0	11.2	12.0	14.4
1.5	11.2	12.0	20.6
2.0	15.5	17.2	21.4
3.0	15.6	17.4	26.9
4.0	19.7	22.4	32.9
5.0	22.4	26.3	36.9
6.0	25.1	29.5	36.9
7.0	25.1	29.5	36.9
8.0	25.1	29.5	39.9
9.0	27.1	31.9	52.8
10.0	35.9	42.3	60.6
11.0	41.2	48.4	60.6
12.0	41.2	48.4	65.5
13.0	44.6	52.4	65.5
14.0	44.6	52.4	65.5

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	10.8	12.0	14.4
1.0	22.7	25.3	30.3
1.5	32.9	36.6	43.9
2.0	54.5	60.5	72.6
3.0	67.8	75.4	90.5
4.0	76.6	85.1	100.0
5.0	85.0	94.5	100.0
6.0	90.0	100.0	100.0
7.0	90.0	100.0	100.0
8.0	90.0	100.0	100.0
9.0	90.0	100.0	100.0
10.0	90.0	100.0	100.0
11.0	90.0	100.0	100.0
12.0	90.0	100.0	100.0
13.0	90.0	100.0	100.0
14.0	90.0	100.0	100.0
15.0	90.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	95.0	22.0
5.0	96.0	22.0
12.0	100.0	22.0

Supplemental Table 4
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal
Source: Morganza to the Gulf Long Duration Salt Water Curves

Commercial Eating & Recreation (EAT)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.0	1.1	1.3
0.5	18.7	20.2	24.1
1.0	18.7	20.2	24.1
1.5	23.2	25.8	31.0
2.0	26.9	29.9	36.7
3.0	29.9	34.0	40.8
4.0	34.6	40.7	50.9
5.0	41.7	49.0	61.3
6.0	41.7	49.0	61.3
7.0	43.2	50.8	63.6
8.0	44.5	52.4	65.5
9.0	48.7	57.3	71.6
10.0	48.7	57.3	71.6
11.0	48.7	57.3	71.6
12.0	51.3	60.4	75.4
13.0	51.3	60.4	75.4
14.0	51.3	60.4	75.4

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	16.8	18.7	22.4
1.0	22.5	25.0	30.1
1.5	42.1	46.8	56.1
2.0	45.2	50.2	60.3
3.0	72.3	80.3	96.4
4.0	86.2	95.8	100.0
5.0	88.4	98.2	100.0
6.0	89.2	99.1	100.0
7.0	90.0	100.0	100.0
8.0	90.0	100.0	100.0
9.0	90.0	100.0	100.0
10.0	90.0	100.0	100.0
11.0	90.0	100.0	100.0
12.0	90.0	100.0	100.0
13.0	90.0	100.0	100.0
14.0	90.0	100.0	100.0
15.0	90.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	77.0	7.0
5.0	83.0	7.0
12.0	100.0	10.0

Commercial Professional Services (PROF)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.5	1.6	1.9
0.5	11.2	12.0	14.4
1.0	11.2	12.0	14.4
1.5	11.2	12.0	20.6
2.0	15.5	17.2	21.4
3.0	15.6	17.4	26.9
4.0	19.7	22.4	32.9
5.0	22.4	26.3	36.9
6.0	25.1	29.5	36.9
7.0	25.1	29.5	36.9
8.0	25.1	29.5	39.9
9.0	27.1	31.9	52.8
10.0	35.9	42.3	60.6
11.0	41.2	48.4	60.6
12.0	41.2	48.4	65.5
13.0	44.6	52.4	65.5
14.0	44.6	52.4	65.5

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	13.3	14.8	18.4
1.0	16.7	18.6	23.2
1.5	30.0	33.3	41.6
2.0	35.1	39.0	48.8
3.0	67.1	74.6	93.2
4.0	83.0	92.2	100.0
5.0	84.7	94.1	100.0
6.0	90.0	100.0	100.0
7.0	90.0	100.0	100.0
8.0	90.0	100.0	100.0
9.0	90.0	100.0	100.0
10.0	90.0	100.0	100.0
11.0	90.0	100.0	100.0
12.0	90.0	100.0	100.0
13.0	90.0	100.0	100.0
14.0	90.0	100.0	100.0
15.0	90.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	95.0	22.0
5.0	96.0	22.0
12.0	100.0	22.0

Commerical Public Facilities (PUBL)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.5	1.6	1.9
0.5	11.2	12.0	14.4
1.0	11.2	12.0	14.4
1.5	11.2	12.0	20.6
2.0	15.5	17.2	21.4
3.0	15.6	17.4	26.9
4.0	19.7	22.4	32.9
5.0	22.4	26.3	36.9
6.0	25.1	29.5	36.9
7.0	25.1	29.5	36.9
8.0	25.1	29.5	39.9
9.0	27.1	31.9	52.8
10.0	35.9	42.3	60.6
11.0	41.2	48.4	60.6
12.0	41.2	48.4	65.5
13.0	44.6	52.4	65.5
14.0	44.6	52.4	65.5

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	36.0	40.0	50.0
1.0	64.8	72.0	90.0
1.5	64.8	72.0	90.0
2.0	64.8	72.0	90.0
3.0	89.7	99.7	100.0
4.0	90.0	100.0	100.0
5.0	90.0	100.0	100.0
6.0	90.0	100.0	100.0
7.0	90.0	100.0	100.0
8.0	90.0	100.0	100.0
9.0	90.0	100.0	100.0
10.0	90.0	100.0	100.0
11.0	90.0	100.0	100.0
12.0	90.0	100.0	100.0
13.0	90.0	100.0	100.0
14.0	90.0	100.0	100.0
15.0	90.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	95.0	22.0
5.0	96.0	22.0
12.0	100.0	22.0

Supplemental Table 5
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal
Source: Morganza to the Gulf Long Duration Salt Water Curves

Autos
Residential Autos (AUTO)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	3.7	2.3	4.7
1.5	13.0	12.0	15.0
2.0	46.7	44.7	48.3
3.0	100.0	100.0	100.0
4.0	100.0	100.0	100.0
5.0	100.0	100.0	100.0
6.0	100.0	100.0	100.0
7.0	100.0	100.0	100.0
8.0	100.0	100.0	100.0
9.0	100.0	100.0	100.0
10.0	100.0	100.0	100.0
11.0	100.0	100.0	100.0
12.0	100.0	100.0	100.0
13.0	100.0	100.0	100.0
14.0	100.0	100.0	100.0
15.0	100.0	100.0	100.0
16.0	100.0	100.0	100.0

Supplemental Table 6
South Central Coastal Louisiana Feasibility Study
Average Annual Damages Reduced by Structural Alternative

Levee Raise Without Project Condition

YEAR	FREQUENCY	VALUE
	-	649,023,454
1000	0.001	649,023,454
500	0.002	649,023,454
250	0.004	406,963,939
100	0.010	301,279,292
50	0.020	145,362,127
36	0.028	100,000,000
35	0.029	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		**7,706,000**

Ring Levee Without Project Condition

YEAR	FREQUENCY	VALUE
	-	1,232,682,203
1000	0.001	1,232,682,203
500	0.002	1,232,682,203
250	0.004	857,774,538
100	0.010	668,247,575
50	0.020	351,391,390
25	0.040	137,162,699
10	0.100	45,628,432
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		**26,883,000**

Levee Raise With Project Condition

YEAR	FREQUENCY	VALUE
	-	649,023,454
1000	0.001	649,023,454
500	0.002	649,023,454
250	0.004	406,963,939
101	0.010	301,279,292
100	0.010	-
50	0.020	-
25	0.040	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		**4,459,000**
AA DAMAGES REDUCED =		**3,247,000**

Ring Levee With Project Condition

YEAR	FREQUENCY	VALUE
	-	1,232,682,203
1000	0.001	1,232,682,203
500	0.002	1,232,682,203
250	0.004	857,774,538
101	0.010	668,247,575
100	0.010	-
50	0.020	-
25	0.040	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		**9,091,000**
AA DAMAGES REDUCED =		**17,792,000**