REVISED INTEGRATED DRAFT FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

ENGINEERING REPORT

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REVISED INTEGRATED DRAFT FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT
DRAFT ENGINEERING REPORT

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DRAFT ENGINEERING REPORT

1.0 PURPOSE

This engineering report summarizes the preliminary engineering and design work completed to support the NED and the NER components of the Southwest Coastal Louisiana Feasibility Study. This report includes hydrologic and hydraulic engineering analyses, including: levee and channel design, hydrologic / Salinity control structure design, shoreline protection/stabilization design, marsh restoration design, Chenier reforestation design for the NED and NER features. Preliminary cost estimates for the Tentatively Selected Plans are presented in Chapter 4 of the Main Report.

1.1 INTRODUCTION

1.1.1 General

The Southwest Coastal Louisiana Study is located in southwestern Louisiana adjacent to Texas and covers an area of approximately 4,700 square miles. The area includes Cameron, Vermillion and Calcasieu Parishes. The Gulf Intracoastal Waterway (GIWW) bisects the area into north and south regions generally running along the existing state coastal zone boundary. The study area is shown in Figure 1.

Cameron Parish is located in the southwest corner of Louisiana. The southern boundary of the parish is the Gulf of Mexico. Eighty-two percent of Cameron Parish is coastal marshes. The parish is chiefly rural and the largest communities are Cameron and Hackberry. Calcasieu Parish is located due north of Cameron Parish. The town of Lake Charles is the parish seat, which is the largest urban area in the study area. Only a small portion of the parish is located in the coastal zone. Vermilion Parish is located due east of Cameron Parish. The southern boundary of the parish is the Gulf of Mexico. Large expanses of Vermilion Parish are open water (lakes, bays, and streams). Approximately 50 percent of the land is coastal marshes. The parish is chiefly rural and the town of Abbeville is the parish seat as well as the largest urban area in the parish.

The area is characterized by extensive coastal marshland interrupted by forests atop relict Chenier ridges and natural ridges. The main physiographic zones of the Chenier Plain include the Gulf Coast Marsh, Gulf Coast Prairies, and Forested Terraced Uplands. The Gulf Coast Marsh is at or near sea level and borders the Gulf of Mexico and most of the large lakes are in this area. The Gulf Coast Prairie extends from the central part of Vermilion and Cameron Parishes into the southern part of Calcasieu Parish, while the Forested Uplands, which occur at or near 25-foot elevation, are located in the northern part of Vermilion and Calcasieu Parishes. Further details of the project setting can be found in the Main Report.

1.1.2 Study Purpose

The National Economic Development (NED) purpose of this study is to provide hurricane and storm damage risk reduction to reduce the risk of flood damages caused by hurricane and storm surges. The

National Ecosystem Restoration (NER) purpose of the study is to significantly restore environmental conditions for the ecosystem of the study area.

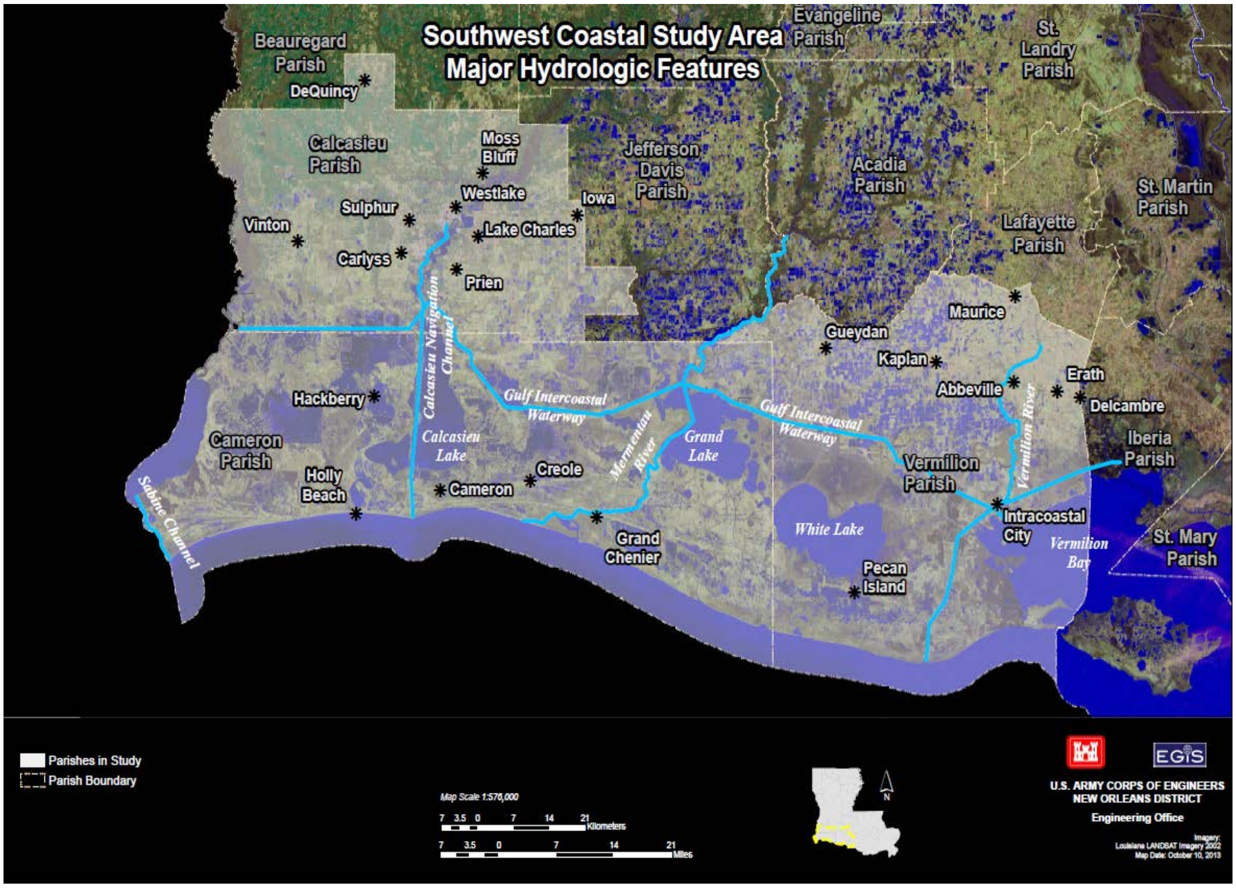

Figure 1 - Study Area

1.1.3 Study Overview

Separate alternatives were developed for the NED and NER objectives and were analyzed independently. An initial array of NED and NER alternatives were evaluated to develop the focused array.
Hurricane and storm damage risk reduction measures were developed and screened using preliminary costs and benefits to identify a focused array of NED alternatives. Details of this initial evaluation can be found in the Appendix C to the Main Report. Components of the NED focused array can be found in Section 1.2 below.

NER plan screening was based on monetary and non-monetary evaluations. Preliminary costs and benefits for marsh restoration, shore protection, Chenier reforestation and water control were estimated. Screening criteria included planning constraints; support for objectives; measure effectiveness; and below average efficiency. Measures that did not meet the screening criteria were retained only in limited instances in which they supported critical adjacent features. Alternative plans for the focused NER array were created by combining measure types into comprehensive strategies. Details of this initial evaluation can be found in the

Appendix C to the Main Report. All elevations presented in this Report are relative to NAVD 88 (2004.65) unless otherwise stated.

1.2 ALTERNATIVES

1.2.1 NED Focused Array

The focused array of NED alternatives analyzed consists of the eight plans identified below. These include six different levee alignments (three in the area around Lake Charles, LA and three in the area around Abbeville, LA), two non-structural plans, and a no action plan. Each of the levee alignments was evaluated at three levels of risk reduction 2% (50-year), 1% (100-year) and .5% (200-year) during final array comparisons.

Plan 0: No Action
Plan 1: Lake Charles Eastbank Levee
Plan 2: Lake Charles Westbank/Sulphur Extended Levee
Plan 3: Lake Charles Westbank/Sulphur South Levee
Plan 4: Delcambre/Erath Levee
Plan 5: Abbeville Levee (Abbeville Ring Levee)
Plan 6: Abbeville to Delcambre Levee
Plan 7: Nonstructural Plan (Justified Reaches Plan)
Plan 8: Nonstructural Plan (100 year Floodplain in 2075)

In a coastal environment, flood risk can be caused by a combination of hurricane surge, waves, wave overtopping of structures, rainfall flooding including riverine flooding due to rainfall, or other sources. In the project area for the 0-10-year events, most of the damages are from rainfall events. For the 50-100-year events, most damages are associated with storm surge. Both storm surge and waves are taken into account in proposed levee designs. Risk in the case of the levee designs is defined as the probability that an area will be flooded by storm surge, resulting in undesirable consequences. ER 1105-2-101 requires project performance to be described in terms of annual chance or exceedance probability and long-term risk rather than level of protection. In terms of annual chance or exceedance probability, a 100-yr levee is designed to withstand a storm surge that has a 1 in 100 chance of occurring in any given year. Section 2 describes how the required 2%, 1% and .5% levee elevations were developed.

The nonstructural plans were evaluated based on several potential measures. One was elevation of residential structures to the 100-year stage under 2075 hydrologic conditions, or by no more than 13 feet (whichever is lower). A second involved acquisition/buyout of residential structures that would require elevation over 13 feet and property owners would receive fair market value for the property acquired. A third measure involved dry flood proofing of non-residential and public structures (excluding industrial buildings and warehouses) for flood depths not greater than three feet above the adjacent ground. A final measure evaluated involved detached flood proofing of industrial buildings and warehouses using barriers or berms not exceeding six feet in height.

Designs and costs were developed for each level of risk reduction for each alignment. The levee alignments referred to above as Plans 1-6 are shown in Figure 2 through Figure 4. Further details on these alignments and how they were developed can be found in the Main Report. This Engineering Report does not cover the nonstructural alternatives in detail. Details of the analysis and selection of the nonstructural plan can be found in the Plan Formulation Appendix and the Economics Appendix.

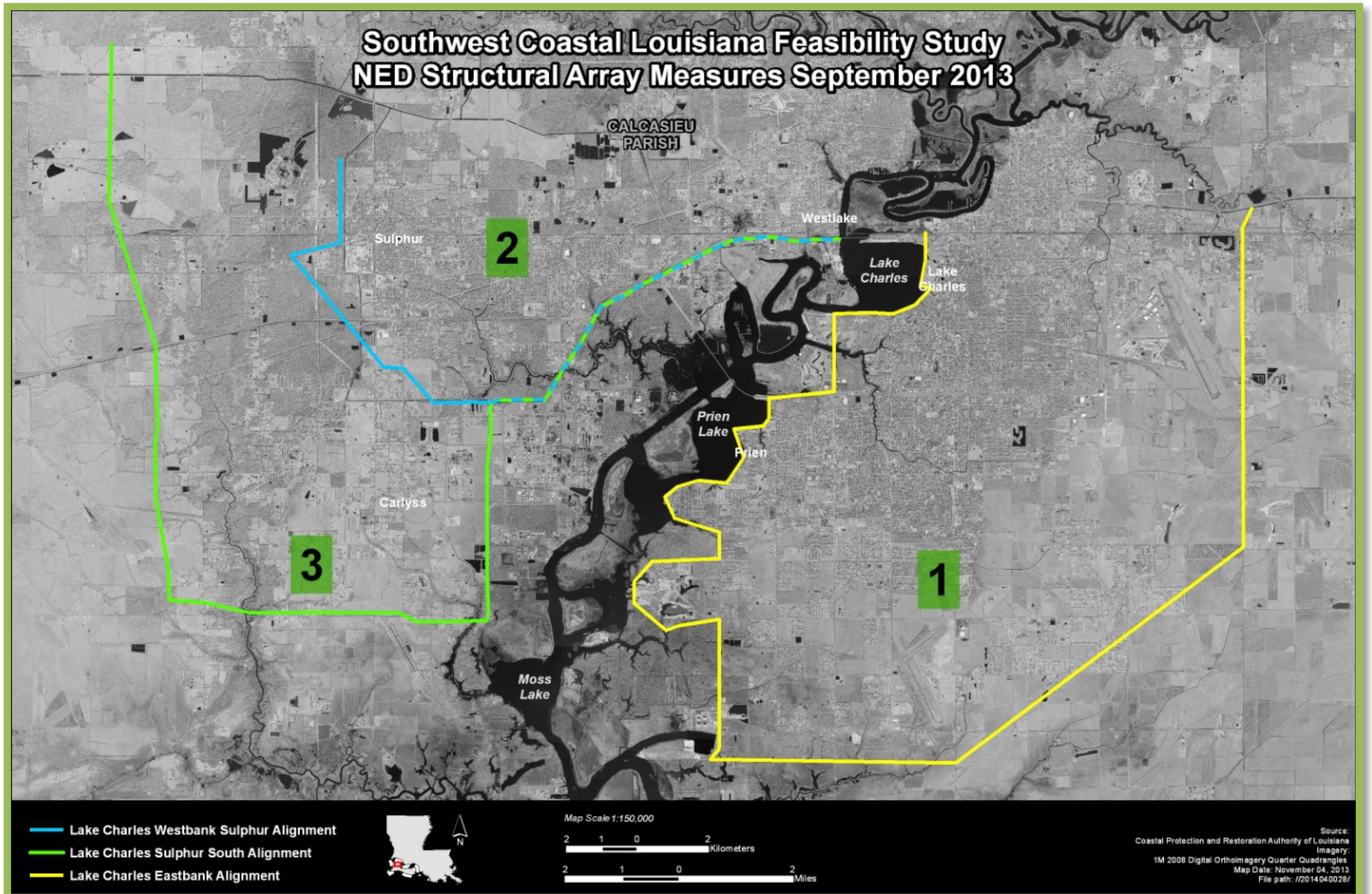

Figure 2 – Lake Charles Area Alignments

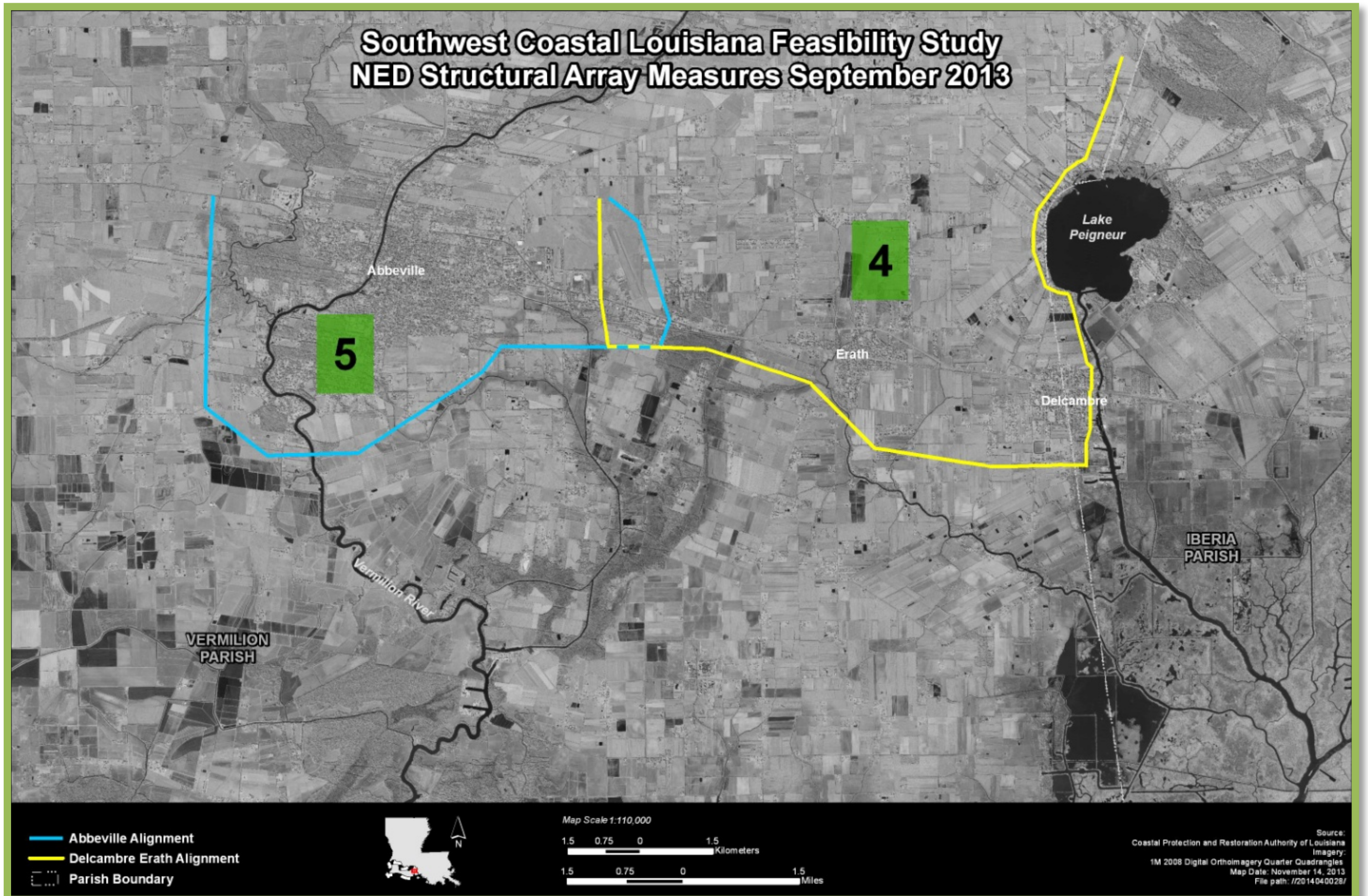

Figure 3 - Abbeville and Delcambre Erath Alignments

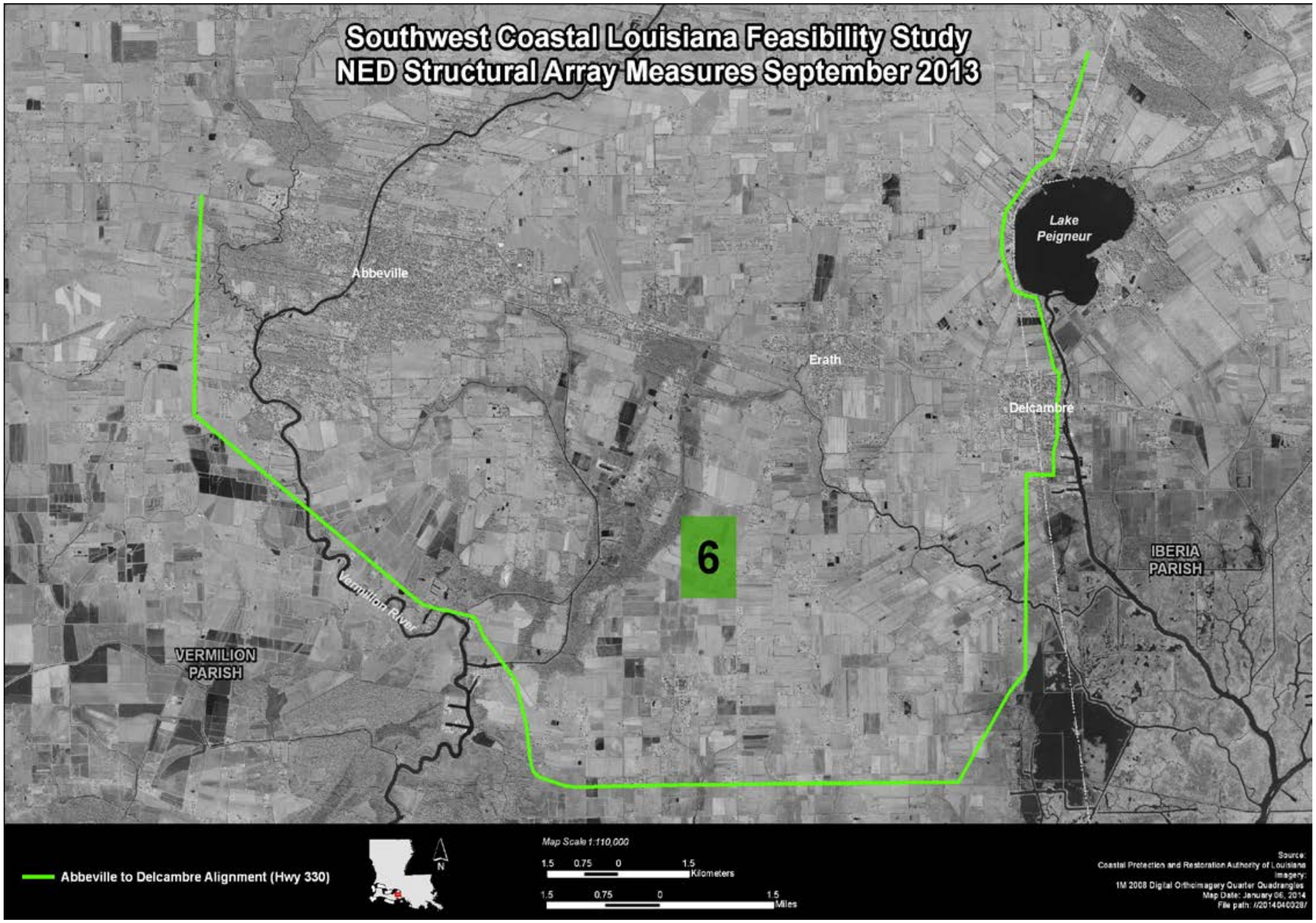

Figure 4 - Abbeville to Delcambre Hwy 330

1.2.2 NER Focused Array

The focused array of NER alternatives is shown in Table 1.

Table 1 - Focused Array of NER Alternatives

PLAN No	ALTERNATIVE NAME
CMA-1	Comprehensive Large Integrated Restoration w/ Entry Salinity Control
CM-1	Comprehensive Large Integrated Restoration
CA-1	Calcasieu Large Integrated Restoration w/ Entry Salinity Control
C-1	Calcasieu Large Integrated Restoration
M-1	Mermentau Large Integrated Restoration
CMA-2	Comprehensive Moderate Integrated Restoration w/ Entry Salinity Control
CM-2	Comprehensive Moderate Integrated Restoration
CA-2	Calcasieu Moderate Integrated Restoration w/ Entry Salinity Control
C-2	Calcasieu Moderate Integrated Restoration
M-2	Mermentau Moderate Integrated Restoration
CMA-3	Comprehensive Moderate Integrated Restoration w/ Gum Cove & Entry Salinity Control
CM-3	Comprehensive Moderate Integrated Restoration
CA-3	Calcasieu Moderate Integrated Restoration w/ Gum Cove & Entry Salinity Control
C-3	Calcasieu Moderate Integrated Restoration
M-3	Mermentau Moderate Integrated Restoration
CMA-4	Comprehensive Small Integrated Restoration w/ Entry Salinity Control
CM-4	Comprehensive Small Integrated Restoration
CA-4	Calcasieu Small Integrated Restoration w/ Entry Salinity Control
C-4	Calcasieu Small Integrated Restoration
M-4	Mermentau Small Integrated Restoration
CM-5	Comprehensive Interior Perimeter Salinity Control
C-5	Calcasieu Interior Perimeter Salinity Control
M-5	Mermentau Interior Perimeter Salinity Control
CM-6	Comprehensive Marsh & Shoreline
C-6	Calcasieu Marsh & Shoreline
M-6	Mermentau Marsh & Shoreline
A	Entry Salinity Control

Alternatives designated by an "A" differ from those without the "A" designation in that the "A" designated alternatives include the Calcasieu Ship Channel Salinity Control Structure. Alternatives designated as "C" or "M" only include features in the Calcasieu Basin or Mermentau Basin respectively.

Table 2 shows the different features included in each comprehensive NER alternative in the Focused Array. Further details on these measures can be found in Section 5 and 6 of this Report and in the Main Report. Maps showing the location of these features can be found in the Main Report.

Table 2 – Features in the NER Alternatives

Feature Location:
Mermentau Basin
Calcasieu Basin

Measure	Feature	No Action	Strategy 1/1A Large Integrated Restoration across Basins	Strategy 2/2A Moderate Integrated Restoration across Basins	Strategy 3/3A Moderate Integrated Restoration + Gum Cove	Strategy 4/4A Small Integrated Restoration	Strategy 5 Interior Perimeter Salinity Control	Strategy 6 Marsh & Shoreline Focus	Strategy 7 (or A) Entry Salinity Control
Hydrologic & Salinity Control									
	7#	**0**	**0/X**	**0/X**	**0/X**	**0/X**	**0**	**0**	**X**
	13*	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	17a-c*	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	48	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	74a	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	407	**0**	**0**	**0**	**X**	**0**	**X**	**0**	**0**
Marsh Restoration									
	3a1	**0**	**0**	**0**	**0**	**X**	**X**	**0**	**0**
	3c1	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	3c2	**0**	**X**	**X**	**X**	**0**	**0**	**X**	**0**
	3c3	**0**	**X**	**X**	**X**	**0**	**0**	**X**	**0**
	3c4	**0**	**X**	**X**	**X**	**0**	**0**	**X**	**0**
	3c5	**0**	**X**	**X**	**X**	**0**	**0**	**X**	**0**
	47a1	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	47a2	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	47c1	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	47c2	**0**	**X**	**0**	**0**	**0**	**0**	**X**	**0**
	124a	**0**	**X**	**0**	**0**	**0**	**0**	**X**	**0**
	124b	**0**	**X**	**0**	**0**	**0**	**0**	**X**	**0**
	124c	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	124d	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	127c1	**0**	**X**	**0**	**0**	**0**	**0**	**X**	**0**
	127c2	**0**	**X**	**X**	**X**	**0**	**0**	**X**	**0**
	127c3	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	306a1	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	306a2	**0**	**X**	**0**	**0**	**0**	**0**	**X**	**0**
Shoreline Protection/Stabilization									
	5a	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	6b1	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	6b2	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	6b3	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**
	16b	**0**	**X**	**0**	**0**	**X**	**X**	**0**	**0**
	99a	**0**	**X**	**0**	**0**	**0**	**0**	**X**	**0**
	113b2	**0**	**X**	**0**	**0**	**0**	**0**	**0**	**0**
Chenier Reforestation (both basins)									
	CR	**0**	**X**	**X**	**X**	**X**	**X**	**X**	**0**

Feature 7 functions both as a stand-alone Strategy/Alternative and an additive feature. *Following refinement of the benefit assessment as a result of technical comments, these features were found to lack positive outputs and were dropped from all plans. Note: Green cells denote features found in the Calcasieu Basin. Blue cells denote features in the Mermentau Basin. An 'X' in a cell indicates the feature is a component of the strategy while a '0' indicates it is not a component of the strategy.

2.0 HYDROLOGY AND HYDRAULICS

2.1 GENERAL

This section describes the hydrology and hydraulic analysis done for the NED alternatives.

2.2 ADCIRC MODELING

A version of the Southern Louisiana ADCIRC (Advanced CIRCulation) model, coupled with the STWAVE (Steady State spectral WAVE) model was developed for analysis of the Southwest Coastal Louisiana alternatives. The ADCIRC model is a two-dimensional, depth-integrated, barotropic time-dependent long wave, hydrodynamic circulation model that can be used to simulate storm surge response to hurricanes and tropical storms. STWAVE is a steady-state, finite difference, spectral model base on the wave action balance equation. STWAVE is used to model nearshore wind-wave growth and propagation. The modeling system used for this study was established by updating existing models used previously for the Joint Storm Surge (JSS) Analysis in Southern Louisiana for the Louisiana Coastal Protection and Restoration (LACPR) Project, as well as the recent flood insurance rate map modernization study conducted by the FEMA (USACE, 2008a and USACE, 2007). Details of the model development and results can be found in Annex 1 of the Engineering Report.

2.3 LEVEE DESIGN

The NED focused array of alternatives contained six levee alignments. The resulting design deliverables consisted of the 2025 and 2075 levee design elevations for all six alignments for the 2%, 1%, and 0.5% return frequencies. The six levee alignments that were analyzed are shown in Figure 5 through Figure 10. Each levee alignment was divided into segments as shown in Figure 5 through Figure 10 for use in determining the design elevations.

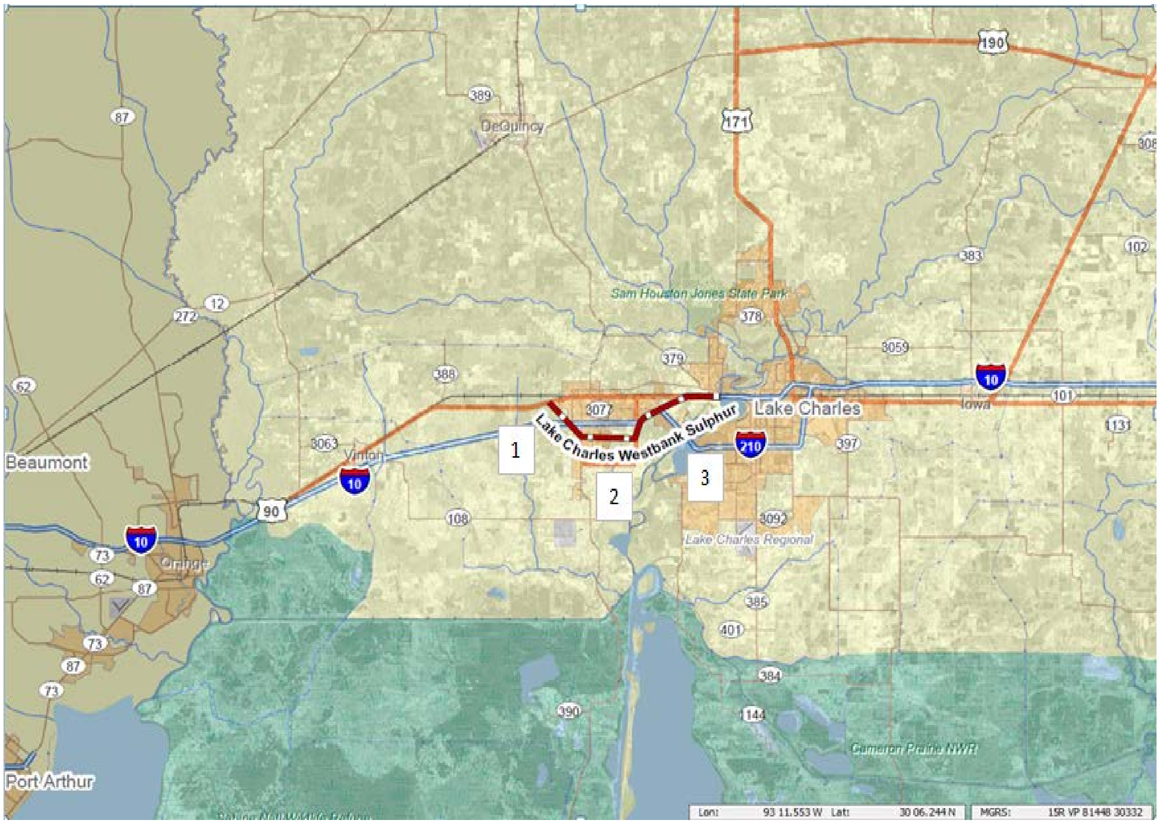

Figure 5– Lake Charles Westbank Sulphur Levee Alignment

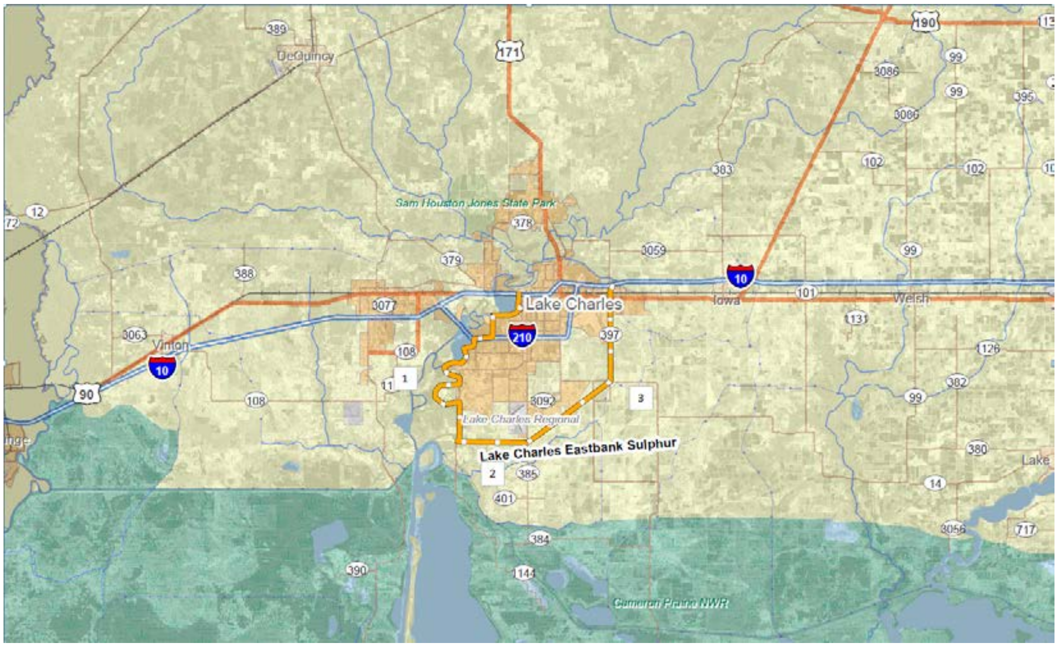

Figure 6 - Lake Charles Eastbank Alignment

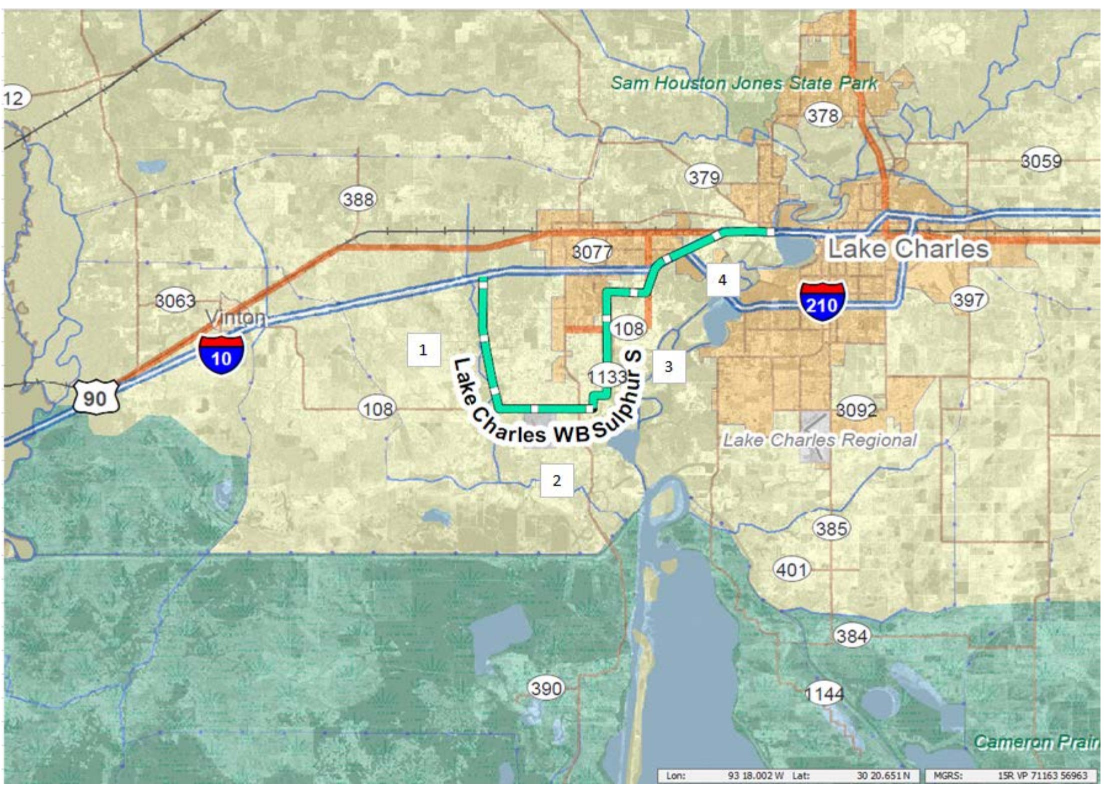

Figure 7 - Lake Charles Westbank Sulphur South Alignment

Figure 8 - Abbeville Ring Levee Alignment

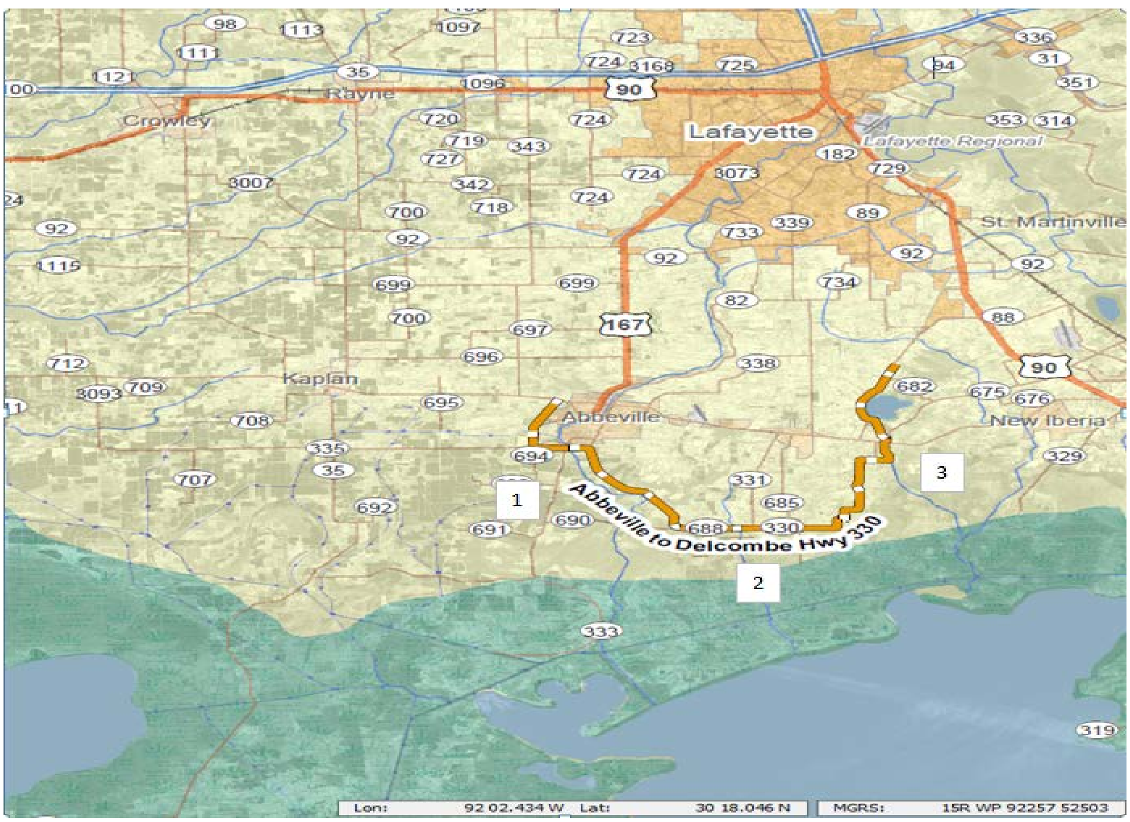

Figure 9 - Abbeville to Delcambre Hwy 330 Levee Alignment

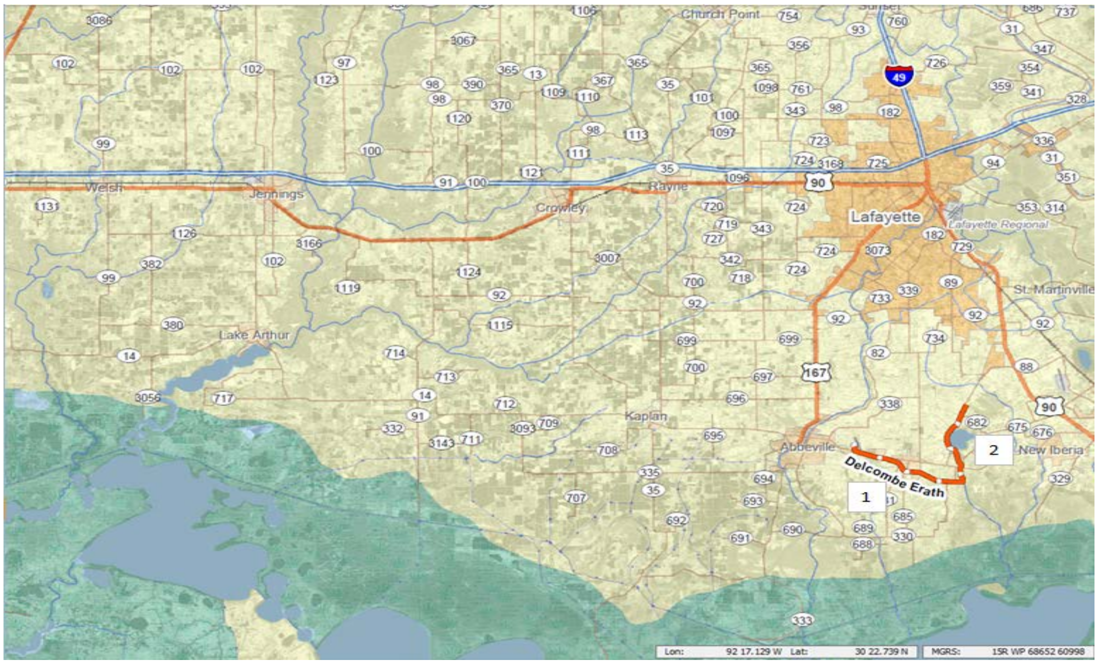

Figure 10 - Delcambre Erath Levee Alignment

2.3.1 Methodology

For the initial preliminary design, limited model information was available. The "without project" hydraulic boundary conditions were obtained from the ADCIRC model simulations for the given project locations. In order to estimate the "with-project" conditions, the "without project" hydraulic boundary conditions (i.e. surface water elevation, wave heights, and wave periods) were used with an adjustment factor of 1 foot for 2025 surface water elevations and 2 feet for 2075 surface water elevations. The increased amount of water elevation was based on observations of the available model results for "without project" and "with project" conditions of other studies, such as the Morganza to the Gulf Post Authorization Change Study and Westshore Lake Pontchartrain Feasibility Study. The increase in water elevations is due to the surge stacking up against the levee. The amount of increase in water elevation is dependent on the location of the levee, the rate of Sea Level Rise and the future condition (2025 or 2075).

The hydraulic boundary conditions for each alignment and return frequency are shown in Table 3 through Table 38.

Table 3 - Lake Charles Westbank Sulphur 2025 2% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	6.6	1.2	1	0.1	2	0.4
2	5.3	1.2	1	0.1	2	0.4
3	7	1.2	1	0.1	2	0.4

Table 4 – Lake Charles Westbank Sulphur 2075 2% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	10.5	1.2	2	0.2	3	0.6
2	9.3	1.2	2	0.2	3	0.6
3	13.1	1.2	2	0.2	3	0.6

Table 5 – Lake Charles Westbank Sulphur 2025 1% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	9	1.2	2	0.2	3	0.6
2	8.5	1.2	2	0.2	3	0.6
3	11.7	1.2	2	0.2	3	0.6

Table 6 – Lake Charles Westbank Sulphur 2075 1% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	13.2	1.2	3	0.3	4	0.8
2	13.3	1.2	3	0.3	4	0.8
3	15.4	1.2	3	0.3	4	0.8

Table 7 – Lake Charles Westbank Sulphur 2025 0.5% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	11.7	1.2	2.5	0.3	4	0.8
2	11.2	1.2	2.5	0.3	4	0.8
3	12.9	1.2	2.5	0.3	4	0.8

Table 8 – Lake Charles Westbank Sulphur 2075 0.5% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	16.6	1.2	4	0.4	5	1.0
2	17	1.2	4	0.4	5	1.0

Table 8 – Lake Charles Westbank Sulphur 2075 0.5% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
3	16.8	1.2	4	0.4	5	1.0

Table 9 - Abbeville to Delcambre Hwy 330 2025 2% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	10.4	1.2	1	0.1	2	0.4
2	11.6	1.2	1	0.1	2	0.4
3	10.7	1.2	1	0.1	2	0.4

Table 10 – Abbeville to Delcambre Hwy 330 2075 2% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	15.2	1.2	2	0.1	3	0.4
2	15	1.2	2	0.1	3	0.4
3	15.3	1.2	2	0.1	3	0.4

Table 11 - Abbeville to Delcambre Hwy 330 2025 1% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	11.6	1.2	2	0.2	3	0.6
2	13.1	1.2	2	0.2	3	0.6
3	12.1	1.2	2	0.2	3	0.6

Table 12 - Abbeville to Delcambre Hwy 330 2075 1% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	16.5	1.2	3	0.3	4	0.8
2	16.5	1.2	3	0.3	4	0.8
3	16.9	1.2	3	0.3	4	0.8

Table 13 - Abbeville to Delcambre Hwy 330 2025 0.5% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	12.6	1.2	2.5	0.3	4	0.8
2	14.2	1.2	2.5	0.3	4	0.8
3	13.1	1.2	2.5	0.3	4	0.8

Table 14 - Abbeville to Delcambre Hwy 330 2075 0.5% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	17.6	1.2	4	0.4	5	1.0
2	17.6	1.2	4	0.4	5	1.0
3	18	1.2	4	0.4	5	1.0

Table 15 - Lake Charles Eastbank Sulphur 2025 2% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	12.6	1.2	2.5	0.3	4	0.8
2	14.2	1.2	2.5	0.3	4	0.8
3	13.1	1.2	2.5	0.3	4	0.8

Table 16 - Lake Charles Eastbank Sulphur 2075 2% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	13	1.2	2	0.2	3	0.6
2	13.4	1.2	2	0.2	3	0.6
3	13.3	1.2	2	0.2	3	0.6

Table 17 - Lake Charles Eastbank Sulphur 2025 1% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	11.2	1.2	2	0.2	3	0.6

Table 17 - Lake Charles Eastbank Sulphur 2025 1% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
2	11	1.2	2	0.2	3	0.6
3	10.7	1.2	2	0.2	3	0.6

Table 18 - Lake Charles Eastbank Sulphur 2075 1% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	15.5	1.2	3	0.3	4	0.8
2	16.1	1.2	3	0.3	4	0.8
3	15.8	1.2	3	0.3	4	0.8

Table 19 - Lake Charles Eastbank Sulphur 2025 0.5% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	12.5	1.2	2.5	0.3	4	0.8
2	12.2	1.2	2.5	0.3	4	0.8
3	11.9	1.2	2.5	0.3	4	0.8

Table 20 - Lake Charles Eastbank Sulphur 2075 0.5% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	17.1	1.2	4	0.4	5	1.0
2	17.6	1.2	4	0.4	5	1.0
3	17.3	1.2	4	0.4	5	1.0

Table 21 - Delcambre Erath 2025 2% Hydraulic Boundary Conditions						
Segment	**Surface Water Elevation (ft)**		**Significant Wave Height (ft)**		**Peak Period (s)**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
1	10.7	1.2	2	0.2	6	1.2
2	10.6	1.2	2	0.2	6	1.2

Table 22 - Delcambre Erath 2075 2% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	15.4	1.2	3	0.3	6	1.2
2	15.4	1.2	4	0.4	7	1.4

Table 23 - Delcambre Erath 2025 1% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	12.1	1.2	3	0.3	7	1.4
2	12	1.2	3	0.3	7	1.4

Table 24 - Delcambre Erath 2075 1% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	17	1.2	4	0.4	7	1.4
2	17	1.2	5	0.5	7	1.4

Table 25 - Delcambre Erath 2025 0.5% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	13.1	1.2	3	0.3	8	1.6
2	13.1	1.2	4	0.4	8	1.6

Table 26 - Delcambre Erath 2075 0.5% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	18.1	1.2	5	0.5	8	1.6
2	18.2	1.2	5	0.5	8	1.6

Table 27 - Lake Charles Westbank Sulphur South 2025 2% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	8.4	1.2	1	0.1	2	0.4
2	9.3	1.2	1	0.1	2	0.4
3	9.3	1.2	1	0.1	2	0.4
4	10	1.2	1	0.1	2	0.4

Table 28 - Lake Charles Westbank Sulphur South 2075 2% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	13.4	1.2	2	0.2	3	0.6
2	13.3	1.2	2	0.2	3	0.6
3	13	1.2	2	0.2	3	0.6
4	13.1	1.2	2	0.2	3	0.6

Table 29 - Lake Charles Westbank Sulphur South 2025 1% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	11.2	1.2	2	0.2	3	0.6
2	11.2	1.2	2	0.2	3	0.6
3	11.2	1.2	2	0.2	3	0.6
4	11.7	1.2	2	0.2	3	0.6

Table 30 - Lake Charles Westbank Sulphur South 2075 1% Hydraulic Boundary Conditions						
Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	17.2	1.2	3	0.3	4	0.8
2	16	1.2	3	0.3	4	0.8
3	15.4	1.2	3	0.3	4	0.8
4	15.4	1.2	3	0.3	4	0.8

Table 31 - Lake Charles Westbank Sulphur South 2025 0.5% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	12.6	1.2	2.5	0.3	4	0.8
2	12.5	1.2	2.5	0.3	4	0.8
3	12.5	1.2	2.5	0.3	4	0.8
4	12.9	1.2	2.5	0.3	4	0.8

Table 32 - Lake Charles Westbank Sulphur South 2075 0.5% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	18.8	1.2	4	0.4	5	1.0
2	17.5	1.2	4	0.4	5	1.0
3	17	1.2	4	0.4	5	1.0
4	16.8	1.2	4	0.4	5	1.0

Table 33 - Abbeville Ring Levee 2025 2% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	10.5	1.2	1	0.1	2	0.4
2	10.5	1.2	1	0.1	2	0.4
3	9.7	1.2	1	0.1	2	0.4

Table 34 - Abbeville Ring Levee 2075 2% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	15.4	1.2	2	0.2	3	0.6
2	15.4	1.2	2	0.2	3	0.6
3	14.9	1.2	2	0.2	3	0.6

Table 35 - Abbeville Ring Levee 2025 1% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)	Significant Wave Height (ft)	Peak Period (s)

	Mean	Std	Mean	Std	Mean	Std
1	11.8	1.2	2	0.2	3	0.6
2	11.8	1.2	2	0.2	3	0.6
3	11.5	1.2	2	0.2	3	0.6

Table 36 - Abbeville Ring Levee 2075 1% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	16.8	1.2	3	0.3	4	0.8
2	16.8	1.2	3	0.3	4	0.8
3	17	1.2	3	0.3	4	0.8

Table 37 - Abbeville Ring Levee 2025 0.5% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	12.8	1.2	2.5	0.3	4	0.8
2	12.8	1.2	2.5	0.3	4	0.8
3	12.8	1.2	2.5	0.3	4	0.8

Table 38 - Abbeville Ring Levee 2075 0.5% Hydraulic Boundary Conditions

Segment	Surface Water Elevation (ft)		Significant Wave Height (ft)		Peak Period (s)	
	Mean	Std	Mean	Std	Mean	Std
1	17.8	1.2	4	0.4	5	1.0
2	17.8	1.2	4	0.4	5	1.0
3	18.2	1.2	4	0.4	5	1.0

The 2025 and 2075 2%, 1%, and 0.5% hydraulic boundary conditions were then used to compute the 2025 and 2075 2%, 1%, and 0.5% annual exceedence levee design elevations. All levees were designed using a slope of 1 on 3. The design criteria for the levees are as follows:

- For the design still water, wave height and wave period, the maximum allowable average wave overtopping of 0.1 cubic feet per second per foot (cfs/ft) at 90% level of assurance and 0.01 cfs/ft at 50% level of assurance for grass-covered levees;
- No minimum freeboard required.

The application of a Monte Carlo analysis was used to determine the levee design elevation. In the Monte Carlo analysis, the overtopping algorithm is repeated to compute the overtopping rate many times. Based on these outputs, a statistical distribution can be derived from the resulting overtopping rates. The parameters that are included in the Monte Carlo analysis are the 1% surge elevation, wave height and wave period.

To determine the overtopping rate in the Monte Carlo analysis, the probabilistic overtopping formulations from Van der Meer (TAW, 2002) are applied for levees (see Figure 11). Along with the geometric parameters (levee height and slope), hydraulic input parameters for determination of the overtopping rate in Equations 1 and 2 are the water elevation (ζ), the significant wave height (H_s) and the peak wave period (T_p).

Van der Meer overtopping formulations

The overtopping formulation from Van der Meer reads (TAW, 2002):

$$\frac{q}{\sqrt{gH_{m0}^3}} = \frac{0.067}{\sqrt{\tan\alpha}}\gamma_b\xi_0 \exp\left(-4.75\frac{R_c}{H_{m0}}\frac{1}{\xi_0\gamma_b\gamma_f\gamma_\beta\gamma_v}\right)$$

$$with \quad \max imum: \quad \frac{q}{\sqrt{gH_{m0}^3}} = 0.2\exp\left(-2.6\frac{R_c}{H_{m0}}\frac{1}{\gamma_f\gamma_\beta}\right) \qquad (1)$$

With:

q : average overtopping rate [cfs/ft]

g : gravitational acceleration [ft/s^2]

H_{m0} : wave height at toe of the structure [ft]

ξ_0: surf similarity parameter [-]

α : slope [-]

R_c : freeboard [ft]

γ : coefficient for presence of berm (b), friction (f), wave incidence (β), vertical wall (v)

The surf similarity parameter $\xi 0$ is defined herein as $\xi_0 = \tan\alpha / \sqrt{s_0}$ with α the angle of slope and s_0 the wave steepness. The wave steepness follows from $s0 = 2\pi H_{m0} / (g\ Tm_{-10}^2)$. The coefficients -4.75 and -2.6 in Equation 1 are the mean values. The standard deviations of these coefficients are equal to 0.5 and 0.35, respectively and these errors are normally distributed (TAW, 2002). The reader is referred to TAW (2002) for definitions of the various coefficients for presence of berm, friction, wave incidence, vertical wall.

Equation 1 is valid for $\xi_0 < 5$ and slopes steeper than 1:8. For values of $\xi_0 > 7$ the following equation is proposed for the overtopping rate:

$$\frac{q}{\sqrt{gH_{m0}^3}} = 10^{-0.92}\exp\left(-\frac{R_c}{\gamma_f\gamma_\beta H_{m0}(0.33+0.022\xi_0)}\right) \qquad (2)$$

The overtopping rates for the range $5 < \xi_0 < 7$ are obtained by linear interpolation of Equation 1 and 2 using the logarithmic value of the overtopping rates. For slopes between 1:8 and 1:15, the solution should be found by iteration. If the slope is less than 1:15, it should be considered as a berm or a foreshore depending on the length of the section compared to the deep water wavelength. The coefficients -0.92 is the mean value. The standard deviation of this coefficient is equal to 0.24 and the error is normally distributed (TAW, 2002).

Figure 11 - Van der Meer Overtopping Formula

Figure 12 graphically shows the overtopping for a levee situation including the most relevant parameters.

In the design process, we use the best estimate 2%, 1%, and 0.5% values for these parameters from the JPM-OS method (Resio, 2007); uncertainty in these values exists. Resio (2007) has provided a method to derive the standard deviation in the 2%, 1%, and 0.5% surge elevations. Standard deviation values of 10% of the average significant wave height and 20% of the peak period were used (Smith, 2006, pers. comm.). In the absence of data, all uncertainties are assumed to be normally distributed.

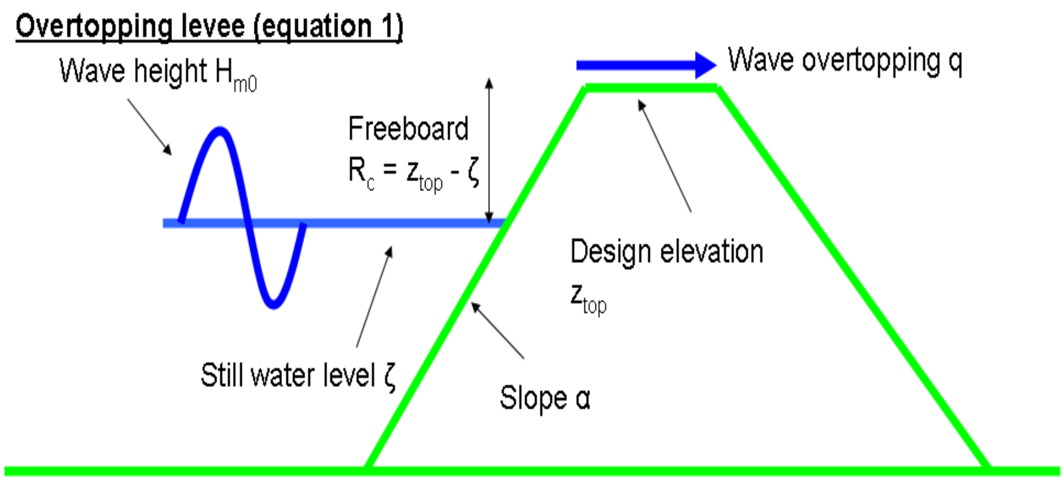

Figure 12 - Definition for Overtopping for Levee

The Monte Carlo Analysis is executed as follows:

1. Draw a random number between 0 and 1 to set the exceedence probability (p).
2. Compute the water elevation from a normal distribution using the mean 1% surge elevation and standard deviation as parameters and with an exceedence probability (p).
3. Draw a random number between 0 and 1 to set the exceedence probability (p).
4. Compute the wave height and wave period from a normal distribution using the mean 1% wave height/wave period and the associated standard deviation and with an exceedence probability (p).
5. Repeat step 3 and 4 for the three overtopping coefficients independently.
6. Compute the overtopping rate for these hydraulic parameters and overtopping coefficients determined in step 2, 4 and 5 using the Van der Meer overtopping formulations for levees or the Franco & Franco equation for floodwalls (see Equations 1 and 2 in the textbox).
7. Repeat the Step 1 through 5 a large number of times. (N)
8. Compute the 50% and 90% confidence limit of the overtopping rate. (i.e. q_{50} and q_{90})

The procedure is implemented in the numerical software package MATLAB because it is a computationally intensive procedure. MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. The computation of the overtopping rate in the present MATLAB routine is limited in the sense that it can only take into account an average slope for the entire cross-section. If a wave berm exists, this effect is included in a berm factor. The following procedure was carried out to determine this berm factor. First, the overtopping rate is computed with PC-Overslag with the best estimates of surge level and waves. Next, the berm factor is calibrated with the Van der Meer overtopping formulations to get exactly same result from PC-Overslag. Then, the berm factor is checked to see if it is in between the recommended range of 0.6 – 1.0. Finally, the calibrated berm factor is applied in the uncertainty analysis (and keep this factor constant) throughout the Monte Carlo analysis in MATLAB.

2.3.2 Results

The analysis was completed and the results were then compiled for levees at the 2%, 1% and 0.5% Design Elevation shown in Table 39 through Table 56.

Table 39 - Lake Charles Westbank Sulphur 2% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	9.0
1	Levee	2075	1V:3H	14.5
2	Levee	2025	1V:3H	8.0
2	Levee	2075	1V:3H	13.5
3	Levee	2025	1V:3H	9.5
3	Levee	2075	1V:3H	17.0

Table 40 - Lake Charles Westbank Sulphur 1% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	13.0
1	Levee	2075	1V:3H	19.5
2	Levee	2025	1V:3H	12.5
2	Levee	2075	1V:3H	19.5
3	Levee	2025	1V:3H	16.0
3	Levee	2075	1V:3H	22.0

Table 41 - Lake Charles Westbank Sulphur 0.5% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	17.0
1	Levee	2075	1V:3H	26.0
2	Levee	2025	1V:3H	16.5
2	Levee	2075	1V:3H	26.5
3	Levee	2025	1V:3H	18.5
3	Levee	2075	1V:3H	26.5

Table 42 - Abbeville to Delcambre Hwy 330 2% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	13.0
1	Levee	2075	1V:3H	19.5
2	Levee	2025	1V:3H	14.0
2	Levee	2075	1V:3H	19.0
3	Levee	2025	1V:3H	13.0
3	Levee	2075	1V:3H	19.5

Table 43 - Abbeville to Delcambre Hwy 330 1% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	15.5
1	Levee	2075	1V:3H	23.0
2	Levee	2025	1V:3H	17.0
2	Levee	2075	1V:3H	23.0
3	Levee	2025	1V:3H	16.0
3	Levee	2075	1V:3H	23.5

Table 44 - Abbeville to Delcambre Hwy 330 0.5% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	18.0
1	Levee	2075	1V:3H	27.0
2	Levee	2025	1V:3H	19.5
2	Levee	2075	1V:3H	27.0
3	Levee	2025	1V:3H	18.5
3	Levee	2075	1V:3H	27.5

Table 45 - Lake Charles Eastbank Sulphur 2% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	12.0
1	Levee	2075	1V:3H	17.0
2	Levee	2025	1V:3H	11.5
2	Levee	2075	1V:3H	17.5
3	Levee	2025	1V:3H	11.5
3	Levee	2075	1V:3H	17.5

Table 46 - Lake Charles Eastbank Sulphur 1% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	15.0
1	Levee	2075	1V:3H	22.0
2	Levee	2025	1V:3H	15.0
2	Levee	2075	1V:3H	22.5
3	Levee	2025	1V:3H	15.0
3	Levee	2075	1V:3H	22.0

Table 47 - Lake Charles Eastbank Sulphur 0.5% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	18.0
1	Levee	2075	1V:3H	26.5
2	Levee	2025	1V:3H	17.5
2	Levee	2075	1V:3H	27.0
3	Levee	2025	1V:3H	17.5
3	Levee	2075	1V:3H	27.0

Table 48 - Delcambre Erath 2% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	15.5
1	Levee	2075	1V:3H	23.0
2	Levee	2025	1V:3H	15.5
2	Levee	2075	1V:3H	26.0

Table 49 - Delcambre Erath 1% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	19.5
1	Levee	2075	1V:3H	27.5
2	Levee	2025	1V:3H	19.5
2	Levee	2075	1V:3H	30.5

Table 50 - Delcambre Erath 0.5% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	21.0
1	Levee	2075	1V:3H	32.0
2	Levee	2025	1V:3H	24.0
2	Levee	2075	1V:3H	32.0

Table 51 - Lake Charles Westbank Sulphur South 2% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	11.0
1	Levee	2075	1V:3H	17.5
2	Levee	2025	1V:3H	11.5
2	Levee	2075	1V:3H	17.5
3	Levee	2025	1V:3H	11.5
3	Levee	2075	1V:3H	17.0
4	Levee	2025	1V:3H	12.5
4	Levee	2075	1V:3H	17.0

Table 52 - Lake Charles Westbank Sulphur South 1% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	15.0
1	Levee	2075	1V:3H	23.5
2	Levee	2025	1V:3H	15.0
2	Levee	2075	1V:3H	22.5
3	Levee	2025	1V:3H	15.0
3	Levee	2075	1V:3H	22.0
4	Levee	2025	1V:3H	16.0
4	Levee	2075	1V:3H	22.0

Table 53 - Lake Charles Westbank Sulphur South 0.5% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	18.0
1	Levee	2075	1V:3H	28.5
2	Levee	2025	1V:3H	18.0
2	Levee	2075	1V:3H	27.0
3	Levee	2025	1V:3H	18.0
3	Levee	2075	1V:3H	26.5
4	Levee	2025	1V:3H	18.5
4	Levee	2075	1V:3H	26.5

Table 54 - Abbeville Ring Levee 2% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	13.0
1	Levee	2075	1V:3H	19.5
2	Levee	2025	1V:3H	13.0
2	Levee	2075	1V:3H	19.5
3	Levee	2025	1V:3H	12.0
3	Levee	2075	1V:3H	19.0

Table 55 - Abbeville Ring Levee 1% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	16.0
1	Levee	2075	1V:3H	23.0
2	Levee	2025	1V:3H	16.0
2	Levee	2075	1V:3H	23.0
3	Levee	2025	1V:3H	15.5
3	Levee	2075	1V:3H	23.5

Table 56 - Abbeville Ring Levee 0.5% Design Elevation				
Segment	**Type**	**Condition**	**Levee Slope**	**Design Elevation (ft) NAVD88 (2004.65)**
1	Levee	2025	1V:3H	18.5
1	Levee	2075	1V:3H	27.5
2	Levee	2025	1V:3H	18.5
2	Levee	2075	1V:3H	27.5
3	Levee	2025	1V:3H	18.5
3	Levee	2075	1V:3H	28.0

2.4 FUTURE WITHOUT PROJECT FREQUENCY CURVES

2.4.1 Methodology

The project covers the Louisiana parishes of Calcasieu, Cameron, and Vermillion. The HEC-RAS model of the Calcasieu Lock Study Feasibility Study was originally calibrated to the November 5, 2002 rainfall event and verified to the August 28 to September 6, 2001 rainfall event, and Agency Technical Review was performed. Since damages from rainfall runoff is not the primary objective for this hurricane and storm surge damage reduction study, the additional areas that were added for the requirements of this study did not need to be recalibrated and verified again.

The study area consists of multiple hydrologic storage areas connected to each other at the lowest perimeter point. Each area has a storage area curve that is basically elevation versus volume in acre-feet. The maximum water surface elevation of each storage area for any given event will have all elevations below that maximum inundated, even if for a very short time. The stage frequency results from each storage area are input into HEC-FDA to perform economic analysis.

The existing conditions year for this study is 2013 and the assumed base year is 2025 (base conditions). The Future Without Project (FWOP) conditions would apply 50 years after construction, or in 2075. For this effort only Intermediate Sea Level Rise was analyzed. This was calculated from a spreadsheet created using guidelines of EC1165-2-212, which combines the total settlement for each of the four downstream gages with the standard accumulation of Intermediate Sea Level Rise for both 2025 and 2075. There are 45 storage areas from the original model, plus an additional 36 storage areas that were added to the eastern and western sides to the model. This created an additional 5 storage areas from the original model and an additional 4 areas in the newly added areas. There were no new channel cross sections taken for the new areas. However, the results of the newer areas were very similar to the pre-existing areas. The nomenclature of the original model storage areas all begin with "SA-", while the additional areas all begin with "XA-". Any storage area with a suffix behind it (such as "-RL" for Ring Levee) represents an anticipated division of an existing area from a possible alternative. A schematic of the HEC-RAS storage areas can be seen in Figure 13.

Four different downstream boundary conditions were used for base and future conditions. They are the following structures: the Calcasieu Lock West, Catfish Point South, Leland Bowman East, and Schooner Bayou East. For base conditions runs, the steady state average elevation of 0.62 was used as the boundary condition for all four locks. The amounts of Relative Sea Level Rise (RSLR) at the Intermediate Level 1 calculated from the spreadsheet mentioned above and based upon EC1165-2-212, were added to existing conditions for each gage to reflect subsidence and the amount of time after 2013. The HEC-RAS model was used to obtain the maximum water surface elevations in each storage area for the 100% as well as the 50%, 20%, 10%, 4%, 2%, and 1% Annual Exceedance Probability (AEP) rainfall events. An ADCIRC storm surge model was run for the same project using the similar storage areas. The storage areas that were not the same were adjusted for comparison purposes. The HEC RAS model results were plotted with the 1% ADCIRC storm surge elevations in the same storage areas in order to determine the governing source of the maximum water surface elevations at the 1% frequency. In most cases, the 1% surge elevations were much greater than the 1% rainfall elevations. In storage areas further north, away from the Gulf of Mexico and the rivers or bayous, the differences between the two decreases until rainfall governs and surge effects are not observed. This situation occurred in less than 10 percent of all storage areas. Land use areas coded into ADCIRC are shown in Figure 14.

ADCIRC surge elevations were available for the 1% and 0.2% AEP events. In order to estimate ADCIRC water elevations for the more frequent events, values were extrapolated between the 1-year HEC-RAS and 100-year ADCIRC results. Basically, the 1-year event would be equal in HEC-RAS and ADICRC (if ADCIRC could be run for the 1-year event). The next step was to find the difference between the 100-year HEC-RAS and 100-year ADCIRC results. The closer the storage area is to the Gulf of Mexico, the larger this difference would be and vice versa. The difference for each storage area is then divided up for all higher frequencies and added to the HEC-RAS results. The finished results were plotted for each storage area, and many had to be smoothed out to provide a curve that would be reasonably expected. Since HEC-RAS results are based upon Partial Duration TP-40 rainfall amounts, these elevations may be slightly over estimated at higher frequency events. The adjusted curves can be seen on Figure 17. Since the year 2025 is very close to the year 2013, results for 2025 were linearly interpolated between the 2013 existing year and the 2075 FWOP year. This resulted in water surface elevations for every storage area in 2025 greater than or equal to the results of 2013.

Because storm surge effects were not included in HEC-RAS model runs, (boundary conditions were not set to account for higher stages caused by storms) there are some limitations to the developed elevation results. However, HEC-RAS model runs with elevated Gulf stages increased the drainage times of runoff but did not increase the peak stages in the storage areas due to the unique topography of the study area.

An average rate of 7 mm per year of marsh accretion within the southwest coastal Louisiana area was found on page 9 of the ERDC/EL TN-10-5 dated August 2010. There are four types of marsh: fresh, intermediate, brackish, and saline. Open water is not to be included for any marsh accretion analysis. The complete list of marsh storage areas are shown in Table 57, and were obtained by comparing storage area boundaries with a map of the marsh areas shown below. Total marsh accretion amounts were found by adding 7 mm of accretion per year to the existing conditions water surface elevations at each of the four downstream boundary conditions to arrive at 0.28 feet maximum for all areas in 2025 and 1.42 feet maximum for all areas in 2075. For the four partial marsh areas, these values were reduced to 50% or 20%, based upon visual inspection of plan views. The appropriate amount of accretion was added to all elevations above the initial water elevation (or base flow) for each applicable marsh area in the HEC-RAS geometry file. The theory behind this very simple method is that the volume at the water surface would be moved up by the required amount of accretion. Samples from two marsh areas are shown in Figure 15 for both 2025 and 2075. These areas are highlighted in red in Table 57. Note that one of these areas only has a 50% accretion rate due to the amount of open water.

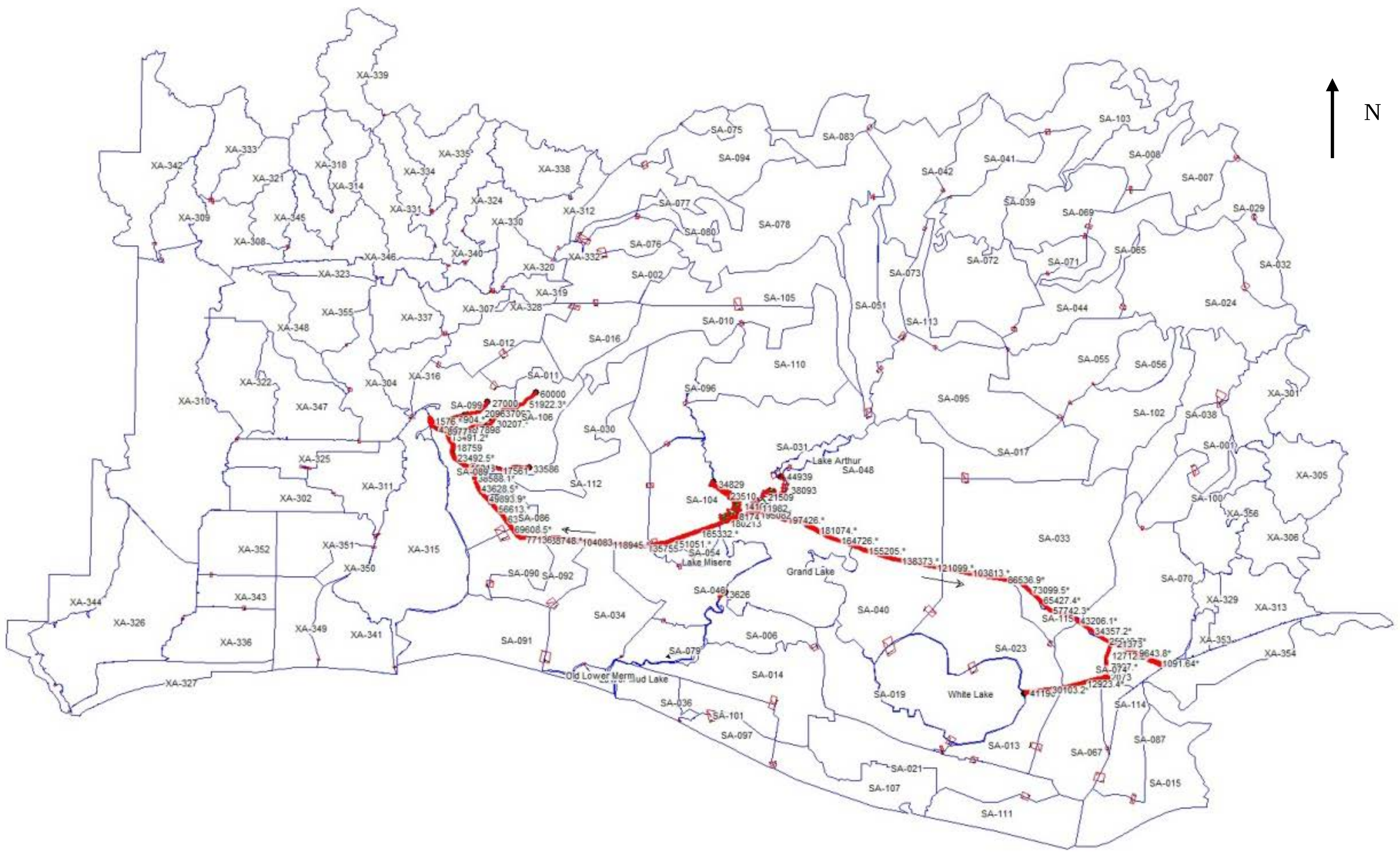

Figure 13 - HEC RAS Storage Areas

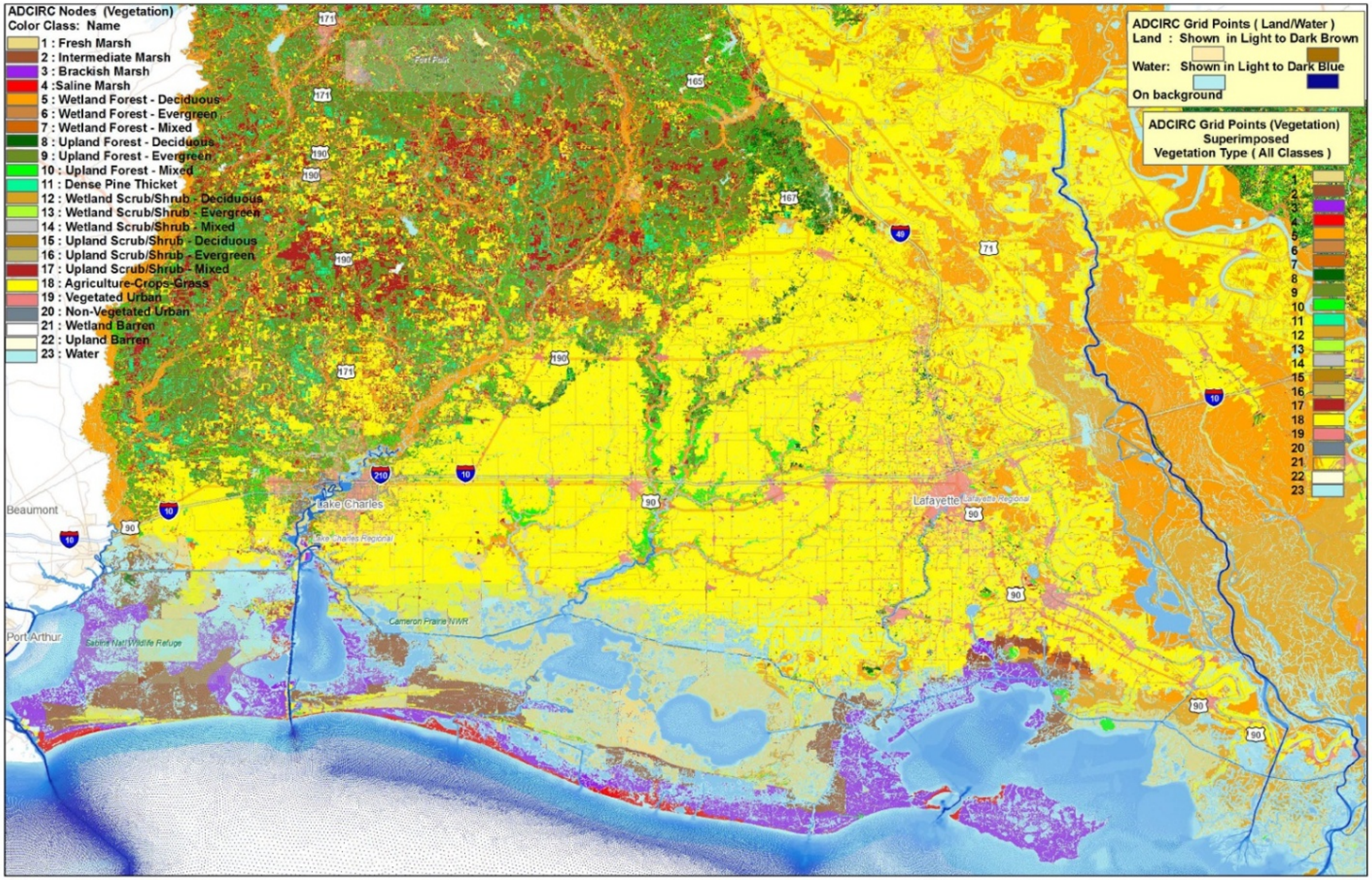

Figure 14 - Land Use Areas Coded Into ADCIRC

Table 57 - Marsh Storage Areas

Area	Min Elev	Base Flow Elev	Marsh %	2075 total (ft.)
SA-006	-6.00	-0.50	100	1.42
SA-013	-5.00	-3.80	100	1.42
SA-014	-5.00	-1.70	100	1.42
SA-015	-8.00	-2.00	100	1.42
SA-019	-4.00	-2.15	100	1.42
SA-021	-5.00	-1.53	100	1.42
SA-023	-7.00	-2.00	100	1.42
SA-034	-5.00	-1.39	100	1.42
SA-036	-3.00	-1.30	100	1.42
SA-040	-4.00	-2.04	100	1.42
SA-046	-3.00	-1.00	100	1.42
SA-054	-2.00	0.57	100	1.42
SA-067	-4.00	-2.00	100	1.42
SA-074	-6.00	0.60	100	1.42
SA-079	-3.00	-1.00	100	1.42
SA-086	-3.00	1.20	100	1.42
SA-087	-5.00	-5.00	100	1.42
SA-089	-3.00	-1.11	100	1.42
SA-090	-3.00	-0.50	100	1.42
SA-091	-15.00	-1.30	100	1.42
SA-092	-4.00	-0.95	100	1.42
SA-097	-3.00	-1.30	100	1.42
SA-101	-5.00	-1.00	100	1.42
SA-107	-3.00	-1.30	100	1.42
SA-111	-3.00	-1.30	100	1.42
SA-114	-3.00	-1.00	100	1.42
SA-115	-5.00	-2.99	100	1.42
XA-326	-3.00	0.47	100	1.42
XA-327	-3.00	0.00	100	1.42
XA-336	-2.00	1.12	100	1.42
XA-341	-2.00	0.00	100	1.42
XA-343	-2.00	1.67	100	1.42
XA-344	-3.00	0.45	100	1.42
XA-349	-3.00	0.00	100	1.42
XA-354	-3.00	0.00	100	1.42
SA-048	-6.00	-1.99	50	0.71
SA-104	-4.00	-1.77	50	0.71
SA-112	-15.00	0.00	50	0.71
SA-031	-20.00	-2.82	20	0.28

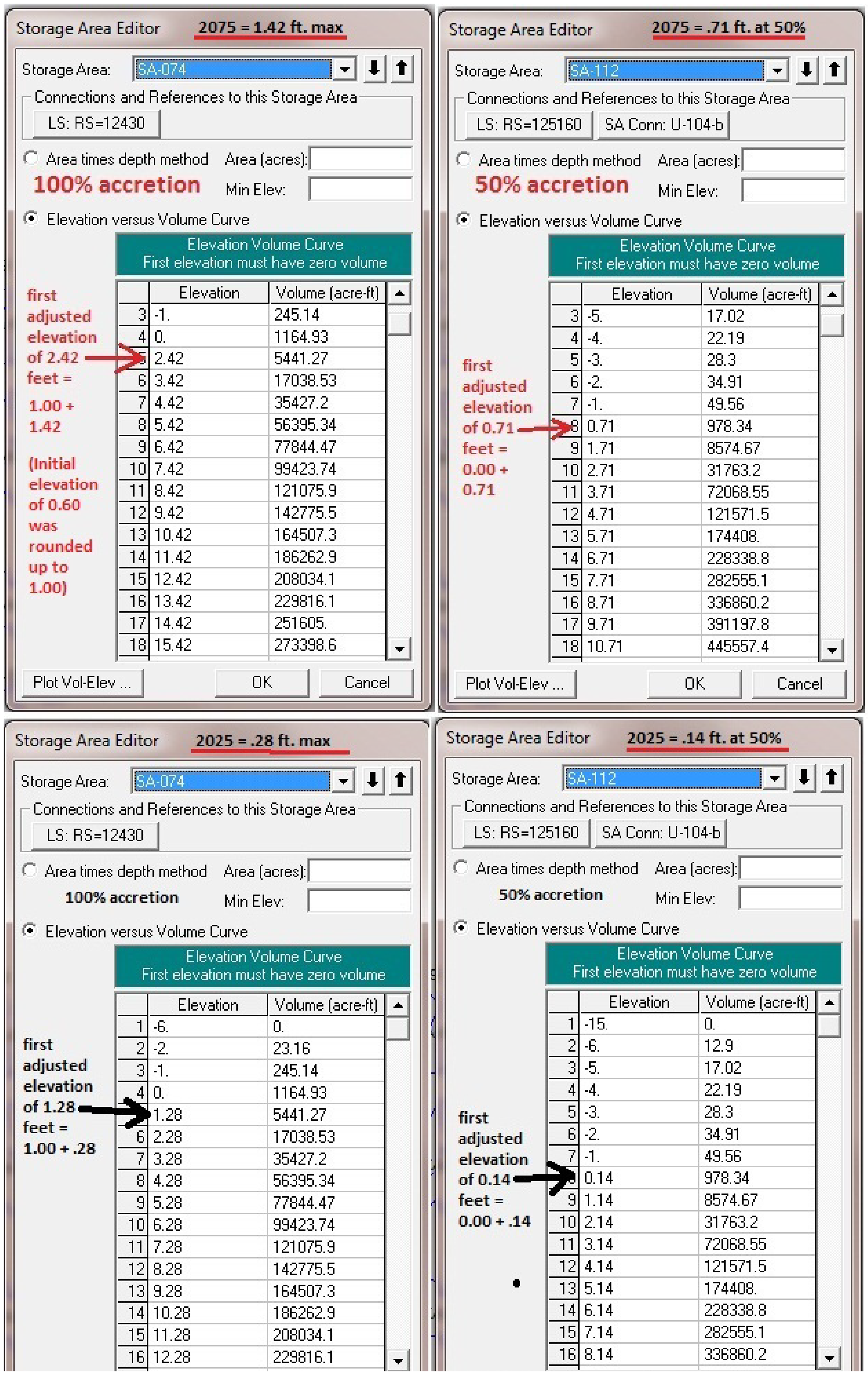

Figure 15 - Adjusted Storage Areas

The full 100% amount of accretion was then subtracted from all four downstream boundary condition elevations that had already been adjusted for Intermediate RSLR. In theory, this would negate the effects of RSLR, but in reality, only the marsh areas saw increased water levels due to higher theoretical land elevations. This caused a very minor backwater effect of less than 0.20 feet in only a few of the upland areas. These adjusted boundary conditions are shown below in Table 58.

Table 58 - Adjusted Boundary Conditions

River	Reach	River Sta	Plan	W.S. Elev (ft)	All are based upon Intermediate RSLR
GIWW	1	62	S75b001	2.04	2075 w/o marsh accretion at Calcasieu Lock West
GIWW	1	62	S25b001	0.84	2025 w/p marsh accretion at Calcasieu Lock West
GIWW	1	62	M75b001	0.62	2075 with marsh accretion at Calcasieu Lock West
GIWW	1	62	M25b001	0.56	2025 with marsh accretion at Calcasieu Lock West
GIWW	7	0	S75b001	2.45	2075 w/o marsh accretion at Leland Bowman East
GIWW	7	0	S25b001	0.92	2025 w/p marsh accretion at Leland Bowman East
GIWW	7	0	M75b001	1.03	2075 with marsh accretion at Leland Bowman East
GIWW	7	0	M25b001	0.64	2025 with marsh accretion at Leland Bowman East
Grand Lake	2 (Mem	134	S75b001	2.62	2075 w/o marsh accretion at Catfish Point South
Grand Lake	2 (Mem	134	S25b001	0.95	2025 w/p marsh accretion at Catfish Point South
Grand Lake	2 (Mem	134	M75b001	1.20	2075 with marsh accretion at Catfish Point South
Grand Lake	2 (Mem	134	M25b001	0.67	2025 with marsh accretion at Catfish Point South
Schooner Bayou	1	1319	S75b001	2.35	2075 w/o marsh accretion at Schooner Bayou East
Schooner Bayou	1	1319	S25b001	0.90	2025 w/p marsh accretion at Schooner Bayou East
Schooner Bayou	1	1319	M75b001	0.93	2075 with marsh accretion at Schooner Bayou East
Schooner Bayou	1	1319	M25b001	0.62	2025 with marsh accretion at Schooner Bayou East

The HEC-RAS model was rerun with the above downstream boundary conditions for 100%-1% rainfall events and the results found were within a range of 1.42 feet maximum to the same runs without marsh accretion. Since the 1% ADCIRC surge elevations were much higher than the 1% HEC-RAS results in most cases, the surge elevations usually governed. The difference between marsh accretion and no accretion at the 100% event for each specific storage area was then linearly interpolated and then added to the 50% through 2% HEC-RAS results from the runs that did not consider marsh accretion. Two areas were chosen to portray this pattern and are shown in Figure 16 and Figure 17. Note that the effect of marsh accretion is much more noticeable in the area on the Gulf itself.

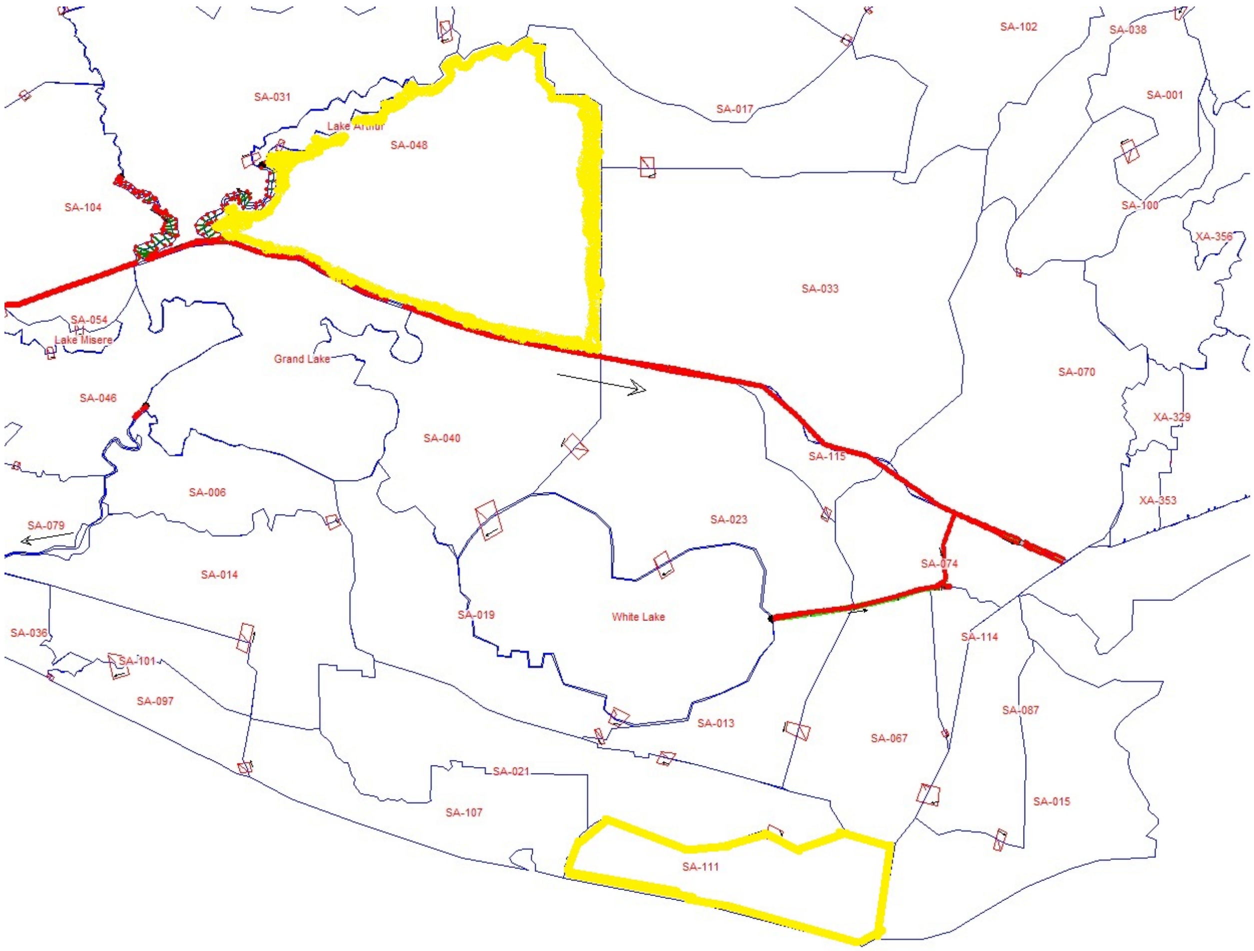

Figure 16 - Storage Areas

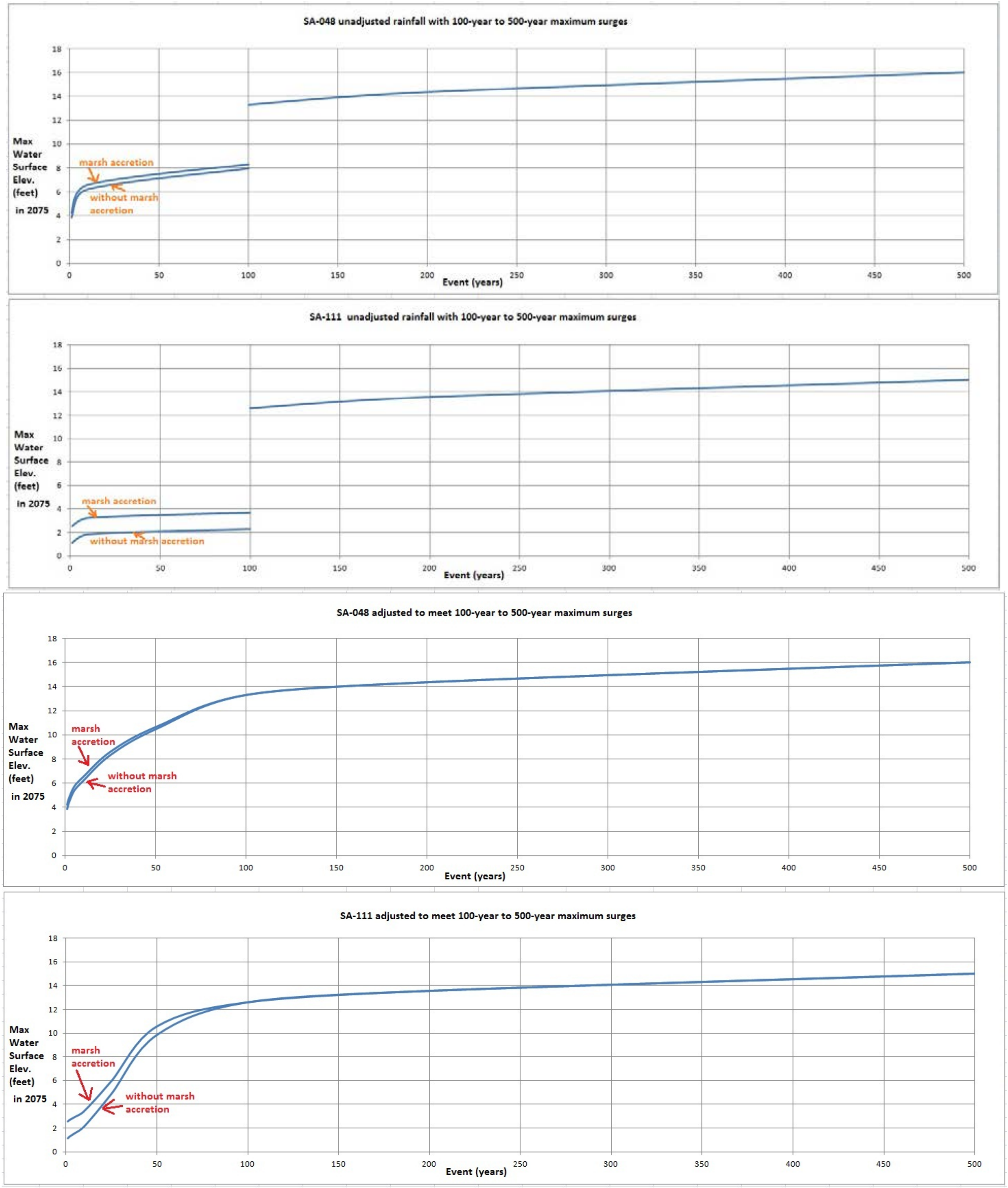

Figure 17 - Adjusted Curves

Table 59 - FWOP With Marsh Accretion

*Values are in feet.

Storage Area	M2025-001	M2025-002	M2025-005	M2025-010	M2025-025	M2025-050	M2025-100	M2025-200	M2025-500
SA-001	5.09	5.52	6.28	6.76	7.61	8.46	9.60	10.36	11.50
SA-006	0.69	0.89	1.27	1.70	3.85	7.74	9.80	10.24	10.90
SA-010	6.44	7.06	8.04	8.71	9.32	9.77	10.20	10.20	10.20
SA-011	8.71	8.86	9.57	10.55	11.28	11.87	12.27	12.34	12.50
SA-012	7.53	8.35	9.69	10.73	11.57	12.17	12.73	12.73	12.73
SA-013	0.93	1.16	1.42	1.91	4.35	8.75	11.10	12.02	13.40
SA-014	0.75	0.97	1.33	1.87	4.61	9.56	12.20	13.32	15.00
SA-015	-1.49	-1.36	-1.10	-0.43	2.95	9.03	12.40	13.40	14.90
SA-016	12.48	13.45	15.06	15.94	16.61	17.09	17.48	17.48	17.48
SA-017	2.46	2.85	3.42	3.90	4.62	5.34	6.30	7.22	8.60
SA-017-RL	2.46	2.85	3.42	3.90	4.62	5.34	6.30	7.22	8.60
SA-019	0.82	1.04	1.32	1.77	4.06	8.18	10.40	11.40	12.90
SA-021	1.01	1.25	1.49	2.00	4.58	9.22	11.70	12.62	14.00
SA-023	0.58	0.73	1.02	1.39	3.27	6.66	8.50	9.02	9.80
SA-030	4.49	4.97	5.51	5.99	6.30	6.70	7.30	8.54	10.40
SA-031	4.08	4.74	5.91	6.82	7.59	8.14	8.65	8.73	8.90
SA-033	2.50	2.90	3.47	3.96	4.84	5.72	6.90	7.74	9.00
SA-033-RL	2.50	2.90	3.47	3.96	4.84	5.72	6.90	7.74	9.00
SA-034	1.40	1.57	1.84	2.40	5.26	10.39	13.10	14.34	16.20
SA-036	0.91	1.17	1.43	1.99	4.77	9.81	12.50	13.54	15.10
SA-038	10.03	10.90	11.95	12.41	12.83	13.09	13.28	13.28	13.28
SA-040	0.58	0.74	1.03	1.32	2.82	5.54	7.00	7.88	9.20
SA-046	1.78	2.17	2.58	2.88	4.43	7.21	8.60	9.92	11.90
SA-048	3.88	4.44	5.44	6.25	6.95	7.44	7.92	8.12	8.60
SA-054	1.38	1.52	1.74	1.98	3.22	5.47	6.60	7.36	8.50
SA-067	0.93	1.16	1.42	1.89	4.26	8.53	10.80	11.80	13.30
SA-070	2.63	3.04	3.68	4.05	5.88	9.17	11.00	11.72	12.80
SA-070-N	2.63	3.04	3.68	4.05	5.88	9.17	11.00	11.72	12.80
SA-070-S	2.63	3.04	3.68	4.05	5.88	9.17	11.00	11.72	12.80
SA-074	1.65	1.81	2.10	2.55	4.79	8.84	11.00	11.60	12.50
SA-079	1.77	2.15	2.56	2.92	4.77	8.10	9.80	11.12	13.10
SA-086	1.69	1.79	1.96	2.27	3.87	6.75	8.30	9.38	11.00
SA-087	-0.05	0.15	0.54	1.04	3.53	8.02	10.50	11.38	12.70
SA-089	0.99	1.19	1.46	1.84	3.81	7.35	9.20	10.16	11.60
SA-090	1.00	1.20	1.47	1.81	3.55	6.68	8.30	9.38	11.00
SA-091	1.35	1.54	1.74	2.22	4.62	8.96	12.80	12.85	14.20
SA-092	1.08	1.28	1.54	1.83	3.32	6.03	7.40	8.32	9.70
SA-096	2.22	2.40	2.76	3.08	4.24	5.77	6.90	7.78	9.10
SA-097	0.91	1.16	1.45	1.98	4.63	9.44	12.00	13.28	15.20
SA-099	7.52	8.34	9.68	10.71	11.55	12.14	12.71	12.71	12.71
SA-099-RL	7.52	8.34	9.68	10.71	11.55	12.14	12.71	12.71	12.71
SA-100	2.63	3.04	3.68	4.20	5.82	7.98	9.60	10.36	11.50
SA-101	0.78	1.01	1.35	1.90	4.72	9.79	12.50	13.58	15.20
SA-104	2.17	2.33	2.65	2.98	4.10	5.61	6.70	7.46	8.60
SA-106	4.46	4.93	5.48	5.96	6.99	8.02	9.40	10.36	11.80

Storage Area	M2075-001	M2075-002	M2075-005	M2075-010	M2075-025	M2075-050	M2075-100	M2075-200	M2075-500
SA-001	5.09	5.52	6.28	6.76	8.78	10.80	13.50	14.42	15.80
SA-006	1.82	2.01	2.35	2.77	5.04	9.14	10.90	11.78	13.10
SA-010	6.52	7.14	8.12	8.78	9.38	9.81	10.20	10.20	10.20
SA-011	8.71	8.86	9.58	10.56	11.29	12.05	13.20	14.29	16.00
SA-012	7.53	8.34	9.68	10.71	11.57	12.16	13.20	14.29	16.00
SA-013	2.04	2.26	2.48	2.99	5.69	10.58	12.80	13.72	15.10
SA-014	1.88	2.09	2.41	2.94	5.71	10.73	13.00	14.04	15.60
SA-015	-1.46	-1.33	-1.07	-0.36	3.21	9.65	13.20	14.12	15.50
SA-016	12.48	13.45	15.07	15.94	16.61	17.09	17.48	17.48	17.48
SA-017	2.46	2.85	3.42	3.90	6.48	9.06	12.50	14.18	16.70
SA-017-RL	2.46	2.85	3.42	3.90	6.48	9.06	12.50	14.18	16.70
SA-019	1.56	1.77	2.03	2.50	4.89	9.23	11.30	12.14	13.40
SA-021	2.12	2.34	2.55	3.06	5.74	10.59	12.80	13.68	15.00
SA-023	0.97	1.12	1.40	1.91	4.47	9.10	11.50	12.46	13.90
SA-030	4.49	4.91	5.45	5.90	7.69	9.48	11.90	13.66	16.30
SA-031	4.40	5.06	6.22	7.12	9.11	11.06	13.60	14.65	16.30
SA-033	2.50	2.90	3.46	3.95	6.39	8.83	12.10	13.14	14.70
SA-033-RL	2.50	2.90	3.46	3.95	6.39	8.83	12.10	13.14	14.70
SA-034	2.33	2.49	2.74	3.31	6.32	11.76	14.30	15.42	17.10
SA-036	2.04	2.29	2.51	3.07	6.02	11.35	13.80	14.96	16.70
SA-038	10.03	10.90	11.95	12.41	12.83	13.09	13.28	13.28	13.28
SA-040	0.98	1.14	1.42	1.93	4.52	9.19	11.60	12.80	14.60
SA-046	2.58	2.96	3.34	3.77	6.02	10.08	11.90	12.86	14.30
SA-048	4.20	4.75	5.74	6.53	8.60	10.64	13.30	14.35	16.00
SA-054	2.39	2.52	2.71	3.16	5.58	9.95	11.90	12.86	14.30
SA-067	2.05	2.27	2.49	2.98	5.54	10.20	12.30	13.06	14.20
SA-070	2.63	3.04	3.68	4.16	6.54	10.82	13.20	14.32	16.00
SA-070-N	2.63	3.04	3.68	4.16	6.54	10.82	13.20	14.32	16.00
SA-070-S	2.63	3.04	3.68	4.16	6.54	10.82	13.20	14.32	16.00
SA-074	2.71	2.85	3.11	3.58	6.03	10.49	12.50	13.38	14.70
SA-079	2.57	2.94	3.32	3.76	6.06	10.23	12.10	13.10	14.60
SA-086	2.12	2.20	2.37	2.88	5.51	10.26	12.70	13.94	15.80
SA-087	0.33	0.53	0.90	1.48	4.39	9.64	12.40	13.08	14.10
SA-089	2.04	2.23	2.46	2.98	5.72	10.66	12.90	14.22	16.20
SA-090	2.05	2.24	2.47	2.98	5.66	10.51	12.70	13.86	15.60
SA-091	2.26	2.44	2.61	3.13	5.88	10.85	13.10	14.22	15.90
SA-092	2.10	2.29	2.51	3.01	5.66	10.45	12.60	13.72	15.40
SA-096	2.68	2.85	3.20	3.72	6.37	11.14	13.60	14.92	16.90
SA-097	2.04	2.28	2.53	3.08	5.94	11.13	13.50	14.58	16.20
SA-099	7.52	8.34	9.67	10.70	11.54	12.49	13.90	15.07	16.90
SA-099-RL	7.52	8.34	9.67	10.70	11.54	12.49	13.90	15.07	16.90
SA-100	2.63	3.04	3.68	4.17	6.63	11.05	13.50	14.42	15.80
SA-101	1.91	2.13	2.43	2.97	5.79	10.88	13.20	14.40	16.20
SA-104	2.65	2.81	3.11	3.60	6.61	10.60	12.90	13.94	15.50
SA-106	4.47	4.90	5.44	5.90	8.10	10.32	13.30	14.46	16.20

Storage Area	M2025-001	M2025-002	M2025-005	M2025-010	M2025-025	M2025-050	M2025-100	M2025-200	M2025-500
SA-107	1.23	1.41	1.71	2.22	4.79	9.43	11.90	12.82	14.20
SA-111	1.43	1.58	1.87	2.35	4.78	9.17	11.50	12.54	14.10
SA-112	2.19	2.37	2.71	3.02	4.56	6.60	8.10	9.10	10.60
SA-114	0.93	1.16	1.41	1.87	4.16	8.30	10.50	11.26	12.40
SA-115	0.58	0.73	1.02	1.46	3.72	7.79	10.00	10.52	11.30
XA-302	1.42	1.62	2.00	2.31	3.83	6.58	8.10	9.54	11.70
XA-304	4.22	4.75	5.72	6.49	7.54	8.60	10.00	11.08	12.70
XA-304-RL	4.22	4.75	5.72	6.49	7.54	8.60	10.00	11.08	12.70
XA-305	4.72	5.27	6.12	6.73	8.01	9.72	11.00	11.96	13.40
XA-306	4.77	5.31	6.16	6.77	8.04	9.31	11.00	11.96	13.40
XA-307	5.85	6.53	7.73	8.67	9.47	10.05	10.61	11.21	12.60
XA-310	3.02	3.27	3.64	3.92	5.37	7.98	9.40	10.36	11.80
XA-311	1.52	1.75	2.12	2.47	4.22	7.36	9.10	10.34	12.20
XA-313	1.28	1.46	1.83	2.34	4.91	9.57	12.10	12.86	14.00
XA-315	1.87	2.13	2.57	2.90	4.53	7.48	9.10	10.06	11.50
XA-316	2.24	2.56	3.11	3.47	5.24	8.44	10.20	11.16	12.60
XA-316-RL	2.24	2.56	3.11	3.47	5.24	8.44	10.20	11.16	12.60
XA-319	5.58	6.09	6.97	7.69	8.33	8.83	9.30	10.20	12.30
XA-320	5.76	6.33	7.34	8.16	8.86	9.36	9.86	10.73	12.10
XA-322	2.24	2.48	2.97	3.28	4.82	6.86	8.40	9.76	11.80
XA-324	10.61	11.94	14.12	15.70	17.02	17.89	18.71	18.71	18.71
XA-325	1.73	1.98	2.35	2.69	4.41	7.49	9.20	10.24	11.80
XA-326	2.05	2.21	2.48	2.80	4.44	7.40	9.00	10.20	12.00
XA-327	1.90	2.10	2.38	2.92	5.63	10.52	13.20	14.60	16.70
XA-329	1.27	1.42	1.77	2.28	4.84	9.46	12.00	12.64	13.60
XA-331	10.14	11.36	13.30	14.76	15.95	16.75	17.54	17.54	17.54
XA-336	1.98	2.17	2.40	2.94	5.65	10.53	13.20	14.60	16.70
XA-337	3.48	4.04	5.02	5.76	7.10	8.43	10.20	11.16	12.60
XA-340	9.97	11.18	13.06	14.38	15.44	16.18	16.90	16.90	16.90
XA-341	1.60	1.82	2.22	2.76	5.49	10.40	13.10	14.42	16.40
XA-343	2.16	2.26	2.45	2.77	4.37	7.25	8.80	10.04	11.90
XA-344	2.33	2.51	2.79	3.11	4.70	7.56	9.10	10.58	12.80
XA-346	13.38	14.94	17.09	18.41	19.45	20.14	20.81	20.81	20.81
XA-347	2.24	2.47	2.95	3.26	4.83	7.64	9.20	10.24	11.80
XA-347-RL	2.24	2.47	2.95	3.26	4.83	7.64	9.20	10.24	11.80
XA-348	5.23	5.90	7.09	7.94	8.66	9.20	10.00	11.08	12.70
XA-348-RL	5.23	5.90	7.09	7.94	8.66	9.20	10.00	11.08	12.70
XA-349	1.42	1.61	2.03	2.43	4.49	8.19	10.20	10.88	11.90
XA-350	1.59	1.81	2.23	2.66	4.80	8.67	10.80	11.08	11.50
XA-351	1.60	1.83	2.22	2.54	4.10	6.94	8.50	9.70	11.50
XA-352	2.48	2.63	2.93	3.22	4.70	7.36	8.80	10.04	11.90
XA-353	1.23	1.41	1.76	2.24	4.69	9.09	11.50	12.02	12.80
XA-354	1.33	1.52	1.90	2.39	4.83	9.21	11.60	12.36	13.50
XA-355	8.39	8.68	9.19	9.56	9.94	10.18	10.44	10.44	10.44
XA-356	5.10	5.63	6.49	7.13	8.20	9.27	10.70	11.50	12.70

Storage Area	M2075-001	M2075-002	M2075-005	M2075-010	M2075-025	M2075-050	M2075-100	M2075-200	M2075-500
SA-107	2.36	2.53	2.79	3.29	5.92	10.67	12.80	13.88	15.50
SA-111	2.57	2.71	2.96	3.44	5.98	10.57	12.60	13.56	15.00
SA-112	2.66	2.83	3.16	3.63	6.04	10.39	12.60	13.80	15.60
SA-114	2.04	2.26	2.48	2.97	5.54	10.20	12.30	13.10	14.30
SA-115	0.97	1.12	1.40	1.93	4.59	9.40	11.90	13.02	14.70
XA-302	1.45	1.65	2.03	2.62	5.53	10.79	13.70	15.10	17.20
XA-304	4.24	4.77	5.74	6.51	8.97	11.43	14.70	15.94	17.80
XA-304-RL	4.24	4.77	5.74	6.51	8.97	11.43	14.70	15.94	17.80
XA-305	4.72	5.27	6.12	6.57	9.30	12.93	15.20	16.16	17.60
XA-306	4.77	5.31	6.16	6.77	9.30	11.83	15.20	16.16	17.60
XA-307	5.89	6.57	7.77	8.71	9.82	10.93	12.40	13.41	15.00
XA-310	3.36	3.61	3.96	4.46	7.01	11.60	14.00	15.92	18.80
XA-311	1.57	1.80	2.17	2.73	5.61	10.76	13.60	15.04	17.20
XA-313	1.69	1.86	2.22	2.82	5.88	11.42	14.30	15.10	16.30
XA-315	2.02	2.28	2.71	3.20	5.69	10.18	12.60	14.16	16.50
XA-316	2.38	2.70	3.24	3.77	6.46	11.28	13.90	15.10	16.90
XA-316-RL	2.38	2.70	3.24	3.77	6.46	11.28	13.90	15.10	16.90
XA-319	5.60	6.11	6.99	7.71	9.12	10.53	12.40	13.41	15.00
XA-320	5.78	6.35	7.36	8.18	9.45	10.72	12.40	13.41	15.00
XA-322	2.24	2.48	2.97	3.51	6.19	11.02	13.70	15.74	18.80
XA-324	10.61	11.94	14.12	15.70	17.02	17.89	18.71	18.71	18.71
XA-325	1.74	1.99	2.36	2.93	5.77	10.87	13.70	15.10	17.20
XA-326	2.67	2.82	3.07	3.52	5.78	9.88	11.90	13.58	16.10
XA-327	2.45	2.64	2.90	3.47	6.37	11.62	14.30	15.46	17.20
XA-329	1.65	1.80	2.13	2.71	5.67	11.00	13.80	14.92	16.60
XA-331	10.15	11.37	13.31	14.77	15.96	16.76	17.54	17.54	17.54
XA-336	2.62	2.80	3.01	3.57	6.47	11.68	14.30	15.58	17.50
XA-337	3.50	4.06	5.04	5.78	8.01	10.24	13.20	14.32	16.00
XA-340	9.98	11.19	13.07	14.39	15.45	16.19	16.90	16.90	16.90
XA-341	1.78	2.00	2.39	2.98	5.95	11.31	14.20	15.44	17.30
XA-343	2.69	2.78	2.96	3.42	5.76	10.00	12.10	13.38	15.30
XA-344	2.85	3.02	3.29	3.80	6.41	11.12	13.50	15.42	18.30
XA-346	13.38	14.94	17.09	18.41	19.45	20.14	20.81	20.81	20.81
XA-347	2.24	2.47	2.95	3.49	6.18	11.01	13.70	15.10	17.20
XA-347-RL	2.24	2.47	2.95	3.49	6.18	11.01	13.70	15.10	17.20
XA-348	5.23	5.90	7.09	7.94	9.97	12.00	14.70	15.94	17.80
XA-348-RL	5.23	5.90	7.09	7.94	9.97	12.00	14.70	15.94	17.80
XA-349	2.15	2.33	2.73	3.20	5.64	10.05	12.20	13.44	15.30
XA-350	1.72	1.94	2.35	2.84	5.32	9.79	12.20	13.36	15.10
XA-351	1.69	1.92	2.31	2.80	5.28	9.76	12.20	13.36	15.10
XA-352	2.71	2.86	3.15	3.60	5.89	10.02	12.20	13.36	15.10
XA-353	1.57	1.75	2.08	2.67	5.63	10.99	13.80	14.88	16.50
XA-354	1.91	2.09	2.46	3.03	5.99	11.30	14.00	14.72	15.80
XA-355	8.39	8.68	9.19	9.56	9.94	10.18	10.44	10.44	10.44
XA-356	5.10	5.63	6.49	7.13	9.34	11.55	14.50	15.02	15.80

Storage Area	2013-001	2013-002	2013-005	2013-010	2013-025	2013-050	2013-100	2013-200	2013-500
SA-001	5.09	5.53	6.34	6.89	7.46	8.00	8.90	9.83	10.80
SA-006	0.42	0.68	1.24	1.71	2.75	4.33	7.40	8.33	9.30
SA-010	6.43	7.05	8.03	8.70	9.31	9.76	10.21	10.58	10.96
SA-011	8.71	8.86	9.57	10.55	11.28	11.87	12.27	12.73	13.13
SA-012	7.53	8.35	9.69	10.73	11.57	12.17	12.73	13.20	13.62
SA-013	0.67	1.00	1.53	2.17	3.69	6.04	10.60	11.78	13.00
SA-014	0.48	0.79	1.46	2.16	3.85	6.48	11.60	12.87	14.20
SA-015	-1.49	-1.24	-0.63	0.17	2.13	5.20	11.20	12.77	14.40
SA-016	12.48	13.45	15.06	15.94	16.61	17.09	17.48	17.85	18.18
SA-017	2.46	2.85	3.42	3.90	4.25	4.49	5.10	6.30	7.40
SA-017-RL	2.46	2.85	3.42	3.90	4.25	4.49	5.10	6.30	7.40
SA-019	0.62	0.91	1.45	2.06	3.45	5.60	9.80	11.56	13.40
SA-021	0.75	1.08	1.61	2.29	3.89	6.38	11.20	12.47	13.80
SA-023	0.46	0.68	1.18	1.73	2.96	4.84	8.50	9.28	10.10
SA-030	4.49	4.97	5.51	5.99	6.30	6.54	6.79	7.97	9.20
SA-031	4.01	4.67	5.84	6.76	7.54	8.10	8.65	9.11	9.55
SA-033	2.50	2.91	3.52	4.08	4.61	5.19	6.10	8.31	10.60
SA-033-RL	2.50	2.91	3.52	4.08	4.61	5.19	6.10	8.31	10.60
SA-034	1.01	1.28	1.88	2.63	4.40	7.11	12.40	13.92	15.50
SA-036	0.64	1.01	1.60	2.34	4.12	6.93	12.40	13.92	15.50
SA-038	10.03	10.90	11.95	12.41	12.83	13.09	13.28	13.45	13.63
SA-040	0.47	0.67	1.10	1.53	2.41	3.71	6.20	7.13	8.10
SA-046	1.36	1.80	2.37	2.94	3.95	5.37	8.00	9.08	10.20
SA-048	3.79	4.36	5.36	6.18	6.89	7.39	7.92	8.36	8.79
SA-054	1.06	1.24	1.58	1.97	2.72	3.80	5.80	6.63	7.50
SA-067	0.67	0.99	1.51	2.12	3.54	5.74	10.00	10.98	12.00
SA-070	2.63	3.09	3.88	4.65	5.86	7.46	10.30	11.87	13.50
SA-070-N	2.63	3.09	3.88	4.65	5.86	7.46	10.30	11.87	13.50
SA-070-S	2.63	3.09	3.88	4.65	5.86	7.46	10.30	11.87	13.50
SA-074	1.42	1.65	2.18	2.77	4.05	6.04	9.90	11.17	12.50
SA-079	1.35	1.80	2.42	3.07	4.34	6.19	9.70	11.02	12.40
SA-086	1.58	1.73	2.05	2.45	3.32	4.64	7.20	8.57	10.00
SA-087	-0.09	0.20	0.85	1.62	3.18	5.50	10.00	12.16	14.40
SA-089	0.65	0.91	1.36	1.86	2.90	4.49	7.50	9.50	11.10
SA-090	0.66	0.91	1.33	1.77	2.69	4.04	6.60	7.80	8.90
SA-091	0.88	1.18	1.72	2.45	4.25	7.07	12.60	14.32	16.10
SA-092	0.72	0.96	1.38	1.83	2.74	4.08	6.60	7.80	8.90
SA-096	2.13	2.32	2.68	3.01	3.29	3.51	3.75	5.83	8.00
SA-097	0.64	0.99	1.59	2.31	4.02	6.69	11.90	13.27	14.70
SA-099	7.52	8.34	9.67	10.71	11.55	12.14	12.71	13.17	13.59
SA-099-RL	7.52	8.34	9.67	10.71	11.55	12.14	12.71	13.17	13.59
SA-100	2.63	3.08	3.83	4.53	5.52	6.77	8.90	10.42	12.00
SA-101	0.51	0.83	1.49	2.21	3.94	6.64	11.90	13.37	14.90
SA-104	2.10	2.28	2.67	3.11	3.73	4.48	5.80	7.00	7.60
SA-106	4.47	4.94	5.49	5.97	6.29	6.52	6.78	7.97	9.20

Storage Area	2013-001	2013-002	2013-005	2013-010	2013-025	2013-050	2013-100	2013-200	2013-500
SA-107	0.96	1.23	1.81	2.53	4.12	6.49	11.10	12.20	14.10
SA-111	1.15	1.39	1.96	2.67	4.22	6.58	11.20	12.43	13.70
SA-112	2.11	2.32	2.75	3.22	3.96	4.94	6.70	7.78	8.90
SA-114	0.67	0.99	1.50	2.11	3.53	5.74	10.00	11.00	12.00
SA-115	0.46	0.69	1.24	1.86	3.29	5.53	9.90	11.17	12.50
XA-302	1.41	1.65	2.17	2.62	3.52	4.79	7.20	8.87	10.60
XA-304	4.22	4.75	5.72	6.49	7.19	7.66	9.10	10.47	11.90
XA-304-RL	4.22	4.75	5.72	6.49	7.19	7.66	9.10	10.47	11.90
XA-305	4.72	5.29	6.21	6.94	7.80	8.74	10.30	11.48	12.70
XA-306	4.77	5.33	6.25	6.98	7.83	8.76	10.30	11.48	12.70
XA-307	5.84	6.52	7.72	8.66	9.46	10.04	10.61	11.10	11.53
XA-310	1.93	2.30	3.00	3.57	4.40	5.51	7.50	8.90	10.90
XA-311	1.51	1.79	2.33	2.88	3.95	5.49	8.40	10.00	11.50
XA-313	1.17	1.44	2.07	2.82	4.32	6.67	11.20	12.30	13.40
XA-315	1.83	2.14	2.72	3.33	4.39	5.84	8.50	10.00	10.90
XA-316	2.20	2.57	3.26	3.98	5.13	6.65	9.40	10.90	11.90
XA-316-RL	2.20	2.57	3.26	3.98	5.13	6.65	9.40	10.90	11.90
XA-319	5.58	6.09	6.97	7.69	8.33	8.83	9.30	9.70	10.12
XA-320	5.75	6.32	7.33	8.15	8.85	9.35	9.86	10.29	10.70
XA-322	2.24	2.52	3.14	3.67	4.63	5.96	8.40	9.72	11.10
XA-324	10.61	11.94	14.12	15.70	17.02	17.89	18.71	19.38	20.01
XA-325	1.73	2.03	2.55	3.13	4.18	5.64	8.40	9.72	11.10
XA-326	1.66	1.95	2.43	2.93	3.88	5.31	8.00	10.01	12.10
XA-327	1.50	1.83	2.51	3.25	4.96	7.61	12.80	14.50	16.20
XA-329	1.22	1.46	2.08	2.83	4.37	6.76	11.40	12.40	13.50
XA-331	10.14	11.36	13.30	14.76	15.95	16.76	17.54	18.18	18.76
XA-336	1.70	2.02	2.61	3.32	5.01	7.65	12.80	14.47	16.20
XA-337	3.47	4.04	5.08	5.92	6.89	7.91	9.40	10.90	11.90
XA-340	9.97	11.18	13.06	14.38	15.44	16.18	16.91	17.51	18.08
XA-341	1.54	1.86	2.54	3.31	5.01	7.62	12.60	14.50	16.00
XA-343	2.02	2.17	2.51	2.95	3.89	5.31	8.00	9.57	11.20
XA-344	1.72	2.04	2.58	3.14	4.18	5.67	8.50	10.50	12.40
XA-346	13.38	14.94	17.09	18.41	19.45	20.14	20.81	21.37	21.90
XA-347	2.24	2.51	3.13	3.67	4.62	5.96	8.40	9.72	11.10
XA-347-RL	2.24	2.51	3.13	3.67	4.62	5.96	8.40	9.72	11.10
XA-348	5.22	5.89	7.08	7.93	8.65	9.15	9.63	10.47	11.90
XA-348-RL	5.22	5.89	7.08	7.93	8.65	9.15	9.63	10.47	11.90
XA-349	1.33	1.59	2.24	2.85	4.20	6.25	10.20	11.57	13.00
XA-350	1.55	1.84	2.47	3.11	4.46	6.46	10.20	11.57	13.00
XA-351	1.57	1.85	2.37	2.91	3.87	5.22	7.70	9.12	10.60
XA-352	2.39	2.59	3.02	3.47	4.31	5.57	8.00	9.57	11.20
XA-353	1.13	1.40	2.00	2.73	4.24	6.54	11.00	11.90	13.00
XA-354	1.19	1.47	2.10	2.81	4.26	6.49	10.80	11.70	12.90
XA-355	8.39	8.68	9.19	9.56	9.94	10.18	10.44	11.16	11.90
XA-356	5.10	5.65	6.55	7.29	8.05	8.83	10.00	10.98	12.00

2.4.2 RESULTS AND REFERENCE TABLES

The original FWOP stage frequency results without marsh accretion are shown in Table 60 for comparison purposes. Note that for the year 2013 shown in Table **59**, the results are the same for both marsh accretion and without marsh accretion, since accretion would not have yet begun at the start of the analysis. Area SA-316 is the only area that has proposed hurricane risk reduction measures and is affected by marsh accretion. This area is on the west side of the Calcasieu River with its northeast portion including Prien Lake. The net increases are 0.18 feet at the 1-year event, and 0.25 feet at the 100-year event. However, the 100-year surge elevation of 13.90 feet far outweighs the 4.86 foot marsh accretion elevation. XA-307 is the only other area showing marginal increase from marsh accretion, which is 0.05 feet at the 1-year event. The two big areas in Lake Charles, SA-012 and SA-099, actually show a very slight decrease (-0.02 to -0.03 feet) at the 1-year event due to marsh accretion. All other areas with proposed hurricane risk reduction projects show less than 0.02 feet being the effect of marsh accretion. These areas are SA-070, XA-304, XA-347, and XA-348. As expected, the areas that are most affected by marsh accretion are the open marsh areas adjacent to bodies of water. The maximum water surface elevations, within the selected storage areas, for the 2025 (2%, 1% and .5%) and 2075 (2%, 1%, and .5%) events can be plotted in GIS. The GIS mapping will show the details and extent of flooding, including flooding of streets.

Table 60 - FWOP Without Marsh Accretion

Storage Area	2025-001	2025-002	2025-005	2025-010	2025-025	2025-050	2025-100	2025-200	2025-500
SA-001	5.09	5.61	6.43	7.03	7.83	8.68	9.60	10.36	11.50
SA-006	0.42	0.84	1.50	2.08	3.33	5.12	9.80	10.24	10.90
SA-010	6.43	7.05	8.03	8.70	9.31	9.67	10.20	10.20	10.20
SA-011	8.71	8.86	9.57	10.55	11.28	11.68	12.27	12.34	12.50
SA-012	7.53	8.35	9.69	10.73	11.57	12.04	12.73	12.73	12.73
SA-013	0.68	1.18	1.85	2.60	4.30	6.79	11.10	12.02	13.40
SA-014	0.47	0.98	1.76	2.57	4.43	7.16	12.20	13.32	15.00
SA-015	-1.49	-1.00	-0.21	0.72	2.88	6.07	12.40	13.40	14.90
SA-016	12.48	13.45	15.06	15.94	16.61	16.96	17.48	17.48	17.48
SA-017	2.46	2.97	3.63	4.21	4.90	5.59	6.30	7.22	8.60
SA-017-RL	2.46	2.97	3.63	4.21	4.90	5.59	6.30	7.22	8.60
SA-019	0.62	1.07	1.71	2.41	3.95	6.21	10.40	11.40	12.90
SA-021	0.75	1.26	1.92	2.71	4.47	7.06	11.70	12.62	14.00
SA-023	0.47	0.86	1.48	2.14	3.57	5.62	8.50	9.02	9.80
SA-030	4.50	5.05	5.63	6.16	6.69	6.94	7.30	8.54	10.40
SA-031	4.01	4.73	5.86	6.79	7.80	8.14	8.65	8.73	8.90
SA-033	2.50	3.02	3.70	4.34	5.15	6.09	6.90	7.74	9.00
SA-033-RL	2.50	3.02	3.70	4.34	5.15	6.09	6.90	7.74	9.00
SA-034	1.01	1.49	2.24	3.10	5.05	7.88	13.10	14.34	16.20
SA-036	0.64	1.20	1.93	2.79	4.74	7.65	12.50	13.54	15.10
SA-038	10.03	10.90	11.95	12.41	12.83	13.01	13.28	13.28	13.28
SA-040	0.47	0.86	1.42	1.99	3.14	4.73	7.00	7.88	9.20
SA-046	1.36	1.92	2.59	3.26	4.49	6.15	8.60	9.92	11.90
SA-048	3.80	4.45	5.43	6.28	7.23	7.50	7.92	8.12	8.60
SA-054	1.06	1.42	1.91	2.44	3.47	4.88	6.60	7.36	8.50
SA-067	0.68	1.16	1.81	2.53	4.13	6.47	10.80	11.80	13.30
SA-070	2.63	3.21	4.05	4.88	6.27	8.08	11.00	11.72	12.80
SA-070-N	2.63	3.21	4.05	4.88	6.27	8.08	11.00	11.72	12.80
SA-070-S	2.63	3.21	4.05	4.88	6.27	8.08	11.00	11.72	12.80
SA-074	1.42	1.83	2.48	3.17	4.64	6.78	11.00	11.60	12.50
SA-079	1.35	1.93	2.64	3.37	4.82	6.84	9.80	11.12	13.10
SA-086	1.58	1.92	2.40	2.94	4.09	5.70	8.30	9.38	11.00
SA-087	-0.09	0.39	1.16	2.03	3.78	6.26	10.50	11.38	12.70
SA-089	0.65	1.10	1.71	2.35	3.68	5.56	9.20	10.16	11.60
SA-090	0.66	1.10	1.68	2.27	3.49	5.17	8.30	9.38	11.00
SA-091	0.88	1.36	2.04	2.87	4.80	7.67	13.10	13.71	14.20
SA-092	0.72	1.15	1.72	2.32	3.52	5.19	7.40	8.32	9.70
SA-096	2.14	2.51	3.03	3.52	4.21	5.32	6.90	7.78	9.10
SA-097	0.64	1.18	1.91	2.75	4.63	7.41	12.00	13.28	15.20
SA-099	7.52	8.34	9.67	10.71	11.65	12.08	12.71	12.71	12.71
SA-099-RL	7.52	8.34	9.67	10.71	11.65	12.08	12.71	12.71	12.71
SA-100	2.63	3.21	4.02	4.80	6.03	7.57	9.60	10.36	11.50
SA-101	0.50	1.02	1.80	2.63	4.52	7.32	12.50	13.58	15.20

Storage Area	2025-001	2025-002	2025-005	2025-010	2025-025	2025-050	2025-100	2025-200	2025-500
SA-107	0.96	1.41	2.11	2.93	4.67	7.16	11.90	12.82	14.20
SA-111	1.15	1.57	2.26	3.05	4.75	7.21	11.50	12.54	14.10
SA-112	2.11	2.49	3.04	3.63	4.64	5.95	8.10	9.10	10.60
SA-114	0.68	1.16	1.80	2.52	4.12	6.47	10.50	11.26	12.40
SA-115	0.47	0.88	1.55	2.27	3.87	6.23	10.00	10.52	11.30
XA-302	1.41	1.85	2.51	3.12	4.33	5.96	8.10	9.54	11.70
XA-304	4.22	4.85	5.84	6.66	7.64	8.54	10.00	11.08	12.70
XA-304-RL	4.22	4.85	5.84	6.66	7.64	8.54	10.00	11.08	12.70
XA-305	4.72	5.39	6.33	7.12	8.23	9.51	11.00	11.96	13.40
XA-306	4.77	5.43	6.37	7.16	8.26	9.53	11.00	11.96	13.40
XA-307	5.84	6.52	7.72	8.66	9.56	9.98	10.61	11.21	12.60
XA-310	2.94	2.65	3.43	4.11	5.21	6.66	9.40	10.36	11.80
XA-311	1.51	1.98	2.65	3.33	4.67	6.51	9.10	10.34	12.20
XA-313	1.17	1.65	2.42	3.28	5.00	7.54	12.10	12.86	14.00
XA-315	1.83	2.29	2.97	3.68	4.96	6.65	9.10	10.06	11.50
XA-316	2.20	2.73	3.52	4.33	5.71	7.52	10.20	11.16	12.60
XA-316-RL	2.20	2.73	3.52	4.33	5.71	7.52	10.20	11.16	12.60
XA-319	5.58	6.09	6.97	7.69	8.43	8.78	9.30	10.20	12.30
XA-320	5.75	6.32	7.33	8.15	8.95	9.31	9.86	10.53	12.10
XA-322	2.24	2.69	3.42	4.07	5.30	6.94	8.40	9.76	11.80
XA-324	10.61	11.94	14.12	15.70	17.02	17.70	18.71	18.71	18.71
XA-325	1.73	2.21	2.86	3.57	4.89	6.65	9.20	10.24	11.80
XA-326	1.96	2.15	2.73	3.33	4.49	6.13	9.00	10.20	12.00
XA-327	1.81	2.08	2.87	3.71	5.58	8.32	13.20	14.60	16.70
XA-329	1.22	1.66	2.41	3.26	5.00	7.54	12.00	12.64	13.60
XA-331	10.14	11.36	13.30	14.76	15.95	16.59	17.54	17.54	17.54
XA-336	1.86	2.24	2.96	3.77	5.62	8.36	13.20	14.60	16.70
XA-337	3.46	4.12	5.15	6.01	7.18	8.48	10.20	11.16	12.60
XA-340	9.97	11.18	13.06	14.38	15.44	16.02	16.90	16.90	16.90
XA-341	1.54	2.05	2.85	3.72	5.58	8.30	13.10	14.42	16.40
XA-343	2.02	2.34	2.82	3.37	4.52	6.16	8.80	10.04	11.90
XA-344	2.20	2.30	2.96	3.63	4.91	6.67	9.10	10.58	12.80
XA-346	13.38	14.94	17.09	18.41	19.45	19.99	20.81	20.81	20.81
XA-347	2.24	2.69	3.41	4.07	5.29	6.94	9.20	10.24	11.80
XA-347-RL	2.24	2.69	3.41	4.07	5.29	6.94	9.20	10.24	11.80
XA-348	5.22	5.95	7.09	7.96	8.91	9.35	10.00	11.08	12.70
XA-348-RL	5.22	5.95	7.09	7.96	8.91	9.35	10.00	11.08	12.70
XA-349	1.33	1.76	2.49	3.20	4.71	6.90	10.20	10.88	11.90
XA-350	1.55	2.00	2.71	3.44	4.94	7.08	10.80	11.08	11.50
XA-351	1.57	2.01	2.64	3.28	4.47	6.08	8.50	9.70	11.50
XA-352	2.39	2.75	3.29	3.84	4.91	6.41	8.80	10.04	11.90
XA-353	1.13	1.60	2.33	3.17	4.89	7.36	11.50	12.02	12.80
XA-354	1.19	1.67	2.43	3.25	4.93	7.35	11.60	12.36	13.50
XA-355	8.39	8.68	9.19	9.56	9.94	10.14	10.44	10.44	10.44
XA-356	5.10	5.73	6.64	7.42	8.40	9.49	10.70	11.50	12.70

Storage Area	2075-001	2075-002	2075-005	2075-010	2075-025	2075-050	2075-100	2075-200	2075-500
SA-001	5.09	5.93	6.77	7.61	9.30	11.40	13.50	14.42	15.80
SA-006	0.42	1.47	2.52	3.56	5.66	8.28	10.90	11.78	13.10
SA-010	6.43	7.05	8.03	8.70	9.31	9.76	10.20	10.20	10.20
SA-011	8.71	8.86	9.58	10.56	11.29	11.88	13.20	14.29	16.00
SA-012	7.56	8.37	9.71	10.74	11.59	12.18	13.20	14.29	16.00
SA-013	0.70	1.91	3.12	4.33	6.75	9.78	12.80	13.72	15.10
SA-014	0.47	1.72	2.98	4.23	6.74	9.87	13.00	14.04	15.60
SA-015	-1.49	-0.02	1.45	2.92	5.86	9.53	13.20	14.12	15.50
SA-016	12.48	13.45	15.07	15.94	16.61	17.09	17.48	17.48	17.48
SA-017	2.46	3.46	4.47	5.47	7.48	9.99	12.50	14.18	16.70
SA-017-RL	2.46	3.46	4.47	5.47	7.48	9.99	12.50	14.18	16.70
SA-019	0.63	1.70	2.76	3.83	5.97	8.63	11.30	12.14	13.40
SA-021	0.77	1.97	3.18	4.38	6.79	9.79	12.80	13.68	15.00
SA-023	0.49	1.59	2.69	3.79	6.00	8.75	11.50	12.46	13.90
SA-030	4.64	5.37	6.09	6.82	8.27	10.09	11.90	13.66	16.30
SA-031	4.03	4.99	5.94	6.90	8.82	11.21	13.60	14.65	16.30
SA-033	2.51	3.47	4.43	5.39	7.31	9.70	12.10	13.14	14.70
SA-033-RL	2.51	3.47	4.43	5.39	7.31	9.70	12.10	13.14	14.70
SA-034	1.01	2.34	3.67	5.00	7.66	10.98	14.30	15.42	17.10
SA-036	0.64	1.96	3.27	4.59	7.22	10.51	13.80	14.96	16.70
SA-038	10.03	10.90	11.95	12.41	12.83	13.09	13.28	13.28	13.28
SA-040	0.49	1.60	2.71	3.82	6.05	8.82	11.60	12.80	14.60
SA-046	1.37	2.42	3.48	4.53	6.64	9.27	11.90	12.86	14.30
SA-048	3.84	4.79	5.73	6.68	8.57	10.94	13.30	14.35	16.00
SA-054	1.06	2.14	3.23	4.31	6.48	9.19	11.90	12.86	14.30
SA-067	0.70	1.86	3.02	4.18	6.50	9.40	12.30	13.06	14.20
SA-070	2.63	3.69	4.74	5.80	7.92	10.56	13.20	14.32	16.00
SA-070-N	2.63	3.69	4.74	5.80	7.92	10.56	13.20	14.32	16.00
SA-070-S	2.63	3.69	4.74	5.80	7.92	10.56	13.20	14.32	16.00
SA-074	1.45	2.56	3.66	4.77	6.98	9.74	12.50	13.38	14.70
SA-079	1.36	2.43	3.51	4.58	6.73	9.42	12.10	13.10	14.60
SA-086	1.59	2.70	3.81	4.92	7.15	9.92	12.70	13.94	15.80
SA-087	-0.09	1.16	2.41	3.66	6.16	9.28	12.40	13.08	14.10
SA-089	0.66	1.88	3.11	4.33	6.78	9.84	12.90	14.22	16.20
SA-090	0.66	1.86	3.07	4.27	6.68	9.69	12.70	13.86	15.60
SA-091	0.88	2.10	3.32	4.55	6.99	10.05	13.10	14.22	15.90
SA-092	0.72	1.91	3.10	4.28	6.66	9.63	12.60	13.72	15.40
SA-096	2.14	3.29	4.43	5.58	7.87	10.74	13.60	14.92	16.90
SA-097	0.64	1.93	3.21	4.50	7.07	10.29	13.50	14.58	16.20
SA-099	7.54	8.36	9.69	10.72	12.06	12.95	13.90	15.07	16.90
SA-099-RL	7.54	8.36	9.69	10.72	12.06	12.95	13.90	15.07	16.90
SA-100	2.63	3.72	4.80	5.89	8.07	10.78	13.50	14.42	15.80
SA-101	0.50	1.77	3.04	4.31	6.85	10.03	13.20	14.40	16.20
SA-104	2.10	3.18	4.26	5.34	7.50	10.20	12.90	13.94	15.50
SA-106	4.61	5.48	6.35	7.22	8.96	11.13	13.30	14.46	16.20

Storage Area	2075-001	2075-002	2075-005	2075-010	2075-025	2075-050	2075-100	2075-200	2075-500
SA-107	0.96	2.14	3.33	4.51	6.88	9.84	12.80	13.88	15.50
SA-111	1.15	2.30	3.44	4.59	6.88	9.74	12.60	13.56	15.00
SA-112	2.11	3.16	4.21	5.26	7.36	9.98	12.60	13.80	15.60
SA-114	0.70	1.86	3.02	4.18	6.50	9.40	12.30	13.10	14.30
SA-115	0.49	1.63	2.77	3.91	6.20	9.05	11.90	13.02	14.70
XA-302	1.41	2.64	3.87	5.10	7.56	10.63	13.70	15.10	17.20
XA-304	4.22	5.27	6.32	7.36	9.46	12.08	14.70	15.94	17.80
XA-304-RL	4.22	5.27	6.32	7.36	9.46	12.08	14.70	15.94	17.80
XA-305	4.72	5.77	6.82	7.86	9.96	12.58	15.20	16.16	17.60
XA-306	4.77	5.81	6.86	7.90	9.99	12.59	15.20	16.16	17.60
XA-307	5.84	6.52	7.72	8.66	9.96	11.34	12.40	13.41	15.00
XA-310	2.94	4.05	5.15	6.26	8.47	11.24	14.00	15.92	18.80
XA-311	1.51	2.72	3.93	5.14	7.56	10.58	13.60	15.04	17.20
XA-313	1.17	2.48	3.80	5.11	7.74	11.02	14.30	15.10	16.30
XA-315	1.83	2.91	3.98	5.06	7.22	9.91	12.60	14.16	16.50
XA-316	2.20	3.37	4.54	5.71	8.05	10.98	13.90	15.10	16.90
XA-316-RL	2.20	3.37	4.54	5.71	8.05	10.98	13.90	15.10	16.90
XA-319	5.58	6.09	6.97	7.69	8.83	10.33	12.40	13.41	15.00
XA-320	5.75	6.32	7.33	8.15	9.35	10.85	12.40	13.41	15.00
XA-322	2.24	3.39	4.53	5.68	7.97	10.84	13.70	15.74	18.80
XA-324	10.61	11.94	14.12	15.70	17.02	17.89	18.71	18.71	18.71
XA-325	1.73	2.93	4.12	5.32	7.72	10.71	13.70	15.10	17.20
XA-326	1.96	2.95	3.95	4.94	6.93	9.42	11.90	13.58	16.10
XA-327	1.81	3.06	4.31	5.56	8.06	11.18	14.30	15.46	17.20
XA-329	1.22	2.48	3.74	4.99	7.51	10.66	13.80	14.92	16.60
XA-331	10.14	11.36	13.30	14.76	15.95	16.75	17.54	17.54	17.54
XA-336	1.86	3.10	4.35	5.59	8.08	11.19	14.30	15.58	17.50
XA-337	3.46	4.43	5.41	6.38	8.33	10.77	13.20	14.32	16.00
XA-340	9.97	11.18	13.06	14.38	15.44	16.18	16.90	16.90	16.90
XA-341	1.54	2.81	4.07	5.34	7.87	11.04	14.20	15.44	17.30
XA-343	2.02	3.03	4.04	5.04	7.06	9.58	12.10	13.38	15.30
XA-344	2.20	3.33	4.46	5.59	7.85	10.68	13.50	15.42	18.30
XA-346	13.38	14.94	17.09	18.41	19.45	20.14	20.81	20.81	20.81
XA-347	2.24	3.39	4.53	5.68	7.97	10.84	13.70	15.10	17.20
XA-347-RL	2.24	3.39	4.53	5.68	7.97	10.84	13.70	15.10	17.20
XA-348	5.22	6.17	7.12	8.06	9.96	12.33	14.70	15.94	17.80
XA-348-RL	5.22	6.17	7.12	8.06	9.96	12.33	14.70	15.94	17.80
XA-349	1.33	2.42	3.50	4.59	6.77	9.48	12.20	13.44	15.30
XA-350	1.55	2.62	3.68	4.75	6.88	9.54	12.20	13.36	15.10
XA-351	1.57	2.63	3.70	4.76	6.89	9.54	12.20	13.36	15.10
XA-352	2.39	3.37	4.35	5.33	7.30	9.75	12.20	13.36	15.10
XA-353	1.13	2.40	3.66	4.93	7.47	10.63	13.80	14.88	16.50
XA-354	1.19	2.47	3.75	5.03	7.60	10.80	14.00	14.72	15.80
XA-355	8.39	8.68	9.19	9.56	9.94	10.18	10.44	10.44	10.44
XA-356	5.10	6.04	6.98	7.92	9.80	12.15	14.50	15.02	15.80

2.4.3 Nonstructural Analysis

Stage probability relationships were provided for existing, 2025 and 2075 without-project conditions. The 2025 and 2075 without project stages were used to determine existing damages and to identify the structures that fall below the 2025 and 2075 stages and would require raising or flood proofing. The 2075 stages were used to determine the amount of raising that would need to be done for those structures to be raised. The Economics Appendix (Appendix D) details the process used to analyze damages and benefits for the nonstructural alternatives.

2.5 PUMPING

Estimates for pumping capacity required for each alternative were based on analysis done for the Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report dated 2009 which analyzed levee alternatives in the same general locations. Table 61 shows the pumping capacity used to estimate cost for each NED alternative.

Table 61 – Pumping Capacity

Alternative	Pumping Capacity
Abbeville Ring Levee	1,000 cfs
Abbeville to Delcambre Hwy 330	3,000 cfs
Delcambre Erath	1,000 cfs
Lake Charles East Bank	3,000 cfs
Lake Charles West Bank Sulphur	1,000 cfs
Lake Charles West Bank Sulphur South	3,000 cfs

2.6 NER MODELING

The effects of the hydrologic and salinity control features of the NER alternatives were assessed using the State of Louisiana Master Plan models and MIKE FLOOD hydrodynamic model. For the focused array of alternatives, the 2012 State Master Plan modeling effort was used with input from the Eco-hydrology module to estimate land and water changes. The alternatives were run under the Intermediate RSLR scenario to predict salinity, water levels, and flows at a 500 m resolution every five years. The results of this modeling effort were input into the Vegetation and Wetland Morphology modules of the State Master Plan modeling system to predict wetland loss and other trends over time. The State Master Plan model included accretion and subsidence projections.

The Wetland Morphology model produced spatial patterns of landscape composition (land and water area), fragmentation (percent edge), soil vertical accretion rates, soil surface elevation, and SOC storage and sequestration for the period of 2010-2060. These outputs are provided for each 5-year interval during the period of study. The temporal changes could be resolved daily, weekly, or monthly, while the spatial resolution ranged from less than 1 km2 to nearly 6,000 km2 per compartment. After the first 25 simulation years, the stage, salinity, and sediment outputs from the Eco-hydrology model were used as input into the Wetland Morphology model. Subsequently, the Wetland Morphology land use and elevation output were used as input to the Eco-hydrology models as a feedback step. The Vegetation model was used to predict species shifts associated with changing salinities. Outputs were calculated at 500 m resolution at 25-year intervals.

The study team also simulated the effects of the H&S measures using the finer-resolution MIKE FLOOD hydrodynamic model, which utilizes a 500x500 meter grid. The results of the MIKE FLOOD model simulations were used to support decisions on screening of hydraulic and salinity control features and to refine the features and their operating plans. Information on the State Master Plan models can be found in the State of Louisiana Master Plan Report (2012). Information on the MIKE FLOOD modeling can be found in Meselhe et al. (2013a).

3.0 SURVEYS

3.1 NED AND NER FOCUSED ARRAY OF ALTERNATIVES

No new surveys were taken for the analysis of the NED and NER focused array of alternatives. Existing statewide LIDAR data was used for this analysis.

3.2 DESIGN SURVEYS

Site specific surveys will be taken for the detailed design of both the NED and NER features might be ultimately recommended.. These surveys will be done for future implementation documents during PED. Surveys for the detailed design of any NED and the NER recommendations will be performed in accordance with the New Orleans District Minimum Survey Standards and the respective survey plans will be approved by the District Datum Coordinator.

4.0 GEOTECHNICAL

4.1 GEOLOGY

The study area is contained within the Pleistocene-aged Prairie Terraces in the northern portion and the Holocene-aged Chenier plain in the southern portion. The Prairie Terraces are characterized by nearly level plains having low relief which are dissected by rivers and streams that flow toward the Gulf of Mexico. The Prairie Terraces are characterized by deltaic and lagoonal deposits laid down during the Farmdalian and Sangamon interglacial periods when sea level was higher than present and sediment was transported south by rivers and streams. These deposits are generally characterized by medium to very stiff silty clays with layers of silt and sand. Based on limited boring data, these deposits are estimated to be over 100 feet thick. Recent alluvial material (sand, silt, and clay) fills the valleys of large rivers and streams.

The Chenier Plain is located south of the Pleistocene terraces and extends from Sabine Pass, Texas eastward to Southwest Point, Louisiana. Chenier plain development is the result of the interplay of four coastal plain rivers, cycles of Mississippi River delta development, and marine processes. Dominant physiographic features in the Chenier Plain are the sandy/shelly cheniers, broad expanses of marsh, rivers, large inland lakes, and the Pleistocene uplands forming the northern boundary of the Chenier Plain. Elevations on the cheniers generally range from approximately +5 to +10 feet.

The Chenier Plain formed in the southwest portion of the coast, away from active deltaic growth. When the Mississippi River was in a more westward position, fine silt and clays were transported by westward flowing nearshore currents and deposited as mudflats along the existing shoreline. When Mississippi River deposition ceased or declined as the River shifted eastward, these mudflats were reworked by marine processes concentrating the coarser grained sediments and shell material into shore-parallel ridges called "cheniers." Introduction of new sediments by the next westward shift of the Mississippi River resulted in isolation of these ridges by accretion of mudflats gulfward of the ridges. Numerous cycles of deposition and erosion are responsible for creating the alternating ridges separated by marshlands characteristic of the Chenier Plain (Gould and McFarlan, 1959; Byrne et al, 1959; Hoyt, 1969). Therefore, most cheniers represent relict shoreline positions. Currently, a portion of Atchafalaya River sediments reaching the coast are being carried westward and deposited as progradational mudflats along the eastern Chenier Plain, representing a new episode of Chenier plain development.

The surface and subsurface of the Chenier Plain is generally characterized by a vertical sequence of marsh, estuarine and marine clays and silts, and Pleistocene deposits. Marsh deposits up to 10 feet thick are comprised mainly of very soft to soft organic clays with peat. Soft to medium estuarine and marine clays and silts located below the marsh deposits are up to 30 feet thick. Pleistocene deposits are at the surface in the vicinity of the Gulf Intracoastal Waterway and slope gulfward to approximately -30 feet in elevation at the coast. Pleistocene deposits are generally characterized by very stiff silty clay, silt, and sand. The Chenier ridges are generally composed of shell and sand material up to 15 feet thick.

The Chicot aquifer underlies most of southwestern Louisiana and extends from central southwestern Louisiana to the Gulf of Mexico and from Sabine Lake to St. Mary Parish. The Chicot aquifer is up to 800 feet thick at its most northern extent and extends to an unknown depth beneath the Gulf of Mexico.

4.2 NED GEOTECHNICAL DESIGN

4.2.1 Design Assumptions

The preliminary analyses performed for this Feasibility Study relied on existing data; no soil borings were taken and no testing was conducted. Soil unit weights and shear strengths of the strata were assigned based upon geological information and geotechnical engineering experience in the region with various projects in the vicinity. Based on this pre-existing data, the determination was made that soil conditions in the study area generally consist of Pleistocene clay at or very close to the ground surface. An assumption was also made that about 10% of the study area has soil conditions where Pleistocene is found beneath a weak layer of soil. This weak layer of soil was assumed to be 20 feet deep.

The average natural ground elevation for all six levee alignments in the focused array was estimated to be at elevation 9.5'. This was based on a comparison of the LIDAR survey data for all of the alignments. Elevation 9.5 feet is an average of a large sample of the survey points. A further assumption was made that an estimated 10% of the alignment area has Pleistocene deeper than at the natural ground surface. It was assumed that in the areas where Pleistocene is at the surface, the only settlement that would be expected would be the shrinkage settlement plus ½ of a foot, with shrinkage settlement assumed to be approximately 10% of the amount of fill needed.

Where necessary, geotextile would be used to minimize the footprint. Geotextile may not be needed in areas where Pleistocene is near the ground surface, but would be needed where the proposed alignments cross existing and abandoned channels, or where Pleistocene is below weak soils.

4.2.2 Design Development

4.2.2.1 Method

Two very basic analyses were done with a simple subsurface soils profile. The first analysis assumed that Pleistocene is at the ground surface and the second assumed that a 20' very weak layer of clay exists between the ground surface and the Pleistocene layer. A typical design section is shown in Figure 18. This section pertains to the Abbeville to Delcambre Hwy 330 levee alignment. A very basic Settle 3D analysis was performed to get a better estimate of what kind of settlement could be expected with Pleistocene at the ground surface and with Pleistocene 20' below the ground surface.

4.2.2.2 Conclusions

Areas with Pleistocene at the ground surface would require a lift to the construction grade elevation listed in Table 62. Areas with Pleistocene below a twenty foot layer of weak soils would require a four foot overbuild (see Table 62). A typical lift schedule for areas with weak soil layers over Pleistocene is shown in Figure 19.

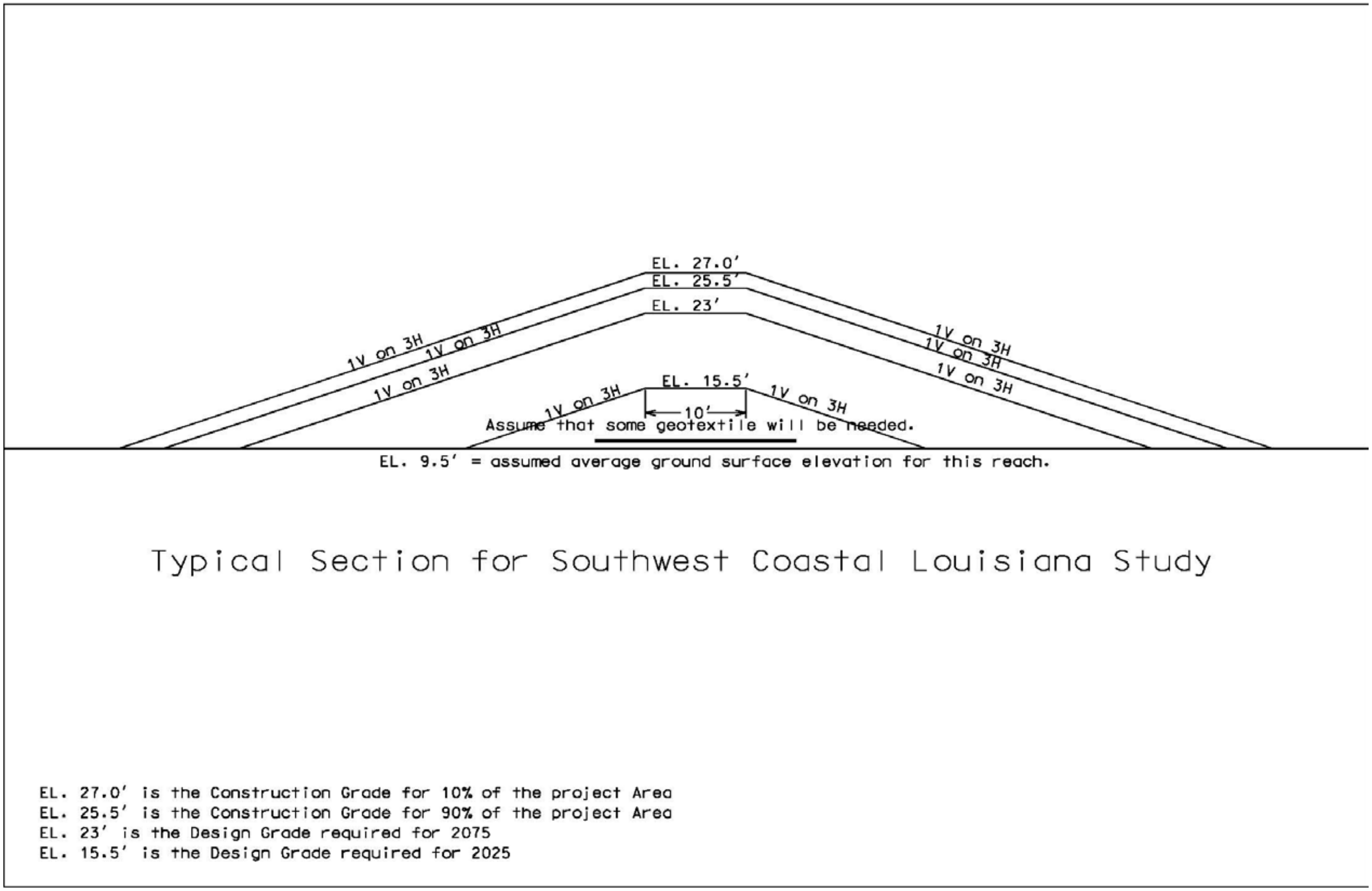

Figure 18 - Typical Section

Table 62 - Required Design Elevations																	
LAKE CHARLES									Amount of shrinkage based on difference between Average natural ground elevation and 2075 Shrinkage is assumed to be 10 % of the amount of fill			Construction Grade Elevation (ft) for 90% of the project area			Construction Grade Elevation (ft) for 10% of the project area		
	2025			2075													
	2%	1%	0.50%	2%	1%	0.50%			2%	1%	0.50%	2%	1%	0.50%	2%	1%	0.50%
Lake Charles Westbank Sulphur Levee							LIDAR Data Elevations					Lake Charles Westbank Sulphur Levee					
Reach 1	9	13	17	14.5	19.5	26	Maximum	19.6	0.18	0.68	1.33	15.0	21.0	28.0	18.5	23.5	30.0
Reach 2	8	12.5	16.5	13.5	19.5	26.5	Minimum	2.8	0.08	0.68	1.38	14.0	21.0	28.5	17.5	23.5	30.5
Reach 3	9.5	16	18.5	17	22	26.5	Average	12.7	0.43	0.93	1.38	18.0	23.5	28.5	21.0	26.0	30.5
							Mode	12.4									
							Median	12.4									
Lake Charles Westbank Sulphur South Levee							LIDAR Data Elevations					Lake Charles Westbank Sulphur South Levee					
	2%	1%	0.50%	2%	1%	0.50%	Maximum	29.7	2%	1%	0.50%	2%	1%	0.50%	2%	1%	0.50%
Reach 1	11	15	18	17.5	23.5	28.5	Minimum	-0.4	0.71	1.31	1.81	19.0	25.5	31.0	21.5	27.5	32.5
Reach 2	11.5	15	18	17.5	22.5	27	Average	10.4	0.71	1.21	1.66	19.0	24.5	29.5	21.5	26.5	31.0
Reach 3	11.5	15	18	17	22	26.5	Mode	9.1	0.66	1.16	1.61	18.5	24.0	29.0	21.0	26.0	30.5
Reach 4	12.5	16	18.5	17	22	26.5	Median	9.9	0.66	1.16	1.61	18.5	24.0	29.0	21.0	26.0	30.5
Lake Charles Eastbank							LIDAR Data Elevations					Lake Charles Eastbank					
	2%	1%	0.50%	2%	1%	0.50%	Maximum	18.3	2%	1%	0.50%	2%	1%	0.50%	2%	1%	0.50%
Reach 1	12	15	18	17	22	26.5	Minimum	-0.4	0.73	1.23	1.68	18.5	24.0	29.0	21.0	26.0	30.5
Reach 2	11.5	15	17.5	17.5	22.5	27	Average	9.7	0.78	1.28	1.73	19.0	24.5	29.5	21.5	26.5	31.0
Reach 3	11.5	15	17.5	17.5	22	27	Mode	13	0.78	1.23	1.73	19.0	24.0	29.5	21.5	26.0	31.0

Table 62 - Required Design Elevations																	
							Median	9.8									
ABBEVILLE									Amount of shrinkage based on difference between average			Construction Grade Elevation (ft) for 90% of project area			Construction Grade Elevation (ft) for 10% of project area		
Abbeville to Delcambre Hwy 330							LIDAR Data Elevations		x			Abbeville to Delcambre Hwy 330					
	2%	1%	0.50%	2%	1%	0.50%	Maximum	18.7	2%	1%	0.50%	2%	1%	0.50%	2%	1%	0.50%
Reach 1	13	15.5	18	19.5	23	27	Minimum	1.5	1.26	1.61	2.01	21.5	25.5	29.5	23.5	27.0	31.0
Reach 2	14	17	19.5	19	23	27	Average	6.9	1.21	1.61	2.01	21.0	25.5	29.5	23.0	27.0	31.0
Reach 3	13	16	18.5	19.5	23.5	27.5	Mode	6.8	1.26	1.66	2.06	21.5	26.0	30.5	23.5	27.5	31.5
							Median	6.3									
Abbeville Ring Levee							LIDAR Data Elevations					Abbeville Ring Levee					
	2%	1%	0.50%	2%	1%	0.50%	Maximum	15.5	2%	1%	0.50%	2%	1%	0.50%	2%	1%	0.50%
Reach 1	13	16	18.5	19.5	23	27.5	Minimum	1.26	0.92	1.27	1.72	21.0	25.0	30.0	23.5	27.0	31.5
Reach 2	13	16	18.5	19.5	23	27.5	Average	10.3	0.92	1.27	1.72	21.0	25.0	30.0	23.5	27.0	31.5
Reach 3	12	15.5	18.5	19	23.5	28	Mode	12.7	0.87	1.32	1.77	20.5	25.5	30.5	23.0	27.5	32.0
							Median	10.3									
Delcambre Erath Levee							LIDAR Data Elevations					Delcambre Erath Levee					
	2%	1%	0.50%	2%	1%	0.50%	Maximum	17.3	2%	1%	0.50%	2%	1%	0.50%	2%	1%	0.50%
Reach 1	15.5	19.5	21	23	27.5	32	Minimum	0	1.47	1.92	2.37	25.0	30.0	35.0	27.0	31.5	36.0
Reach 2	15.5	19.5	24	26	30.5	32	Average	8.3	1.77	2.22	2.37	28.5	33.5	35.0	30.0	34.5	36.0
Maximum	15.5	19.5	24	26	30.5	32	Mode	8									
Minimum	8	12.5	16.5	13.5	19.5	26	Median	8									
Average	12.1	15.7	18.6	18.4	23.0	27.6	Average of all Average values	9.7									

Table 62 - Required Design Elevations						
Mode	11.5	15	18.5	17	22	26.5
Median	12	15.5	18.25	17.5	22.75	27

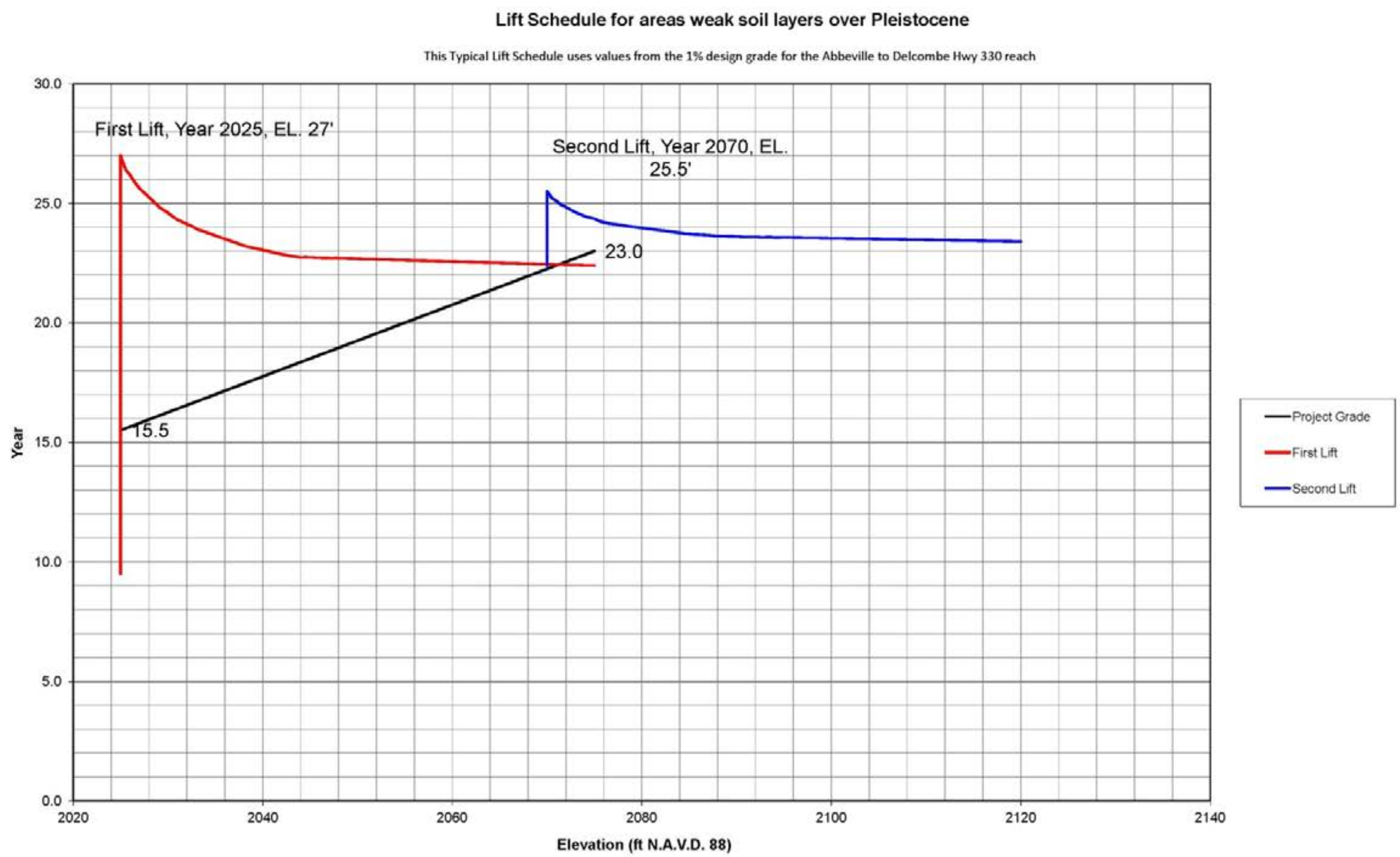

Figure 19 - Lift Schedule

4.3 NER GEOTECHNICAL ANALYSIS

4.3.1 Design Assumptions

The preliminary analyses performed for this Feasibility Study relied on existing data; no soil borings were taken and no testing was conducted. Volumes adjustments due to settlement were based on broad assumptions using values typically included in the Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) planning process and through the development of regional settlement curves using historical data.

5.0 DESIGN

5.1 NED

Table 63 - Alternatives	
Alternatives	Length (Linear Feet)
Abbeville Ring Levee	53,267
Delcambre Erath	68,593
Abbeville to Delcambre	142,205
Lake Charles East Bank	177,573
Lake Charles West Bank Sulphur	72,073
Lake Charles West Bank Sulphur South	140,833

The above alternatives were analyzed utilizing the one basic geotextile reinforced Typical Section depicted in Figure 18. First lift fill for year 2025 quantity computations were derived using In-Roads software and the existing LIDAR survey data on file. Various construction grades for 90% of the study area and 10% of the study area were provided and analyzed accordingly. (See Table 62) Based on Geotech team input, settlement and shrinkage factors were added to the net values to determine the final computations provided in the report. All alternatives included second lift levee enlargement assuming two feet of settlement and a one foot overbuild to obtain the year 2075 elevation quantity computations.

It was assumed that construction of selected levee reaches would be made in two lifts to the design elevations and dimensions provided in the final construction document. Material used for embankment would be levee grade material meeting the USACE Hurricane Storm Damage Risk Reduction System (HSDRRS) guidelines. All levee grade material would be moisture controlled and compacted as per the specific ASTM standards. Compaction techniques and efforts vary but typically include combinations of rollers, scrapers, dozers and dump trucks to achieve the required 90% maximum dry density compaction. The embankment operation would include borrow pit management, clearing and grubbing of the levee footprint, placement of embankment material, and turfing of all disturbed areas.

Borrow material for the levees would be obtained locally. The average haul distance between the borrow source and the construction site is assumed to be 25 miles one way trip. Borrow pit geometry is typically 1V on 3H side and end slopes with an excavated bottom elevation of -20.0 NAVD88 (2004.65). Borrow pits are generally sized assuming in place borrow to in place levee embankment ratio of 2:1 applied after stripping the top 3'-5' of unsuitable material for levee construction.

5.2 NER FEATURES

Design details for the marsh restoration/nourishment features, the shoreline protection/stabilization features; and Chenier reforestation features included in the alternatives for the NER focused array are described in this section.

5.2.1 Marsh Restoration/Nourishment

5.2.1.1 General

5.2.1.1.1 Marsh Restoration/Nourishment Acreage

Total acres of land restored or nourished by these measures was determined from shapefiles developed for each feature. USGS established land/water ratios for each feature. Marsh restoration involves the placement of dredged material in shallow open water areas and extensively broken marsh. Marsh nourishment refers to the placement of a thin layer of dredged material into broken marsh. Renourishment refers to the maintenance required to keep the feature at the desired elevation and can be either restoration, nourishment or a combination of both.

5.2.1.1.2 Fill Volumes

The total estimated volume of marsh fill material required to construct the individual measure using one initial lift is based on the target marsh elevation at target year zero (TY0). Target year zero is defined as the year construction is completed and benefits begin to accrue. Assumptions for bottom elevations for areas were derived using information from recently constructed projects near the project areas, from depth information obtained during the CWPPRA planning process, and from information from nearby Coastwide Reference Monitoring System (CRMS) stations. Marsh restoration fill area bottom elevations are average elevations and are not meant to represent the deepest part of the open water restoration areas. These assumptions are represented in the cost estimates. Volumes adjustments due to settlement were based on broad assumptions using values typically included in the CWPPRA planning process and through the development of regional settlement curves. Target marsh elevations were estimated using information from recently constructed projects near the project areas and from information from nearby CRMS stations.

5.2.1.1.3 Cut Volume

Total dredging quantity required for the individual feature used the estimated volume of marsh fill material required multiplied by a cut-to-fill ratio of 1.3. This volume is the gross cubic yards required and is the amount assumed to be dredged to achieve the required marsh fill. This amount is referred to as gross cubic yards in this Engineering Report. Elsewhere in the report it is referred to as cubic yards (1.3 million cubic yards as opposed to 1.3M gross cubic yards). These numbers both refer to the amount of material to be dredged and are the same number.

5.2.1.1.4 Borrow Source

Areas identified for potential borrow sources include nearby lakes, rivers and the Gulf of Mexico. Several of the marsh restoration features have been evaluated using beneficial use of dredged material from the Calcasieu Ship Channel. Each feature has been evaluated individually, i.e., no attempt has been made to designate certain areas of the ship channel for use to grouping of projects or to develop a schedule of material usage based on current maintenance dredging cycles. Such evaluations will be performed considering the features carried forward. Calcasieu Lake was not considered as a borrow source as it is designated as public oyster seed grounds.

5.2.1.1.5 Earthen Containment Dikes

Earthen containment dikes will be constructed using in-situ material from the interior of each marsh restoration/nourishment feature area. Borrow area for the containment dike will be refilled during hydraulic dredging. Typical section of the containment dike includes a crest width of 5 feet, side slopes of 4(H):1(V), and a crown elevation with 1 foot of freeboard above the initial slurry elevation. Containment dikes are assumed to be maintained during construction. Bottom elevation of the earthen containment dikes was assumed to coincide with the assumed bottom elevation of the respective marsh restoration and marsh nourishment areas.

5.2.1.2 Feature 3c1 Beneficial Use of Dredged Material from Calcasieu Ship Channel

Feature 3c1 is a marsh restoration and nourishment feature located adjacent to the eastern rim of Calcasieu Lake and is situated within the Cameron-Creole Watershed area. The feature will consist of converting approximately 1,765 acres of open water to marsh habitat, along with the nourishment of approximately 450 acres of adjacent wetlands, through maintenance dredging of material to be borrowed from the Calcasieu Ship Channel. Approximately 10.2 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 92,500' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V.

One renourishment cycle at TY30 is estimated to include 787 acres of marsh restoration along with 1,317 acres of marsh nourishment. Approximately 5.6 million cubic yards of borrow from the Calcasieu Ship Channel will be required for this renourishment cycle.

5.2.1.3 Feature 3c2 Beneficial Use of Dredged Material from Calcasieu Ship Channel

Feature 3c2 is a marsh restoration feature located adjacent to the eastern rim of Calcasieu Lake and is situated within the Cameron-Creole Watershed area.

The feature will consist of converting approximately 1,131 acres of open water to marsh habitat through dedicated dredging of material to be borrowed from the Calcasieu Ship Channel. Approximately 6.3 million gross cubic yards of borrow will be required for this marsh restoration feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 60,500' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V.

One renourishment cycle at TY30 is estimated to include 205 acres of marsh restoration along with 869 acres of marsh nourishment. Approximately 2.2 million cubic yards of borrow from the Calcasieu Ship Channel will be required for this renourishment cycle.

5.2.1.4 Feature 3c3 Beneficial Use of Dredged Material from Calcasieu Ship Channel

Feature 3c3 is a marsh restoration feature located adjacent to the eastern rim of Calcasieu Lake and is situated within the Cameron-Creole Watershed area. The feature will consist of converting approximately 1,293 acres of open water to marsh habitat through maintenance dredging of material from the Calcasieu Ship Channel. Approximately 7.0 million gross cubic yards of borrow will be required for this marsh restoration feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 46,000' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 240 acres of marsh restoration along with 998 acres of marsh nourishment. Approximately 2.5 million cubic yards of borrow from the Calcasieu Ship Channel will be required for this renourishment cycle.

5.2.1.5 Feature 3c4 Beneficial Use of Dredged Material from Calcasieu Ship Channel

Feature 3c4 is a marsh restoration feature located adjacent to the southeastern rim of Calcasieu Lake and is situated within the Cameron-Creole Watershed area. The feature will consist of converting approximately 1,018 acres of open water to marsh habitat through maintenance dredging of material from the Calcasieu Ship Channel or approximately 2 miles offshore within state waterbottoms. Approximately 5.5 million gross cubic yards of borrow will be required for this marsh restoration feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 37,000' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 174 acres of marsh restoration along with 793 acres of marsh nourishment. Approximately 2.2 million cubic yards of borrow from the Calcasieu Ship Channel or approximately 2 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.6 Feature 3c5 Beneficial Use of Dredged Material from Calcasieu Ship Channel

Feature 3c5 is a marsh restoration feature located adjacent to the southeastern rim of Calcasieu Lake and is situated within the Cameron-Creole Watershed area. The feature will consist of converting approximately 3,328 acres of open water to marsh habitat through maintenance dredging of material from the Calcasieu Ship Channel or to be borrowed from approximately 2 to 3 miles offshore within state waterbottoms. Approximately 17.8 million gross cubic yards of borrow will be required for this marsh restoration feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 71,300' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 586 acres of marsh restoration along with 5,576 acres of marsh nourishment. Approximately 6.3 million cubic yards of borrow from approximately 2 to 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.7 Feature 3a1 Beneficial Use of Dredged Material from Calcasieu Ship Channel

Feature 3a1 is a marsh restoration feature located adjacent to the southern shoreline of the GIWW west of the Calcasieu Ship Channel near Black Lake. The feature will consist of converting approximately 599 acres of open water to marsh habitat through dredging of maintenance material from the Calcasieu Ship Channel. Approximately 5.3 million gross cubic yards of borrow will be required for this marsh restoration feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 44,700' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 62 acres of marsh restoration along with 507 acres of marsh nourishment. Approximately 1.0 million cubic yards of borrow from the Calcasieu Ship Channel will be required for this renourishment cycle.

5.2.1.8 Feature 47a1 Marsh Restoration Using Dredged Material South of Highway 82

Feature 47a1 is a marsh restoration and nourishment feature located adjacent to the south side of Highway 82 approximately 4.5 miles west of Grand Chenier.

The feature will consist of converting approximately 88 acres of open water to marsh habitat, along with the nourishment of approximately 933 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 3.0 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.5' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 68,300' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V.

One renourishment cycle at TY30 is estimated to include 70 acres of marsh restoration along with 900 acres of marsh nourishment. Approximately 1.5 million cubic yards of borrow from approximately 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.9 Feature 47a2 Marsh Restoration Using Dredged Material South of Highway 82

Feature 47a2 is a marsh restoration and nourishment feature located on the south side of Highway 82 approximately 4.5 miles west of Grand Chenier. Feature 47a2 is located immediately south of Feature 47a1.

The feature will consist of converting approximately 1297 acres of open water to marsh habitat, along with the nourishment of approximately 126 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 8.8 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.5' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 41,000' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 125 acres of marsh restoration along with 1,227 acres of marsh nourishment. Approximately 1.5 million cubic yards of borrow from approximately 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.10 Feature 47c1 Marsh Restoration Using Dredged Material South of Highway 82

Feature 47c1 is a marsh restoration and nourishment feature located on the south side of Highway 82 approximately 4.5 miles west of Grand Chenier.

The feature will consist of converting approximately 1,304 acres of open water to marsh habitat, along with the nourishment of approximately 4 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 8.6 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.5' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 35,200' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V.

One renourishment cycle at TY30 is estimated to include 55 acres of marsh restoration along with 1,188 acres of marsh nourishment. Approximately 1.8 million cubic yards of borrow from approximately 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.11 Feature 47c2 Marsh Restoration Using Dredged Material South of Highway 82

Feature 47c2 is a marsh restoration feature located on the south side of Highway 82 approximately 4.5 miles west of Grand Chenier. Feature 47c2 is located immediately south of Feature 47a2.
The feature will consist of converting approximately 445 acres of open water to marsh habitat through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 2.9 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.5' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 23,000' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 24 acres of marsh restoration along with 399 acres of marsh nourishment. Approximately 650,000 cubic yards of borrow from approximately 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.12 Feature 124a Marsh Restoration at Mud Lake

Feature 124a is a marsh restoration and nourishment feature located north of Mud Lake and west of West Cove. The feature will consist of converting approximately 886 acres of open water to marsh habitat, along with the nourishment of approximately 217 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from the Calcasieu Ship Channel. Approximately 5.5 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 77,300' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 146 acres of marsh restoration along with 902 acres of marsh nourishment. Approximately 1.9 million cubic yards of borrow from West Cove or the Calcasieu Ship Channel will be required for this renourishment cycle.

5.2.1.13 Feature 124b Marsh Restoration at Mud Lake

Feature 124b is a marsh restoration and nourishment feature located adjacent to Mud Lake west of the Calcasieu Ship Channel. The feature will consist of converting approximately 271 acres of open water to marsh habitat, along with the nourishment of approximately 71 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from the Calcasieu Ship Channel. Approximately 1.6 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.5' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 48,500' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V.

One renourishment cycle at TY30 is estimated to include 60 acres of marsh restoration along with 265 acres of marsh nourishment. Approximately 660,000 cubic yards of borrow from Mud Lake will be required for this renourishment cycle.

5.2.1.14 Feature 124c Marsh Creation at Mud Lake

Feature 124c is a marsh restoration and nourishment feature located adjacent and north of Highway 82 and east of Mud Lake. The feature will consist of converting approximately 1,908 acres of open water to marsh habitat, along with the nourishment of approximately 734 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 11.1 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.5' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 52,600' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V.
One renourishment cycle at TY30 is estimated to include 352 acres of marsh restoration along with 2,158 acres of marsh nourishment. Approximately 4.7 million cubic yards of borrow from approximately 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.15 Feature 124d Marsh Restoration at Mud Lake

Feature 124d is a marsh restoration and nourishment feature located west of the Calcasieu Ship Channel and adjacent to the southern rim of West Cove. The feature will consist of converting approximately 159 acres of open water to marsh habitat, along with the nourishment of approximately 448 acres of adjacent wetlands, through maintenance dredging of material to be borrowed from the Calcasieu Ship Channel or dedicated dredging from West Cove. Approximately 1.4 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.5' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 32,500' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 103 acres of marsh restoration along with 474 acres of marsh nourishment. Approximately 1.2 million cubic yards of borrow from the Calcasieu Ship Channel or West Cove will be required for this renourishment cycle.

5.2.1.16 Feature 127c1 Marsh Restoration at Pecan Island

Measure 127c1 is a marsh restoration and nourishment feature located west of the Freshwater Bayou Canal and approximately 5 miles north of the Freshwater Bayou locks. The feature will consist of converting approximately 1,088 acres of open water to marsh habitat, along with the nourishment of approximately 89 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 9.3 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 36,100' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 94 acres of marsh restoration along with 1,024 acres of marsh nourishment. Approximately 1.8 million cubic yards of borrow from approximately 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.17 Feature 127c2 Marsh Restoration at Pecan Island

Feature 127c2 is a marsh restoration and nourishment feature located west of the Freshwater Bayou Canal and approximately 5 miles north of the Freshwater Bayou locks.
The feature will consist of converting approximately 1,309 acres of open water to marsh habitat, along with the nourishment of approximately 14 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 11.1 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 39,900' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V.
One renourishment cycle at TY30 is estimated to include 79 acres of marsh restoration along with 1,178 acres of marsh nourishment. Approximately 1.9 million cubic yards of borrow from approximately 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.18 Feature 127c3 Marsh Restoration at Pecan Island

Feature 127c3 is a marsh restoration and nourishment feature located west of the Freshwater Bayou Canal and approximately 5 miles north of the Freshwater Bayou locks. The feature will consist of converting approximately 832 acres of open water to marsh habitat, along with the nourishment of approximately 62 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 7.3 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 46,000' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 45 acres of marsh restoration along with 425 acres of marsh nourishment. Approximately 781,000 cubic yards of borrow from Freshwater Bayou will be required for this renourishment cycle.

5.2.1.19 Feature 306a1 Rainey Marsh Restoration – Southwest Portion (Christian Marsh)

Feature 306a1 is a marsh restoration and nourishment feature located east of the Freshwater Bayou Canal and approximately 5 miles north of the Freshwater Bayou locks.
The feature will consist of converting approximately 627 acres of open water to marsh habitat, along with the nourishment of approximately 1,269 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 3 miles offshore within state waterbottoms. Approximately 8.1 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 108,000' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the

earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V.
One renourishment cycle at TY30 is estimated to include 317 acres of marsh restoration along with 1,484 acres of marsh nourishment. Approximately 3.5 million cubic yards of borrow from approximately 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.1.20 Feature 306a2 Rainey Marsh Restoration – Southwest Portion (Christian Marsh)

Feature 306a2 is a marsh restoration and nourishment feature located east of the Freshwater Bayou Canal, approximately 9 miles north of the Freshwater Bayou locks, and west of the McIlhenny Canal. The feature will consist of converting approximately 1,400 acres of open water to marsh habitat, along with the nourishment of approximately 1,105 acres of adjacent wetlands, through dedicated dredging of material to be borrowed from approximately 1 mile nearshore in Vermilion Bay or 3 miles offshore within state waterbottoms. Approximately 13.4 million gross cubic yards of borrow will be required for this marsh restoration and nourishment feature. The material will be transported directly to the restoration site via pipeline.

The dredged material will be placed to achieve a post-construction marsh target elevation of +1.4' NAVD88 (2004.65). During construction, effluent from dewatering will be discharged into adjacent wetlands via spill box weirs. Approximately 48,900' of earthen containment dikes will be constructed from in-situ material located within the marsh restoration/nourishment area. The borrow area used for construction of the earthen containment dike will be refilled during the placement of dredged material. One foot (1') of freeboard will be maintained at all times during dredge discharge operations. The earthen containment dikes will be constructed to an approximate 5' crown width and slopes no steeper than 4H:1V. One renourishment cycle at TY30 is estimated to include 456 acres of marsh restoration along with 1,924 acres of marsh nourishment. Approximately 4.8 million cubic yards of borrow from approximately 1 mile nearshore in Vermilion Bay or 3 miles offshore within state waterbottoms will be required for this renourishment cycle.

5.2.2 Shoreline Protection/Stabilization

5.2.2.1 General

Shoreline protection measures consist of breakwaters, shoreline revetment and nearshore dikes. The terms restoration, stabilization and fortification all refer to methods of shoreline protection. No reestablishment of eroded shoreline is included in these features. The total estimated volume of rock required to construct the shoreline protection features generally assumed an open water contour elevation of -1.0 foot NAVD88 (2004.65), with varying crest elevations and included additional volume to account for the initial and long term consolidation settlement. Assumptions for bottom elevations and crest elevations for project areas were derived using information from recently constructed projects near the project areas and/or information obtained during the CWPPRA planning process. A 250-lb class rock was assumed for the breakwaters. No preliminary hydraulic analysis was performed to provide criteria such as stone size, crown width and height. No actual field data has been collected for this preliminary quantity and cost estimating effort. Surveys will be performed on features carried forward into the next implementation phase. Additionally, no geotechnical information was collected during this phase of the study.

5.2.2.2 Features 6b1, 6b2 and 6b3 Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou

These three feature reaches, 6b1 (approx. 11.1 miles), 6b2 (approx. 8.1 miles) and 6b3 (approx. 7.2 miles); consist of the construction of a reef breakwater with a lightweight aggregate (LWA) core. The encapsulated LWA core decreases the bearing pressure and allows greater crest elevation and increased wave attenuation. The design of this feature incorporates the design and construction of a portion of a CWPPRA demonstration project (ME-18) along the Rockefeller Refuge shoreline. The breakwater will be located along the approximate -4 foot contour approximately 150 ft offshore. The feature includes geotextile fabric overlying geogrid, 1 foot of bedding stone with 3.75 feet of LWA core to be initially covered by approximately 4 feet of armor stone. The structure will have a crest width of 18 ft with 2(H):1(V) side slopes. Flotation dredging is anticipated for access to the site for construction equipment and material barges. Flotation excavation along the alignment will be limited to an 80-foot bottom width channel not to exceed elevation -7.0' NAVD88 (2004.65). One maintenance lift at Target Year (TY) 25 consisting of approximately 10% of the original armor stone quantity is included.

5.2.2.3 Features 16bNE, 16bSE and 16bW Fortify Spoil Banks of GIWW & Freshwater Bayou Features 16bNE, 16bSE and 16bW Fortify Spoil Banks of GIWW & Freshwater Bayou Bank

These three feature reaches, 16bNE (approx. 3.1 miles), 16bSE (approx. 9.1 miles) and 16bW (approx. 3.2 miles), consist of the construction of rock revetment shoreline protection along critical areas of the Freshwater Bayou navigation canal. Armoring of the shoreline is intended to prevent the shoreline from breaching so that salt water does not negatively impact the surrounding freshwater marshes and lakes in the Mermentau Basin. Implementation of similar shoreline protection projects along Freshwater Bayou has halted the shoreline erosion along those reaches. The proposed rock revetment feature will be located at the approximate -1.0 foot contour. Crown elevation will be 4.0' NAVD88 (2004.65) with a 4' crown width and 3(H):1(V) side slopes. The rock dike will be underlain with geotextile fabric to minimize settlement. Limited flotation dredging is anticipated for access to the site for construction equipment and material barges. Flotation excavation along the alignment will be limited to an 80-foot bottom width channel not to exceed elevation -7.0' NAVD88 (2004.65). A maintenance lift at TY15 consisting of approximately 15% of the initial rock quantity is included. A second maintenance at TY25 consisting of approximately 10% of the initial rock quantity is also included.

5.2.2.4 Feature 113b2 Stabilize Shoreline of Vermilion, East & West Cote Blanche Bays: SW Section

This feature consists of the construction of approximately 8.0 miles of a nearshore rock dike at the approximate -1.0 foot contour for the purpose of reducing shoreline erosion and protection of the adjacent marsh. The dike will be constructed to a crown elevation of 4.0' NAVD88 (2004.65) with a 4' crown width and 3(H):1(V) side slopes. The rock dike will be underlain with geotextile fabric to minimize settlement. Flotation dredging is anticipated for access to the site for construction equipment and material barges. Flotation excavation along the alignment will be limited to an 80-foot bottom width channel not to exceed elevation -7.0' NAVD88 (2004.65). The rock dike will be accommodated with gaps to allow continued fish and wildlife access into the interior marshes. A maintenance lift at TY15 consisting of approximately 15% of the initial rock quantity is included. A second maintenance at TY25 consisting of approximately 10% of the initial rock quantity is also included.

5.2.2.5 Feature 99a Gulf Shoreline Restoration: Freshwater Bayou to South Point/Marsh Island

This feature consists of the construction of approximately 1.75 miles of rock breakwaters and is a continuation of existing breakwaters. The breakwaters will be constructed at the approximate -1.2 foot contour to a crown elevation of 4.5' NAVD88 (2004.65) with a crown width of 5.0 feet and 3(H):1(V) side slopes. The rock breakwaters will be underlain with geotextile fabric to minimize settlement. Breakwater segments will be approximately 280 feet in length with 175 gapping between breakwaters. Flotation dredging is anticipated for access to the site for construction equipment and material barges. Flotation excavation along the alignment will be limited to an 80-foot bottom width channel not to exceed elevation -7.0' NAVD88 (2004.65). A maintenance lift at TY15 consisting of approximately 15% of the initial rock quantity is included. A second maintenance at TY25 consisting of approximately 10% of the initial rock quantity is also included.

5.2.2.6 Feature 5a Holly Beach Shoreline Stabilization – Breakwaters

This feature consists of the construction of approximately 8.7 miles of rock breakwaters and is a continuation of existing breakwaters. The breakwaters will be constructed at the approximate -1.0 foot contour to a crown elevation of 3.5' NAVD88 (2004.65) with a crown width of 4.0 feet and 3(H):1(V) side slopes. The rock breakwaters will be underlain with geotextile fabric to minimize settlement. Breakwater segments will be approximately 280 feet in length with 175 gapping between breakwaters. Flotation dredging is anticipated for access to the site for construction equipment and material barges. Flotation excavation along the alignment will be limited to an 80-foot bottom width channel not to exceed elevation -7.0' NAVD88 (2004.65). A maintenance lift at TY15 consisting of approximately 15% of the initial rock quantity is included. A second maintenance at TY25 consisting of approximately 10% of the initial rock quantity is also included.

5.2.3 Chenier Reforestation

Chenier reforestation consists of replanting of 435 seedlings per acre at 10' x 10' spacing, in 22 Chenier locations on 1,400 acres in Cameron and Vermilion parishes. Areas eligible for Chenier reforestation consist of areas greater than five feet in elevation and with low shoreline erosion rates, provided the existing canopy coverage is less than 50% unless nearby development would prevent achieving study objectives. This feature also includes the removal of certain invasive species.

6.0 STRUCTURAL FEATURES

6.1 NED

Potential structures were identified using the proposed alternative levee alignments and existing mapping. An attempt was made to identify the major structures that would be required. Three basic types of structures were used for cost estimating purposes: sector gates, stop log gates and drainage culverts. Sector gate structures would consist of a 56' wide sector gate with or without sluice gates. Structures with sluice gates would have a total width of 600 feet. Stop log gates would be 20' or 30' wide. Drainage culvert structures would consist of 2 – 6'x6' culverts. Structures would be constructed to the 2075 design elevations. Basic quantities were taken from designs developed for the Morganza to the Gulf of Mexico, Louisiana Post Authorization Change Report and adjusted as required to meet the requirements for each alternative. The number and type of structures for each alternative levee alignment are listed in Table 64.

Table 64 – Structures

Alternative	**Structure Description**
Abbeville Ring Levee	Sector Gate with Sluice Gates
	Stop Log Gates (2) – 20' width
	Drainage structure
Abbeville to Delcambre – Hwy 330	Sector Gate with Sluice Gates
	Stop Log Gates (4) – 2-20' wide and 2-30' wide
	Drainage Structures (2)
Delcambre Erath	Stop Log Gate – 30' wide
	Drainage Structure
Lake Charles East Bank	Sector Gate
	Stop Log Gate – 20' wide
	Drainage Structure (2)
Lake Charles West Bank Sulphur	Stop Log Gates
	Drainage Structure – 30' wide
Lake Charles West Bank Sulphur South	Stop Log Gates (2) – 30' wide
	Drainage Structure (3)

6.1.1 Sector Gate Structures

Sector gated structures would provide flood risk reduction (closure) during storm events while allowing normal navigation at many of the waterways intersecting the flood risk reduction alignment. Typical sector gates with and without sluice gates are shown in Figure 20 and Figure 21. These structures were sized based on the apparent width of the existing waterway. The sill elevation at each location was selected based on the prevailing bottom elevation at the site. Standard sector gate widths of 56 feet were used. Each sector gate structure would be a pile founded, reinforced concrete structure at the required sill elevation and width to maintain navigation in the waterway. The structure would have emergency and/or maintenance stop logs and separate control houses on each wall. A timber guidewall with a protective cellular dolphin at the end would be provided on both sides of each approach channel to the structure.

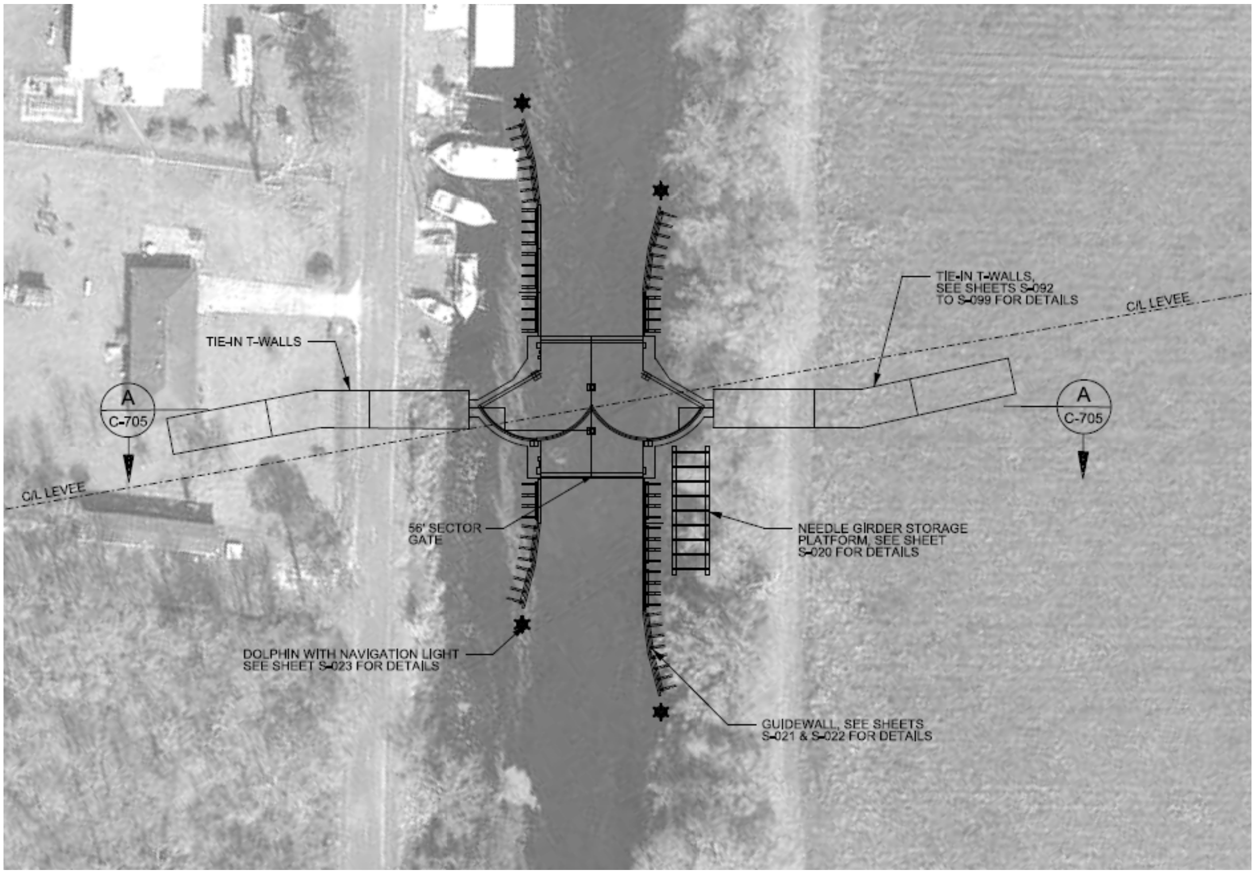

Figure 20 - Typical 56' Sector Gate

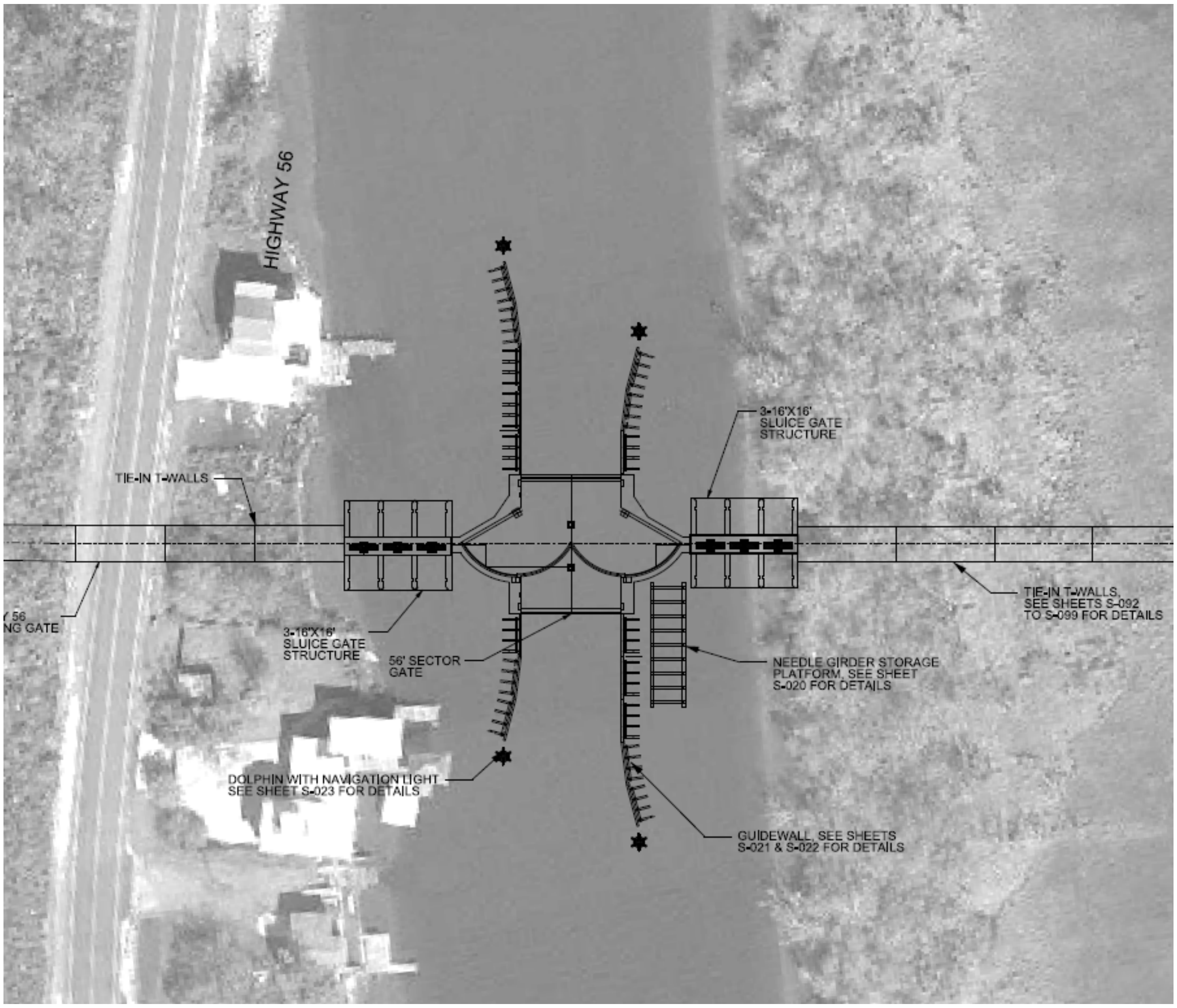

Figure 21 - Typical Sector Gate With Sluice Gates

6.1.2 Stop Log Gates

For smaller waterways which intersect the flood protection, stop log gates provide flood protection (closure) while taking up a smaller footprint than a sector gate. A typical stop log gate is shown in Figure 22. Gate operation however, is of longer duration than a sector gate, requiring earlier closure of the structure prior to an event. The stop log gates were sized based on the apparent width of the existing waterway. Two stop log gate sizes were used, 20' and 30'. The sill elevation at each location was selected based on the prevailing bottom elevation at the site. Each gate structure would be a pile founded, reinforced concrete structure. The structure would be 42 feet long and will have a usable navigation width of 20 or 30 feet. The total width of the structure would be 70 feet.

Slots in the middle of the structure walls provide for gate placement. The gates consist of horizontal plate girders which carry loads to the adjacent concrete walls. Loads would be transferred from the bulkheads to

the concrete walls through reaction plates. Two vertical braced frames would be placed under the lifting points to provide vertical support under lifting and storage conditions. Rollers would be placed on the ends of the gate to assist in placing them in the slots.
The main walls of the structure adjacent to the navigation channel would be 5 feet wide. Timber guide walls and end dolphins would be provided on both sides of each approach channel. When not employed, gates would be stored on-site on a platform. Access to the platform would be via the crane platform.

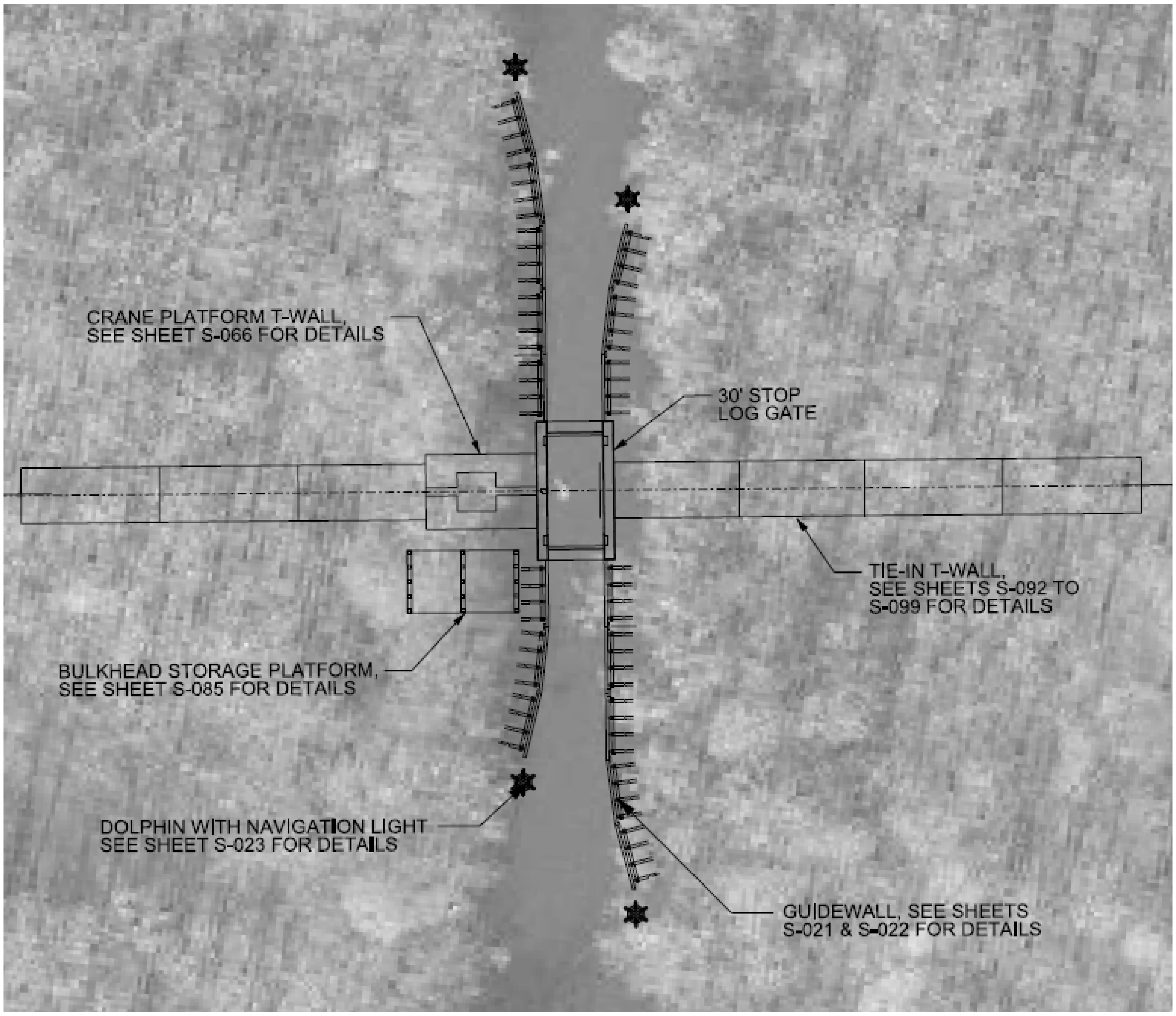

Figure 22 - Typical Stop Log Gate

6.1.3 Drainage Structures

Drainage structures with sluice gates would provide drainage through the flood protection at various locations within the planning area. A typical drainage structure is shown in Figure 23. Each structure would consist of a pile founded, reinforced concrete structure with trash screens, operating platforms, and provisions for dewatering. The sluice gate structures would connect into the existing flood protection on each side of the structure with a T-wall. The sluice gates would have the capability to be operated manually or will be mechanically actuated with portable motors.

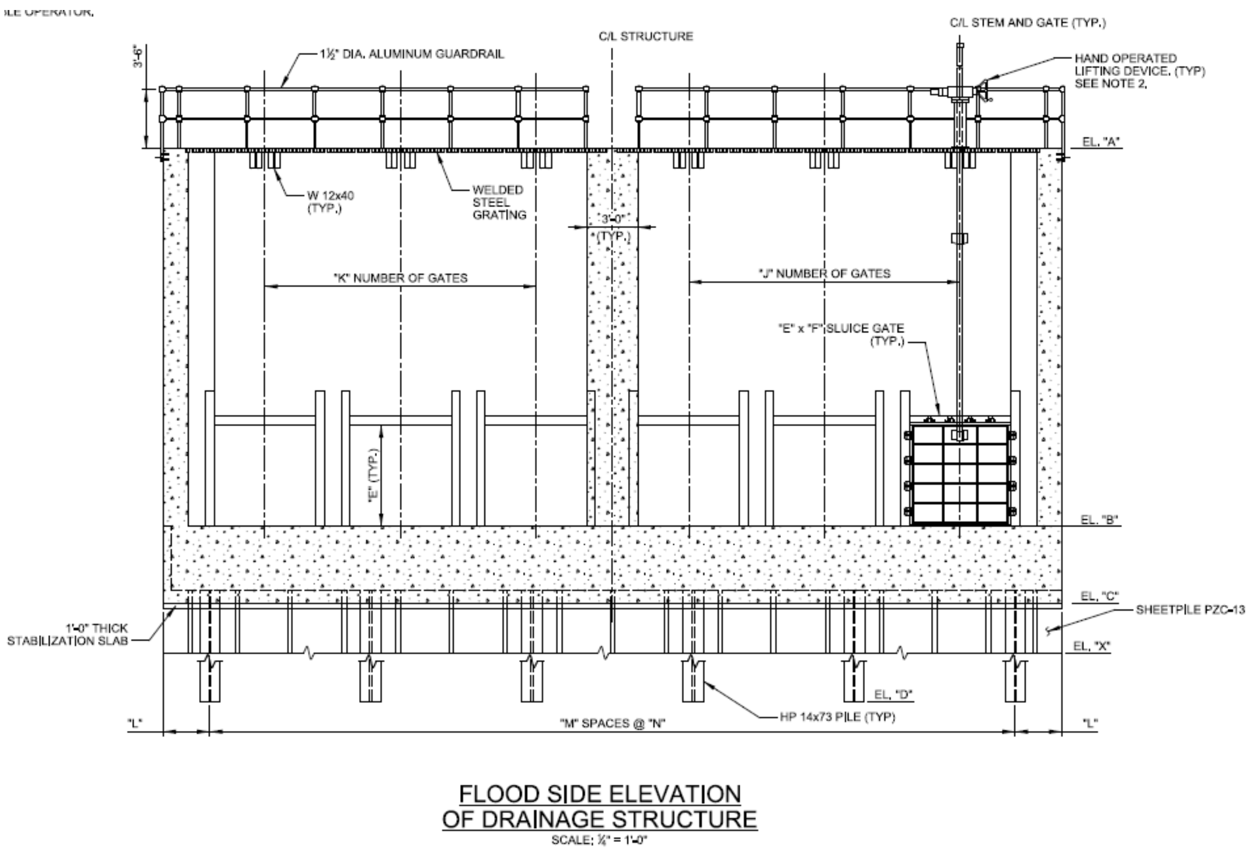

Figure 23 - Typical Drainage Structure

6.2 NER STRUCTURAL FEATURES

Design assumptions and cost estimates for hydrologic and salinity control features included in the focused NER array for this study were taken from the 2012 Louisiana Comprehensive Master Plan for a Sustainable Coast.

7.0 RELOCATIONS

7.1 NED ALTERNATIVES

Relocations were not specifically identified for developing costs for the NED alternatives. For the purpose of developing parametric cost estimates of relocations costs were accounted for by taking 2% of the construction costs. As a cross check of this assumption the relocations for the recently completed Morganza to the Gulf PAC Study accounted for approximately 4% of the project cost.

7.2 NER ALTERNATIVES

No relocations were specifically identified in the State Master Plan for the NER features. Since the NER features generally involve only surface level construction, and avoidance of any significant infrastructure would be the preferred construction approach, no relocations are anticipated. As a result no costs for relocations were included in the NER feature estimates.

8.0 OPERATION, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION (OMRR&R)

8.1 NED

OMRR&R estimates were developed for the structures, levees and pump stations for each NED levee alternative in the focused array. The estimates used were initially developed for use in the LACPR Final Technical Report completed in 2009. Estimates for structures include annual operation and maintenance cost as well as periodic refurbishment. OMRR&R estimates for levees assume $10,000 per mile per year for maintenance which includes grass cutting. The average annual OMRR&R cost is shown in Table 65.

There are no expected OMRR&R requirements identified for the Non-structural measures considered in this study.

Table 65 Estimated Annual OMRR&R

Alternative	Estimated Annual OMRR&R
Abbeville Ring Levee	$276,000
Delcambre Erath	$240,000
Abbeville to Delcambre	$566,000
Lake Charles East Bank	$604,000
Lake Charles West Bank Sulphur	$205,000
Lake Charles West Bank Sulphur South	$444,000

8.2 NER

Marsh creation OMRR&R consists of a 30-yr marsh renourishment cycle. The acres of renourishment needed were based on land loss estimates. Shoreline protection OMRR&R estimates for features with breakwaters were based on performing two additional maintenance lifts at year 15 and year 25. Year 15 lift assumes 15% of the initial rock tonnage would be needed and year 25 lift assumes another 10% of the initial rock tonnage would be needed. Features with lightweight aggregate cores assumed one maintenance event at year 25 and 10% of the initial armor stone tonnage would be needed. The assumptions are based on predicted settlement based on experience with previous projects in the study area. The hydraulic and salinity structure features assumed one maintenance event at year 15. The OMRR&R costs for the structure were taken from costs developed for the State Master Plan. OMRR&R assumptions are for individual measures are included in the measure descriptions in Section 5. OMRR&R cost for individual features is shown in Table 68 found in Section 9.1 .

9.0 COST ESTIMATES

9.1 NED COST ESTIMATES

The cost estimates for the NED alternatives were prepared based on readily available New Orleans District data and quantities provided by the PDT.

The cost estimate was developed in the TRACES Mii cost estimating software and used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. All features were estimated based on standard construction methods which are common to the New Orleans District and South Louisiana. The estimates assumed access was available to proposed areas unless otherwise stated. This philosophy was taken wherever practical. It was supplemented with estimating information from other sources where necessary such as quotes, historical bid data, A-E estimates, and previously approved similar studies (Morganza to the Gulf of Mexico, Louisiana Post Authorization Change Report). The intent was to provide or convey a "fair and reasonable" estimate that which depicts the local market conditions. The estimates assume a typical application of tiered subcontractors. Given the unknown economic status during project time, demands from non-governmental civil works projects were not considered to dampen the competition and increase prices.

9.1.1 NED Structural Alternative Estimates

Estimate Structure: The estimate is structured to reflect the projects performed. The estimates are subdivided by USACE feature codes and by local "reach" name.

Bid competition: It is assumed that there will not be an economically saturated market and that bidding competition will be present.

Contract Acquisition Strategy: It is assumed that the contract acquisition strategy will be similar to past projects with some negotiated contracts, focus and preference of small business/8(a), and large, unrestricted design/bid/build contracts. There is no declared contract acquisition plan/types at this time, so typical MVN goals have been included.

Labor Shortages: It is assumed there will be a normal labor market.

Labor Rates: Local labor market wages are above the local Davis-Bacon Wage Determination and actual rates have been used. This is based upon local information and payroll data received from the New Orleans District Construction Representatives and estimators with experiences in past years.

Materials: Cost quotes are used on major construction items when available. Recent quotes may include borrow material, concrete, steel and concrete piling, rock, gravel and sand, and deep soil mixing. Assumptions include:

a. materials will be purchased as part of the construction contract. The estimate does not anticipate government furnished materials. Prices include delivery of materials.

b. Concrete - will be purchased from commercial batch plants.

c. Borrow Material and Haul - Borrow material is considered the highest risk in the contracts, given the large quantities required, uncertainties of sources and materials near the many contract locations. Specific borrow sources have not been established so a conservative estimated haul distance was used when using off-site material. Borrow pits currently in use are within this distance. All borrow material is assumed Government furnished as it is a local sponsor responsibility. No contractor furnished borrow source are used.

The borrow quantity calculations followed the MVN Geotechnical guidance:

Hauled Levee: 10 BCY (bank cubic yards) of borrow material = 12 LCY (loose cubic yards) hauled = 8 ECY (embankment cubic yards) compacted.

An assumed average one-way haul distance of 25 miles was used unless a committed borrow source has been confirmed available. This decision is based upon discussions with the New Orleans District cost engineers and Project Delivery Team (PDT).

Haul speeds are estimated using 40 mph speed average given the long distances and rural areas.

d. Rock and stone - The Louisiana area has no rock sources. Historically, rock is barged from northern sources on the Mississippi River. This decision is based upon local knowledge, experience and supported with cost quotes.

Equipment: Rates used are based from the latest USACE EP-1110-1-8, Region III. Adjustments are made for fuel, filters, oil and grease (FOG) prices and facility capital cost of money (FCCM). Use of owned verses rental rates was considered based on small business, large business, and local equipment availability.

a. Trucking: The estimate assumed independent self-employed trucking subcontractors due to the large numbers of trucks required.

b. Dozers: dozers of the D-5/D-6 variety were chosen based on historical knowledge. Heavier equipment gets mired in the mud and soft soils.

c. Severe Rates: Severe equipment rates were used where appropriate.

Fuel: Fuels (gasoline, on and off-road diesel) were based on local market averages for on-road and off-road. The Team found that fuels fluctuate irrationally; thus, used an average.

Crews: Major crew and productivity rates were developed and studied by senior USACE estimators familiar with the type of work. All of the work is typical to the New Orleans District. The crews and productivities were checked by local MVN estimators, discussions with contractors and comparisons with historical cost data. Major crews include haul, earthwork, piling, concrete, and deep soil mixing.

Unit Prices: The unit prices found within the various project estimates will fluctuate within a range between similar construction units such as floodwall concrete, earthwork, and piling. Variances are a result of differing haul distances (trucked or barged), small or large business markups, subcontracted items, designs and estimates by others.

Relocation Cost: Relocation costs are defined as the relocation of public roads, bridges, railroads, and utilities required for project purposes. Due to the limited time available for investigation, an allowance of 2.0% of construction cost was used.

Mobilization: Contractor mobilization and demobilization are based on the assumption that many of the contractors will be coming from within a 500 mile radius. Based on historical studies, Pre-Katrina detailed Government estimates for mobilization averaged 4.9 to 5% of the construction costs. The estimate utilizes the approx. 5% value at each contract. The 5% value matches well with the 5% value prescribed by Walla Walla District, which has studied historical rates.

Field Office Overhead: The estimate used a field office overhead rate of 12% for the prime contractor at budget level development. Based on historical studies and experience, Walla Walla District has recommended typical rates ranging from 9% to 12% for large civil works projects. The 12% rate considers the possibility of maintenance and management of work camps and kitchens. The applied rates were previously discussed on similar projects among numerous USACE District cost engineers including Walla Walla, Vicksburg, Norfolk, Huntington, St. Paul and New Orleans.

Overhead assumptions include: Superintendent, office manager, pickups, periodic travel, costs, communications, temporary offices (contractor and government), office furniture, office supplies, computers and software, as-built drawings and minor designs, tool trailers, staging setup, utility service, toilets, safety equipment, security and fencing, small hand and power tools, project signs, traffic control, surveys, temp fuel tank station, generators, compressors, lighting, and minor miscellaneous.

Home Office Overhead: Estimate percentages range based upon consideration of 8(a), small business and unrestricted prime contractors. The rates are based upon estimating and negotiating experience, and consultation with local construction representatives. Different percents are used when considering the contract acquisition strategy regarding small business 8(a), competitive small business and large business, high to low respectively. The applied rates were previously discussed on similar projects among numerous USACE District cost engineers including Walla Walla, Vicksburg, Norfolk, Huntington, St. Paul and New Orleans.

Taxes: Local taxes will be applied, using an average between the parishes that contain the work. Reference the LA parish tax rate website: http://www.laota.com/pta.htm

Bond: Bond is assumed 1% applied against the prime contractor, assuming large contracts. No differentiation was made between large and small businesses.

E&D and S&A: USACE Costs to manage design (PED) and construction (S&A) are based on New Orleans District Programmatic Cost Estimate guidance:

a. Planning, Engineering & Design (PED): The PED cost includes such costs as project management, engineering, planning, designs, investigations, studies, reviews, value engineering and engineering during construction (EDC). Historically New Orleans District has used an approximate 12% rate for E&D/EDC, applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis have reported values ranging from 10-15%. A rate of 12% for E&D/EDC was applied.

b. Supervision & Administration (S&A): Historically, New Orleans District used a range from 5% to 15% depending on project size and type applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis report values ranging from 7.5-10%. Consideration includes that a portion of the S&A effort could be performed by contractors. An S&A rate of 8% was applied.

Table 66 - NED Structural Cost Estimates

Alignment	Level of Risk Reduction	Estimated Cost
Abbeville Ring Levee	2%	$286,043,668
	1%	$344,105,662
	.5%	$447,742,511
Delcambre Erath	2%	$359,417,088
	1%	$470,793,469
	.5%	$589,491,453
Abbeville Delcambre	2%	$726,253,790
	1%	$885,237,639
	.5%	$1,117,889,012
East Bank Lake Charles	2%	$815,634,955
	1%	$1,015,364,226
	.5%	$1,260,363,306
West Bank Lake Charles Sulphur	2%	$142,812,830
	1%	$199,252,279
	.5%	$327,052,735
West Bank Lake Charles Sulphur South	2%	$456,320,325
	1%	$629,124,749
	.5%	$883,942,322

The Total Costs shown in Table 66 are developed as follows:

1. Construction costs were developed in the Mii estimate (levees, sector/stoplog gates, ECS).
2. Construction costs were then entered into the Excel spreadsheet "Cost By Year 2 Oct 13.xlsx" on the "TOTAL Costs" tab.
3. Contingency, E&D, EDC, S&A, Real Estate, Pump Stations, and Relocations are added in on "Cost By Year 2 Oct 13.xlsx", "TOTAL Costs" tab for a Total Cost per Reach and Level of Risk Reduction as shown in Table 66 of Engineering Report.
4. The Excel spreadsheet "Cost By Year 2 Oct 13.xlsx" also includes a tab for each Reach which takes the "TOTAL Costs" and determines yearly costs for Economic analysis.

9.1.2 NED Non-structural Alternative Estimates

9.1.2.1 General

The cost per square foot for raising a structure was based on data obtained during interviews with representatives of three major metropolitan New Orleans area firms that specialize in the structure elevation. Composite costs were derived for residential structures by type: slab and pier foundation, one story and two story configuration, and for mobile homes. Table 67- displays the costs for each of the five residential categories analyzed. The cost per square foot to raise an eligible residential structure to the target height was multiplied by the footprint square footage of each structure to compute the costs to elevate the structure. Full estimates for the Non-structural alternatives are fully developed as an output of the HEC-FDA economic analysis model. The description of this model, and the manner in which the per-square foot unit costs, are applied can be found in the Appendix D – Economics.

The nonstructural cost estimate was checked employing the TRACES Mii cost estimating software. Elevation contractors were contacted to verify cost estimating assumptions. This information, along with known construction data was fed into the TRACES Mii cost estimating software to validate the unit costs for structure elevation.

Estimate Philosophy: The estimate development used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. This philosophy was taken wherever practical within the time constraints. It was supplemented with estimating information from other sources where necessary such as quotes, bid data, and A-E estimates. The intent was to provide or convey a "fair and reasonable" estimate that which depicts the local market conditions. The estimates

Table 67-Cost per Square Foot of Elevating Residential Structures
(2012 Price Level In Dollars)

	1STY-SLAB			2STY-SLAB			1STY-PIER			2STY-PIER			MOBHOM		
Ft. Raised	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max
1	62	70	77	70	77	85	54	62	69	61	68	76	30	34	38
2	62	70	77	70	77	85	54	62	69	61	68	76	30	34	38
3	64	71	79	71	79	86	57	64	72	63	71	78	30	34	38
4	66	74	81	76	84	91	57	64	72	63	71	78	30	34	38
5	66	74	81	76	84	91	57	64	72	63	71	78	38	42	45
6	68	75	83	78	85	93	58	66	73	65	72	80	38	42	45
7	68	75	83	78	85	93	58	66	73	65	72	80	38	42	45
8	70	78	85	80	88	96	60	67	75	66	74	81	38	42	45
9	70	78	85	80	88	96	60	67	75	66	74	81	38	42	45
10	70	78	85	80	88	96	60	67	75	66	74	81	38	42	45
11	70	78	85	80	88	96	60	67	75	66	74	81	38	42	45
12	70	78	85	80	88	96	60	67	75	66	74	81	38	42	45
13	73	80	88	85	93	101	61	69	76	68	75	83	38	42	45

assume a typical application of tiering subcontractors. Given the long time over which this project/program is to be constructed and the unknown economic status during that time, demands from non-governmental civil works projects were not considered to dampen the competition and increase prices.

Estimate Structure: The estimate is structured to reflect the projects performed. The estimates are subdivided by USACE feature codes.

Bid competition: It is assumed that there will not be an economically saturated market and bidding competition will be present.

Contract Acquisition Strategy: There is no declared contract acquisition plan/type at this time and it is anticipated that the Federal Government will not issue contracts but only provide monies. Any contracts would be directly between building owner and contractors.

Labor Shortages: It is assumed there will be a normal labor market.

Labor Rates: Local labor market wages are above the local Davis-Bacon Wage Determination and actual rates have been used. This is based upon local information and payroll data received from the New Orleans District Construction Representatives and estimators with experiences in past years.

Materials: Cost quotes are used on major construction items when available, although quantities per site are small relatively speaking. Recent quotes may include borrow material, concrete, steel and concrete piling, rock, gravel and sand. Assumptions include:

a. materials will be purchased as part of the construction contract. The estimate does not anticipate government furnished materials. Prices include delivery of materials.

b. Concrete - will be purchased from commercial batch plants.

c. Borrow Material and Haul - Specific borrow sources have not been established so a conservative estimated haul distance was used when using off-site material. All borrow material is assumed contractor furnished.

An assumed average one-way haul distance of 20 miles was used unless a committed borrow source has been confirmed available.

Equipment: Minimal equipment is required for this work. Rates used are based from the latest USACE EP-1110-1-8, Region III.

Crews: Major crew and productivity rates were reviewed by senior USACE estimators familiar with the type of work. All of the work is typical to the New Orleans District. The crews and productivities were checked by local MVN estimators, discussions with contractors and comparisons with historical cost data.

Most crew work hours are assumed to be 8 hrs 5 days/wk which is typical to the area.

Relocation Cost: Relocation costs are defined as the relocation of public roads, bridges, railroads, and utilities required for project purposes. These costs are not applicable.

Mobilization: Contractor mobilization and demobilization are based on the assumption that most of the contractors will be coming from within the Gulf Coast/Southern region.

Field Office Overhead: Included in contractor quotes for turnkey operations. The contracts are anticipated to be relatively small, simple operations, so "Field" overhead will be small.

Home Office Overhead: Included in contractor quotes for turnkey operations. The contracts are anticipated to be relatively small, simple operations by small, local established companies, so "Home" overhead will be minimal.

Taxes: Local taxes will be applied, using an average between the parishes that contain the work. Reference the LA parish tax rate website: http://www.laota.com/pta.htm

E&D and S&A: USACE Costs to manage design (PED) and construction (S&A) are based on New Orleans District Programmatic Cost Estimate guidance:

a. Planning, Engineering & Design (PED): PED cost is not included as it is anticipated that the Federal Government will not plan, engineer, and design the projects. All actions will be directly between building owner and the contractor they select. E&D will be included in contractor's price if needed.

b. Supervision & Administration (S&A): S&A cost is not included as it is anticipated that the Federal Government will not administer the contracts. All actions will be directly between building owner and the contractor they select. S&A will be included in contractor's price.

9.1.2.2 Escalation

The unit costs were originally developed in 2012 by local vendor quote or A/E report and have been escalated to 2014. The indexed costs have been validated by comparison to one of the same local vendors in Apr 2014 and the indexed costs are at or above the 2014 quote. Escalation used in the Mii and TPCS is based upon the US Army Corps of Engineers Engineering Manual (EM) 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS) revised 30 Mar 2014.

9.1.3 Contingencies

Contingencies were not developed using the USACE Cost and Schedule Risk Analysis (CSRA) process. Contingencies were based upon similar projects, such as Morganza to the Gulf PAC, that were developed using the CSRA process. A contingency of 30% was used for levee and control structure items and 25% for pumping stations.

9.1.4 Alternative Estimates

The estimates for the levee alternatives included in the focused array of alternatives are shown in Table 66. These numbers included Real Estate, E&D, S&A, relocations and contingencies. Estimates for the Non-structural alternatives contain the same components but are fully estimated as an output of the HEC-FDA economic analysis model. The description of this model, and the manner in which the-per square foot unit costs, are applied can be found in the Appendix D – Economics. The preliminary estimated costs do not include mitigation, monitoring and adaptive management.

9.2 NER COST ESTIMATES

9.2.1 Feature and Alternative Costs

The cost estimates for the measures, combined to make up the focused array of NER alternatives, were prepared in an expedited manner based on readily available data and quantities. The estimated costs were derived upon an analysis of each line item evaluating quantity and cost were based on in-house knowledge and experience in estimating and constructing similar projects. Cost Estimates were developed using historical data and a recent version of the CWPPRA cost estimating spreadsheet that has been used for many years for restoration projects. In addition to relying upon recent bid tabulations, the spreadsheet developed by Texas A&M Center for Dredging Studies was utilized to estimate unit rates for hydraulic dredging. All features were estimated based on standard construction methods all of which are common to South Louisiana. The estimates assumed access was available to proposed areas unless otherwise stated. Each element was developed independently and assumed equipment availability is not an issue. Operation and maintenance events were estimated and also included in the cost estimates. OMRR&R requirements were discussed in the description of the design of individual features. A 25% contingency was added to the measure estimates. E&D, S&A, and real estate were not included in the costs for individual measures. The first cost and OMRR&R estimates for the measures included in the NER focused array of alternatives are shown in Chapter 4 of the main report.

Table 68 - NER Feature Estimates

Measure	First Cost	OMRR&R
CALCASIEU		
7 – Salinity Control Structure in the Calcasieu Ship Channel	$315,778,000	$63,160,000
17 – Salinity Control Structures Alkali Ditch, Crab Gully and Black Lake Bayou	$32,866,000	$2,660,000
48 – Salinity Control Structure at Sabine Pass	$21,769,000	$10,520,000
74a – Cameron: Spillway Structures at East Calcasieu Lake	$4,328,000	$830,000
407 – GIWW at Gum Cove Ridge Structure	$240,480,000	$48,100,000
3c1 – Beneficial use of Dredged Material from the Calcasieu Ship Channel	$117,802,030	$67,941,441
3c2 – Beneficial use of Dredged Material from the Calcasieu Ship Channel	$77,070,598	$32,433,230
3c3 – Beneficial use of Dredged Material from the Calcasieu Ship Channel	$83,947,114	$35,137,836
3c4 – Beneficial use of Dredged Material from the Calcasieu Ship Channel	$50,121,614	$21,147,761
3c5 – Beneficial use of Dredged Material from the Calcasieu Ship Channel	$146,057,904	$54,639,970
3a1 – Beneficial use of Dredged Material from the Calcasieu Ship Channel	$66,576,486	$17,835,142
124a – Marsh Restoration at Mud Lake	$54,178,577	$15,098,977
124b – Marsh Restoration at Mud Lake	$21,794,722	$4,716,678
124c – Marsh Restoration at Mud Lake	$65,163,555	$29,566,130
124d – Marsh Restoration at Mud Lake	$13,826,622	$10,360,810
5a – Holly Beach Shoreline Stabilization	$43,644,018	$17,251,455
510a – Blue Buck Ridge Restoration	$91,062	
510b – Hackberry Ridge Restoration	$25,721	
510d – Front Ridge Restoration	$79,994	
604 – Sabine Oyster Reef*	0	
MERMENTAU		
13 – Structure on Little Pecan Bayou	$4,005,000	$790,000
47a1 – Marsh Restoration South of Highway 82	$32,698,038	$19,346,537
47a2 – Marsh Restoration South of Highway 82	$73,725,657	$22,719,765
47c1 – Marsh Restoration South of Highway 82	$70,993,097	$19,113.914
47c2 – Marsh Restoration South of Highway 82	$29,083,323	$10,897,564

Measure	First Cost	OMRR&R
127c1 – Marsh Restoration at East Pecan Island	$105,383,774	$28,038,625
127c2 – Marsh Restoration at East Pecan Island	$123,443,158	$27,417,711
127c3 – Marsh Restoration at East Pecan Island	$84,352,747	$9,097,015
306a1 – Rainey Marsh Restoration	$97,159,850	$45,851,023
306a2 – Rainey Marsh Restoration	$168,410,323	$64,215,103
6b1 – Shoreline Restoration: Calcasieu River to Freshwater Bayou	$104,780,685	$16,139,775
6b2 – Shoreline Restoration: Calcasieu River to Freshwater Bayou	$76,571,740	$11,976,464
6b3 – Shoreline Restoration: Calcasieu River to Freshwater Bayou	$68,096,051	$10,704,819
16b – Fortify Spoil Banks at GIWW and Freshwater Bayou	$67,773,307	$26,125,453
99a – Gulf Shoreline Restoration: Freshwater Bayou to South Point/Marsh Island	$12,198,599	$3,401,744
113b2 – Shoreline Stabilization of Vermillion	$35,104,143	$13,385,533
509c – Bill Ridge Restoration	$5,409	
416 – Grand Chenier Ridge	$44,114	

- There is no cost associated with measure 604, the Sabine Oyster Reef, as it consists of prevention of harvesting of oysters on existing reefs.

These costs for the measures contained in each NER alternative in the focused array were combined to develop total costs for each alternative analyzed. Total costs for alternatives and details about the analysis can be found in the Main Report.

The Total Costs shown in Chapter 4 of the Main Report are developed as follows:

1. Measures for NER alternatives are listed in Table 2 of this report. Each Measure has an alpha-numeric identifier which can be used to trace cost development in estimate files.
2. Marsh and Shoreline construction costs plus contingency are developed in Excel files from the State of LA. Each file has the corresponding alpha-numeric "Measure" identifier in the file name.
3. Hydrology and Salinity Control Structure costs are developed in "2012 MP Costs for SW Coastal HandS Control Measures.pdf".
4. Total construction cost plus contingency per Measure is shown in Table 67 of Engineering Report. These costs per Measure would then be used to determine the various NER alternatives based on Table 2.
5. Construction costs plus other account features (PED, Real Estate, Adaptive Management, Construction Management) are added in Table 69 to develop a Total First cost.

10.0 CONSTRUCTION SCHEDULE

10.1 NED FOCUSED ARRAY

For all alternatives in the focused array it was assumed that Engineering and Design (E&D) and Real Estate acquisition would start in 2017 and construction would begin in 2019. The construction duration would be six years with completion in 2024.

10.2 NER FOCUSED ARRAY

10.2.1 Marsh Restoration

The construction period for marsh restoration measures was assumed to range from 1 to 4 years. Construction was assumed to start in 2022. There would be one renourishment event that would last from .5 to 1.5 years and would start year 2051.

10.2.2 Shoreline Protection/Stabilization

Construction of shoreline protection features ranged from 1 to 3 years beginning in 2022. Maintenance events would be one year in duration and would occur in 2036 and 2046.

10.2.3 Hydrologic/Salinity Control Structures

Construction of salinity control structures would range from one to three years beginning in 2022.

10.2.4 Chenier Reforestation

Chenier reforestation would begin in 2022 and would extend from one to two years.

11.0 RISK AND UNCERTAINTY

11.1 NED

Because of the nature of the analysis performed there are several areas of risk and uncertainty involved in the development of the NED alternative plan feature cost. Some of these are listed below.

1. There are inherent risks and uncertainties in the use of any model. In addition the required levee elevations were developed based on the use of the without project ADCIRC runs. Benefit estimates were also based on the without project ADCIRC stage data.
2. The ADCIRC and HEC-RAS models were run independently and although the combined effects were accounted for in the stage-frequency analysis the method used may result in under prediction of the additive effects of surge and rainfall flooding.
3. There are uncertainties in the development of RSLR rate estimates. Actual RSLR may be higher or lower than the rates used in modeling and damage and benefits analysis.
4. Induced flooding: Since no with-project ADCIRC data was available no estimates of induced flooding were developed.
5. Foundation Design: No site specific boring data was available for this effort. Existing data in the vicinity was used to develop levee designs. One levee design was done for use in all alternatives. As most of the study area has uniformly good soil foundation conditions this is not considered a high risk.
6. Structures: An effort was made to identify the major structures that would be required but it is possible that more structures would be needed.
7. Mitigation requirements not required.
8. A conservative estimate was assumed for Real Estate Requirements for all levee alternatives.
9. Real Estate costs for borrow have not been developed.
10. Relocations were added as 2% of the construction costs.
11. Pumping requirements were developed based on work done for the LACPR project. Pumping requirements used were considered minimal amounts. Actual requirements may be different. Additional drainage work may be needed to get the water to the pumping stations.
12. Levee alignments were developed using existing mapping. These preliminary alignments were used to develop cost estimates. Alignments may need to be shifted to avoid existing structures or for other reasons.
13. Quantities developed assume levee for the entirety of each alignment. There is a possibility that some reaches of floodwall may be needed in more developed areas such as Lake Charles.
14. Because no borrow sites have been identified, borrow was assumed to be available within a 25 mile radius. Borrow may be available at a closer distance.
15. No costs for road gates/ramps were included in the estimate.
16. Risk and uncertainty for features of the non structural plan is discussed in the Economics Appendix.

11.2 NER

Because of the nature of the analysis performed there are several areas of risk and uncertainty involved in the development of the NER alternative cost and benefits. Some of these are listed below.

1. No site specific surveys were taken and marsh fill quantities and shoreline protection quantities were based on estimates of depth using existing data.
2. No site specific borings were taken and settlement of shoreline protection and marsh restoration/nourishment measures was estimated based on available data.
3. Site specific borrow areas have not been developed and testing of the borrow areas for suitability and availability of borrow material has not been done. It was assumed that suitable material would be available within the distance used for cost estimating.
4. It was assumed that pipeline access would be available for marsh restoration/nourishment features.
5. Uncertainties in the State Master Plan and MIKE Flood modeling done to evaluate the effects of the restoration features.

12.0 REFERENCES

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