UPPER BARATARIA BASIN, LOUISIANA

SECOND DRAFT FEASIBILITY REPORT

AND

INTEGRATED ENVIRONMENTAL IMPACT STATEMENT

ENGINEERING

APPENDIX A

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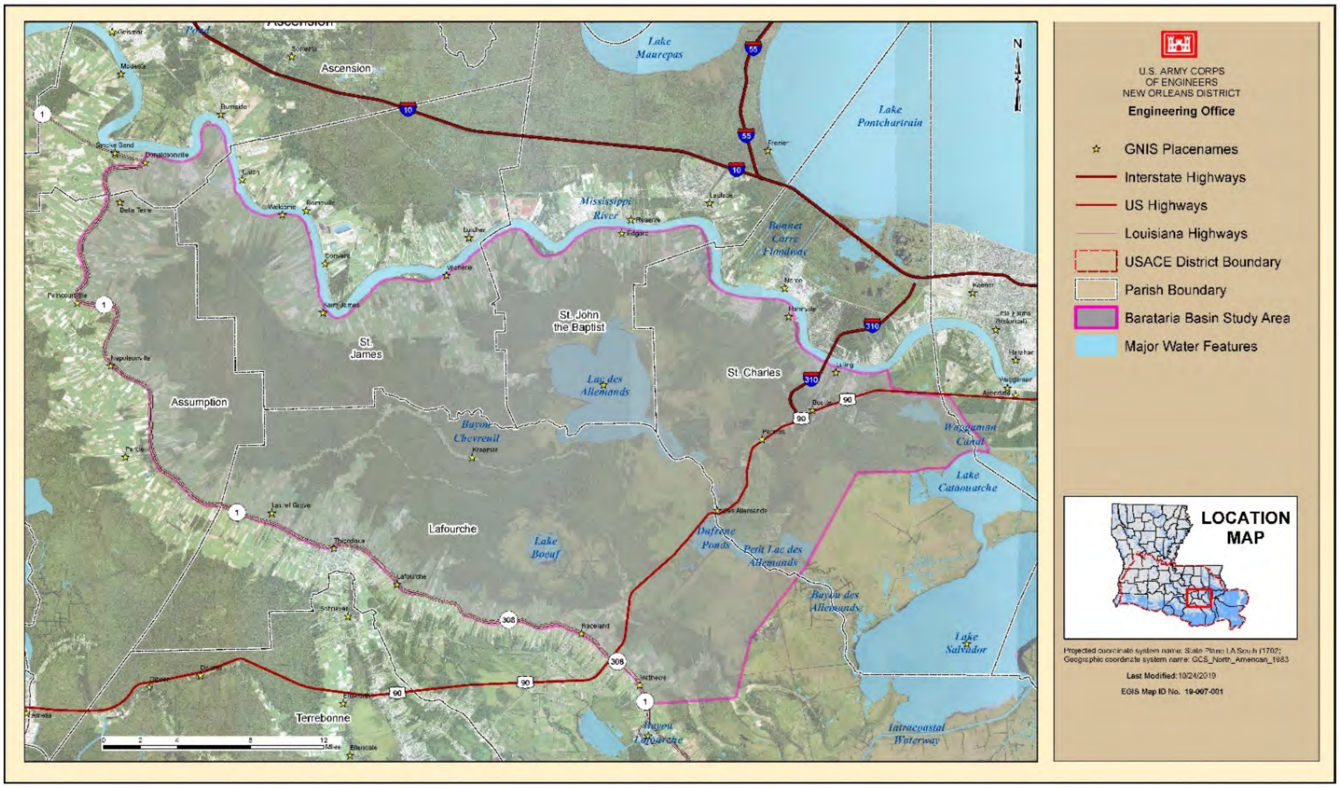
INTRODUCTION

The Upper Barataria Basin (UBB) study area is part of the larger Barataria Basin watershed, covering approximately 800 square miles, and is characterized by low, flat terrain with wetlands, numerous navigation channels, drainage canals and natural bayous that drain into Lake Salvador and eventually the Gulf of Mexico. The study area includes communities in seven southeast Louisiana parishes: Ascension, Assumption, Jefferson, Lafourche, St. Charles, St. James and St. John the Baptist Parishes. The study area is bounded on the north and east by the Mississippi River Levee, on the west by Bayou Lafourche and extends south of U.S. Highway 90 approximately 1.1 miles southeast of the town of Mathews, LA before it turns east (see figure below).



Location of Study Area

The area is prone to coastal storm damages from tidal surges, tropical storm surges and rainfall events, resulting in flood damages to industrial, commercial and agricultural facilities as well as residential structures and critical evacuation routes. The purpose of the project is to provide hurricane and storm damage risk reduction to the developed areas of the seven parishes that are included in this study. This includes reducing the risk to human life, health and safety by reducing flood impacts to structures, evacuation routes and critical infrastructure, as well as increasing community resiliency before, during and after flooding events.

National Environmental Policy Act (NEPA) regulations (40 CFR 1502.14(d)) require that the future without project conditions be considered with any final array of plans. Eight structural levee alignments, one structural alternative (with no levee included) and one nonstructural solution represented the alternatives under consideration (herein labeled as Alternatives 1 through 10), along with the future without project condition. Each structural alternative had several features, including levees, floodwalls, floodgates and pumping stations, while the nonstructural alternative consisted of elevating houses and other floodproofing measures. These alternatives were each evaluated in order to select the best approach to reduce flood impacts in communities throughout the study area. Each alternative also evaluated environmental measures designed to protect and/or minimize the impacts to nearby wetlands and transportation evacuation routes (such as U.S. Highway 90) located in the study area.

The Engineering Appendix, as an integral part of the Upper Barataria Basin, Louisiana Draft Feasibility Report, provides the engineering information that supports the results and conclusions outlined in the main report. This effort used various USACE regulations and engineering assumptions, along with existing data that was available. The approach was part of the current 3 x 3 x 3 SMART planning method that is used to conduct Feasibility studies. This method was, therefore, used to perform the required engineering investigations in order to properly evaluate the alternatives under consideration and reach a selection of the Tentatively Selected Plan (TSP), which is now the Recommended Plan (RP). The Engineering Appendix is presented in two sections: Section 1 describes the RP, including details that were developed during further design analysis of the TSP, and Section 2 describes the Screening Phase, which outlines what alternatives were considered and the scope of the engineering investigations that were conducted, as well as the results.

1 RECOMMENDED PLAN (RP)

Information provided herein describes the details of the RP. The RP provides approximately a 1% Annual Exceedance Probability (AEP) level of risk reduction in the Baseline Year of 2026. This is also known as the base year and is part of a 50-year planning horizon that is generally used for USACE projects. The year 2026 was decided as the base year for economic and hydraulic conditions since it is possible that the proposed levee could be designed and constructed by then with sufficient funding and authorization.

The RP (known as Alternative 1 – U.S. Highway 90 - Segment 1 Extension) for the UBB study includes the construction of an approximately 30.6-mile (approximately 161,300 linear ft) structural alignment near the communities of Boutte, Paradis, Des Allemands and Raceland. The system starts in Luling, where it connects to the Mississippi River Levee through the Davis Pond Diversion Structure West Guide Levee, continues south, improving upon and updating deficiencies in the St. Charles Parish Levee, crosses Bayou Des Allemands with a 270-ft barge gate structure and continues parallel to U.S. Highway 90 before it ties into high ground across the basin near Raceland. Hydraulic reaches throughout the alignment, known as A through H, are shown in Figure 1-1. An overview of the RP, including all features, is shown in Figures 1-2 and 1-3.

All elevations are referenced to the North American Vertical Datum of 1988 (NAVD 88 (2009.55)), unless otherwise noted.

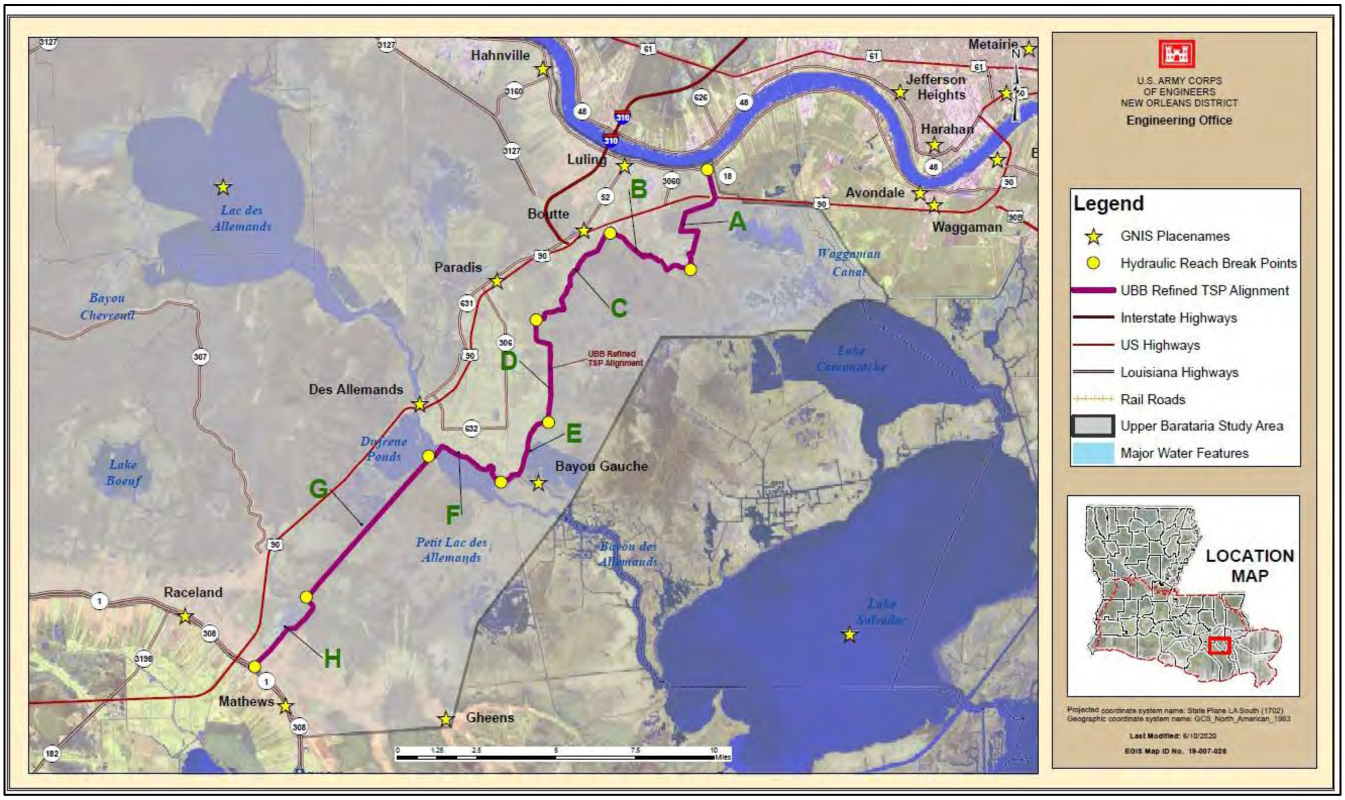


Figure 1-1: Hydraulic Reaches A through H

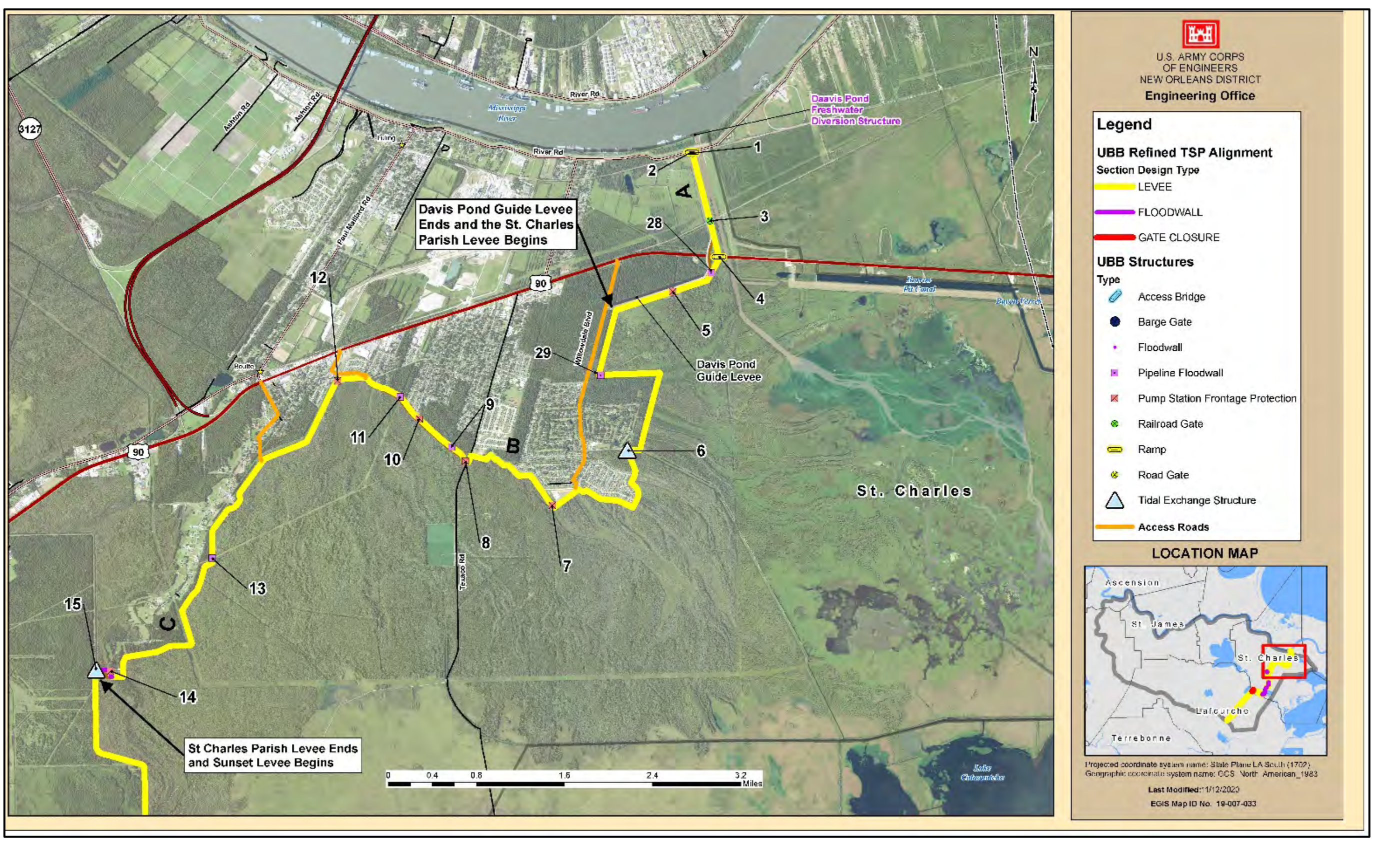


Figure 1-2: Overview of Recommended Plan (RP) – Hydraulic Reaches A through C (Northern)

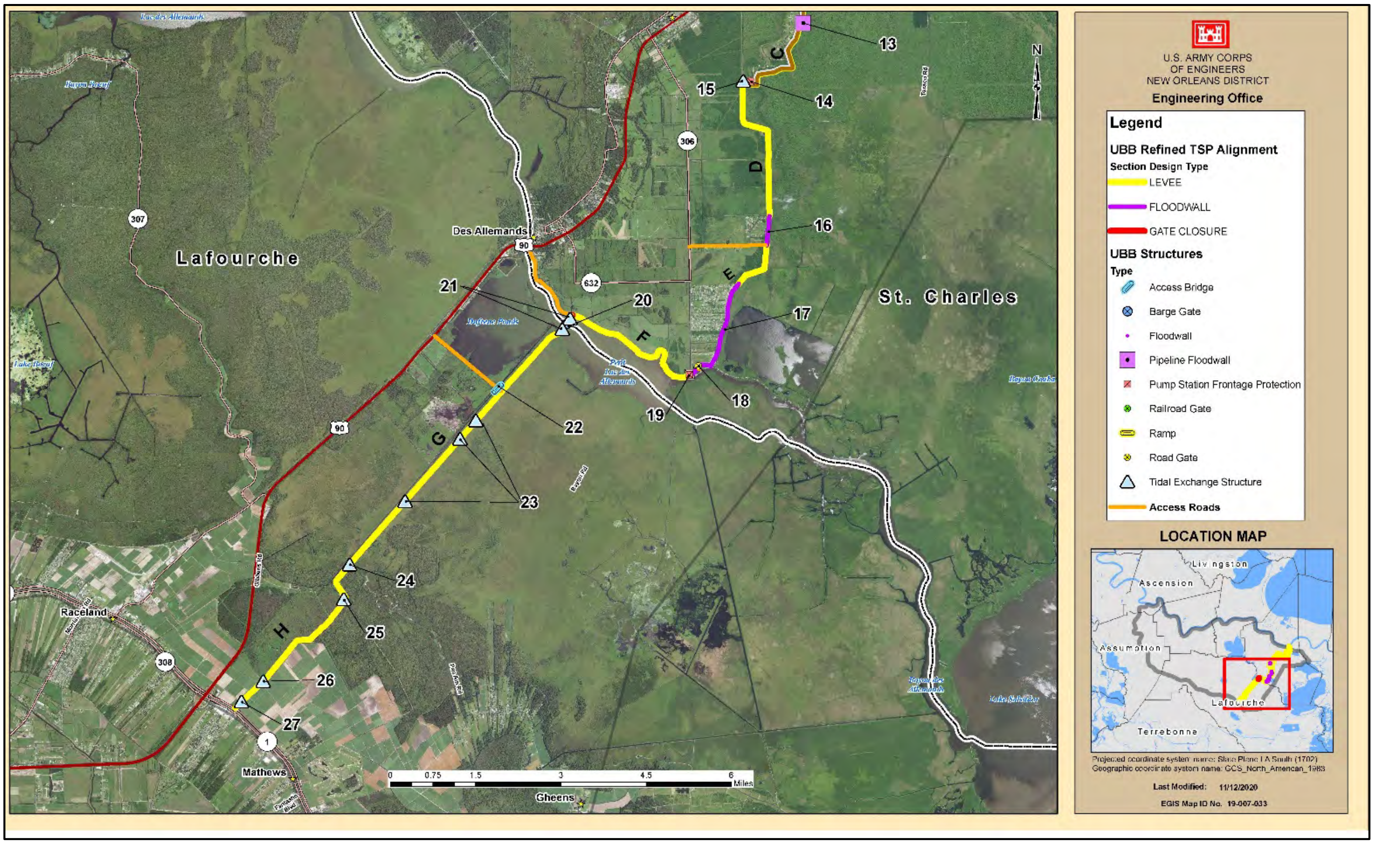


Figure 1-3: Overview of Recommended Plan (RP) – Hydraulic Reaches C through H (Southern)

Table 1-1 (Features Listed in Figures 1-2 and 1-3 – Overview Map of RP)

Numbered Feature on Map	Feature Description
1	River Road crossing ramp
2	Union Pacific Railroad crossing
3	BNSF Railroad crossing
4	U.S. Highway 90 Crossing Ramp
5	Davis Pond Pump Station frontage protection
6	Willowdale Pump Station, two new tidal exchange structures
7	Willowridge Pump Station frontage protection
8	Cousins Pump Station frontage protection
9	T-wall section for East Gas Pipeline
10	Kellogg Pump Station frontage protection
11	T-wall section for West Gas Pipeline
12	Ellington Pump Station frontage protection
13	T-wall section for Magnolia Pipeline
14	Magnolia Ridge Pump Station frontage protection
15	Existing Paradise Control Structure
16	Floodwall section in Hydraulic Reach D, Top of Wall (TOW) El 15.0 ft
17	Floodwall section in Hydraulic Reach E, TOW El 18.5 ft
17	a. Floodwall type T-1, TOW El 18.5 ft
17	b. Floodwall type T-2, TOW E. 18.5 ft
17	c. Floodwall type T-3, TOW El 18.5 ft
18	45-ft wide Highway 306 (Bayou Gauche) Roller Gate, TOW El 18.5 ft
19	Crawford Canal Pump Station fronting protection, TOW El 18.5 ft (50 LF of floodwall)
20	270-ft Barge Gate crossing Bayou Des Allemands, TOW El 18.5 ft
21	Environmental structures on either side of the 270-ft Bayou Des Allemands Barge Gate, (12) 15 ft x 20 ft box culverts with sluice gates
22	Godchaux Canal Bridge, TOW El 9.5 ft
23	Drainage Structure – (4) 6 ft x 6 ft Reinforced Concrete (RC) box culverts with sluice gates, in 3 different locations
24	Drainage Structure – (4) 6 ft x 6 ft RC box culverts with sluice gates
25	Drainage Structure – (4) 6 ft x 6 ft RC box culverts with sluice gates
26	Drainage Structure – (2) 84-inch RC Pipe (RCP) culverts with sluice gates
27	Drainage Structure – (1) 60-inch RCP culvert with sluice gates
28	T-wall section, Enterprise and Shell Pipeline Crossing (Davis Pond Crossing #1)
29	T-wall section, Bridgeline Enlink Pipeline Crossing (Davis Pond Crossing #2)

1.1 Levee System

The RP alignment, as stated above, ties into the existing St. Charles Parish levee (which was built to a design elevation of 7.5 ft) at the southern end. The alignment then traverses across the UBB in a southwesterly direction, paralleling U.S. Highway 90 on its eastern side, and ends at the Lafourche Parish levee near Raceland, LA.

The construction of the RP alignment, including the structural features, hereafter referred to as the "levee system", would be based on approximately a 1% AEP level of risk reduction and a year 2026 intermediate Relative Sea Level Rise (RSLR) condition. The levee and all structural features were designed according to Hurricane Storm Damage and Risk Reduction System (HSDRRS) specifications. For a complete list of the HSDRRS specifications and guidelines (dated June 2012), refer to the following website:

https://www.mvn.usace.army.mil/Missions/Engineering/Hurricane-Design-Guidelines/

The levee system consists of earthen levees, floodwalls (T-walls) east of Des Allemands along the Paradise Canal, one 45 linear ft roller gate structure at Bayou Gauche and one 270 linear ft barge gate structure across Bayou Des Allemands. The earthen levees include 1 Vertical on 4 Horizontal (1V:4H) side slopes and a 10 ft-wide crown, with various design elevations (the construction grade elevation would be higher to allow for settlement) along the alignment, and designed to include multiple lifts over the 50-year period of analysis. The first lift, projected to occur in the year 2026 would lift the levee to an elevation of 14.0 ft except in hydraulic reaches F and H, where it would be constructed to an elevation of 16.0 ft after settlement. Subsequent lifts would sustain the 1% AEP over the period of analysis. Material settlement over the period of analysis has also been incorporated into the material quantities for each of the alignment's hydraulic reaches.

Borrow material for construction is proposed to come from sites estimated to be within 15 miles of where US Highway 90 crosses Bayou Des Allemands. Existing Government borrow sites were not available within the designated distance. Potential borrow sites on farm lands (avoiding swamp and marsh lands) were identified in Raceland and can be seen in Figure 1-4. Not all of the lands from the potential pits in Figure 1-4 are intended to be used. A total of 5,200,400 cubic yards of soil is needed for the first lift in the year 2026, and a grand total of 8,812,700 cubic yards is needed over the entire authorized 50-year period of analysis to sustain the 1% AEP design elevations out to the year 2076. It was assumed that 10 ft to 15 ft of usable material could be found in these sites. The borrow pit needed for the quantity of soil would be approximately 500 acres.

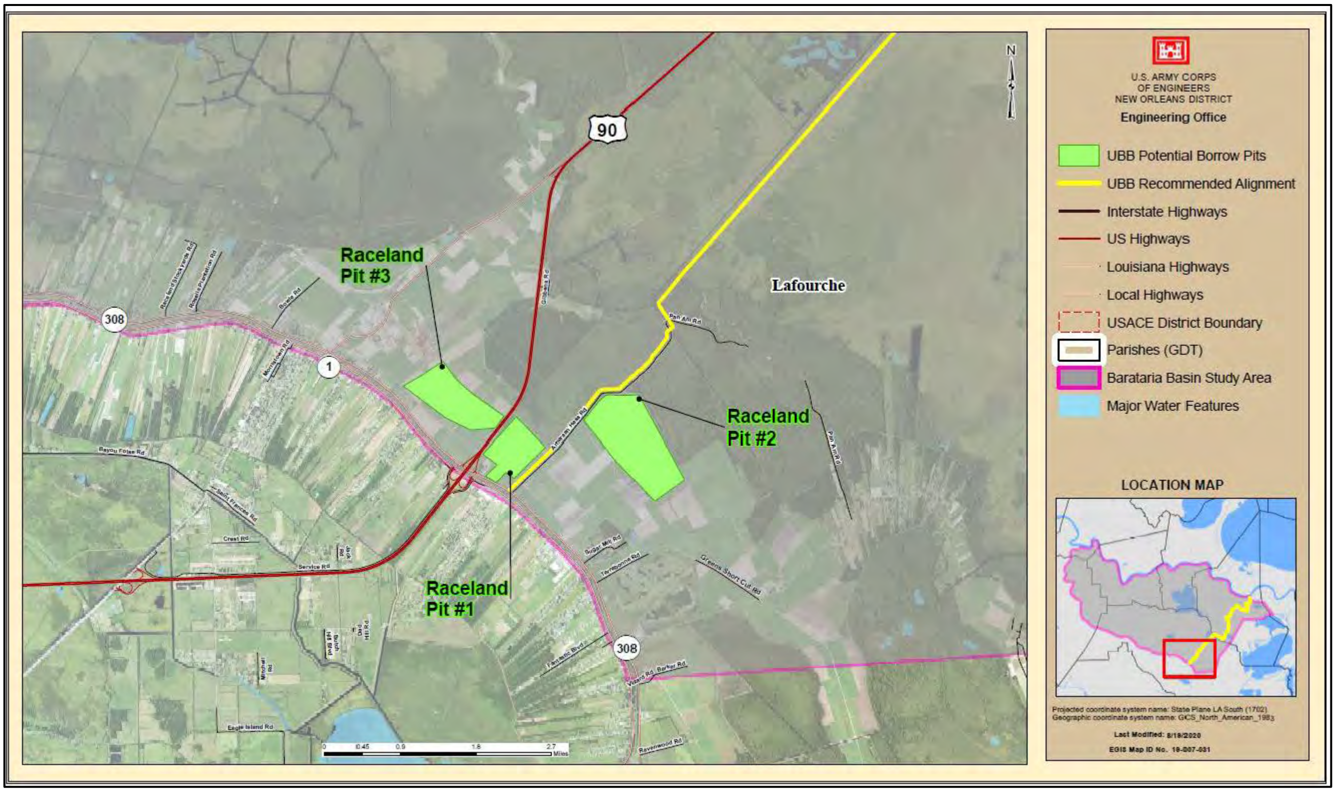


Figure 1-4: Potential Earthen Borrow Sources Near Raceland

1.2 Hydraulic Connectivity

Hydrologic connectivity would be maintained to the extent practicable through water control structures, except when those structures are closed during tropical events, as the risk reduction system is only authorized to address storm surge caused by tropical events. The risk reduction system is not authorized to mitigate or reduce impacts to the swamps within the project area, caused by higher day-to-day water levels resulting from increases in sea level rise (SLR). Rainfall events and high tides could still cause significant flooding of the swamps within the levee-enclosed project area. All drainage features through the levee system were sized to match the existing gravity drainage system, and would mimic the existing drainage patterns when the system is not closed. Any operational changes implemented to address changing SLR conditions or for any other non-project-related purpose would be considered a separate project purpose requiring separate authorization, new National Environmental Protection Act (NEPA) documentation and/or permit approvals.

1.3 Proposed Design for Construction by Hydraulic Reach

All listed access routes to access hydraulic reaches A through H would each have a 40-ft wide footprint. There is a designated staging area and access route for each hydraulic reach listed below. All of the staging areas together represent a total of approximately 20 acres. All of the access routes together represent a total of approximately 40 acres. Table 1-2 provides all details of footprint width and Right-of-Way (ROW) required to construct the proposed alignment. It should be noted that the term “frontage protection” at existing pump stations entails T-walls with the pump discharge pipes going through the wall, along with pipe supports and riprap.

1.3.1 Hydraulic Reach A

Hydraulic Reach A begins at the Mississippi River levee and extends approximately 24,710 ft south and is split into two hydraulic subreaches, A-1 and A-2, dependent on the location of the existing canal. In Hydraulic Subreach A-1, the existing canal is on the floodside of the existing levee, approximately 6,280 ft in length. In Hydraulic Subreach A-2, the existing canal is on the landside of the existing levee, approximately 18,430 ft in length. The proposed earthen levee has a centerline shifted away from the existing canals, built off the existing Davis Pond West Guide Levee with a landside shift and berm (Hydraulic Subreach A-1) and the existing St. Charles Levee, with a floodside shift and berm (Hydraulic Subreach A-2). All of the existing levee footprints, including ROW, were incorporated into the proposed levee design.

From the Mississippi River Levee, the Hydraulic Subreach A-1 alignment continues south where it crosses River Road, the Union Pacific railroad track, the BNSF railroad track and U.S. Highway 90. Ramps would be constructed for the River Road and U.S. Highway 90 crossings. Two railway gates would be constructed where the Union Pacific railroad track and the BNSF railroad track cross the alignment. Hydraulic Subreach A-1 ends and Hydraulic Subreach A-2 begins just south of U.S. Highway 90. Hydraulic Subreach A-2 continues south. The existing Davis Pond pump station would receive new frontage protection. At the Willowdale pump station, two existing tidal exchange structures, located on either side of the structure, would need to be replaced. New T-wall sections, one measuring 152 ft and one measuring 298 ft, would be constructed to allow the Enterprise/Shell pipeline and the Bridgeline Enlink pipeline to pass through the levee alignment without impacting the integrity of the alignment. Hydraulic Reach A would initially be constructed to a height of 14 ft in the year 2026, with an expected settlement of 1.5 ft by the year 2054. A second lift is proposed in the year 2054, to elevation 16 ft, in order to maintain the 1% AEP design elevation over the authorized 50-year period of analysis.

Hydraulic Reach A would be accessed from U.S. Highway 90 to Willowdale Boulevard and then to Lafayette Drive. Three staging areas are proposed for use during the construction of the levee alignment and structures within Hydraulic Reach A. The first staging area is located off Willowdale Boulevard and measures approximately 0.7 acres in size. A second staging area, approximately one acre in size, is located along Willowdale Boulevard. The third staging area, approximately one acre in size, is located next to River Road. The third staging area would be utilized for construction of the ramp over the levee for River Road and the two railroad roller gate structures (Union Pacific to the north and the BNSF to the south). Refer to Figure 1-5 for the locations of the staging areas.

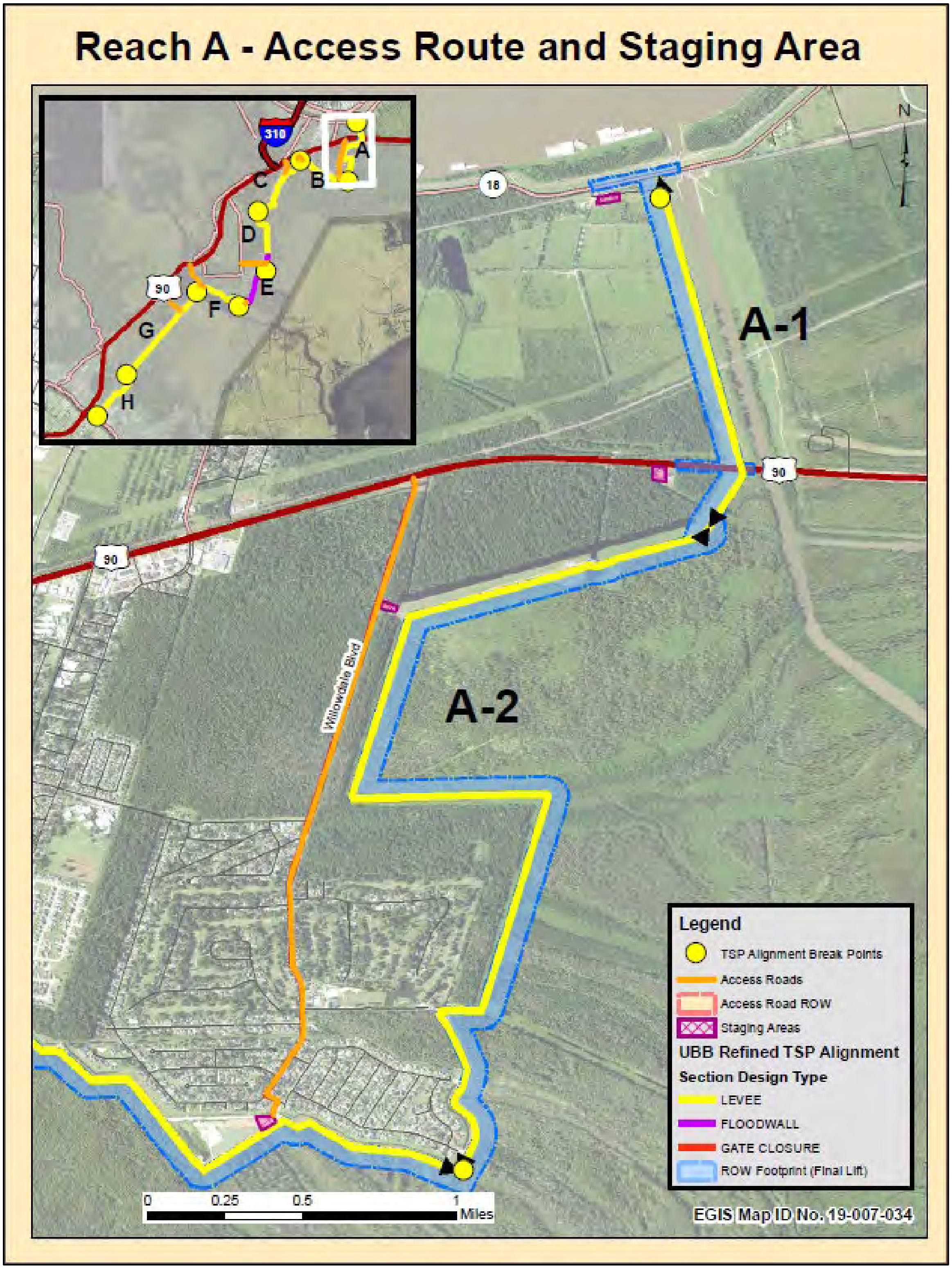


Figure 1-5: Hydraulic Reach A Access Road and Staging Areas

1.3.2 Hydraulic Reach B

Hydraulic Reach B begins at Willowdale Pump Station and measures approximately 17,100 ft in length. The proposed new construction centerline of Hydraulic Reach B would be shifted away from the existing canal, which is on the landside of the existing levee, similar to Hydraulic Subreach A-2. All of the existing levee footprint, including ROW, has been incorporated into the proposed levee design.

Continuing southwest from the Willowdale Pump Station, along the St. Charles Parish Levee, frontage protection would be needed at the Willowridge, Kellogg and Cousins pump stations. Due to the design elevation requirements, T-wall sections would be constructed in order to accommodate both the East Gas Pipeline and the West Gas Pipeline. The T-wall would allow the gas pipelines to pass through the alignment while maintaining the integrity of the alignment.

Hydraulic Reach B would initially be constructed to an elevation of 14.0 ft in the year 2026, with an expected settlement of 1.5 ft by the year 2054. A second and final lift to elevation 16.0 ft is proposed in the year 2054 in order to maintain the 1% AEP design elevation over the authorized 50-year period of analysis.

Hydraulic Reach B would be accessed from the same access route as that used for Hydraulic Reach A. A second access route for Hydraulic Reach B would be from U.S. Highway 90 to River Ridge Drive and then to Primrose Street. There is an approximately one acre staging area, located off Lafayette Drive, next to the alignment, proposed for Hydraulic Reach B. Refer to Figure 1-6 for the location of the staging area.

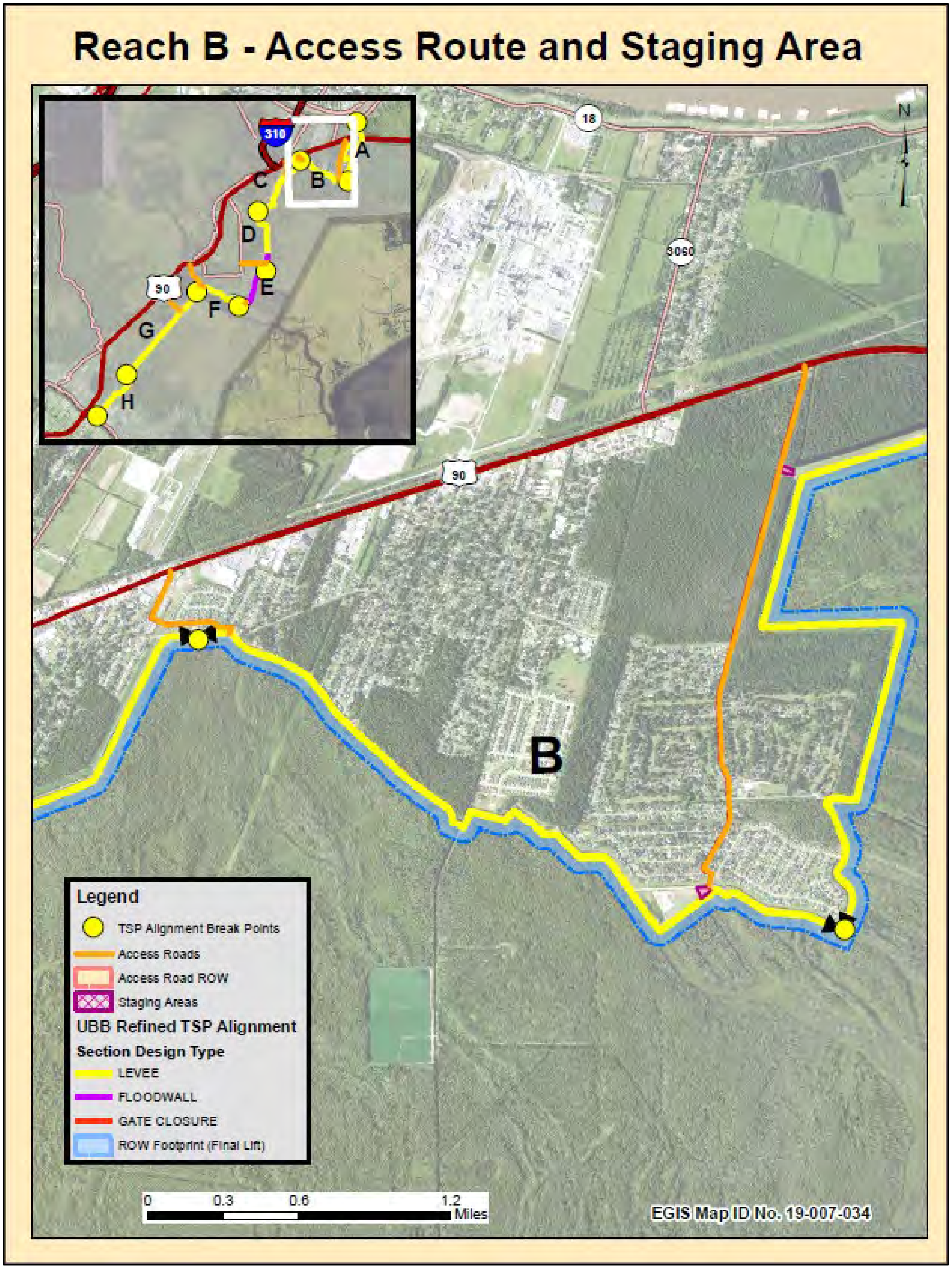


Figure 1-6: Hydraulic Reach B Access Road and Staging Area

1.3.3 Hydraulic Reach C

Hydraulic Reach C begins at the Ellington Pump Station, measures approximately 22,600 ft in length and continues to elevate the St. Charles Levee. The proposed new centerline of Hydraulic Reach C would be shifted away from the existing canal, which is on the landside of the existing levee, similar to previously-defined Hydraulic Subreach A-2 and Hydraulic Reach B. All of the existing levee footprint, including ROW, has been incorporated into the proposed levee design.

Continuing from the Ellington Pump Station, along the St. Charles Parish Levee footprint, the levee alignment turns back south along the St. Charles Parish Levee. Fronting protection would be placed at the Ellington Pump Station and a new T-wall section, measuring approximately 135 ft long, would be constructed to allow the Magnolia pipeline to pass through the levee alignment without impacting the integrity of the alignment. Hydraulic Reach C would initially be constructed to an elevation of 14.0 ft in the year 2026, with an expected settlement of 1.5 ft by the year 2054. A second (final) lift to elevation 16.0 ft is proposed in the year 2054 in order to maintain the 1% AEP design elevation over the authorized 50-year period of analysis.

Hydraulic Reach C would be accessed from U.S. Highway 90 and then to Magnolia Ridge Road. The proposed staging area for Hydraulic Reach C would be located off Magnolia Ridge Road and would be approximately 1.6 acres in size. Refer to Figure 1-7 for the location of the staging area.

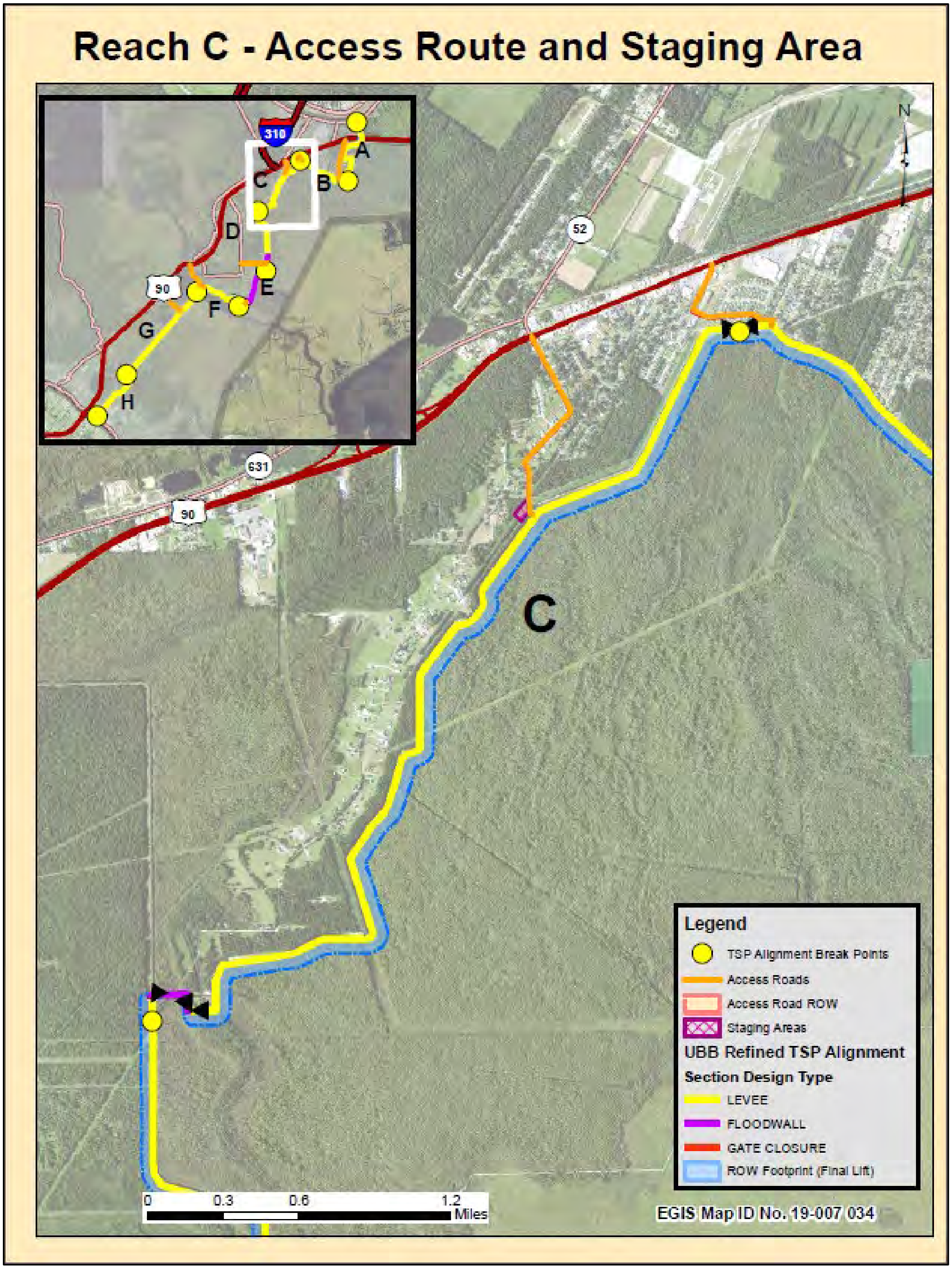


Figure 1-7: Hydraulic Reach C Access Road and Staging Area

1.3.4 Hydraulic Reach D

Hydraulic Reach D begins just south of the Paradise Control Structure at the end of Hydraulic Reach C, and measures approximately 19,000 ft in length. This reach would be constructed on top of the existing Sunset Levee. The proposed new centerline of Hydraulic Reach D continues south, and would be shifted away from the existing canal, which is on the floodside of the existing levee, similar to Hydraulic Subreach A-1. All of the existing levee footprint, including ROW, has been incorporated into the proposed levee design.

Within Hydraulic Reach D there is one section of T-wall, measuring approximately 2,700 ft, which would be constructed in order to avoid existing houses and utilities along the levee alignment. The T-wall has a 10-ft wide base slab, with an 80-ft construction easement and an elevation of 15.0 ft. The T-wall would be constructed via the ROW from the landside. The Hydraulic Reach D levee portion would initially be constructed to an elevation of 14.0 ft in the year 2026, with an expected settlement of 1.5 ft by the year 2056. A second (final) lift to elevation 16.0 ft is proposed in the year 2056 in order to maintain the 1% AEP design elevation over the authorized 50-year period of analysis.

Hydraulic Reach D would be accessed from Bayou Gauche Road (LA Highway 306) and then to Grand Bayou Road, using a 1,527 ft long temporary access route. The 40-ft wide access road would be constructed using crushed stone for the road surface that cuts across a local field to the alignment. The proposed staging area for Hydraulic Reach D would be located off of Grand Bayou Road and is approximately 2.2 acres in size. Refer to Figure 1-8 for the location of the staging area.

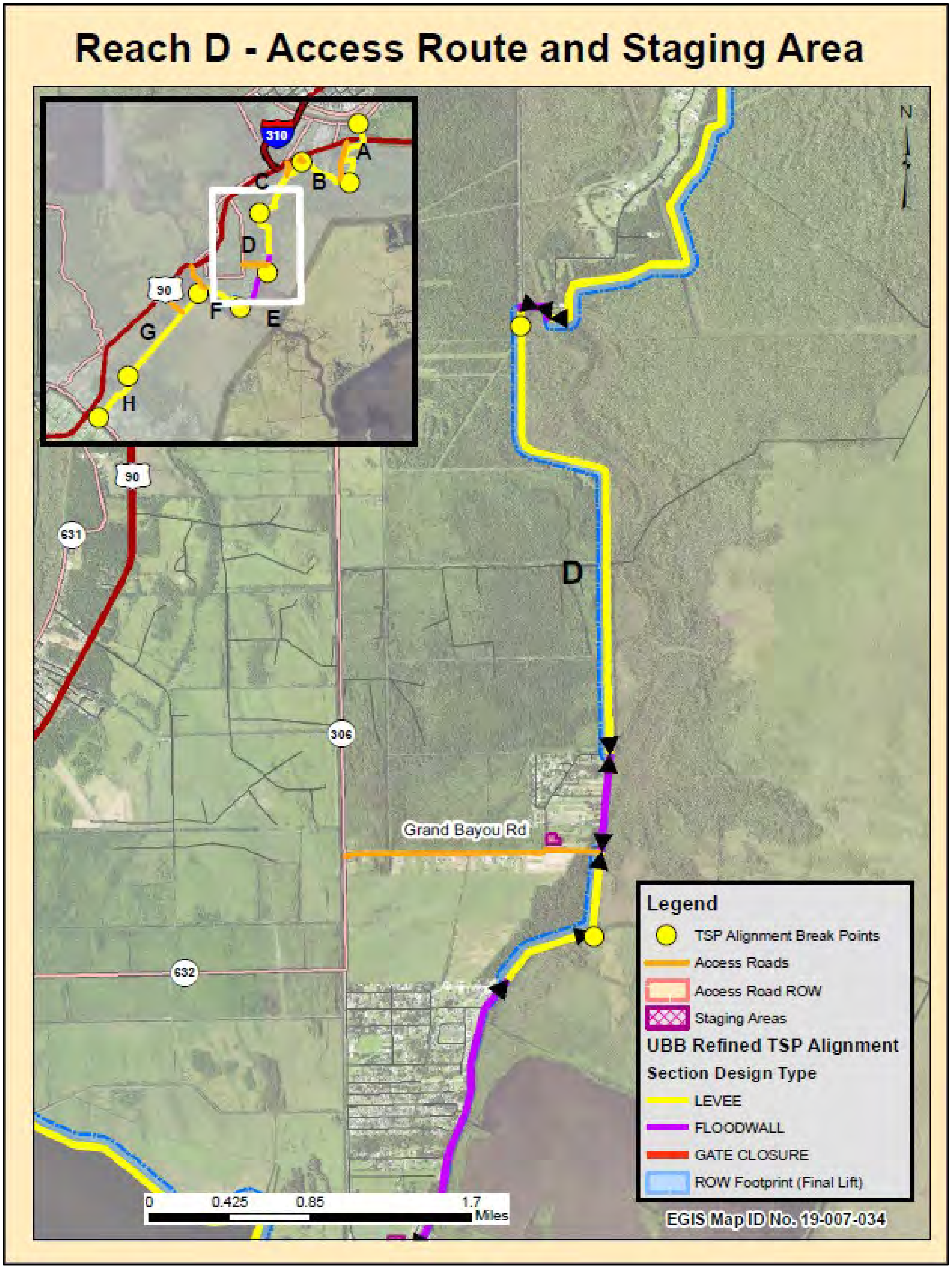


Figure 1-8: Hydraulic Reach D Access Road and Staging Area

1.3.5 Hydraulic Reach E

Hydraulic Reach E begins just south of Grand Bayou Road. It is a combination of earthen levee and floodwalls, which total approximately 14,600 ft. The earthen levee portion measures approximately 3,340 ft in length while the floodwall portion measures approximately 11,230 ft in length. The earthen levee portion of the hydraulic reach would be constructed on top of the existing Sunset Levee, with a new proposed centerline shifted away from the existing canal, which is on the floodside of the existing levee, similar to Hydraulic Subreach A-1 and Hydraulic Reach D. All of the existing levee footprint, including ROW, has been incorporated into the proposed levee design.

Due to the minimal room for construction between the existing canal and the existing structures along the canal, the proposed floodwall portion (T-wall design) would be constructed to an elevation of 18.5 ft, with a 10 ft to 20 ft-wide concrete slab at the base. Within the T-wall section, where the alignment crosses LA Highway 306, a roller gate would be constructed in the alignment. This roller gate would remain open during normal day-to-day operations and would only be closed preceding a tropical event. A 400-ft long section of T-wall is also needed for a pipeline just west of the Crawford Canal where Hydraulic Reach E ties into Hydraulic Reach F. The small portions of earthen levee in this hydraulic reach would initially be constructed to an elevation of 14.0 ft in the year 2026, with an expected settlement of 1.5 ft by the year 2038. A second lift to elevation 16.0 ft is proposed for the year 2038, with an expected settlement of 1.0 ft by the year 2059. A third and final lift to an elevation of 18.5 ft is proposed in the year 2059 to maintain the 1% AEP design elevation over the authorized 50-year period of analysis. The T-wall would be designed to maintain the 1% AEP upon initial construction in the year 2026.

Hydraulic Reach E would be accessed directly from Bayou Gauche Road with a proposed staging area of approximately 2 acres (also located off of Bayou Gauche Road). Refer to Figure 1-9 for the access route and staging area location. A new access route would be constructed for the community outside the system at the end of Badeaux Lane because the floodwall eliminates access to the community. The permanent access route would be from LA Highway 306, just outside the T-wall, and would allow access to the community with a 30-ft wide road.

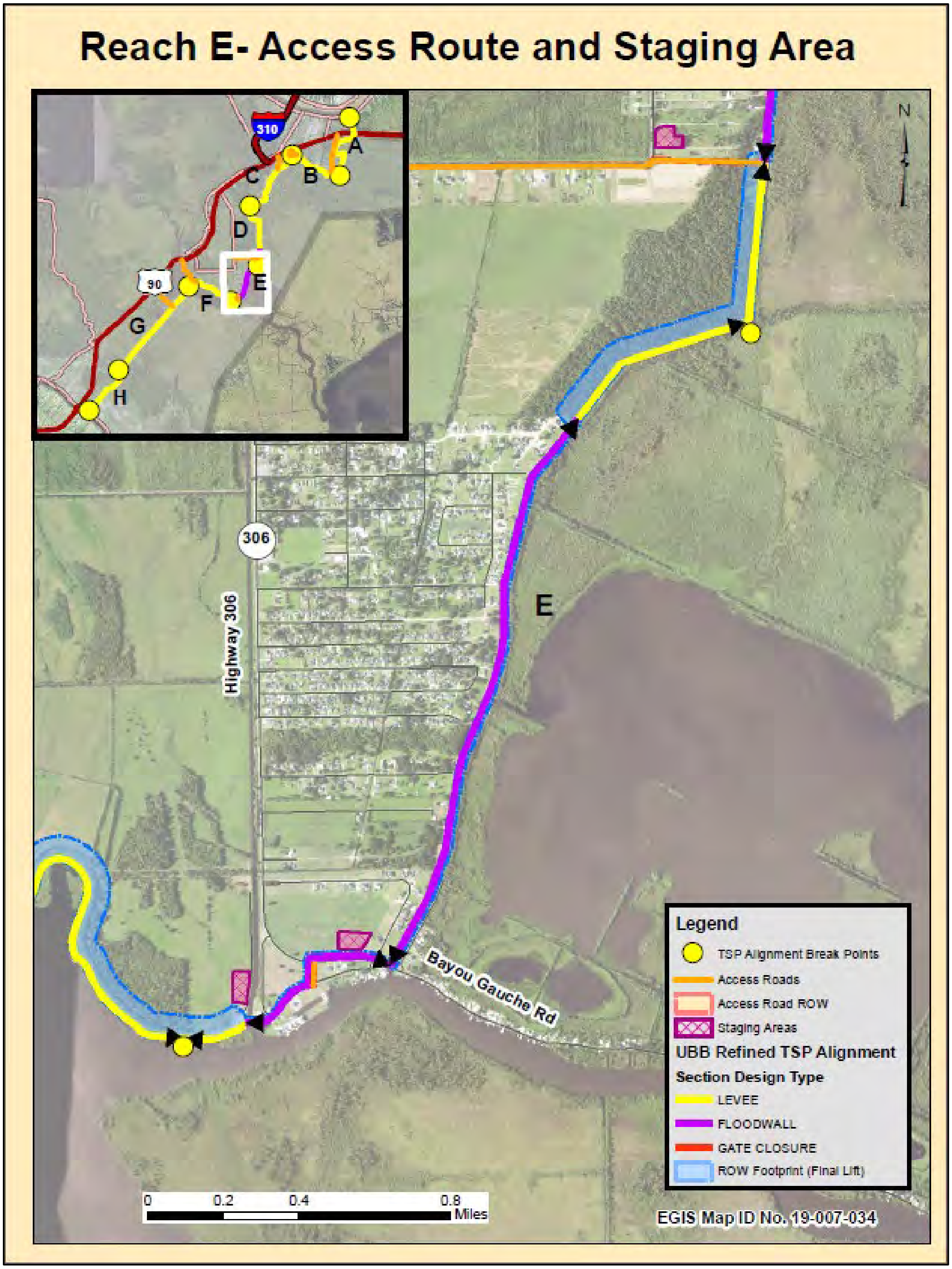


Figure 1-9: Hydraulic Reach E Access Road and Staging Area

1.3.6 Hydraulic Reach F

Hydraulic Reach F begins just past the Crawford Canal pump station. It measures approximately 15,400 ft in length. This hydraulic reach would be constructed on top of the existing Sunset Levee. The new proposed centerline of Hydraulic Reach F continues south and would be shifted away from the bayou, which is on the floodside of the existing levee, similar to Hydraulic Subreach A-1 and Hydraulic Reaches D and E. All of the existing levee footprint of the Sunset Levee, including ROW, has been incorporated into the proposed levee design.

Hydraulic Reach F consists of mostly earthen levee, and includes a 270-ft barge gate structure as well as culverts with sluice gates. The barge gate would be constructed across Bayou Des Allemands. It would incorporate six 15-ft x 20-ft concrete box culverts on each side of the gate, for a total of twelve culverts with sluice gates (there would be no screens on the culverts). The channel where the structure would be placed would require dredging in order to achieve a sill elevation around (-) 14.0 ft to (-) 19.0 ft. Dredge material would be placed in potential disposal sites downstream stable enough for marsh creation. Refer to the Dredge Disposal Plan in Appendix E of the Upper Barataria Basin Final Feasibility Report. The earthen levee would initially be constructed to an elevation of 16.0 ft in the year 2026, with an expected settlement of 1.7 ft by the year 2044. A second and final lift to elevation 18.5 ft is proposed for the year 2044 to maintain the 1% AEP design elevation over the authorized 50-year period of analysis.

Access for Hydraulic Reach F would be by way of a temporary crushed stone access road, 40 ft wide and approximately 4,575 linear ft long, constructed from the end of Down The Bayou Road to the barge gate crossing on top of the existing Sunset Levee. Access to this route will be via U.S. Highway 90 to the eastern side of Bayou Des Allemands, via Down The Bayou Road near the proposed barge gate placement site. The temporary access road would be removed and the area returned to pre-construction conditions once construction has been completed.

Hydraulic Reach F has two proposed staging areas. The first staging area is located west of the Crawford Canal pump station. The second proposed staging area is located on the east bank of Bayou Des Allemands, where the alignment crosses the bayou. Both proposed staging areas are approximately 2.2 acres in size. Refer to Figure 1-10 for the access route and staging area locations.

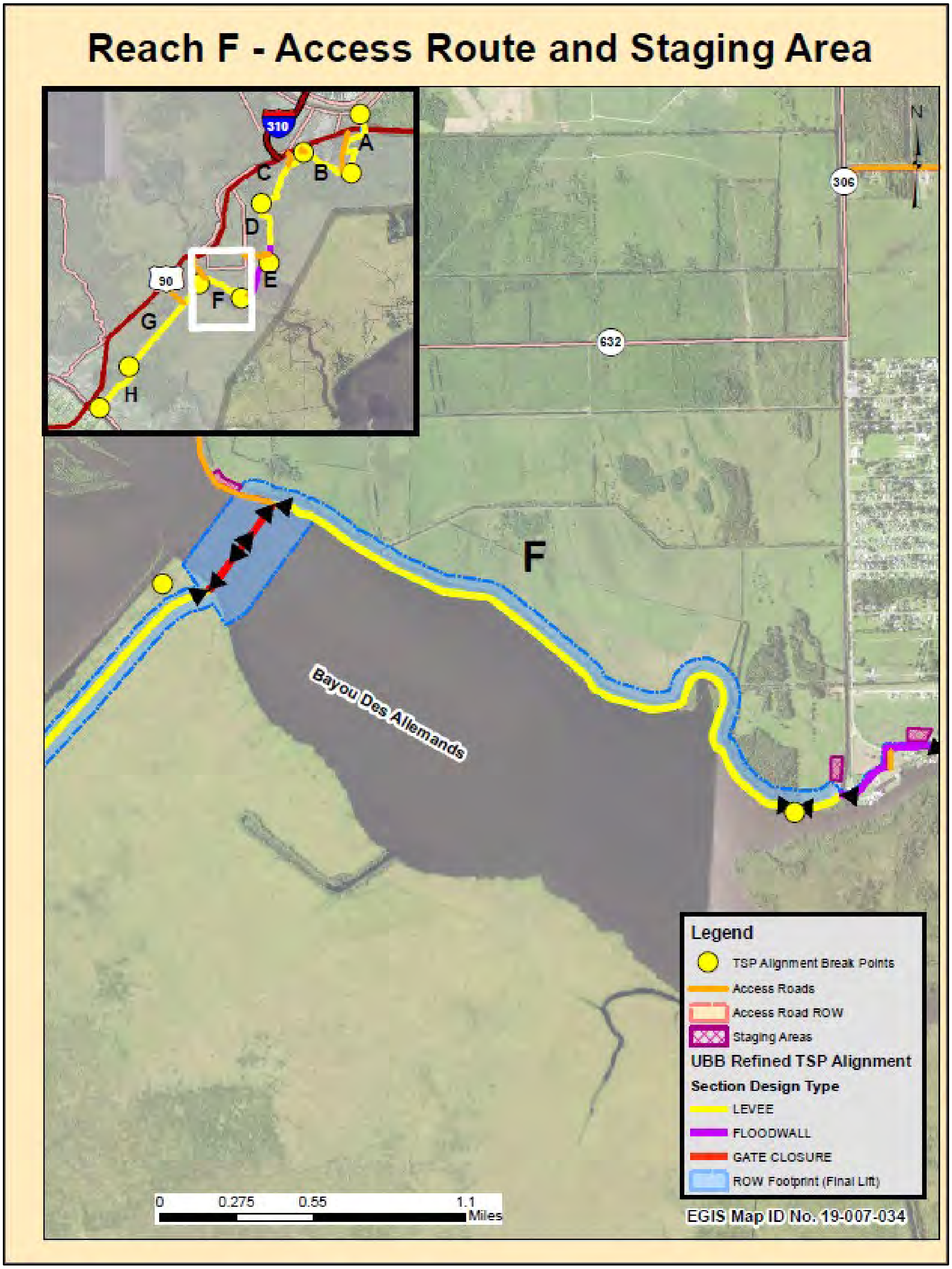


Figure 1-10: Hydraulic Reach F Access Road and Staging Areas

1.3.7 Hydraulic Reach G

Hydraulic Reach G begins on the southern bank of Petit Lac Des Allemands and continues parallel to U.S. Highway 90 through the existing marsh. Hydraulic Reach G measures approximately 31,000 ft in length, with no existing levees currently located in this reach. Geotechnical reinforcement has been incorporated into the levee design to reduce the footprint in this reach.

The proposed action includes construction of a new levee with berms on both sides of the levee. The new constructed levee would incorporate five sets of culverts, with each set consisting of four 6 ft x 6 ft concrete box culverts with sluice gates (no screens), which are needed to maintain the hydraulic flows in and out of the marsh (through small tributaries as well as oil and gas line canals) on the southern side of the alignment. The proposed levee for Hydraulic Reach G would initially be constructed to an elevation of 14.0 ft in the year 2026, with a second and final lift to an elevation of 16.0 ft proposed in the year 2054 in order to maintain the 1% AEP design elevation over the authorized 50-year period of analysis.

Access to Hydraulic Reach G would be from U.S. Highway 90 via a new constructed permanent access road just southwest of Dufrene Ponds. The new access road would measure approximately 7,925 ft in length and would have a crushed stone surface. The access road includes construction of a permanent bridge across the Godchaux Canal in order to gain access to the alignment for construction and future operation and maintenance. The proposed staging area for Hydraulic Reach G, approximately 2.3 acres in size, would be located on the north-east corner of where the Godchaux Canal and the access route intersect. Refer to Figure 1-11 for the access route and staging area locations. These structures would be constructed using the temporary access route located along the alignment within the ROW. Refer to Figures 1-2 and 1-3 for the locations of these hydraulic structures.

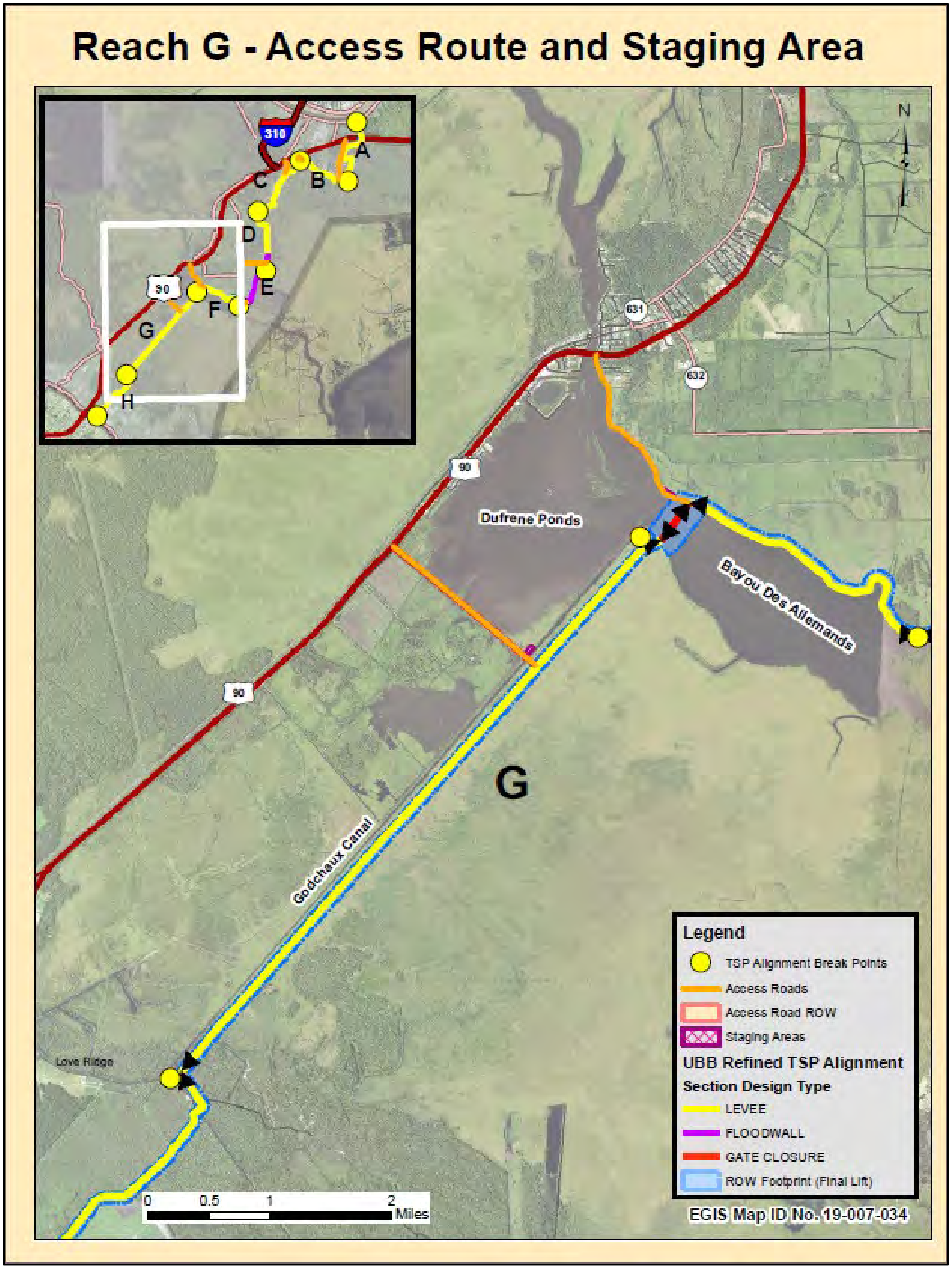


Figure 1-11: Hydraulic Reach G Access Road and Staging Area

1.3.8 Hydraulic Reach H

Hydraulic Reach H begins where Gibbons Road meets the alignment and continues to parallel U.S. Highway 90 through the existing marsh and follows next to Amerada Hess Road. Hydraulic Reach H measures approximately 16,900 ft in length, with no existing levees currently in place. Geotechnical fabric has been incorporated into the levee design to reduce the footprint in this reach.

The proposed construction for Hydraulic Reach H includes new levee construction with berms on both sides of the levee, which would parallel U.S. Highway 90 through the existing marsh. The new constructed levee would incorporate two sets of culverts for hydraulic exchange from the north to the south of the alignment. Each set consists of two 84-inch diameter culverts with sluice gates and one 60-inch diameter culvert with a sluice gate (no screens). The proposed levee for Hydraulic Reach H would be constructed with one lift to an elevation of 16.0 ft in the year 2026 in order to maintain the 1% AEP design elevation over the authorized 50-year period of analysis.

Hydraulic Reach H and a portion of Hydraulic Reach G would be accessed using Amerada Hess Road. For access along the project site, it was assumed access would be for the length of the reach. A 40-ft wide access road positioned at least 15 ft from the levee toe is proposed. A two-acre staging area is proposed along the intersection of LA Highway 308 and Amerada Hess Road. Refer to Figure 1-12 for the locations of the access road and staging area. These structures would be constructed using the temporary access route located along the alignment within the right of way. Refer to Figures 1-2 and 1-3 for the locations of these hydraulic structures.

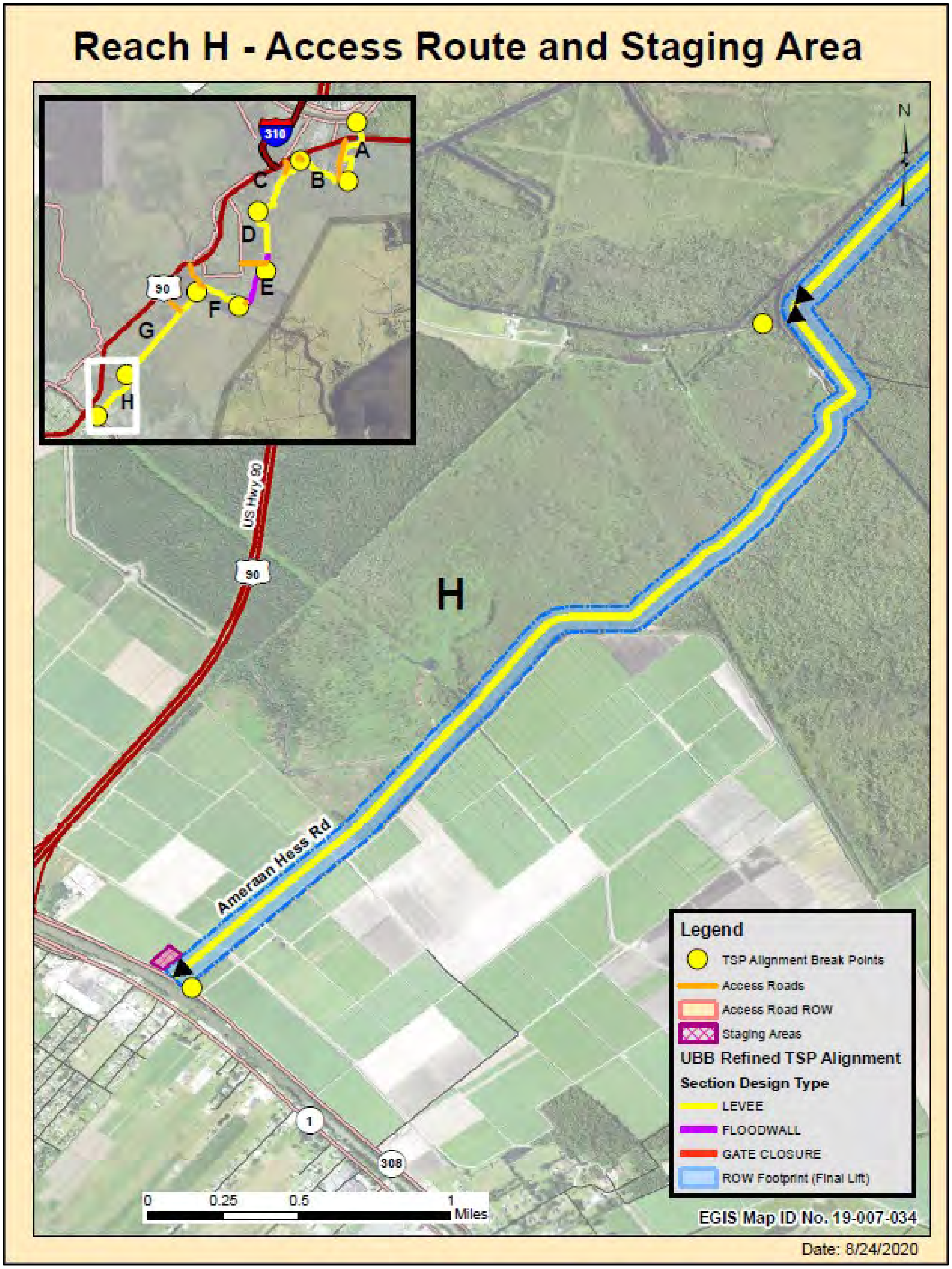


Figure 1-12: Hydraulic Reach H Access Road and Staging Area

1.4 Type of Equipment for Construction

Types of construction equipment that will be needed for construction include typical construction equipment and complex construction equipment, including cranes, backhoes, bulldozers, pile drivers and rollers.

1.5 Existing Footprints and New Levee Construction

There is an existing levee between the Mississippi River and Bayou Des Allemands that is incorporated into the new levee construction. Nearly all of the existing levee footprint, including existing ROW, would be used in the new levee construction. The levee would offset from the side opposite the water bodies (Davis Pond Canal, existing St Charles Levee Canal, the Paradise Canal and Bayou Des Allemands). The total cross sections include the existing levee, new levee construction in the year 2026 and new levee new construction in the year 2076. The levee reach extending between Bayou Des Allemands and Raceland does not have an existing levee. Refer to Table 1-2 for the earthen levee measurements. The table does not include T-wall widths (in which 80 ft of ROW is designated for the construction).

Table 1-2: Earthen Levee Footprint Widths

	Existing Levee	Year 2026 Construction		Final Lift Construction	
Reach	Levee including ROW (ft)	Toe-To-Toe (ft)	Levee including ROW (ft)	Toe-To-Toe (ft)	Levee including ROW (ft)
A, Davis Pond	285	125	190	173	238
A	100	125	190	236	301
B	100	125	190	236	301
C	100	125	190	236	301
D	100	125	190	173	238
E	75	122	187	244	309
F	130	169	234	244	309
G	0	170	250	170	250
H	0	170	250	170	250

Note – The ROW included in the levee design is for temporary construction of the levees.

1.6 Nonstructural Measures

The 1% AEP design levee is estimated to induce flooding in the communities of Bayou Gauche, Gheens and Mathews, which are located outside of the system on the east side of the levee. The induced flooding is greatest within the community of Bayou Gauche, which is directly adjacent to the levee. This area is estimated to receive 1.0 to 1.5 ft of induced flooding under existing conditions, and 2 ft to 4 ft under future conditions. In order to mitigate for the induced flooding, 64 structures in Bayou Gauche will be elevated. Due to the presence of existing or proposed flood risk reduction measures in Gheens and Mathews, the extent of induced flooding in those communities is more uncertain and will be investigated further in the Preliminary Engineering and Design (PED) phase of the study. Currently, it is estimated that 173 structures will be elevated in the community of Gheens. In the community of Mathews, it is estimated that 35 structures will be elevated and three nonresidential structures will be retrofitted with dry flood proofing.

1.7 Hydrology and Hydraulics

The RP levee alignment design elevations are sufficient to provide risk reduction from a hurricane event that would produce a 1% AEP surge elevation and associated waves. The design elevations presented in this section were determined using the 1% AEP surge elevation, 1% AEP wave height and 1% AEP peak wave period, and assume simultaneous occurrence of maxima of surge level and wave characteristics. These assumptions are conservative and are in line with a resilient design approach.

1.7.1 Exterior Analysis – Hydraulic Levee Design

Levee and structural design elevations were determined for the 1% AEP return period for the RP alignment. This analysis was performed using results from the with-project ADCIRC modeling.

Methodology

The hydraulic boundary conditions for each hydraulic reach for the 1% AEP return period for the years 2026 and 2076 were obtained from the 2017 CPRA ADCIRC with-project model runs and tabulated in Figures 1-13 and 1-14 below, where WSE is the water surface elevation in ft NAVD88 (2004.65), Hs is the significant wave height in ft, and Tp is the peak period in seconds.

Changes in water surface elevations will occur in the future (year 2076) due to 50 years of intermediate relative sea level rise. Design elevations for the future condition scenario are considered to reflect conditions that are likely to exist in the year 2076. Changes in surge elevations will occur in the future due to subsidence and sea level rise (SLR). Refer to Annex 10, Storm Surge Assessment (ADCIRC Analysis), for more information.

1% AEP Existing Conditions (Year 2026) Intermediate SLR				
Hydraulic Reach	SWE (ft)	Standard Deviation	Hs (ft)	Tp (seconds)
A	7.7	0.8	1.7	2.7
B	7.1	0.8	1.7	2.4
C	7.2	0.8	1.8	2.3
D	7.1	0.8	1.9	2.6
E	6.8	0.8	2.9	3.5
F	6.7	0.8	3.9	3.9
G	6.8	0.8	3.3	3.2
H	5.5	0.8	2.1	2.4

Figure 1-13: 1% AEP – Year 2026 Hydraulic Boundary Conditions

1% AEP Future Conditions (Year 2076) Intermediate SLR				
Hydraulic Reach	SWE (ft)	Standard Deviation	Hs (ft)	Tp (seconds)
A	11.3	0.8	2.0	3.4
B	11.2	0.8	1.9	3.2
C	11.1	0.8	2.0	3.2
D	11.0	0.8	2.5	3.4
E	10.8	0.8	4.4	4.3
F	10.8	0.8	4.5	4.2
G	10.3	0.8	3.2	3.2
H	9.8	0.8	2.7	3.3

Figure 1-14: 1% AEP – Year 2076 Hydraulic Boundary Conditions

Design criteria for the levee and structure elevations also consider wave overtopping limits. Guidelines for establishing the overtopping rate threshold (i.e., the threshold associated with the onset of levee erosion and damage) for different types of embankments can be found in Engineering Manual (EM) 1110-2-1100 (Part VI), Table VI-5-6. These threshold values are consistent with those that are adopted by the Technical Advisory Committee on Flood Defense in the Netherlands (Technische Adviescommissie voor de Waterkeringen) (TAW, 1989 and TAW, 2002). After consultation with the American Society of Civil Engineers (ASCE) External Review Panel, the following wave overtopping rates have been established for the New Orleans District hurricane risk reduction systems:

- For the design water surface elevation, 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;

- For the design water surface elevation, wave height and wave period, the maximum allowable average wave overtopping of 0.1 cfs/ft at 90% level of assurance and 0.03 cfs/ft at 50% level of assurance for floodwalls with appropriate protection on the back side.

The application of a Monte Carlo analysis is then used to determine the overtopping rate through the use of a MATLAB script for overtopping. The probabilistic overtopping formulations from Van der Meer are applied for the levees. Besides the geometric parameters (levee height and slope), hydraulic input parameters for determination of the overtopping rate in Equation 1 and 2 are the water elevation (ζ), the significant wave height (H_s) and the peak wave period (T_p). The Van der Meer overtopping formula is shown in Figure 1-15. Definitions for overtopping of a levee are shown in Figure 1-16.

Van der Meer overtopping formulations

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

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

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

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 $\xi0$ 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 $s0 = 2\pi H_{m0} / (g\, T_{m-10}^2)$. 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 1-15: Van der Meer Overtopping Formulations

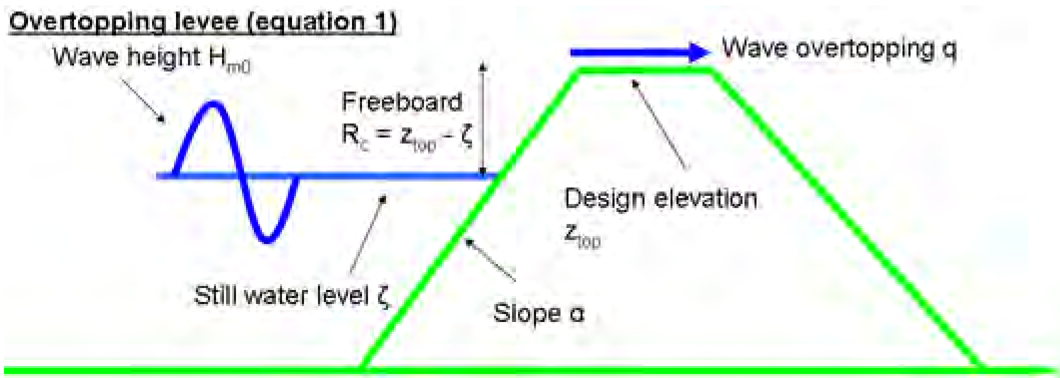


Figure 1-16: Definitions for Overtopping of a Levee

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% AEP 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% AEP wave height/wave period and the associated standard deviation and with an exceedence probability (p).
5. Repeat steps 3 and 4 for the three overtopping coefficients independently.
6. Compute the overtopping rate for these hydraulic parameters and overtopping coefficients determined in steps 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 Figure 1-16).
7. Repeat step 1 through 5 a large number of times. (N)
8. Compute the 50% and 90% confidence limits of the overtopping rate. (i.e., q_{50} and q_{90}).

Results

The resulting levee design elevations, using the HSDRRS guidelines for earthen levee overtopping, with a threshold of q90 = 0.1 cfs/ft and q50 = 0.01 cfs/ft for levees with a 1V:4H slope, are contained in Figures 1-17 and 1-18. Refer to Annex 11, 1% AEP (Year 2026 and Year 2076) Levee Overtopping Output Plots, for more information.

1% AEP Existing Conditions (Year 2026) Intermediate SLR	
Hydraulic Reach	Levee Elevation (ft), NAVD88 (2004.65)
A	10.0
B	10.0
C	10.0
D	9.5
E	11.0
F	12.5
G	11.0
H	8.5

Figure 1-17: 1% AEP – Year 2026 Hydraulic Levee Design Elevations

1% AEP Future Conditions (Year 2076) Intermediate SLR	
Hydraulic Reach	Levee Elevation (ft), NAVD88 (2004.65)
A	14.5
B	14.5
C	14.5
D	14.5
E	17.5
F	17.5
G	14.5
H	13.5

Figure 1-18: 1% AEP – Year 2076 Hydraulic Levee Design Elevations

The recommended design elevation for floodwalls and other structures is the future conditions elevation. This design elevation should be no less than the future condition design elevation of adjacent levees. Floodwalls and other structures require extensive reconstruction in the future. Incorporating future changes into the design of these structures is a prudent design consideration. Refer to Figure 1-19 for the future design elevations for floodwalls and other structures.

1% AEP Future Conditions (Year 2076) Intermediate SLR	
Hydraulic Reach	Structure Elevation (ft), NAVD88 (2004.65)
A	14.5
B	14.5
C	14.5
D	15.0
E	18.5
F	18.5
G	15.5
H	14.0

Figure 1-19: 1% AEP – Year 2076 Hydraulic Structural Design Elevations

Conclusion

Modeling results analyzed during feasibility level design of the RP alignment showed that the levee system would potentially induce flooding on the floodside of the levee alignment while reducing flooding due to storm surge on the landside. Hydrologic modeling (ADCIRC and SWAN) shows that the RP could potentially induce flooding in the areas outside of the risk reduction system (with a change in water surface elevations ranging from around 1 ft in the northern portion of the alignment to around 2 ft in the southern portion of the alignment) as shown in Figure 1-20 below. The project will incorporate features to mitigate for any potential induced flooding such as ring levees and house raisings for affected communities.

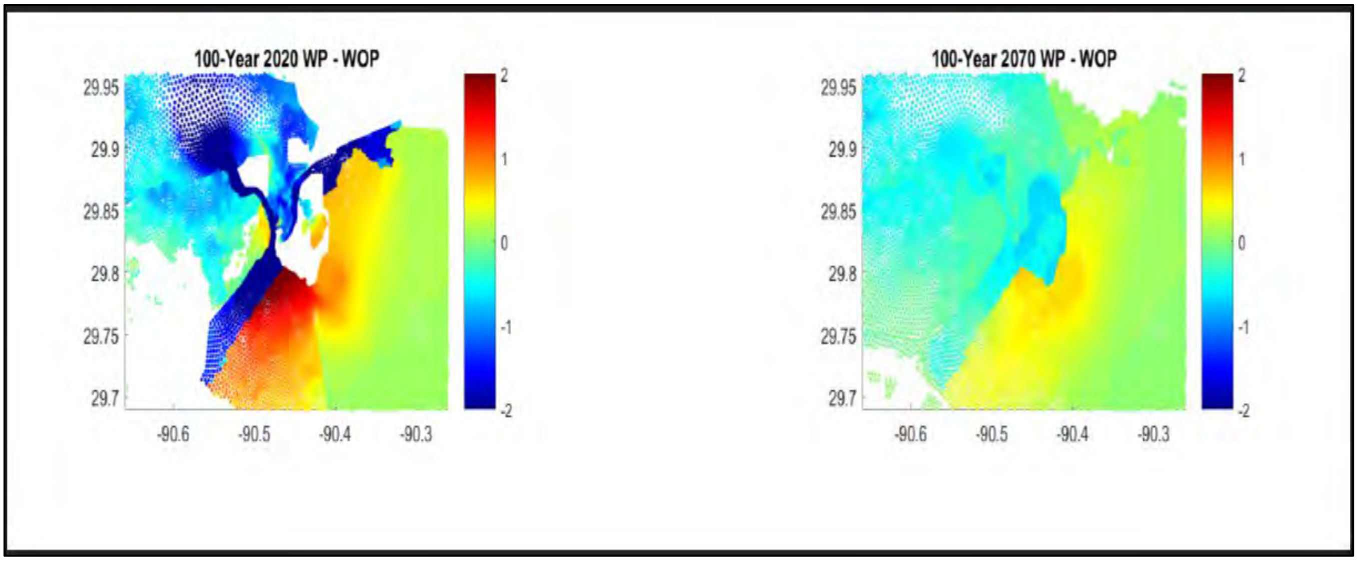


Figure 1-20: With-Project and Without-Project Water Elevation Difference Plots in Ft

1.7.2 Interior Analysis – Hydraulic Levee Design

The hydrologic routing and impounding of rain water in the area between U.S. Highway 90 and Hydraulic Reaches G and H of the proposed levee alignment were investigated. This analysis incorporated the existing without- project condition for the RP levee alignment using the 10% AEP 24-hour rainfall frequency.

Methodology

The area of interest was analyzed using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 5.0.6. The latest version of HEC-RAS that was available at the time of model development was used for the hydraulic modeling. HEC-RAS is designed to perform one-dimensional (1D) and two-dimensional (2D) hydraulic calculations for a full network of natural and constructed channels. The HEC-RAS modeling system is capable of simulating one-dimensional, two-dimensional and combined one/two-dimensional unsteady flow through a full network of open channels, floodplains and alluvial fans. The unsteady flow component can be used to perform subcritical, supercritical and mixed-flow regime (subcritical, supercritical, hydraulic jumps and draw-downs) calculations in the unsteady flow computations module. For this analysis, the 2D unsteady flow model mesh used for the initial calibrated HEC-RAS modeling was also used for this model.

The National Oceanic and Atmospheric Administration's (NOAA) Atlas 14-point precipitation frequency estimates were used for precipitation inputs. A 24-hour precipitation duration was used for the 10% AEP event. The HEC-RAS model was run using a 3-week simulation time window for the AEP event. Refer to Table 1-3 below for the 24-hour precipitation estimate for the 10% AEP event.

Table 1-3: NOAA Atlas 14 Precipitation Frequency Estimates

Point precipitation frequency estimates (inches)										
NOAA Atlas 14 Volume 9 Version 2										
Data type: Precipitation depth										
Project area: Southeastern States										
PRECIPITATION FREQUENCY ESTIMATES										
by duration for ARI (years):	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr	1000-yr
24-hr:	4.67	5.47	6.92	8.27	10.30	12.10	13.90	16.00	18.90	21.30

Results

Depths at locations in and around the area of interest (Figure 1-21) are shown in Figures 1-22 through 1-25. The area contains four existing major channels, three of which run north to south and one that runs east to west. The timeframes captured for this analysis are: initial, after week one, after week two and after week 3. The scale shows depths in ft from 0 (light blue) to 6 (dark blue).

Figure 1-21: Upper Barataria Basin Area of Interest

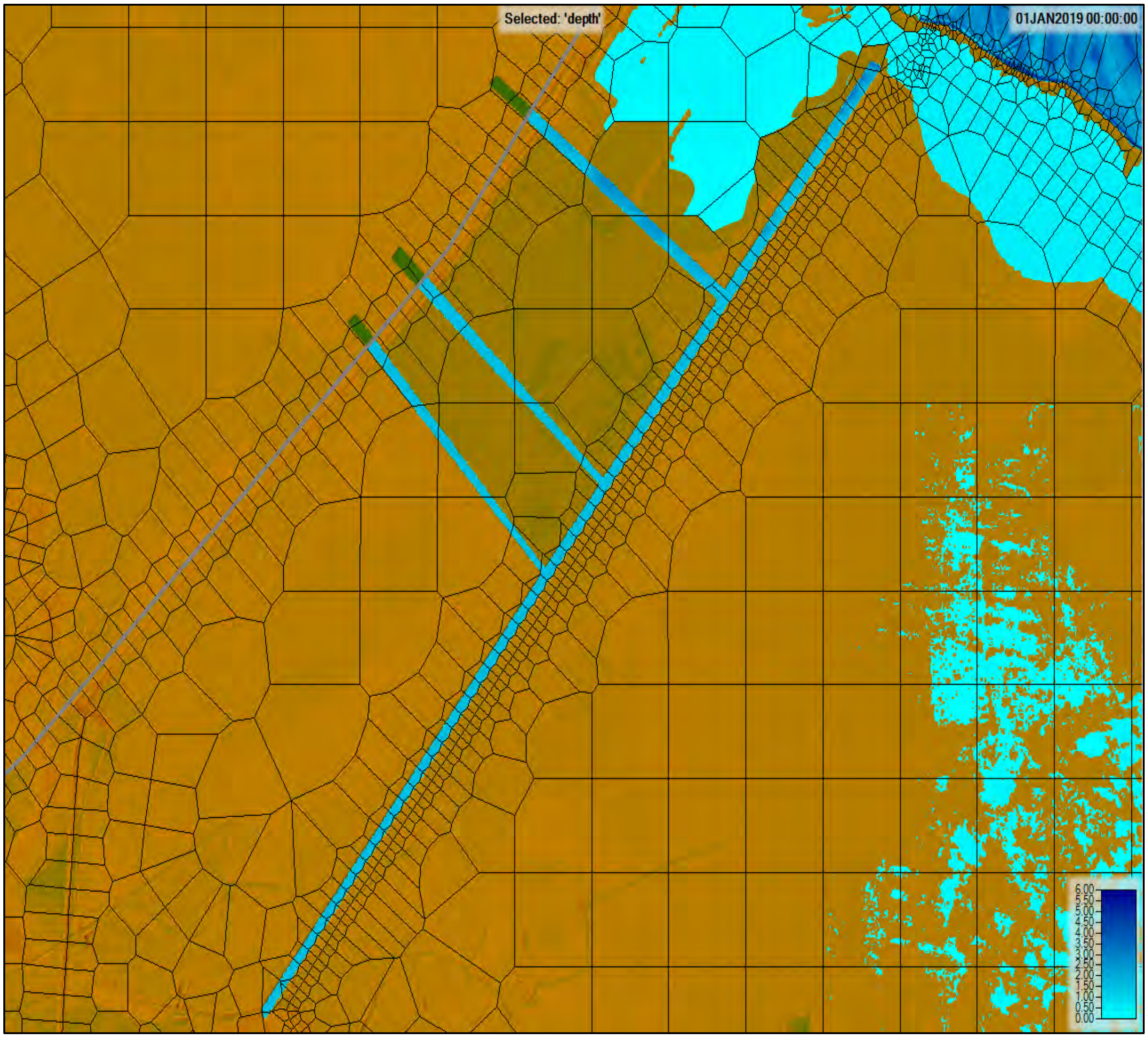


Figure 1-22: Initial Depths in the Upper Barataria Basin Area of Interest

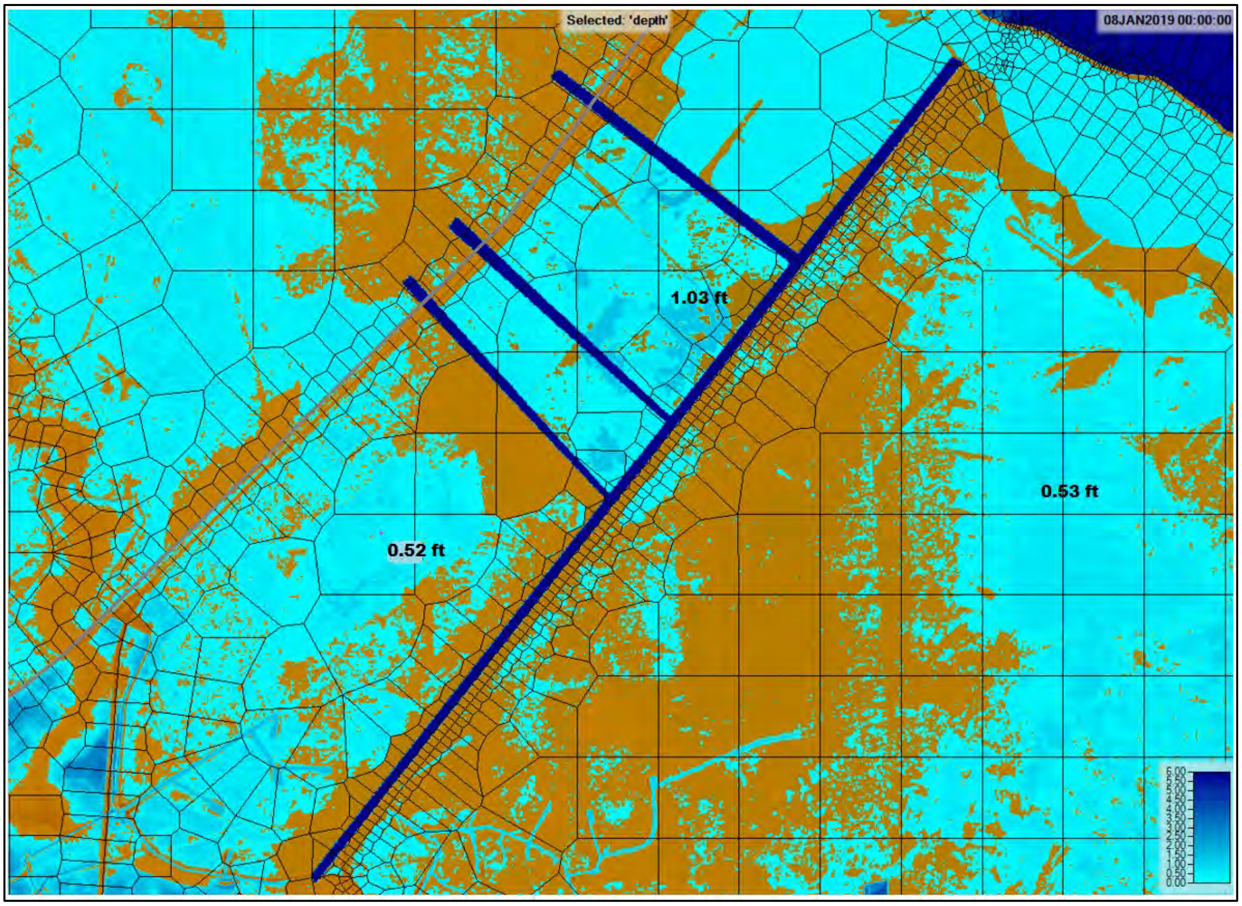


Figure 1-23: Depths After Week One in the Upper Barataria Basin Area of Interest

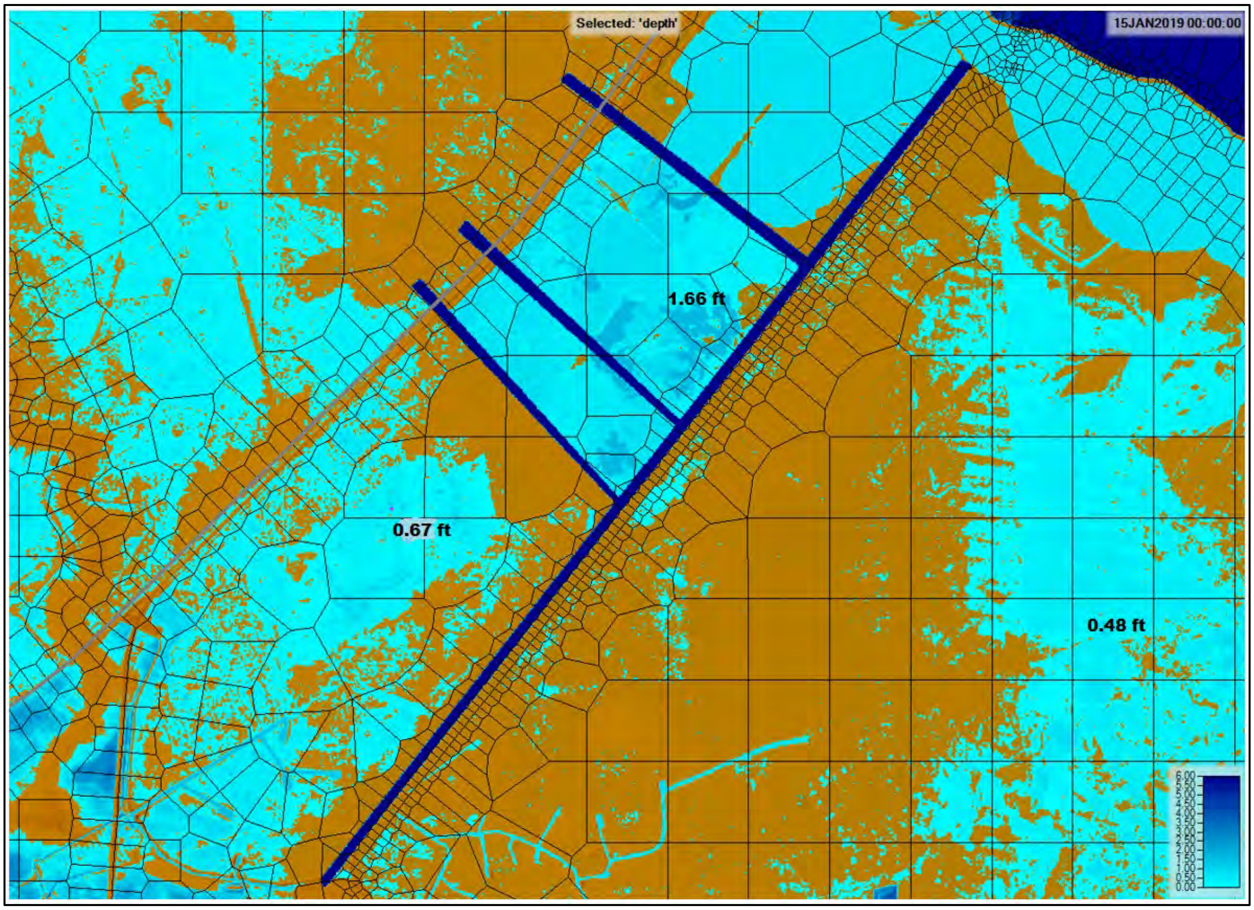


Figure 1-24: Depths After Week Two in the Upper Barataria Basin Area of Interest

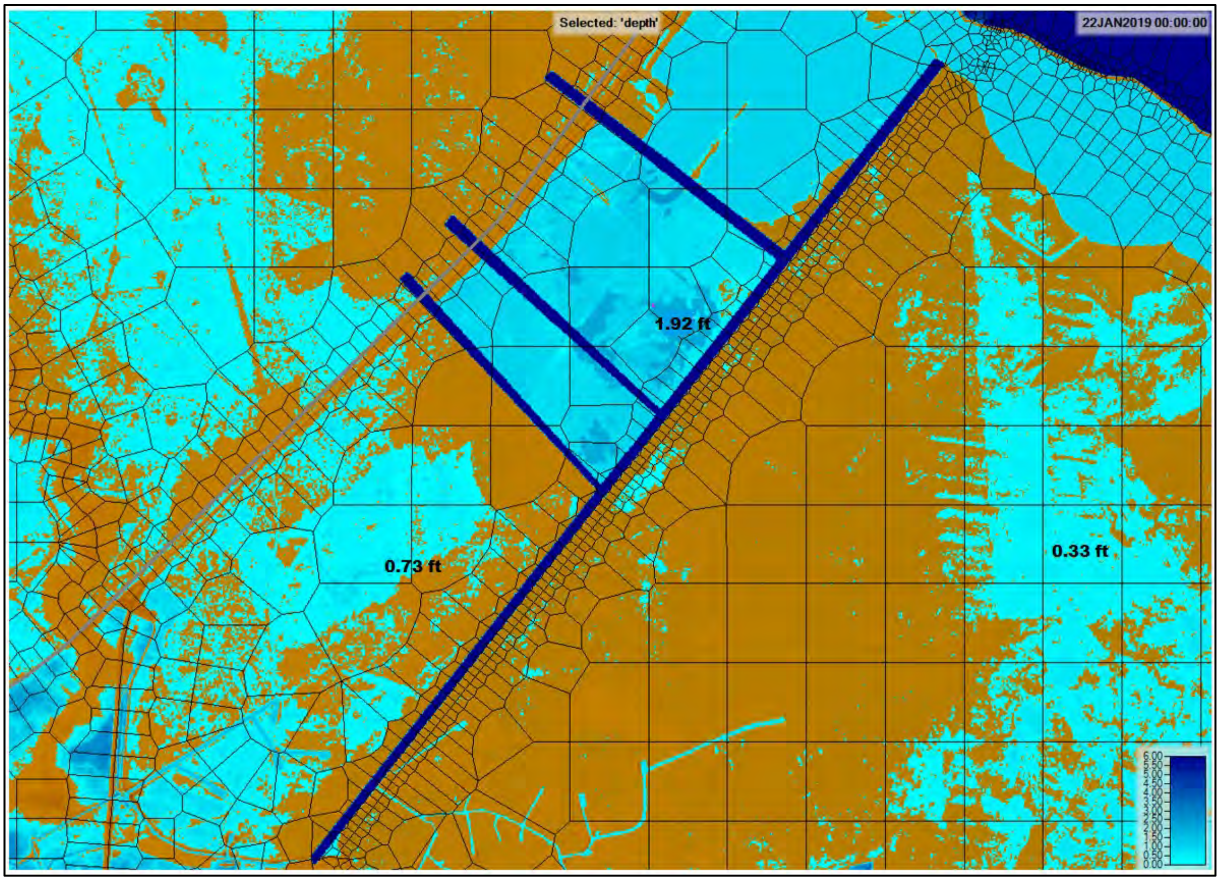


Figure 1-25: Depths After Week Three in the Upper Barataria Basin Area of Interest

Conclusion

Given the results over the three-week timespan, the water depths produced by the 10% AEP 24-hour rainfall between the proposed levee and U.S. Highway 90 maintains a level of less than 2 ft as shown in Figures 1-23 through 1-25. The water in this location appears to be confined in the area by a spoil bank south of the major canal that runs east to west, which coincides with the location of the proposed levee alignment. Therefore, the addition of the proposed levee alignment will likely not exacerbate the impoundment of water on the landside since the rainfall is already confined in the area of interest for the without-project condition. Due to the incremental change in water depths for the without-project condition, it could be concluded that overtopping of the proposed levee alignment may increase the water depths slightly and take a little longer time to drain from the area, but further with-project modeling is needed to quantify those effects.

A 270-ft wide barge gate with a top of wall elevation of 18.5 ft, as well as adjacent 20 ft-wide sluice gates (each with a top of gate elevation of 18.5 ft) are proposed where Reach F crosses Bayou Des Allemands. The proposed barge gate and adjacent sluice gates provide the same conveyance capacity as the railroad (RR) restriction north of the proposed gate location. This would not result in a "bottleneck" situation (which would cause water to stack behind the gate), resulting in elevated water levels on the landside. During normal hydro-meteorological conditions, all gates will remain open to allow free navigation, fish passage and drainage of landside floodwaters. Deviations from this condition may occur for maintenance or emergencies (e.g., pollutant spills). Barge gate closure will occur when all of the following criteria are applied:

a) The National Weather Service has issued a Small Craft Advisory for Barataria Bay associated with a tropical event in the Gulf of Mexico.

b) A storm surge of a certain elevation has been forecast for the project area.

c) Water levels at the gate exceed a certain elevation OR wind speeds exceed a certain speed OR exterior stage equals interior stage.

The water elevations are based on available storage inside the protected area and the goal of not exceeding certain water elevations are based on personnel safety and safe operation of site equipment (e.g., cranes). Stage equalization is needed because the barge gate can only move under zero head. Exact elevations would be determined by future modeling efforts.

The Upper Barataria Basin is rather expansive, ranging around 610 square miles for the area north of U.S. Highway 90. This large area allows for extensive storage capacity. The storage capacity would allow the rain water to be stored within the basin while the gates are closed, resulting in minimal flooding within the system due to rainfall.

The levee system is designed for a 1% Level of Risk Reduction (LORR), which means a storm of a greater magnitude than a 1% LORR storm would be required to overtop the proposed levees. Given that scenario, the with-project condition would limit the propagation of surge up into the basin while the without-project condition would allow surge to propagate further into the basin, thus requiring a longer time for the water to exit since most of the water drains to Bayou Des Allemands and out of the system.

1.8 Geotechnical

1.8.1 Background

Earthwork stability templates, settlement and lift schedule predictions were prepared for cost estimating purposes only. The templates and lift schedules were used to determine the levee footprints, costs, mitigation needs and borrow needs.

The earthwork stability templates were determined with stability analyses and settlement estimates. Lift schedules based on the settlement estimates were also produced.

By a comparison of the available soil properties in the project area, it was determined the soil properties used in the St. Charles Parish levee design reports produced a good representation of the soils in the area. The soil properties used in the stability analysis combine the soil properties in the Magnolia Ridge Levee Project – Report 1 – Earthen Levees – Report and Figures, Pdf Page 45 of 49, and the Sunset Levee Geotechnical Report Reach 7. This was decided to be a conservative approach to determining a conceptual levee design for this area. All elevations are referenced to the NAVD88 datum.

One hundred and forty three borings, which were mostly five-inch undisturbed borings, along the proposed alignment were available from the USACE New Orleans District (CEMVN) database.

Local levee districts provided geotechnical reports about local levees, including Willowridge, Ellington, Magnolia Ridge and Sunset. These geotechnical reports contained boring information, stability analyses and some settlement analyses.

1.8.2 Soil Design Reaches

This project contains Hydraulic Reaches A, B, C, D, E, F, G and H. The same soil properties were used to model all of the levees in these various hydraulic reaches. Levee elevations varied between the hydraulic reaches due to the required hydraulic elevations and overbuild needed because of settlement. Descriptions of the subsoil conditions can be found on plates 17 and 18 in the “Upper Barataria Basin Risk Reduction 10% Conceptual Design Report”, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018.

1.8.3 Methodology and Assumptions

The analyses were performed in accordance with the HSDRRS Design Guidelines dated 23 October 2007, with the Geotechnical section updated on 14 June 2012. It should be noted the scope of this study does not include all cases required by the HSDRRS guidelines. The scope of this study only includes an evaluation of the Q-Case (i.e., undrained) parameters for the Top of Levee (TOL), Still Water Level (SWL) and the Low Water Level (LWL). The SWL elevations were determined by the hydraulics designer.

1.8.4 Design Information

The levee was analyzed with crown elevations of 14.0 ft, 16.0 ft and 18.5 ft.

Locations of the borings used in the analyses can be found in the geotechnical drawings for the RP (sheets 8 through 10) of Annex 13. Subsoil profiles of the borings used in the analyses can be found on sheets 11 through 13 of the geotechnical drawings in Annex 13. Design parameters used in the stability analyses can be found on sheet 14 of the geotechnical drawings in Annex 13. Design parameters used in the settlement calculations can be found on sheets 15 and 16 of the geotechnical drawings in Annex 13.

1.8.5 Stability Analyses

The levee was analyzed with crown elevations of 14.0 ft, 16.0 ft and 18.5 ft (refer to Tables 1-4 through 1-6 for factors-of-safety).

The stability of the earthen levees was determined using soil properties from the Magnolia Ridge and Sunset geotechnical reports. Both of these levees are on the alignment of the RP and in St. Charles Parish. These reports were used because it appeared they provided a good representation of the general soil properties in the area. The program SLOPE/W version 10.0.0.17401 from the GeoStudio 2019 Suite of programs used the Spencer Method to determine typical levee cross sections to be used in the cost estimate.

The earthen levees generally consist of a 10-ft wide levee crown with 1V:4H side slopes. A simple assumption that the SWL was two ft below the top of the levee was used in each analysis. Stability analyses can be found on sheets 19 through 33 of the geotechnical drawings in Annex 13.

The levees in Hydraulic Reaches G and H use geotextile reinforcement. Geotextile reinforcement was used to reduce the size of the levee footprint. The geotextile reinforcement was designed for the levee with an elevation of 16.0 ft. It is 100 ft wide at an elevation of 0.0 ft and is 10,500 lbf/ft. A levee design with an elevation of 14.0 ft for the geotextile reinforcement section was not needed because the same geotextile reinforcement is used in the levee design for the later lift to an elevation of 16.0 ft (refer to Table 1-7 for factors-of-safety).

Table 1-4: Summary of Analysis for Levee with Crown Elevation of 14.0 ft

Name of Analysis	Required Factor of Safety	Calculated Factor of Safety	* Drawing Number
Construction Grade	1.2	1.48	19
Low Water Level	1.4	1.60	20
Still Water Level	1.5	1.53	21

* From the Geotechnical Drawings in Annex 13

Table 1-5: Summary of Analysis for Levee with Crown Elevation of 16.0 ft

Name of Analysis	Required Factor of Safety	Calculated Factor of Safety	* Drawing Number
Construction Grade	1.2	1.44	22
Low Water Level	1.4	1.44	23
Still Water Level	1.5	1.50	24

* From the Geotechnical Drawings in Annex 13

Table 1-6: Summary of Analysis for Levee with Crown Elevation of 18.5 ft

Name of Analysis	Required Factor of Safety	Calculated Factor of Safety	* Drawing Number
Construction Grade	1.2	1.56	25
Low Water Level	1.4	1.45	26
Still Water Level	1.5	1.60	27

* From the Geotechnical Drawings in Annex 13

Table 1-7: Summary of Analysis for Levee with Crown Elevation of 16.0 ft and Geotextile

Name of Analysis	Required Factor of Safety	Calculated Factor of Safety	* Drawing Number
Construction Grade – Around Geotextile Reinforcement	1.2	1.34	28
Construction Grade – Through Geotextile Reinforcement	1.2	1.35	29
Low Water Level – Around Geotextile Reinforcement	1.4	1.40	30
Low Water Level – Through Geotextile Reinforcement	1.4	1.41	31
Still Water Level – Around Geotextile Reinforcement	1.5	1.5	32
Still Water Level – Through Geotextile Reinforcement	1.5	1.4	33

* From the Geotechnical Drawings in Annex 13

1.8.6 Settlement Analyses

The Settle3D Version 4.013 Build date: Nov 24 2017 13:21:12, by Rocscience Inc., was used for the settlement analyses. Embankment loads were used to model the typical levee sections found in the stability analyses. Soil properties from the Magnolia Ridge project were used to model the soil for the entire study area. This assumption was based upon the limited data available in the study area. It was assumed the soil was normal to slightly over-consolidated in this area. The settlement parameters used in the settlement calculations can be found in the geotechnical drawings of Annex 13 (sheets 15 and 16). The amount of settlement was determined for each levee height. The amount of settlement was used to develop lift schedules for each hydraulic reach (refer to Table 1-8). Calculations were provided for each levee lift shown on the lift schedules in Table 1-8, since the elevation needed to be increased each time the levee was lifted to ensure the levee reached the required grade in the year 2073.

Soil parameters from the Magnolia Ridge Geotechnical Report were used to model the subsurface conditions for this project. Settlement parameters for the Sunset Levee were not available. Settlement was performed with Rocscience's Settle3 program. The settlement estimate was used in conjunction with the provided required hydraulic elevations to develop settlement curves for Hydraulic Reaches A through H.

Table 1-8: Summary of Lift Schedules

Hydraulic Reach	First Lift Elevation	Second Lift Elevation	Third Lift Elevation
A	14.0 ft in Year 2026	16.0 ft in Year 2054	N/A
B, C and D	14.0 ft in Year 2026	16.0 ft in Year 2056	N/A
E	14.0 ft in Year 2026	16.0 ft in Year 2038	18.5 ft in Year 2059
F	16.0 ft in Year 2026	18.5 ft in Year 2044	N/A
G	14.0 ft in Year 2026	16.0 ft in Year 2044	N/A
H	16.0 ft in Year 2026	N/A	N/A

1.8.7 Potential Borrow Sites

Various borrow sites were considered for this project. Potential borrow sites near the recommended alignment, which were cleared for the HSDRRS projects, were considered. The sites that are likely to be used for borrow can be found in the geotechnical drawings of Annex 13 (sheet 34). The borrow material for construction is proposed to come from borrow sites within 15 miles of the project area. Potential borrow material can come from farm land near the community of Raceland (as shown on sheet 34 of the geotechnical drawings of Annex 13). It should be noted that only some of the lands (not all of the lands) from the potential pits are intended to be used.

1.8.8 Results and Conclusions

Stability analyses and settlement calculations were used to develop the lift schedules and typical cross sections for each hydraulic reach. The levee cross sections typically consist of a levee with a 10-ft wide crown, with 1V:4H side slopes with stability berms.

1.9 Civil Design

The side slopes used for all of the levee structural alternatives were 1V:4H. The base elevations ranged from 4.0 ft to (-) 4.0 ft so, for consistency, it was decided to use a weighted average across all hydraulic reaches of 0.0 ft. For those hydraulic reaches with an existing levee, the existing levee heights varied. Therefore, a composite existing elevation of 7.0 ft was used. The footprint width and design varied among the hydraulic reaches and are outlined below.

1.9.1 Hydraulic Subreach A-1 and Hydraulic Reach D

For the first lifts in the year 2026, the levees will be constructed with a lift to an elevation of 14.0 ft. The existing David Pond West Guide Levee is on the floodside of the existing levees so the lifts will be shifted to the landside and assumed to tie in at the centerline of the existing levee at an elevation of 7.0 ft, with 1V:4H side slopes. For the second and last lift, which will be in the year 2054 for Hydraulic Subreach A-2 and in the year 2056 for Hydraulic Reach D, the first lift to an elevation of 14.0 ft is assumed to have settled to an elevation of 12.5 ft. The second lift, to an elevation of 16.0 ft, will be tied into the existing levees with another landside shift, while maintaining the 1V:4H side slopes (refer to Figure 1-26).

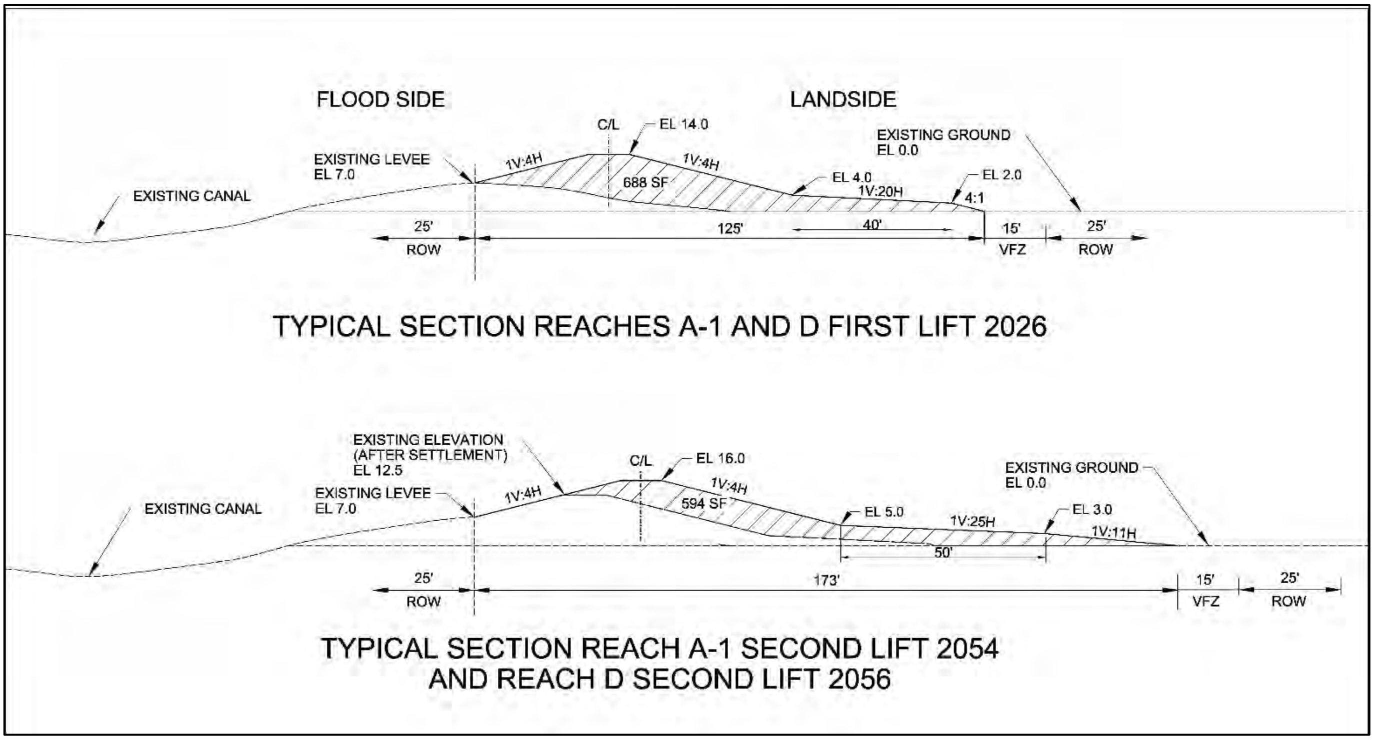


Figure 1-26: Typical Cross Sections for Hydraulic Subreach A-1 and Hydraulic Reach D

1.9.2 Hydraulic Subreach A-2 and Hydraulic Reaches B and C

For the first lifts in the year 2026, the levees will be constructed with a lift to an elevation of 14.0 ft. The St. Charles Parish levee is on the landside of the existing levees so the lifts will be shifted to the floodside and assumed to tie in at the centerline of the existing levee at an elevation of 7.0 ft with 1V:4H side slopes. For the second and last lift, which will be in the year 2054 for Hydraulic Subreach A-2 and in the year 2056 for Hydraulic Reaches B and C, the first lift to an elevation of 14.0 ft is assumed to have settled to an elevation of 12.5 ft. The second lift, to an elevation of 16.0 ft, will be tied into the existing levee with another floodside shift, while maintaining the 1V:4H side slopes (refer to Figure 1-27).

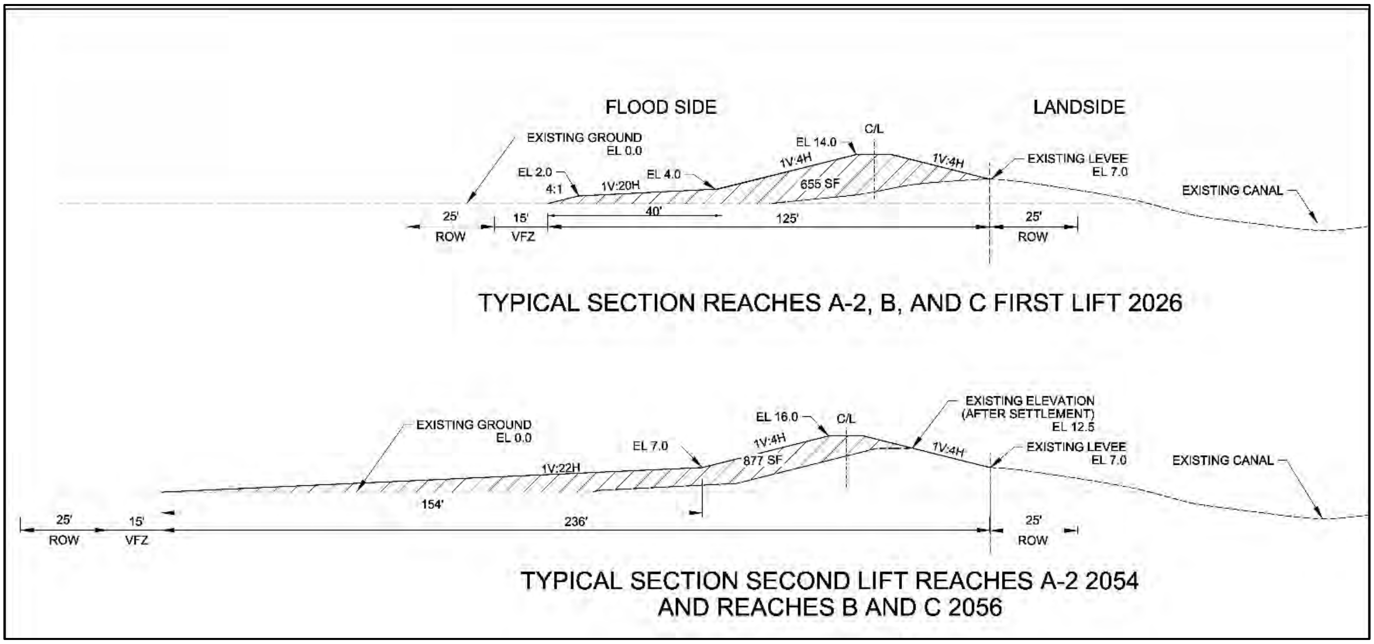


Figure 1-27: Typical Cross Sections for Hydraulic Subreach A-2 and Hydraulic Reaches B and C

1.9.3 Hydraulic Reach E

For the first lift in the year 2026, the levee will be constructed with a lift to an elevation of 14.0 ft. The Sunset Levee is on the floodside of the existing levees so the lift will be shifted to the landside and assumed to tie in at the centerline of the existing levee at an elevation of 7.0 ft with 1V:4H side slopes. For the second lift, which will be in the year 2038, the first lift to an elevation of 14.0 ft is assumed to have settled to an elevation of 12.5 ft. A second lift to an elevation of 16.0 ft will be tied into the existing levee with another floodside shift, maintaining the 1V:4H side slopes. For the third and last lift, which will be in the year 2059, the second lift to an elevation of 16.0 ft is assumed to have settled to an elevation of 15.25 ft. The third lift, to an elevation of 18.5 ft, will be tied into the existing levee with another floodside shift, while maintaining the 1V:4H side slopes (refer to Figure 1-28).

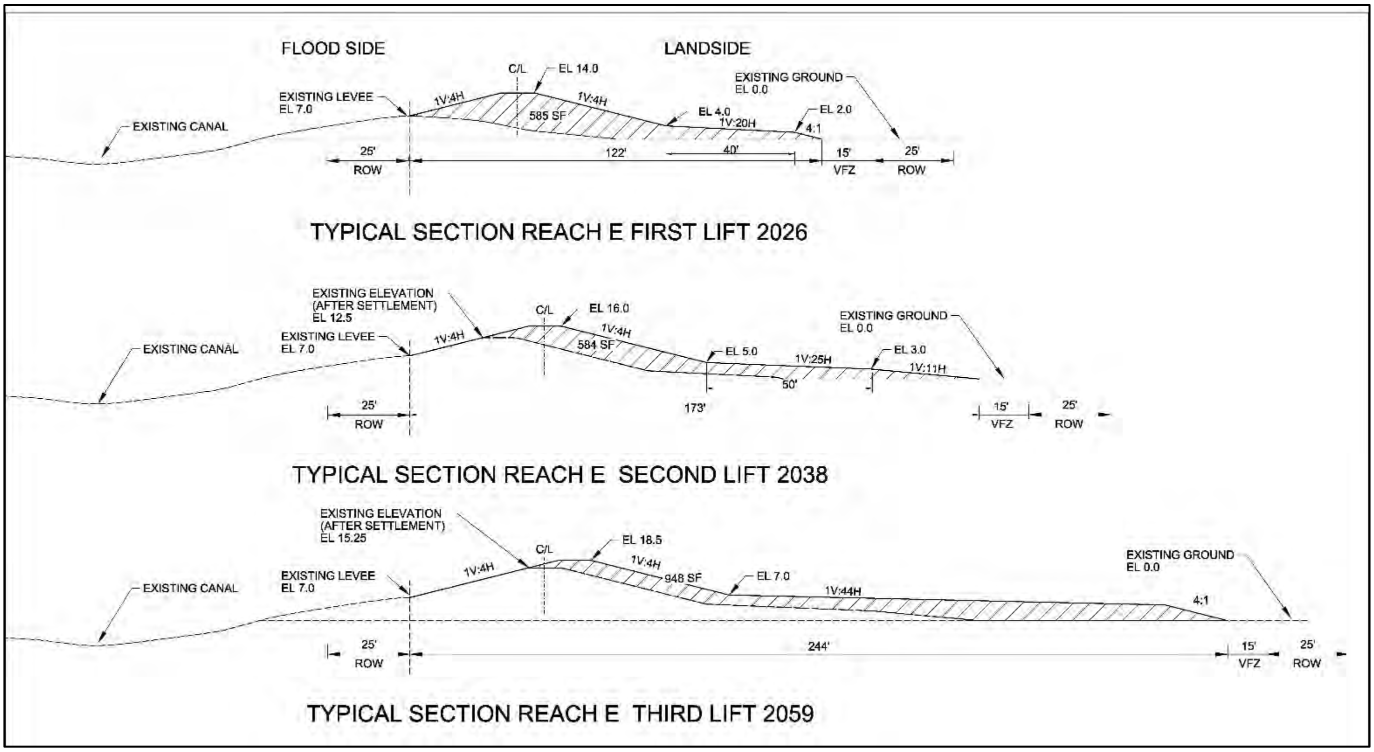


Figure 1-28: Typical Cross Sections for Hydraulic Reach E

1.9.4 Hydraulic Reach F

For the first lift in the year 2026, the levee will be constructed with a lift to an elevation of 14.0 ft. The Sunset Levee is on the floodside of the existing levees so the lift will be shifted to the landside and assumed to tie in at the centerline of the existing levee at an elevation of 7.0 ft with 1V:4H side slopes. For the second and last lift, which will be in the year 2044, the first lift to an elevation of 14.0 ft is assumed to have settled to an elevation of 12.5 ft. The second lift, to an elevation of 16.0 ft, will be tied into the existing levee with another floodside shift, while maintaining the 1V:4H side slopes (refer to Figure 1-29).

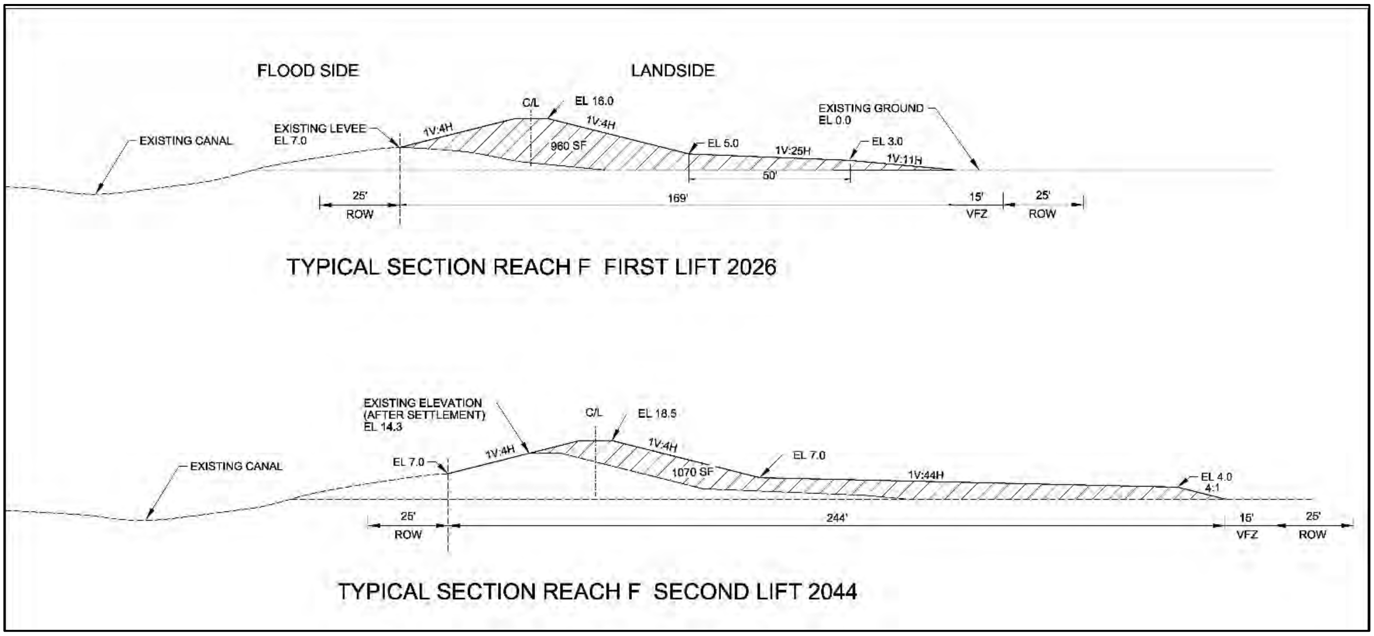


Figure 1-29: Typical Cross Sections for Hydraulic Reach F

1.9.5 Hydraulic Reaches G and H

These two hydraulic reaches do not have existing levees, and will be built from the ground with a layer of 10,000 lbs/ft geotextile reinforcement placed at an elevation of 0.0 ft. The first lift for each hydraulic reach will be in the year 2026, at an elevation of 14.0 ft with 1V:4H side slopes and stability berms on both sides. Hydraulic Reach H will only have one lift. Hydraulic Reach G will have an additional lift in the year 2044, to an elevation of 16.0 ft. It is assumed that the previous lift for Hydraulic Reach G will have settled to an elevation of 12.5 ft, so the new lift will be built as typical straddle construction on top of the existing material to an elevation of 16.0 ft, while maintaining the 1V:4H side slopes. It is assumed that the stability berms will not need to be lifted (refer to Figure 1-30).

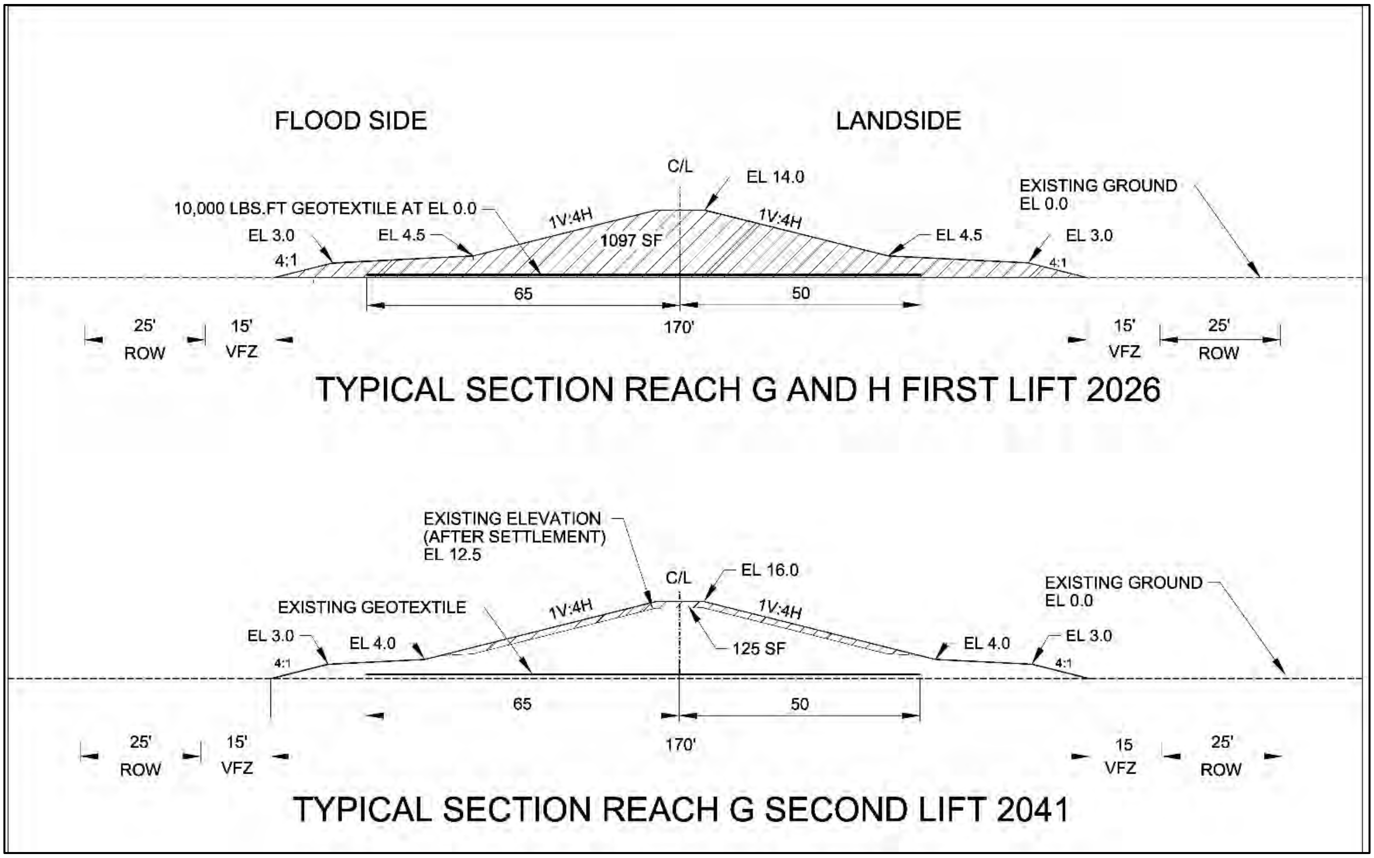


Figure 1-30: Typical Cross Sections for Hydraulic Reaches G and H

For the total footprint width, for those hydraulic reaches without an existing levee (G and H), an additional 15 ft was added to each side to account for the vegetative free zone (VFZ) for maintenance purposes. Another 25 ft was added to each side for construction easement and fertilizing, seeding, clearing and grubbing. For hydraulic reaches with an existing levee (A, B, C, D, E and F), an additional 15 ft was added to the stability berm side to account for the VFZ for maintenance purposes. An additional 25 ft for construction easement and fertilizing, seeding, clearing and grubbing was also included. On the existing levee side, 25 ft was added to account for VFZ and fertilizing, seeding, clearing and grubbing. Therefore, the overall distance for the seeding, mulching, fertilizing, clearing and grubbing quantities is an additional 80 ft, added to the toe-to-toe width of the levee for Hydraulic Reaches G and H, and an additional 70 ft added to the toe-to-toe width for Hydraulic Reaches A, B, C, D, E and F. For silt fence quantities, the hydraulic reach length was doubled, with an additional 25% added for staging areas.

1.10 Structural Design

This section describes the design and features of the structures included in the RP. All structural features were designed according to HSDRRS specifications, USACE engineering manuals (EMs), Engineering Regulations (ERs) and industry standards. All detail computations for the structures are provided in Annex 12.

The RP alignment includes approximately 13,623 linear feet (lf) of floodwall (T-wall) along the Paradise Canal, a 45-ft wide roller gate crossing LA Highway 306 (Bayou Gauche Rd.), a bridge at Godchaux Canal, two RR crossing gates, two ramps, fronting protection for seven pump stations, five drainage structures, five pipeline-crossing T-walls, two tidal exchange structures and the gate structures across Bayou Des Allemands, which includes a 270-lf barge gate structure, twelve box culverts with sluice gates and 500 lf of T-walls. The system starts in Luling, where it connects to the Mississippi River levee through the Davis Pond Diversion Structure West Guide Levee, continues south, improving upon and updating deficiencies in the St. Charles Parish levee, crosses the Bayou Des Allemands gate structure and continues parallel to U.S. Highway 90 before it ties into high ground across the basin near Raceland. Table 1-10 below, shows the list of structures, their location along the alignment and their features. The entire UBB alignment is divided into Hydraulic reaches, known as A through H. The different reaches and their start/ stop coordinates are presented in Table 1-9 below.

Table 1-9: Hydraulic Reach Beginning and Ending Coordinates

Reach Start/Stop	Latitude	Longitude
A begins	29°55'46.99"N	90°19'20.89"W
A ends B begins	29°53'2.65"N	90°19'54.05"W
B ends C begins	29°54'3.90"N	90°22'27.26"W
C ends D begins	29°51'41.97"N	90°24'48.51"W
D ends E begins	29°48'53.03"N	90°24'26.87"W
E ends F begins	29°47'15.10"N	90°25'57.71"W
F ends G begins	29°47'59.03"N	90°28'13.82"W
G ends H begins	29°44'8.25"N	90°32'6.69"W
H ends	29°42'13.93"N	90°33'44.94"W

Table 1-10: Structures along RP Alignment

	Structure	Reach	TOW Elevation (ft)	TOS Elevation (ft)	Width (ft)	Length (ft)
1	River Road crossing ramp	A	14.5	-	-	155
2	Union Pacific Railroad crossing	A	14.5	8.16	8	107.5
3	BNSF Railroad crossing	A	14.5	5.51	8	149.25
4	U.S. Highway 90 Crossing Ramp	A	14.5	-	-	180
5	Davis Pond Pump Station frontage protection	A	14.5	(-) 1.0	15	350
6	Willowdale Pump Station, two new tidal exchange structures	A	14.5	(-) 2.0	15	108
7	Willowridge Pump Station frontage protection	B	14.5	(-) 1.0	15	116.33
8	Cousins Pump Station frontage protection	B	14.5	(-) 4.0	15	175
9	T-wall section for East Gas Pipeline	B	14.5	1.0	15	82
10	Kellogg Pump Station frontage protection	B	14.5	(-) 2.0	15	110
11	T-wall section for West Gas Pipeline	B	14.5	1.0	15	140

Structure		Reach	TOW Elevation (ft)	TOS Elevation (ft)	Width (ft)	Length (ft)
12	Ellington Pump Station frontage protection	C	14.5	(-) 1.0	15	131
13	T-wall section for Magnolia Pipeline	C	14.5	1.0	15	133.5
14	Magnolia Ridge Pump Station frontage protection	C	14.5	(-) 1.0	15	1,196
15	Existing Paradise Control Structure	C	14.5			
16	Floodwall section in Hydraulic Reach D, Top of Wall (TOW) El 15.0 ft	D	15.0	7.5	10	2,799.8
17	Floodwall section in Hydraulic Reach E, TOW El 18.5 ft	E	18.5	7.5	10	8316
18	Floodwall type T-1, TOW El 18.5 ft	E	18.5	5.0	15	650
19	Floodwall type T-2, TOW E. 18.5 ft	E	18.5	1.0	15	625
20	Floodwall type T-3, TOW El 18.5 ft	E	18.5	(-) 3.0	20	1,232
21	45-ft wide Highway 306 (Bayou Gauche) Roller Gate, TOW El 18.5 ft	E	18.5	2.0	9.67	45
22	Crawford Canal Pump Station fronting protection, TOW El 18.5 ft (70 LF of floodwall)	E	18.5	(-) 3.0	20	70
23	270-ft Barge Gate crossing Bayou Des Allemands, TOW El 18.5 ft	F	18.5	(-) 10.0	61	320
24	Bayou Des Allemands Barge Gate, (12) 15 ft x 20 ft box culverts with sluice gates	F	18.5	(-) 10.0	50	288
25	Godchaux Canal Bridge, TOW El 9.5 ft	G	9.5	-	12	120
26	Drainage Structure – (4) 6 ft x 6 ft Reinforced Concrete (RC) box culverts with sluice gates, in 3 different locations	G	16	(-) 6.0	170	48
27	Drainage Structure – (4) 6 ft x 6 ft RC box culverts with sluice gates	G	16	(-) 6.0	170	48
28	Drainage Structure – (4) 6 ft x 6 ft RC box culverts with sluice gates	H	16	(-) 6.0	170	48
29	Drainage Structure – (2) 84-inch RC Pipe (RCP) culverts with sluice gates	H	16	(-) 6.0	168	24
30	Drainage Structure – (1) 60-inch RCP culvert with sluice gates	H	16	0.0	98	10

Structure		Reach	TOW Elevation (ft)	TOS Elevation (ft)	Width (ft)	Length (ft)
31	T-wall section, Enterprise and Shell Pipeline Crossing (Davis Pond Crossing #1)	A	14.5	1.0	15	152
32	T-wall section, Bridgeline Enlink Pipeline Crossing (Davis Pond Crossing #2)	A	14.5	1.0	15	297.75
33	Bayou Des Allemands Barge Gate, T-walls	F	18.5	(-) 10.0	42	500

The 1% AEP design elevations shown in Figures 1-31 and 1-32 were used for the design of each structure and the determination of quantities (for cost estimating purposes). The Upper Barataria Basin Risk Reduction 10% Conceptual Design Report, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018, was used as a basis for updating quantities and reanalyzing structures based on the new design elevations. It was determined that the structures along the alignment would not include a 2 ft of structural superiority. Therefore, structures along Hydraulic Reaches A through C would maintain the same TOW elevations as presented in the Screening Phase of this appendix. The structures that would need to be adjusted in height, reevaluated and have quantities revised would be structures in Hydraulic Reaches D through H.

1% Future Conditions (Year 2076) Intermediate SLR	
Hydraulic Reach	**Structure Elevation (ft) NAVD88(2004.65)**
A	14.5
B	14.5
C	14.5
D	15.0
E	18.5
F	18.5
G	15.5
H	14.0

Figure 1-31: 1% Future Conditions (Year 2076) Structure Elevations

1% Future Conditions (Year 2076) Intermediate SLR	
Hydraulic Reach	*** Levee Elevation (ft) NAVD88(2004.65)**
A	14.5
B	14.5
C	14.5
D	14.5
E	17.5
F	17.5
G	14.5
H	13.5
*1V:4H Levee Slope	

Figure 1-32: 1% Future Conditions (Year 2076) Levee Elevations

1.10.1 Hydraulic Reach D

Structures along Hydraulic Reach D include reinforced concrete T-walls along the Sunset Drainage District near the Grand Bayou community. The T-wall consists of a 10-ft wide, 2.5-ft thick base slab and a 2-ft thick stem with TOW elevation of 15.0 ft. The Top of Slab (TOS) elevation would be 7.5 ft. The T-walls will be supported by two rows of 82.5-ft long steel H-piles, spaced at 6.0 ft on centers. The piles will be battered at 1H:5V. The T-walls will include a sheet pile cutoff wall below the concrete slab with a minimum tip elevation of (-) 35.0 ft.

1.10.2 Hydraulic Reach E

Structures along Hydraulic Reach E include reinforced concrete T-walls along the Sunset Drainage District near the Green Acres Community and continues along the alignment of the existing Sunset Drainage District levee until it reaches LA Highway 306. It then runs westward along the northern edge of LA Highway 306 until turning southward toward Bayou Gauche.

The T-wall near Green Acres Community consists of a 10-ft wide, 2.5-ft thick base slab and a 2-ft thick stem with a TOW elevation of 18.5 ft. The TOS elevation is 7.5 ft. The T-walls are supported by two rows of 82.5-ft long steel H-piles, spaced at 6.0 ft on centers. The piles are battered at 1H:5V. The T-walls include a sheet pile cutoff wall below the concrete slab with a minimum tip elevation of (-) 35.0 ft.

T-walls along LA Highway 306 consist of 20-ft wide, 4.0-ft thick base slabs, with 3.25-ft thick stems. The TOW elevation for the T-walls is 18.5 ft. The TOS elevation is (-) 3.0 ft. The T-walls are supported by four rows of steel H-piles driven to an elevation of (-) 73.0 ft, spaced at 5.0 ft on centers. The piles are battered at 1H:2V. The T-walls include a 31-ft 3-inch sheet pile cutoff wall below the concrete slab.

Frontal protection T-walls are constructed on the floodside of the Crawford Canal Pump Station. Dimensions and features of the wall match those of the T-walls along LA Highway 306.

A 45-ft steel roller gate across LA Highway 306 would be installed to connect the T-wall alignment on both sides of the highway. Quantities for the roller gate were determined based on quantities available in the "Upper Barataria Basin Risk Reduction 10% Conceptual Design Report", prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018. The applicable features were increased by 15% to obtain the quantities for the required TOW elevation of 18.5 ft for the structure. The roller gate consists of a 9.5-ft wide, 3-ft thick slab with an elevation of the top of the slab at 2.0 ft and two rows of 18-inch diameter pipe piles supporting the structure. The piles are each 138 ft long.

Approximately 400 lf of T-wall needs to be constructed about 700 ft west of the Crawford Canal Pump Station. Existing pipelines cross this section of floodwall. The exact depth of the pipelines are presently unknown. Further investigation needs to be performed during the PED phase to determine the depth at which the pipelines cross the cutoff sheet pile underneath the T-wall. A T-wall, rather than a levee, was selected for this area due to existing valves that are located too close to the proposed centerline of the alignment, and to avoid further loading over the pipelines. The T-wall consists of a 15-ft wide, 2.5-ft thick base slab, with a 2.0-ft thick stem. The TOW elevation is 18.5 ft. The TOS elevation is 0.0 ft. The T-wall is supported by 3 rows of steel H-piles driven to an elevation of (-) 73.0 ft, spaced at 5.0 ft on centers. The piles are battered at 1H:2V. The T-walls include a 31-ft 3-inch sheet pile cutoff wall below the concrete slab. Further analysis needs to be performed on the wall during the PED phase due to the uncertainty of the location and depth of existing pipelines.

1.10.3 Hydraulic Reach F

Hydraulic Reach F is located mainly in the Bayou Des Allemands area, between Lac Des Allemands and Lake Salvador. Structures along this hydraulic reach consist of the main flood control structure which includes the 270-ft Bayou Des Allemands Barge Gate, twelve 15-ft x 20-ft concrete box culverts with sluice gates (without trash screens) and 500 ft of reinforced concrete T-walls.

The 270 ft barge gate has a sill elevation of (-) 10.0 ft and a TOW elevation of 18.5 ft. The piles for the landing and storage areas for the barge gate consist of 24-inch diameter pipe piles that are each 155 ft long. Similar to the steel roller gate in Hydraulic Reach E, the pertinent features for the barge gate were increased by 15% to obtain the quantities for the required TOW elevation of 18.5 ft for the structure.

Twelve 15-ft x 20-ft concrete box culverts with sluice gates (without trash screens) in the bayou were added next to the 270-ft barge gate to conserve flow, with no restrictions. The structures would have to be placed in the bayou until hydraulic modeling can be performed in PED. Six culverts would be placed on each side of the barge gate structure. The slab thickness of the box culvert structure is 8 ft, and is supported by 24-inch diameter pipe piles spaced at 10 ft on centers. The piles are each 119 ft long and battered at 1H:3V.

The T-wall monoliths were placed on the alignment next to the sluice gate structures. The T-walls tie into the levees on each side of the Bayou Des Allemands control structure. The same methodology used in the Sunset Drainage District levee walls was used for the design of the T-walls. Wave loads and geotechnical data for the analysis of the floodwall were obtained from Appendix 6 of the "Upper Barataria Basin Risk Reduction 10% Conceptual Design Report", prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018. The T-wall consists of a 42-ft wide, 5-ft thick base slab and a tapered stem with a base thickness of 5.0 ft. The TOS elevation is (-) 10.0 ft and the TOW elevation is 18.5 ft. The T-walls are supported by 5 rows of 24-inch diameter steel pipe piles. The piles are each 180 ft long and spaced at 8 ft on centers. The piles are battered at 1H:2V. The T-walls include a sheet pile cutoff wall below the concrete slab with a minimum tip elevation of (-) 100.0 ft.

1.10.4 Hydraulic Reach G

Structures in Hydraulic Reach G consist of the access bridge across the Godchaux Canal and four drainage structures which allow flow to cross the levee alignment during normal operations.

The bridge structure is located on the landside of the levee alignment in Hydraulic Reach G. It consists of a single-lane precast concrete slab, with concrete railings supported on a steel pipe pile bent. The precast concrete spans represent a typical precast bridge. The removable bridge span consists of a steel bridge with a steel grating bridge deck. The bottom of the steel bridge framing is at an elevation of 8.0 ft. The top of the bridge grating is at an elevation of 9.5 ft.

Each proposed drainage structure includes four 6-ft x 6-ft reinforced concrete box culverts with sluice gates (without trash screens). The structures include sheet pile headwall and steel walkways for access to operate the sluice gates. The structures are supported by vertical 24-inch diameter steel pipe piles. Quantities for the structures were updated from those presented in the “Upper Barataria Basin Risk Reduction 10% Conceptual Design Report”, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018, based on new levee cross sections provided by the geotechnical designer for Hydraulic Reaches G and H. The new levee crown elevation is 16.0 ft. The pile spacing was determined based on the weight of the structure in two different sections. The first section was assumed to be at the center 60 ft of the levee, where the top of levee elevation is 16.0 ft. The second section was determined to be outside of the center 60 ft of the levee, with the levee elevation at 10.0 ft. For the first and second sections, the pile spacing was determined to be 8 ft on centers and 10 ft on centers, respectively. The piles have a tip elevation of (-) 185.0 ft, based on the pile curves provided in the “Upper Barataria Basin Risk Reduction 10% Conceptual Design Report”, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018.

1.10.5 Hydraulic Reach H

Hydraulic Reach H requires three drainage structures to maintain drainage at the end of the project alignment.

One of the drainage structures is a structure with four 6-ft x 6-ft reinforced concrete box culverts with sluice gates (without trash screens). It has the same features as the drainage structures described in paragraph 1.10.4 (“Hydraulic Reach G”) above.

The two other drainage structures consist of reinforced concrete pipe culverts with sluice gates (without trash screens). One structure includes a 60-inch diameter reinforced concrete pipe and the other structure includes two 80-inch diameter reinforced concrete pipes. The structures also include reinforced concrete headwalls and steel access walkways to operate the sluice gates.

1.10.6 Structural Design Criteria

Cast-in-place concrete shall have a 28-day compressive strength of 4,000 psi. Pre-stressed concrete shall have a minimum of 4,000 psi strength.

Clear cover

2 inches (minimum) for sections equal to or less than 12 inches thick

3 inches (minimum) for sections greater than 12 inches thick but less than 24 inches thick

4 inches (minimum) for sections equal to or greater than 24 inches thick

The T-walls along the alignment that required reevaluation were analyzed using a Computer Program “Pile Group Analysis (CPGA)” Program. The load cases and overstress factors in Table 1-11 were used to determine pile lengths for walls in Hydraulic Reaches D and E, as well as for the T-walls adjacent to the 270-ft barge gate in the Bayou Des Allemands structure. The load cases in Table 1-12 were used to determine the stem thicknesses of the T-walls.

Table 1-11: Load Cases for T-wall Pile Design

Load Case	Load Description	Overstress	Factored Loads
LC1	Normal Operation	0%	(D + EH + EV)
LC3	Construction	16.67%	(D + Sur)
LC4	Construction + Wind	33%	(D + Sur + W)
LC5	Flowline + Impervious Uplift	0%	(D + EH + EV + HF + IU)
LC6	Flowline + Pervious Uplift	0%	(D + EH + EV + HF + PU)
LC7	Flowline + Impervious Uplift + Wind + Debris	33%	(D + EH + EV + HF + IU + I + W)
LC8	Flowline + Pervious Uplift + Wind + Debris	33%	(D + EH + EV + HF + PU + I + W)
LC9	Freeboard + Impervious Uplift + Debris	33%	(D + EH + EV + HTW + I + IU)
LC10	Freeboard + Pervious Uplift + Debris	33%	(D + EH + EV + HTW + I + PU)

Table 1-12: Load Cases for T-wall Stem Design

Load Case	Load Description	Load Category	Factored Loads
LC1	Normal Operation	Usual	2.2(D + EH + EV)
LC3	Construction	Unusual	1.6(D + Sur)
LC4	Construction + Wind	Unusual	1.6(D + Sur + Wind)
LC5	Flowline + Impervious Uplift	Unusual	1.6(D + EH + EV + HF+ IU)
LC6	Flowline + Pervious Uplift	Unusual	1.6(D + EH + EV + HF+ PU)
LC7	Flowline + Impervious Uplift + Wind + Debris	Unusual	1.6(D + EH + EV + HF+ IU + I + W)
LC8	Flowline + Pervious Uplift + Wind + Debris	Unusual	1.6(D + EH + EV + HF+ PU + I + W)
LC9	Freeboard + Impervious Uplift + Debris	Extreme	1.2D + 1.35EHD + 0.9EHR + 1.35EV + 1.3(HTW + I + IU)
LC10	Freeboard + Impervious Uplift + Debris	Extreme	0.9D + 1.35EHD + 0.9EHR + 1.0EV + 1.3(HTW + I + IU)
LC11	Freeboard + Pervious Uplift + Debris	Extreme	1.2D + 1.35EHD + 0.9EHR + 1.35EV + 1.3(HTW + I + PU)
LC12	Freeboard + Pervious Uplift + Debris	Extreme	0.9D + 1.35EHD + 0.9EHR + 1.0EV + 1.3(HTW + I + PU)

D = Dead Load

EH = Horizontal Soil Load

EV = Vertical Soil Load

ES = Surcharge Load (200 psf)

W = Wind Load

HF = Water at Flowline

PU = Pervious Uplift

IU = Impervious Uplift

I = Debris Impact

HTW = Water at Top of Wall

Sur = Surcharge

Geotechnical data provided in the "Upper Barataria Basin Risk Reduction 10% Conceptual Design Report", prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018 was used to evaluate the foundation of these structures. Detailed methodology analysis, laboratory results, soil borings and pile capacity curves were provided by Eustis Engineering and was included in Appendix 4 of the report referenced above. The pile capacity curves provided were used to determine the pile tip elevations for the T-walls along the alignment.

1.10.7 Steel Reinforcement

Steel reinforcing shall be ASTM A615 Grade 60 with f_y = 60 ksi. Steel reinforcing for pre-stress concrete shall be grade 270 strands (270,000 psi).

Maximum Flexural Reinforcement

0.25 ρ_b (recommended)
0.5 ρ_b (permitted with special studies)
ρ_b = balanced steel ratio

Minimum Flexural Reinforcement

As recommended in EM 1110-2-2104

Temperature Reinforcement

As recommended in EM 1110-2-2104

1.10.8 Reinforced Concrete Load Factors

Load factors and combinations are as recommended in EM 1110-2-2104.

The strength reduction factor for bending shall be 0.9.

The strength reduction factor for shear shall be 0.75.

1.10.9 Wind Loads

From ASCE 7-10 (Eq 27.3-1):

Velocity pressure, q_z, evaluated at height z shall be calculated by the following equation:

$$q_z = 0.00256\, K_z K_{zt} K_d V^2 \ (lb/ft^2)$$

K_d = wind directionality factor defined in Section 26.6 (.85 solid freestanding walls)

K_z = velocity pressure exposure coefficient defined in Section 29.3.1 (1.03 for z<15 cat D)

K_{zt} = topographic factor defined in Section 26.8.2 (1.0, no ramp up effect)

V = basic wind speed from Section 26.5 (158 mph)

q_z = 56.0 (lb/ft^2)

1.10.10 Uplift

Uplift pressure was determined for both pervious and impervious conditions based on the following assumptions:

- Impervious: sheet pile cut-off is 100% effective

- Pervious: uplift slopes uniformly along the base from floodside uplift at floodside edge of base to landside uplift at landside edge of base

1.10.11 Debris Load

A debris load of 0.5K/ft shall be applied to the top of floodwall for TOW load cases.

1.10.12 Soil Loads

Vertical soil loads are determined from the unit weight of the material. Lateral soil loads used a K_0 of 0.8.

1.11 Relocations

1.11.1 General Description

The USACE Relocations PDT member performed an investigation of the existing public utilities and facilities located within the proposed project area, while considering the current design requirements for the RP. In the event that such a facility, utility, highway, railroad, cemetery or town would affect the construction, operation, maintenance, repair, replacement or rehabilitation of the project, then the CEMVN Relocations PDT member must determine the appropriate utility disposition of the impacted facility. Some facilities may usually require either a permanent or temporary physical adjustment or displacement to support project activities, engineering requirements and operation and maintenance needs.

The RP relocations investigations included database research, such as the National Pipeline Database, State Online Natural Resources Information System (SONRIS), Louisiana Department of Natural Resources (LADNR), HTST-IHS, Penwell and the National Pipeline Mapping System (NPMS) data.

Based on the research and investigations that were conducted, utilities and two roadways located within the Project Area (see Figures 1-2 and 1-3) are expected to be impacted by the RP.

1.11.2 Methodology

A review of multiple pipeline databases was used to investigate the facilities located within the U.S. Highway 90 Full Alignment project area. A site visit was not conducted. The utilities located during our investigation, using the databases, were cross-referenced with utilities identified in the "Upper Barataria Basin Risk Reduction 10% Conceptual Design Report", prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018. The facilities that could be potentially impacted by the project were the pipelines, overhead electrical transmission lines and electrical distribution lines.

The impacts on these pipelines were based on the assumption that the project will use HSDRRS criteria, dated February 2007, which addresses the following as acceptable methods of pipeline relocation: directional drilling; structural elevated support; pipeline sleeve for T-wall/seepage reduction construction; and direct contact (also known as “up-and-over”) with the proposed flood protection. It was determined, as a measure of reducing relocation costs, that both pipe sleeving beneath the inverted concrete T- wall and the direct contact relocation method were used for this methodology.

The T-wall method focuses on passing the existing pipeline beneath the inverted concrete T-wall by way of installing a sleeve through a sheet pile seepage cutoff wall allowing the pipeline to remain in place. This method consists of constructing a pile-founded, inverted concrete T-wall flanked by a sheet-pile wall driven on either side and beneath to provide seepage reduction measures for flood protection. The concrete T-wall is then built around the in-situ pipeline. This method is more conducive for pipelines that are approximately 20 ft or less apart and are unable to be re-routed as a temporary bypass within the pipeline right-of-way. There are several areas in the project alignment (e.g., Hydraulic Reaches A, B, C and E) that were identified as needing concrete T-walls.

With the direct contact method, the pipeline owner has the option of relocating the pipeline by placing it directly onto the surface of the new constructed hurricane levee, allowing it to cross up and over the proposed levee design section. This requires the pipeline owner to relocate the pipeline when the levee is raised because of settlement and change in design grade. The pipeline

owners must also determine that the pipeline can sustain the settlement and resulting stresses that are associated with it. Slope pavement or other approved methods must be installed over the pipeline throughout transition area. This method was assumed for single or dual pipelines that have enough space to be re-routed as a bypass or direct contact with the new levee design section.

Electric Transmission Lines in the area were assumed to meet the minimum clearance criteria over the proposed levee crossings, which is 22 ft at 50kV, and plus 0.4 inches for every 1.0 kV above 50kV.

U.S. Highway 90 and River Road are impacted by the proposed flood protection and have to be relocated. These roads will most like be raised using the direct contact method. Similar to the pipelines, the roadways are placed on the surface of the new constructed earthen levee outside of the levee design section. Design engineers determine how much additional fill is needed to avoid the roadways sinking into the design section over time, due to the high volume of traffic along these roadways.

1.11.3 Results

The results of the facility relocations investigations are set forth in Table 1-13 for the RP, which contains a description of the only facilities located within the project area.

The estimated cost for utility relocations for the RP is $30,737,000. The information in Table

1-13 includes the utility owner, the type of utility, size, location and the number of utilities. The estimated costs for relocations included a contingency of (29%), which was applied to all relocation costs.

Table 1-13: Utilities within the Project Alignment

HYDRAULIC REACH	OWNER	DIAMETER	PRODUCT	* STATION
A	Unknown	Unknown	River Road	219+00
A	Atmos	Unknown	Gas	184+00
A	Enterprise Pelican	26 inches	Natural Gas	Unknown
A	Nustar	6 inches	Anhydrous Ammonia	170+60
A	Shell	6 inches	Propylene	Unknown
A	Unknown	Unknown	Highway 90	168+00
A	Enterprise	10 inches	Natural Gas Liquid	160+20
A	Shell	20 inches	Crude	160+00
A	Shell	24 inches	Crude	159+80
A	Enlink	12.75 inches	Natural Gas	77+00
B	St. Charles Parish	12 inches	Sewer Force Main	147+08 to 125+00
B	St. Charles Parish	16 inches	Waste Water Discharge	147+08 to 125+00
B	St. Charles Parish	8 inches	Force Main	147+08 to 125+00
B	St. Charles Parish	12 inches	Force Main	147+08 to 125+00
B	Enlink	12.75 inches	Natural Gas	135+00
B	Enlink	8 inches	Natural Gas	101+00 to 102+50
B	Enlink	14 inches	Natural Gas	101+00 to 102+50
B	Phillips 66	14 inches	Liquid Carbon Dioxide	101+00 to 102+50
B	Columbia Gulf	16 inches	Natural Gas	101+00 to 102+50
C	Gulf South	12 inches	Natural Gas	10+00 to 68+25
C	Atmos	24 inches	Natural Gas	10+00 to 15+00
C	Gulf South	30 inches	Natural Gas	10+00 to 68+25
C	Phillips 66	14 inches	Liquid Carbon Dioxide	95+99 to 97+35
C	Columbia Gulf	16 inches	Natural Gas	95+99 to 97+35
C	Enlink	16 inches	Natural Gas	95+99 to 97+35

HYDRAULIC REACH	OWNER	DIAMETER	PRODUCT	* STATION
D	Enlink	22 inches	Natural Gas	24+50
E	Phillips 66	6 inches	Natural Gas Liquids	339+60
E	Phillips 66	6 inches	Natural Gas Liquids	339+80
E	Williams Energy	10 inches	Liquid	340+00
E	Phillips 66	14 inches	Natural Gas Liquids	340+20
E	Phillips 66	20 inches	Natural Gas Liquids	340+40
E	Enlink	30 inches	Natural Gas	340+60
G,H	Gulf South	30 inches	Natural Gas	10+00 to 85+00
G,H	Gulf South	Unknown	Natural Gas	10+00 to 85+00
G,H	Gulf South	Unknown	Natural Gas	10+00 to 85+00
G,H	Gulf South	Unknown	Natural Gas	10+00 to 85+00
G	Phillips 66	8 inches	Natural Gas Liquids	92+50
H	Transcontinental Gas	10 inches	Natural Gas	242+00
H	Gulf South	12 inches	Natural Gas	251+00
H	Abandoned	6 inches	Gas	Unknown
H	Texas Eastern Transmission	Unknown	Natural Gas	Unknown
H	LOOP LLC	48 inches	Crude Oil	339+00
H	Crimson Gulf	12.75 inches	Crude	394+90
H	Crimson Gulf	16 inches	Crude	395+10

* Stations are based on stationing used in the “Upper Barataria Basin Risk Reduction 10% Conceptual Design Report”, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018.

1.11.4 Pipeline Owners

There are multiple pipelines and two roadways within the project area of the RP, with each crossing project access corridors or running parallel to the proposed flood protection alignments, as described in Section 1.11.1 of this appendix. Refer to Table 1-13 for more information.

1.11.5 Conclusions

Based on the preliminary findings of the relocations investigations, it was determined that the existing pipelines and roadways within the project area of the RP ***will*** be impacted, either requiring relocations of the affected utilities/facilities or providing pipeline protection over the affected utilities during construction. The relocations process towards compensability is expected to be incorporated and coordinated with the utility owners throughout the design and development of the Plans & Specifications for the RP.

1.12 Cost Estimates

1.12.1 Cost Estimate Development

Cost estimate for the RP was developed using the latest TRACES MII cost estimating software, and used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, subcontractor and prime contractor markups. This philosophy was used wherever practical within the time constraints. It was supplemented with estimating information from other sources where necessary such as quotes, bid data and Architect/Engineer (A/E) estimates. The estimate assumed a typical application of levels of subcontractors.

The intent of the cost estimate was to provide or convey a “fair and reasonable” estimate and, where cost detail was provided, it depicted the local market conditions. All of the construction work (e.g., levees, floodwalls, gate structures, control structures, dredging, excavation, dewatering, pilings, rock, etc.) is common to the gulf coast region. The construction sites are mostly accessible from land with additional water access available for the construction of the barge gate structure. Site access is easily provided from U.S. Highway 90 and other various local highways. Water access is available from the Gulf Intracoastal Waterway (GIWW) through Lake Salvador, Bayou des Allemands and Petit Lac des Allemands waterways to the barge gate site.

At this time there are no nonstructural costs (i.e., house raising or flood proofing buildings) included in the RP, but will be revisited during the P.E.D. phase.

Refer to Annex 15 for more detailed information regarding cost estimate development for the RP (including assumptions and methodologies).

1.12.2 Cost Estimate

Table 1-14 shows the baseline project cost for the RP. This information was taken from the Total Project Cost Summary (TPCS). All costs are at October 2020 price levels.

Table 1-14: Final Costs for Recommended Plan

Feature	Cost	Contingency	Total
01 Lands and Damages	$76,863,000	$19,216,000	$96,079,000
02 Relocations	$23,827,000	$6,910,000	$30,737,000
06 Fish and Wildlife Facilities	$339,392,000	$98,424,000	$437,816,000
11 Levees and Floodwalls	$509,516,000	$147,760,000	$657,276,000
15 Floodway Control and Diversion Structures	$181,014,000	$52,494,000	$233,508,000

Feature	Cost	Contingency	Total
18 Cultural Resources Preservation	$1,100,000	$319,000	$1,419,000
30 Planning, Engineering and Design (P.E.D)	$216,244,000	$62,711,000	$278,955,000
31 Construction Management	$116,033,000	$33,650,000	$149,683,000
TOTAL	$1,463,989,000	$421,482,000	**$1,885,472,000**

1.13 Life Safety Risk Assessment

Life Safety Risk Assessment has been inventoried. It was determined that the analysis will be conducted during the PED phase. A life safety risk assessment preliminary effort for this phase is included as Annex 14 to the Engineering Appendix.

2 SCREENING PHASE

The information below was used in the plan formulation process to identify the TSP described in the Draft Report. After the TSP was selected, the team may refine the design of the TSP with additional engineering and environmental investigations. This information is presented in the sections above.

National Environmental Policy Act (NEPA) regulations (40 CFR 1502.14(d)) require that a no action option always be considered a viable alternative in any final array of plans. This represents the future that will likely occur if USACE takes no action. The no action plan is the default choice.

Figure 2-1 displays the 10 alternatives that were considered (other than the no action alternative).

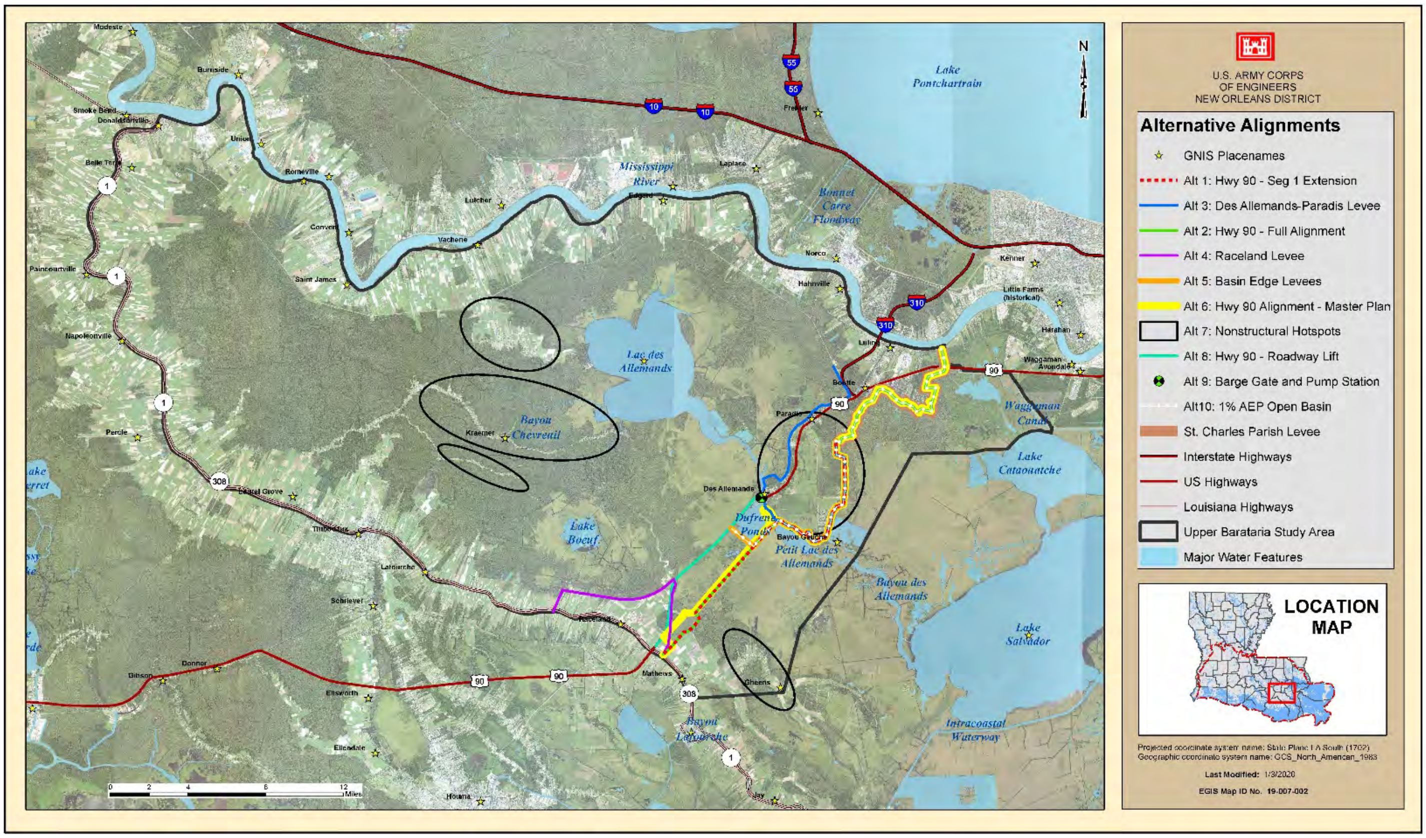


Figure 2-1: The Ten Alternative Alignments

The sections herein describe the 10 alternative alignments that were considered (other than the no action alternative). The Final Array (for selection of the TSP) eventually consisted of Alternatives 1, 2, 7, 10 and the no action alternative only.

2.1 Alternative 1 – U.S. Highway 90 - Segment 1 Extension

Figure 2-2: Alternative 1 – U.S. Highway 90 – Segment 1 Extension

2.1.1 Levee System

The Alternative 1 levee alignment ties into the existing St. Charles Parish levee (which was built to a design elevation of 7.5 ft) at the southern end. The alignment then traverses across the UBB in a southwesterly direction, paralleling U.S. Highway 90 on its eastern side, and ends at the Lafourche Parish levee near Raceland, LA. The earthen levee design elevation is 7.5 ft. This levee is approximately 15.9 miles in length and incorporates a 270 ft-barge gate, as well as other structures which are described below.

2.1.2 Floodwalls

Floodwalls (T-walls), comprising a total of 12,253 linear ft, have a top of wall design elevation of 9.5 ft (which includes 2 ft of structural superiority). The floodwalls include fronting protection for the existing Crawford Canal pump station.

2.1.3 Floodgates

There are three floodgates along the alignment: A roller gate, 45 ft wide, at Bayou Gauche; a 17 ft x 16 ft x 9.5 ft-stop log gate at Godchaux Canal; and a 270 ft-barge gate crossing Bayou Des Allemands.

2.1.4 Drainage Structures

There are two gravity drainage structures (each one has four 6 ft x 6 ft-reinforced concrete box culverts with sluice gates). The gravity drainage structures are located between 16 miles and 25 miles southwest of the entrance to Dufrene Ponds. There are also two tidal exchange structures (one with two 84 inch-diameter reinforced concrete pipe culverts with sluice gates and one with a 60 inch-diameter reinforced concrete pipe culvert with sluice gates). The tidal exchange structures are located between 16 miles and 25 miles southwest of the entrance to Dufrene Ponds. A control structure consisting of two 10 ft x 10 ft-sluice gates is located in the vicinity of Paradis, LA.

2.1.5 Pumping Stations

Adding new pump stations was not considered during the screening phase. It was assumed that any existing pump stations in the area would have adequate capacity to address drainage concerns.

2.1.6 Bridges

There is a single lane steel grating removable access bridge, approximately 20 ft x 12 ft, at the stop log gate at Godchaux Canal.

2.1.7 Relocations

Refer to Section 2.15 of this appendix for relocations information.

2.1.8 Screening Result

This alternative was included in the Final Array.

2.2 Alternative 2 – U.S. Highway 90 – Full Alignment

Figure 2-3: Alternative 2 – U.S. Highway 90 – Full Alignment

2.2.1 Levee System

The Alternative 2 levee alignment traverses across the UBB in a southwesterly direction, connecting the northeast portion to the southeast portion of the basin, paralleling U.S. Highway 90 on its eastern side, and ends at the Lafourche Parish levee near Raceland, LA. The earthen levee design elevation is 8.5 ft (which therefore elevates the existing St. Charles Parish levee). It was determined this elevation would yield the greatest benefits (i.e., damages prevented). This levee is approximately 30.44 miles in length and incorporates a 270 ft-barge gate, as well as other structures which are described below.

2.2.2 Floodwalls

Floodwalls (T-walls), comprising a total of 14,401 linear ft, have a top of wall design elevation of 10.5 ft (which includes 2 ft of structural superiority). The floodwalls include fronting protection for seven existing pump stations, which are at the following locations: Davis Pond, Willowridge, Cousins, Kellogg, Ellington, Magnolia Ridge and Crawford Canal.

2.2.3 Floodgates

There are five floodgates along the alignment: A roller gate, 45 ft-wide, at Bayou Gauche; a 17 ft x 16 ft x 10.5 ft-stop log gate at Godchaux Canal; two Railroad gates (one 50 ft wide for the Union

Pacific Railroad and one 35 ft wide for the BNSF Railroad); and a 270 ft-barge gate crossing Bayou Des Allemands.

2.2.4 Drainage Structures

There are two gravity drainage structures (each one has four 6 ft x 6 ft-reinforced concrete box culverts with sluice gates). The gravity drainage structures are located between 16 miles and 25 miles southwest of the entrance to Dufrene Ponds. There are also four tidal exchange structures (one with two 84 inch-diameter reinforced concrete pipe culverts with sluice gates and one with a 60 inch-diameter reinforced concrete pipe culvert with sluice gates, as well as two existing tidal exchange structures (in which each one has three 4 ft x 4 ft-sluice gates) in the St. Charles Parish levee alignment that would need to be replaced). The tidal exchange structures are located between 16 miles and 25 miles southwest of the entrance to Dufrene Ponds. A control structure consisting of two 10 ft. x 10 ft-sluice gates is located in the vicinity of Paradis, LA.

2.2.5 Pumping Stations

Adding new pump stations was not considered during the screening phase. It was assumed any existing pump stations in the area would have adequate capacity to address drainage concerns.

2.2.6 Bridges

There is a single lane steel grating removable access bridge, approximately 20 ft x 12 ft, at the stop log gate at Godchaux Canal.

2.2.7 Road Ramps

There are two existing road ramps that will be raised to an elevation of 8.5 ft: River Road and U.S. Highway 90.

2.2.8 Relocations

Refer to Section 2.15 of this appendix for relocations information.

2.2.9 Screening Result

This alternative was included in the Final Array.

2.3 Alternative 3 – Des Allemands – Paradis Levee

Figure 2-4: Alternative 3 – Des Allemands – Paradis Levee

2.3.1 Levee System

The Alternative 3 levee alignment ties into the existing St. Charles Parish levee (which was built to a design elevation of 7.5 ft) at the southern end. The alignment then traverses in a southwesterly direction, crosses U.S. Highway 90, traverses around the community of Des Allemands, LA, proceeds in a northeasterly direction, paralleling U.S. Highway 90 on its western side, and ends northwest of Boutte, LA by connecting to a local parish levee. The earthen levee design elevation is 7.5 ft. This levee is approximately 20.6 miles in length and incorporates some other structures which are described below.

2.3.2 Floodwalls

Floodwalls (T-walls), comprising a total of 10,863 linear ft, have a top of wall design elevation of 9.5 ft (which includes 2 ft of structural superiority). The floodwalls include fronting protection for the existing Crawford Canal pump station.

2.3.3 Floodgates

There are two floodgates along the alignment: A roller gate, 45 ft wide, at Bayou Gauche and a 50 ft-wide Railroad gate at Des Allemands, LA.

2.3.4 Drainage Structures

There are no drainage structures that apply to this alignment.

2.3.5 Pumping Stations

Adding new pump stations was not considered during the screening phase. It was assumed any existing pump stations in the area would have adequate capacity to address drainage concerns.

2.3.6 Bridges

There are no bridges that apply to this alignment.

2.3.7 Relocations

Refer to Section 2.15 of this appendix for relocations information.

2.3.8 Screening Result

This alternative was eliminated from further consideration due to the construction costs of the levees and structures, which yielded a benefit-to-cost (B/C) ratio of less than 1.0.

2.4 Alternative 4 – Raceland Levee (Raceland Loop)

Figure 2-5: Alternative 4 – Raceland Levee (Raceland Loop)

2.4.1 Levee System

The Alternative 4 levee alignment (a ring berm) traverses around the community of Raceland, LA, while crossing U.S. Highway 90 at one point. This levee is approximately 11.3 miles in length, and capitalizes on the natural ridges around Raceland. It includes a railroad crossing gate and roller gate structures.

2.4.2 Screening Result

This alternative was eliminated from further consideration due to Future Without Project (FWOP) conditions, which resulted in no damages in the Raceland area at all, even during the occurrence of a 0.2% AEP storm event.

2.5 Alternative 5 – Basin Edge Levee

Figure 2-6: Alternative 5 – Basin Edge Levee

2.5.1 Levee System

The Alternative 5 levee alignment ties into the existing St. Charles Parish levee (which was built to a design elevation of 7.5 ft) at the southern end. The alignment then traverses in a south to southwesterly direction, traversing around the community of Des Allemands, LA, and ends at U.S. Highway 90, southwest of Des Allemands. The earthen levee design elevation is 7.5 ft. This levee is approximately 12.5 miles in length and incorporates other structures which are described below. It should be noted that, initially, this alternative also included the Raceland Levee, but the alternative was later modified to reflect the deletion of the Raceland Levee portion (see Alternative 4 above).

2.5.2 Floodwalls

Floodwalls (T-walls), comprising a total of 10,863 linear ft, have a top of wall design elevation of 9.5 ft (which includes 2 ft of structural superiority). The floodwalls include fronting protection for the existing Crawford Canal pump station.

2.5.3 Floodgates

There are three floodgates along the alignment: A roller gate, 45 ft wide, at Bayou Gauche; a 17 ft x 16 ft x 10.5 ft-stop log gate at Godchaux Canal; and a 270 ft-barge gate crossing Bayou Des Allemands.

2.5.4 Drainage Structures

There are no drainage structures that apply to this alignment.

2.5.5 Pumping Stations

Adding new pump stations was not considered during the screening phase. It was assumed any existing pump stations in the area would have adequate capacity to address drainage concerns.

2.5.6 Bridges

There are no bridges that apply to this alignment.

2.5.7 Relocations

Refer to Section 2.15 of this appendix for relocations information.

2.5.8 Screening Result

This alternative was eliminated from further consideration due to the construction costs of the levees and structures, which yielded a B/C ratio of less than 1.0.

2.6 Alternative 6 – U.S. Highway 90 Alignment – State of LA Master Plan

Figure 2-7: Alternative 6 – U.S. Highway 90 Alignment – State of LA Master Plan

2.6.1 Levee System

The Alternative 6 levee alignment (which follows the same alignment outlined in the 2017 State of Louisiana Coastal Master Plan) traverses across the UBB in a southwesterly direction, connecting the northeast portion to the southeast portion of the basin, paralleling U.S. Highway 90 on its eastern side, and ends at the Lafourche Parish levee near Raceland, LA. The earthen levee design elevation varies from 6.0 ft to 10.0 ft (for existing conditions) and from 7.5 ft to 13.0 ft (for future conditions), which represents a 1% AEP level of risk reduction (in accordance with the State of LA Master Plan). This levee is approximately 40.2 miles in length and incorporates a 270 ft-barge gate, as well as other structures which are described below.

2.6.2 Floodwalls

Floodwalls (T-walls), comprising a total of 14,401 linear ft, have a top of wall design elevation that varies from 9.5 ft to 15.0 ft (which includes 2 ft of structural superiority). The floodwalls include fronting protection for seven existing pump stations, which are at the following locations: Davis Pond, Willowridge, Cousins, Kellogg, Ellington, Magnolia Ridge and Crawford Canal.

2.6.3 Floodgates

There are eight floodgates along the alignment: A roller gate, 45 ft wide, at Bayou Gauche; a 17 ft x 16 ft x 10.5 ft-stop log gate at Godchaux Canal; two Railroad gates (one 50 ft wide for the Union Pacific Railroad and one 35 ft wide for the BNSF Railroad); three roadway swing gates (two 50 ft wide at U.S. Highway 90 and one 35 ft wide at River Road); and a 270 ft-barge gate crossing Bayou Des Allemands.

2.6.4 Drainage Structures

There are two gravity drainage structures (each one has four 6 ft x 6 ft-reinforced concrete box culverts with sluice gates). The gravity drainage structures are located between 16 miles and 25 miles southwest of the entrance to Dufrene Ponds. There are also four tidal exchange structures (one with two 84 inch-diameter reinforced concrete pipe culverts with sluice gates and one with a 60 inch-diameter reinforced concrete pipe culvert with sluice gates, as well as two existing tidal exchange structures (in which each one has three 4 ft x 4 ft-sluice gates) in the St. Charles Parish levee alignment that would need to be replaced). The tidal exchange structures are located between 16 miles and 25 miles southwest of the entrance to Dufrene Ponds. A control structure consisting of two 10 ft x 10 ft-sluice gates is located in the vicinity of Paradis, LA.

2.6.5 Pumping Stations

Adding new pump stations was not considered during the screening phase. It was assumed any existing pump stations in the area would have adequate capacity to address drainage concerns.

2.6.6 Bridges

There are no bridges that apply to this alignment.

2.6.7 Relocations

Refer to Section 2.15 of this appendix for relocations information.

2.6.8 Screening Result

This alternative was eliminated from further consideration due to the construction costs of the levees and structures, which yielded a B/C ratio of less than 1.0.

2.7 Nonstructural Measures

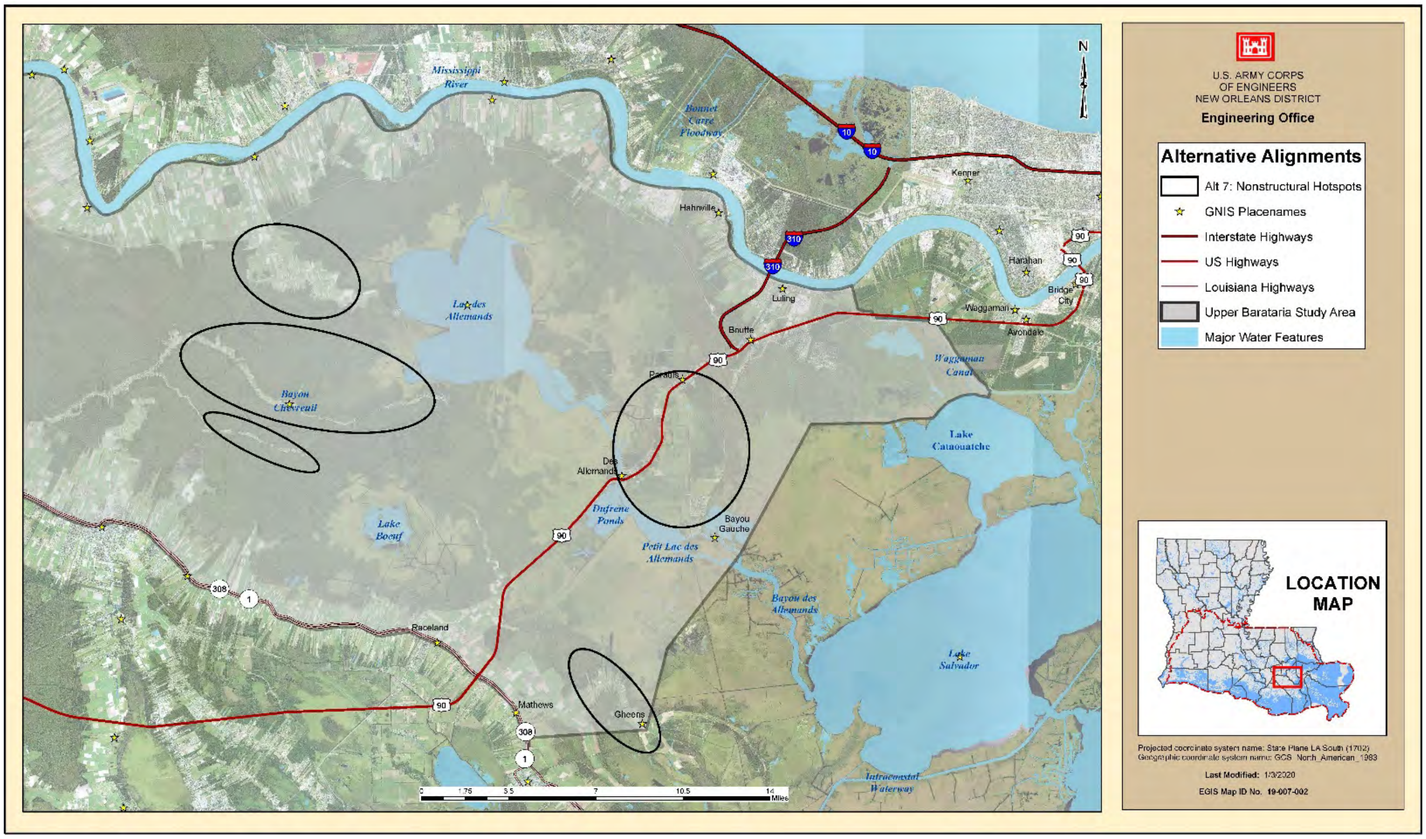


Figure 2-8: Alternative 7 – Nonstructural Measures (Hotspots)

This alternative does not involve structural features. Instead, nonstructural measures included elevating residential and non-residential structures above the FWOP flood stage, as well as the implementation of floodproofing measures. Nonstructural measures can be either a stand-alone alternative or used in combination with structural alternatives. The nonstructural methods described herein only apply to specific areas in the basin (known as "Hotspots") in which the first floor elevation was below the FWOP flood stage and where flood damages would be expected to occur. These areas are shown in Figure 2-8 above.

2.7.1 Residential Structures

Elevation costs were based on the difference (in ft) between the original first floor elevation and the target elevation (the 1% AEP FWOP flood stage) for each structure. The number (in ft) that each structure was raised was rounded to the closest one-ft increment, with the exception that structures less than one ft below the target elevation were rounded-up to one ft. Elevation costs by structure were totaled to yield an estimate of the total structure elevation costs. The cost per square ft for raising a structure was based on data obtained during interviews with representatives of three major metropolitan New Orleans area firms that specialize in structure elevation. Composite costs were derived for residential structures by type: slab and pier foundation, one-story and two-story configuration and for mobile homes. These composite unit costs also vary by the number of ft that structures may be elevated. The cost per square ft to raise an individual structure to the target height was multiplied by the footprint square footage of each structure to compute the costs to elevate the structure (refer to Table 2-1 below). Additionally, a labor estimate of $15,000 per structure to complete required administrative activities by the Federal Government in implementing this nonstructural measure was added to the cost of implementation.

2.7.2 Non-Residential Structures

The dry floodproofing measure was applied to all non-residential structures. Separate cost estimates were developed to floodproof these structures based on their relative square footage. The total cost varied as follows: $115,255 if the square footage was between zero and 20,000 square ft; $357,050 if the square footage was between 20,000 and 100,000 square ft; and $899,648 if the square footage was greater than 100,000 square ft. These costs were developed for the Donaldsonville to the Gulf, Louisiana Feasibility Study evaluation, prepared by CEMVN, dated March 2011, by contacting local contractors; the costs were then escalated to October 2019 prices. Additionally, a labor estimate of $15,000 per structure to complete required administrative activities by the Federal Government in accomplishing this nonstructural measure was added to the cost of implementation.

2.7.3 Operation, Maintenance, Repair, Replacement and Rehabilitation

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

Table 2-1: Cost per square ft of to Raise Residential Structures (October 2019 Price Level)

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

2.7.4 Screening Result

This alternative was included in the Final Array.

2.8 Alternative 8 – U.S. Highway 90 Lift Alignment

Figure 2-9: Alternative 8 – U.S. Highway 90 Lift Alignment

2.8.1 Levee System

The Alternative 8 levee alignment (developed with the U.S. Fish and Wildlife Service (USFWS) as a possible environmentally-preferred plan to restore the natural hydrology across the basin) traverses across the UBB in a southwesterly direction, connecting the northeast portion to the southeast portion of the basin, paralleling U.S. Highway 90 on its eastern side, and ends at the Lafourche Parish levee near Raceland, LA. The earthen levee design elevation varies from 6.0 ft to 10.0 ft (for existing conditions) and from 7.5 ft to 13.0 ft (for future conditions), which represents a 1% AEP level of risk reduction. This levee is approximately 32.5 miles in length and incorporates a 270 ft-barge gate, as well as other structures which are described below. The section of levee west of Bayou Des Allemands would have U.S. Highway 90 on top of it for approximately 10 miles.

2.8.2 Floodwalls

Floodwalls (T-walls), comprising a total of 14,401 linear ft, have a top of wall design elevation that varies from 9.5 ft to 15.0 ft (which includes 2 ft of structural superiority). The floodwalls include fronting protection for seven existing pump stations, which are at the following locations: Davis Pond, Willowridge, Cousins, Kellogg, Ellington, Magnolia Ridge and Crawford Canal.

2.8.3 Floodgates

There are eight floodgates along the alignment: A roller gate, 45 ft wide, at Bayou Gauche; a 17 ft x 16 ft x 10.5 ft-stop log gate at Godchaux Canal; two Railroad gates (one 50 ft wide for the Union Pacific Railroad and one 35 ft wide for the BNSF Railroad); three roadway swing gates (two 50 ft wide at U.S. Highway 90 and one 35 ft wide at River Road); and a 270 ft-barge gate crossing Bayou Des Allemands.

2.8.4 Drainage Structures

There are two gravity drainage structures (each one has four 6 ft x 6 ft-reinforced concrete box culverts with sluice gates). The gravity drainage structures are located between 16 miles and 25 miles southwest of the entrance to Dufrene Ponds. There are also four tidal exchange structures (one with two 84 inch-diameter reinforced concrete pipe culverts with sluice gates and one with a 60 inch-diameter reinforced concrete pipe culvert with sluice gates, as well as two existing tidal exchange structures (in which each one has three 4 ft x 4 ft sluice gates) in the St. Charles Parish levee alignment that would need to be replaced). The tidal exchange structures are located between 16 miles and 25 miles southwest of the entrance to Dufrene Ponds. A control structure consisting of two 10 ft x 10 ft-sluice gates is located in the vicinity of Paradis, LA.

2.8.5 Pumping Stations

Adding new pump stations was not considered during the screening phase. It was assumed any existing pump stations in the area would have adequate capacity to address drainage concerns.

2.8.6 Bridges

There are no bridges that apply to this alignment.

2.8.7 Relocations

Refer to Section 2.15 of this appendix for relocations information.

2.8.8 Screening Result

This alternative was eliminated from further consideration due to USACE policy which prohibits a large highway from being placed upon a Federal levee. The Louisiana Department of Transportation and Development in the past has not supported the placement of roadways upon levees. This alternative also would not be in compliance with multiple USACE levee and earthen dam engineering and design regulations (such as EM 1110-2-2300), risk analysis regulations (such as ER 1105-2-101 and EM 1110-2-1619), encroachment regulations, cost analysis regulations (such as ER 1110-2-1302), National Flood Insurance Program levee certification regulations (such as EC 1110-6067), flood fighting and emergency operations regulations (such as ER 1130-2-530) and Operation, Maintenance, Repair, Replacement and Rehabilitation regulations (such as ER1130-2-530 and ER1110-2-401).

2.9 Alternative 9 – Basin Rainfall Alternative

Figure 2-10: Alternative 9 – Basin Rainfall Alternative

2.9.1 Levee System

Alternative 9 (developed to prevent rainfall damages) incorporates the placement of a pump station and a 270 ft-barge gate in the location where U.S. Highway 90 crosses Bayou Des Allemands.

2.9.2 Floodwalls

There are no floodwalls that apply to this alternative.

2.9.3 Floodgates

There is a 270 ft-barge gate crossing Bayou Des Allemands.

2.9.4 Drainage Structures

There are no drainage structures that apply to this alternative.

2.9.5 Pumping Stations

A 3,200 cubic feet per second (cfs) pump station located at Bayou Des Allemands is needed for a 10-year rainfall event.

2.9.6 Bridges

There are no bridges that apply to this alternative.

2.9.7 Relocations

Refer to Section 2.15 of this appendix for relocations information.

2.9.8 Screening Result

This alternative was eliminated from further consideration based on the storage capability of 17 billion cubic feet within the basin itself, which would equate to a water surface elevation of 1 ft. Economic results indicated minimal damages in the areas of the basin where this alternative would be most effective. Therefore, there were nearly no damages to be prevented with a basin wide rainfall alternative.

2.10 Alternative 10 – 1% AEP Open Basin

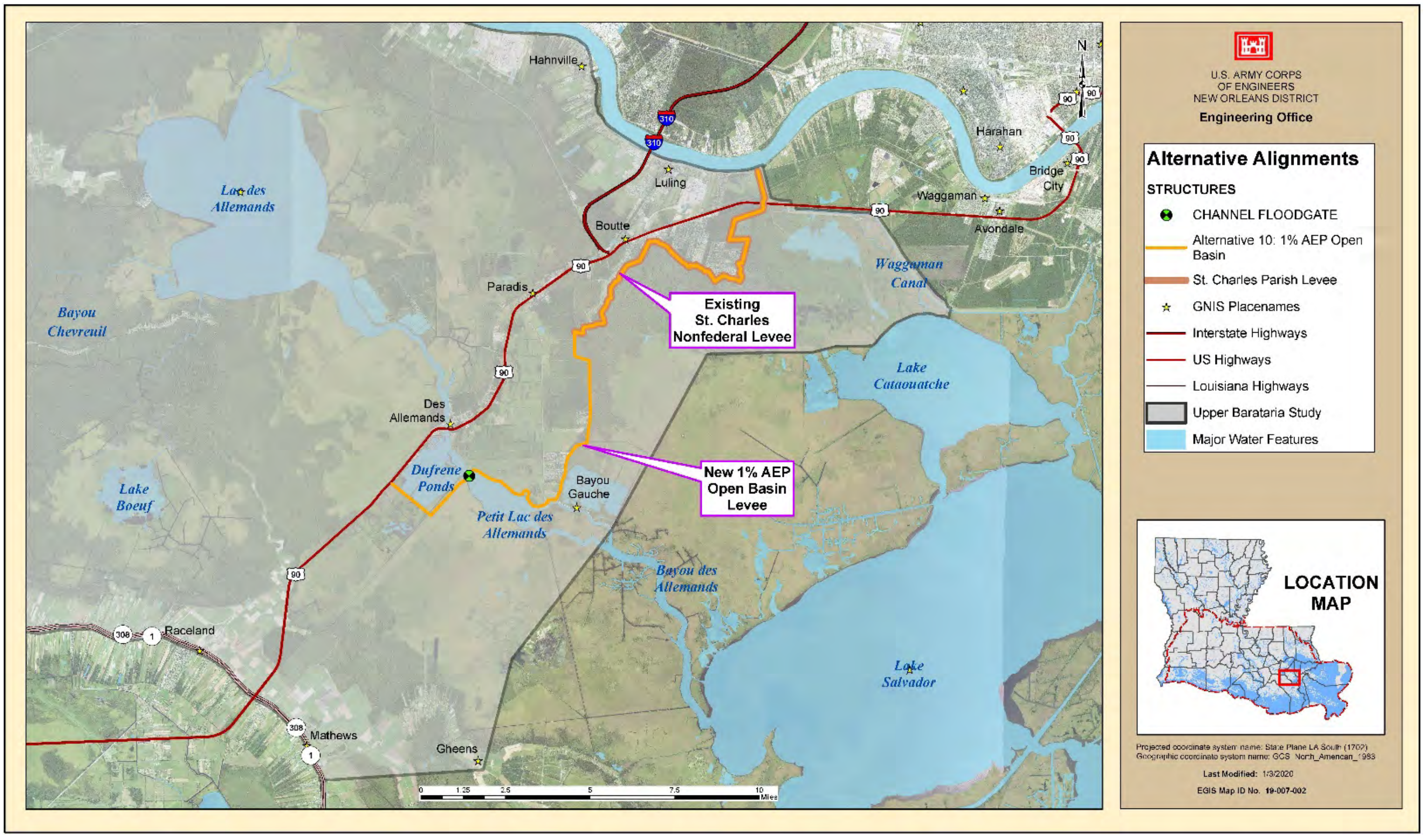


Figure 2-11: Alternative 10 – 1% AEP Open Basin Alternative

2.10.1 Levee System

The Alternative 10 levee alignment ties into the existing St. Charles Parish levee (which was built to a design elevation of 7.5 ft) at the southern end. The alignment then traverses in a south to southwesterly direction, traversing around the community of Des Allemands, LA, and ends at U.S.

Highway 90, just across Bayou Des Allemands, southwest of Des Allemands. The earthen levee design elevation is 12.0 ft (which represents a 1% AEP level of risk reduction), and therefore elevates and extends the existing St. Charles Parish levee. This levee is approximately 24.0 miles in length and incorporates a 270 ft-barge gate, as well as other structures which are described below.

2.10.2 Floodwalls

Floodwalls (T-walls), comprising a total of 14,401 linear ft, have a top of wall design elevation of 14.0 ft (which includes 2 ft of structural superiority). The floodwalls include fronting protection for seven existing pump stations, which are at the following locations: Davis Pond, Willowridge, Cousins, Kellogg, Ellington, Magnolia Ridge and Crawford Canal.

2.10.3 Floodgates

There are four floodgates along the alignment: A roller gate, 45 ft wide, at Bayou Gauche; two Railroad gates (one 50 ft wide for the Union Pacific Railroad and one 35 ft wide for the BNSF Railroad); and a 270 ft-barge gate crossing Bayou Des Allemands.

2.10.4 Drainage Structures

There are two existing tidal exchange structures (in which each one has three 4 ft x 4 ft-sluice gates) in the St. Charles Parish levee alignment that would need to be replaced). The tidal exchange structures are located near the Willowdale pump station. A control structure consisting of two 10 ft x 10 ft-sluice gates is located in the vicinity of Paradis, LA.

2.10.5 Pumping Stations

Adding new pump stations was not considered during the screening phase. It was assumed any existing pump stations in the area, as well as the storage area in the basin itself (behind U.S. Highway 90) would have adequate capacity to address drainage concerns.

2.10.6 Bridges

There are no bridges that apply to this alignment.

2.10.7 Relocations

Refer to Section 2.15 of this appendix for relocations information.

2.10.8 Screening Result

This alternative was included in the Final Array.

2.11 Hydraulics and Hydrology

2.11.1 Exterior Analysis – Hydraulic Levee Design

Levee design elevations were investigated for the 2%, 1%, 0.5% and 0.2% annual exceedance probabilities for storm surges for seven different levee alignments. Figures 2-12 through 2-19 show the different levee alignment alternatives, including hydraulic reaches.

Figure 2-12: Alternative 1 – U.S. Highway 90 – Segment 1 Extension – With Hydraulic Reaches

Figure 2-13: Alternative 2 – U.S. Highway 90 – Full Alignment – With Hydraulic Reaches

Figure 2-14: Alternative 3 – Des Allemands – Paradis Levee – With Hydraulic Reaches

Figure 2-15: Alternative 4 – Raceland Levee (Raceland Loop) – With Hydraulic Reaches

Figure 2-16: Alternative 5 – Basin Edge Levee – With Hydraulic Reaches

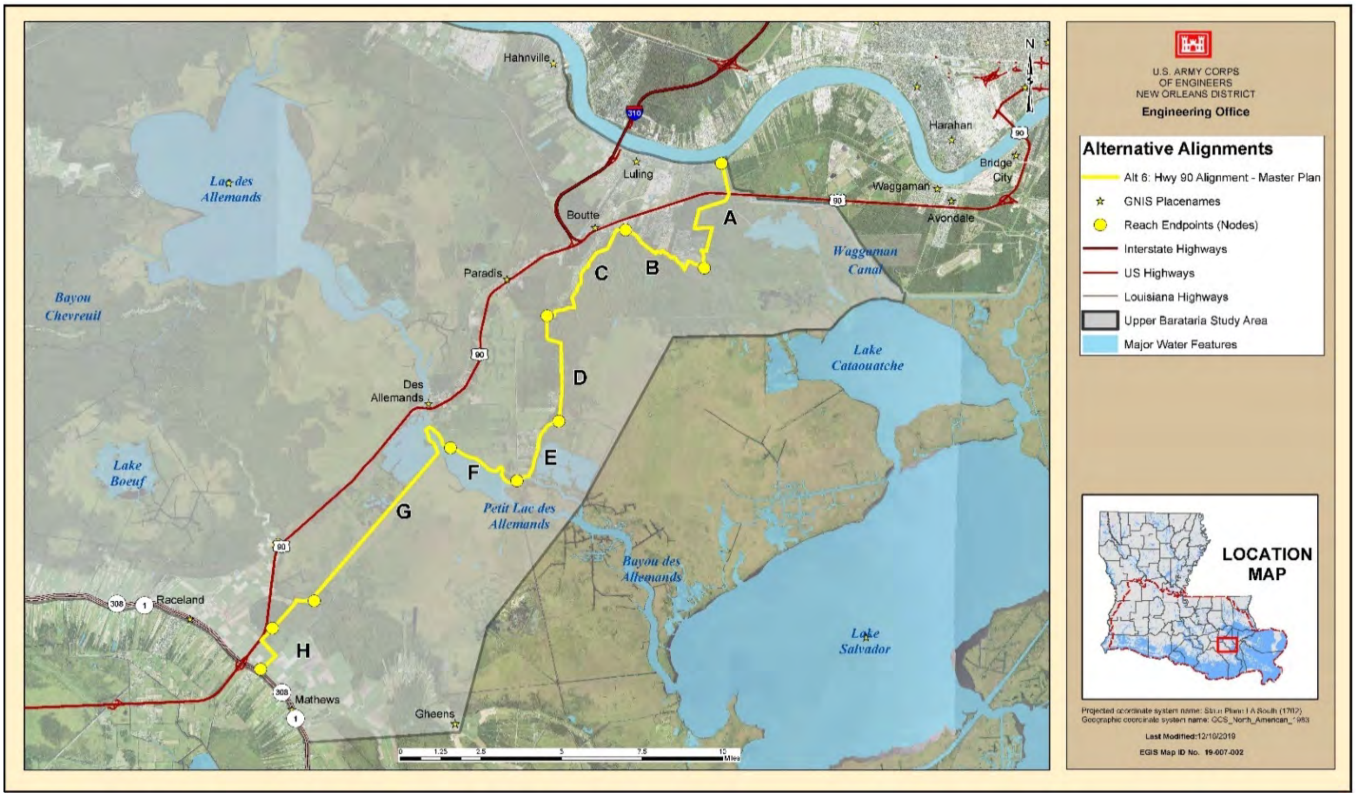


Figure 2-17: Alternative 6 – U.S. Highway 90 Alignment – State of LA Master Plan – With Hydraulic Reaches

Figure 2-18: Alternative 8 – U.S. Highway 90 Lift Alignment – With Hydraulic Reaches

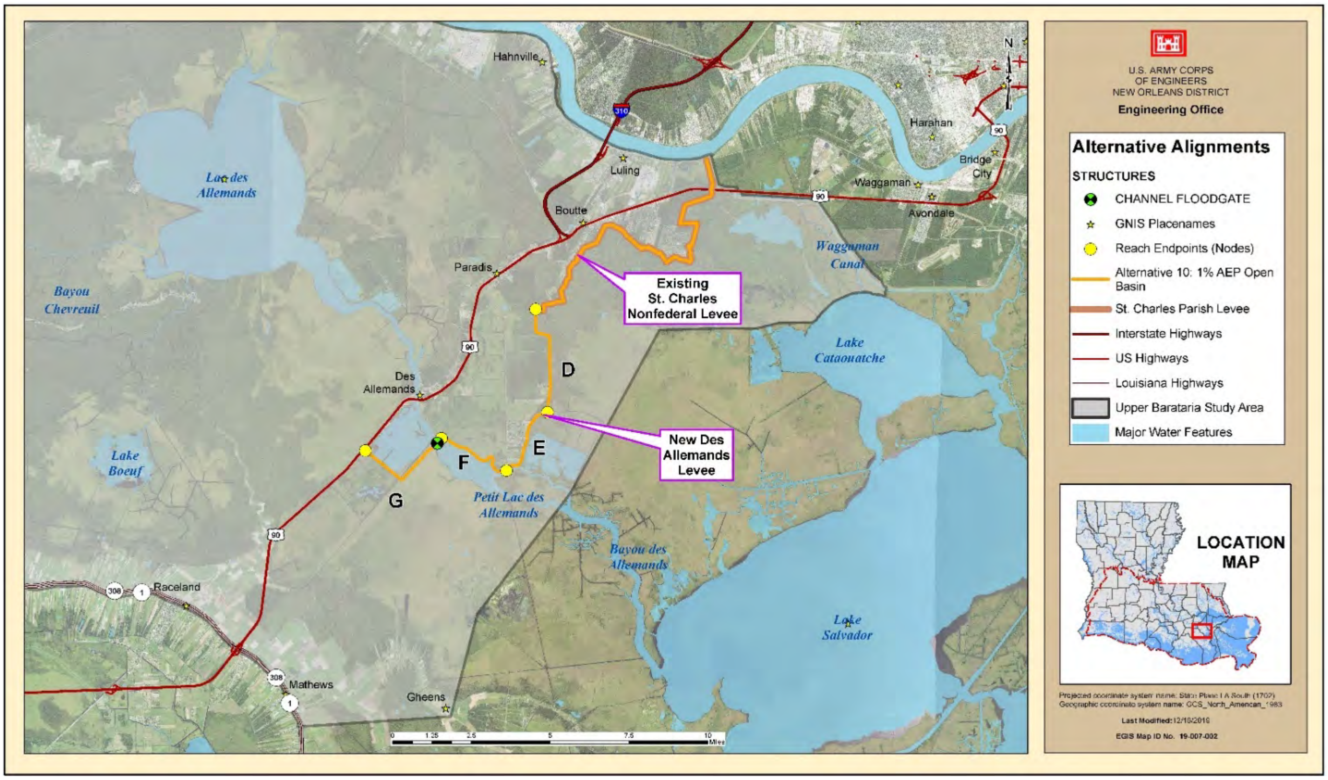


Figure 2-19: Alternative 10 – 1% AEP Open Basin

Methodology

The hydraulic boundary conditions for each hydraulic reach for the 2%, 1%, 0.5% and 0.2% Annual Exceedance Probabilities (AEP) for the years 2023 and 2073 were obtained from the 2017 ADCIRC model runs performed by the Coastal Protection and Restoration Authority (CPRA) and are tabulated on Figures 2-20 through 2-27 below, where WSE is the water surface elevation, Hs is the significant wave height and Tp is the peak period.

Changes in water surface elevations will occur in the future (2073) due to 50 years of intermediate relative sea level rise. Design elevations for the future condition scenario are considered to reflect conditions that are likely to exist in the year 2073. Changes in surge elevations will occur in the future due to subsidence and sea level rise. Refer to Annex 4 (CPRA Coastal Master Plan-Attachment-C3-25.1-Storm Surge-FINAL, dated 05 April 2017) and Annex 5 (CPRA-Appendix D-24 Storm Surge-Wave Model (ADCIRC) Technical Report 4719157-1 (1) dated April 2017) for more information. Refer to Annex 8 for information on relative sea level and climate change. Refer to Annex 9 for information on the probability masses, related to the combined probability of the hurricane parameters listed under synthetic storms.

2% Existing Conditions (2023)				
Hydraulic Reach	WSE (ft)	Std. Dev.	Hs (ft)	Tp (s)
A	5.1	0.8	2.4	3.0
B	4.2	0.8	2.4	3.0
C	4.2	0.8	2.4	3.0
D	4.2	0.8	2.4	3.0
E	4.1	0.8	2.4	3.0
F,K	3.8	0.8	2.4	3.0
G	3.8	0.8	2.4	3.0
H	3.2	0.8	2.4	3.0
I	3.7	0.8	2.4	3.0
J	2.2	0.8	2.4	3.0

Fig. 2-20 – 2% 2023 Hydraulic Boundary Conditions

2% Future Conditions (2073)				
Hydraulic Reach	WSE (ft)	Std. Dev.	Hs (ft)	Tp (s)
A	8.0	0.8	2.4	3.0
B	7.3	0.8	2.4	3.0
C	6.8	0.8	2.4	3.0
D	6.3	0.8	2.4	3.0
E	6.5	0.8	2.4	3.0
F,K	5.8	0.8	2.4	3.0
G	5.8	0.8	2.4	3.0
H	5.6	0.8	2.4	3.0
I	5.5	0.8	2.4	3.0
J	3.7	0.8	2.4	3.0

Fig. 2-21 – 2% 2073 Hydraulic Boundary Conditions

1% Existing Conditions (2023)				
Hydraulic Reach	WSE (ft)	Std. Dev.	Hs (ft)	Tp (s)
A	6.5	0.8	2.4	3.0
B	5.5	0.8	2.4	3.0
C	5.5	0.8	2.4	3.0
D	5.4	0.8	2.4	3.0
E	5.2	0.8	2.4	3.0
F,K	4.6	0.8	2.9	3.1
G	4.6	0.8	2.4	3.0
H	4.0	0.8	2.4	3.0
I	4.4	0.8	2.4	3.0
J	2.6	0.8	2.4	3.0

Fig. 2-22 – 1% 2023 Hydraulic Boundary Conditions

1% Future Conditions (2073)				
Hydraulic Reach	WSE (ft)	Std. Dev.	Hs (ft)	Tp (s)
A	9.5	0.8	2.4	3.0
B	8.9	0.8	2.4	3.0
C	8.2	0.8	2.4	3.0
D	7.4	0.8	2.4	3.0
E	7.5	0.8	3.3	3.4
F,K	7.1	0.8	3.3	3.3
G	7.0	0.8	2.4	3.0
H	7.0	0.8	2.4	3.0
I	6.9	0.8	2.4	3.0
J	4.2	0.8	2.4	3.0

Fig. 2-23 – 1% 2073 Hydraulic Boundary Conditions

0.5% Existing Conditions (2023)				
Hydraulic Reach	WSE (ft)	Std. Dev.	Hs (ft)	Tp (s)
A	7.5	0.8	2.4	3.0
B	6.5	0.8	2.4	3.0
C	6.5	0.8	2.4	3.0
D	6.4	0.8	2.4	3.0
E	6.1	0.8	2.5	3.2
F,K	5.5	0.8	3.4	3.5
G	5.5	0.8	2.4	3.0
H	5.0	0.8	2.4	3.0
I	5.2	0.8	2.4	3.0
J	3.0	0.8	2.4	3.0

Fig. 2-24– 0.5% 2023 Hydraulic Boundary Conditions

0.5% Future Conditions (2073)				
Hydraulic Reach	WSE (ft)	Std. Dev.	Hs (ft)	Tp (s)
A	10.6	0.8	2.4	3.0
B	9.9	0.8	2.4	3.0
C	9.1	0.8	2.4	3.0
D	8.6	0.8	2.4	3.0
E	8.6	0.8	3.8	3.2
F,K	8.3	0.8	3.8	3.5
G	8.2	0.8	2.4	3.0
H	8.2	0.8	2.4	3.0
I	8.0	0.8	2.4	3.0
J	4.8	0.8	2.4	3.0

Fig. 2-25– 0.5% 2073 Hydraulic Boundary Conditions

0.2% Existing Conditions (2023)				
Hydraulic Reach	WSE (ft)	Std. Dev.	Hs (ft)	Tp (s)
A	8.9	0.8	2.4	3.0
B	8.2	0.8	2.4	3.0
C	8.1	0.8	2.4	3.0
D	7.8	0.8	2.4	3.0
E	7.6	0.8	2.9	3.6
F,K	6.7	0.8	3.8	3.9
G	6.6	0.8	2.4	3.0
H	6.4	0.8	2.4	3.0
I	6.4	0.8	2.4	3.0
J	3.4	0.8	2.4	3.0

Fig. 2-26– 0.2% 2023 Hydraulic Boundary Conditions

0.2% Future Conditions (2073)				
Hydraulic Reach	WSE (ft)	Std. Dev.	Hs (ft)	Tp (s)
A	11.9	0.8	2.4	3.0
B	11.4	0.8	2.4	3.0
C	10.6	0.8	2.4	3.0
D	10.6	0.8	2.4	3.0
E	10.7	0.8	4.3	3.6
F,K	10.2	0.8	4.3	3.9
G	9.7	0.8	2.4	3.0
H	10.2	0.8	2.4	3.0
I	9.5	0.8	2.4	3.0
J	6.9	0.8	2.4	3.0

Fig. 2-27– 0.2% 2073 Hydraulic Boundary Conditions

The application of a Monte Carlo analysis is used to determine the overtopping rate through the use of a MATLAB script for overtopping. The probabilistic overtopping formulations from Van der Meer are applied for the levees. In addition to 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 (Hs) and the peak wave period (Tp). For the design water surface elevation, wave height and wave period, the maximum allowable average wave overtopping of 0.1 cubic ft. 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. The Van der Meer overtopping formula is shown below.

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 ξ0 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).

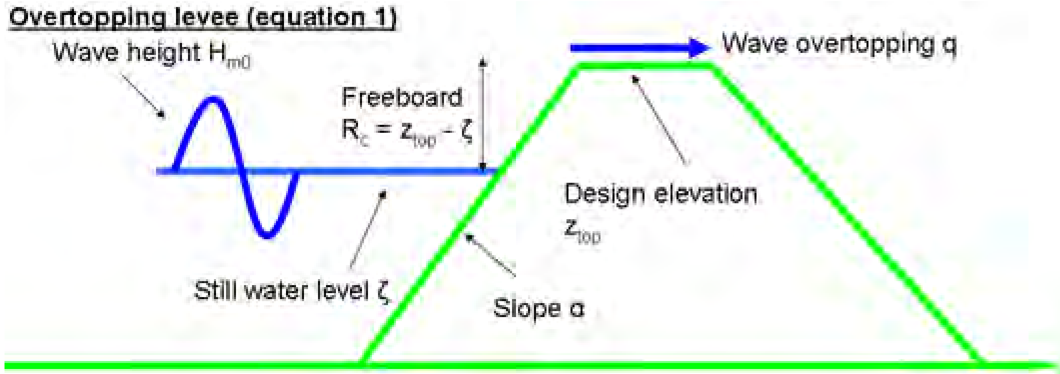


Figure 2-28 – Definitions for Overtopping of a Levee

The Monte Carlo Analysis is executed as follows:

9. Draw a random number between 0 and 1 to set the exceedence probability (p).
10. 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).
11. Draw a random number between 0 and 1 to set the exceedence probability (p).
12. 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).
13. Repeat steps 3 and 4 for the three overtopping coefficients independently.
14. Compute the overtopping rate for these hydraulic parameters and overtopping coefficients determined in steps 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).
15. Repeat Steps 1 through 5 a large number of times. (N)
16. Compute the 50% and 90% confidence limit of the overtopping rate. (i.e. q_{50} and q_{90})

Results

The resulting levee design elevations produced using an overtopping threshold of q90 = 0.1 cfs/ft and q50 = 0.01 cfs/ft for levees with a 1V:4H slope are shown in Figures 2-29 through 2-36 below. Refer to Annex 7 for the levee design elevation output plots which provide more information on the elevations used for overtopping analysis.

2% Existing Conditions (2023)	
Hydraulic Reach	Levee Elevation (ft.)
A	8.5
B	7.5
C	7.5
D	7.5
E	7.5
F,K	7.0
G	7.0
H	6.5
I	7.0
J	5.5

Fig. 2-29 – 2% 2023 Hydraulic Design Elevations

1% Existing Conditions (2023)	
Hydraulic Reach	Levee Elevation (ft.)
A	10.0
B	9.0
C	9.0
D	8.5
E	8.5
F,K	8.5
G	7.5
H	7.5
I	7.5
J	6.0

Fig. 2-30 – 1% 2023 Hydraulic Design Elevations

0.5% Existing Conditions (2023)	
Hydraulic Reach	Levee Elevation (ft.)
A	11.0
B	10.0
C	10.0
D	9.5
E	9.5
F,K	10.0
G	9.0
H	8.5
I	8.5
J	6.5

Fig. 2-31 – 0.5% 2023 Hydraulic Design Elevations

0.2% Existing Conditions (2023)	
Hydraulic Reach	Levee Elevation (ft.)
A	12.0
B	11.5
C	11.5
D	11.0
E	12.0
F,K	12.5
G	10.0
H	9.5
I	9.5
J	6.5

Fig. 2-32 – 0.2% 2023 Hydraulic Design Elevations

2% Future Conditions (2073)	
Hydraulic Reach	Levee Elevation (ft.)
A	11.5
B	10.5
C	10.0
D	9.5
E	10.0
F,K	9.0
G	9.0
H	9.0
I	9.0
J	7.0

Fig. 2-33 – 2% 2073 Hydraulic Design Elevations

1% Future Conditions (2073)	
Hydraulic Reach	Levee Elevation (ft.)
A	13.0
B	12.0
C	11.5
D	10.5
E	12.0
F,K	11.5
G	10.5
H	10.5
I	10.0
J	7.5

Fig. 2-34 – 1% 2073 Hydraulic Design Elevations

0.5% Future Conditions (2073)	
Hydraulic Reach	Levee Elevation (ft.)
A	14.0
B	13.0
C	12.5
D	12.0
E	13.0
F,K	13.5
G	11.5
H	11.5
I	11.5
J	8.0

Fig. 2-35 – 0.5% 2073 Hydraulic Design Elevations

0.2% Future Conditions (2073)	
Hydraulic Reach	Levee Elevation (ft.)
A	15.0
B	14.5
C	14.0
D	14.0
E	16.0
F,K	16.0
G	13.0
H	13.5
I	13.0
J	10.0

Fig. 2-36 – 0.2% 2073 Hydraulic Design Elevations

2.11.2 Interior Analysis – Hydraulic Levee Design

The hydrologic routing and impounding of rain water for the existing without project and future without project conditions for 7 different levee alignment alternatives were investigated, using annual rainfall frequencies of 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.2% AEP. Figure 2-37 shows the extent of the study area. Figures 2-38 through 2-44 show the alternative alignments that were investigated.

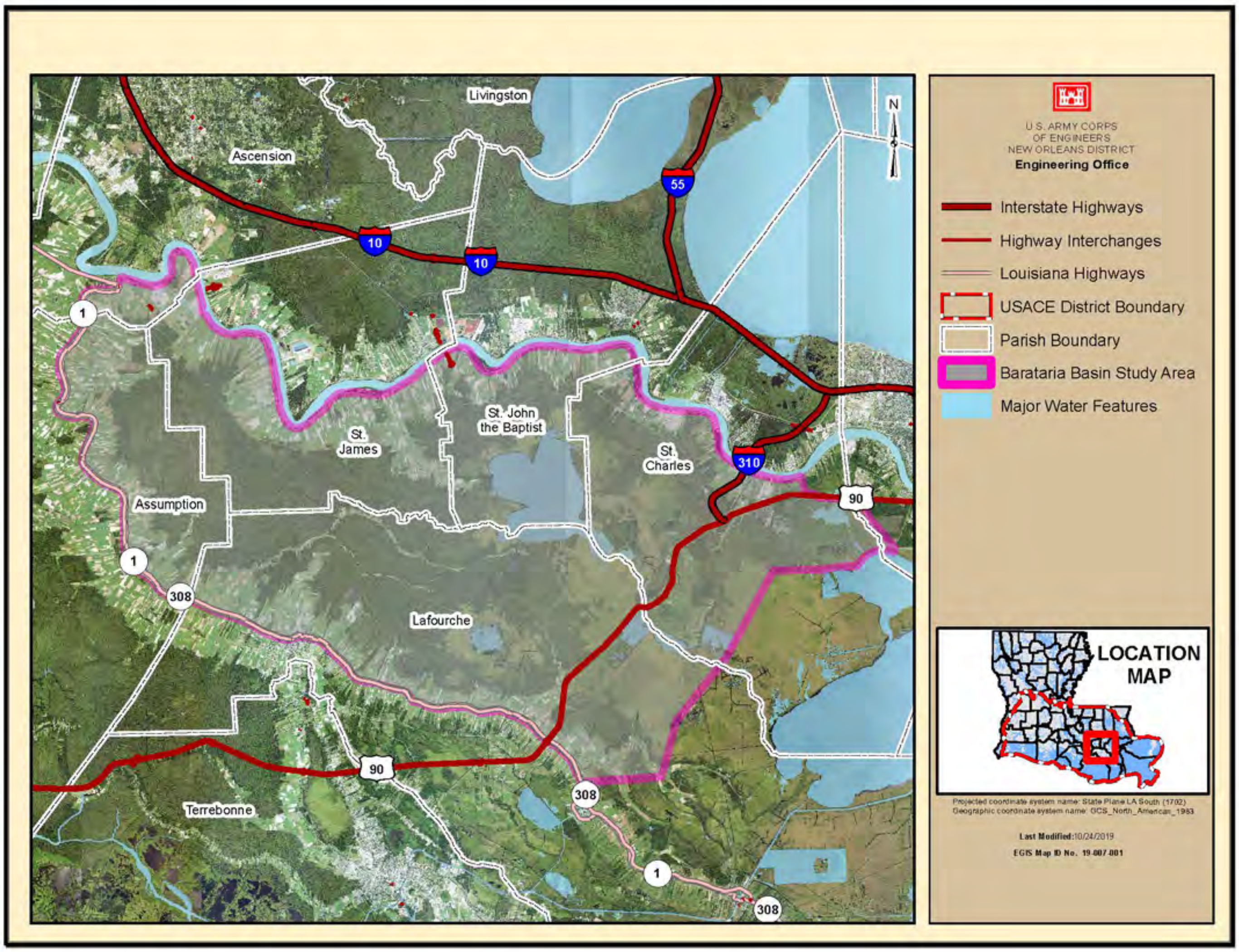


Figure 2-37: Upper Barataria Basin Study Area


Hahnville
Luling
Harahan
Bridge City
Waggaman
Avondale
Boutte
Paradis
Lac des Allemands
Bayou Chevreuil
Waggaman Canal
Lake Cataouatche
Des Allemands
Dufrene Ponds
Bayou Gauche
Petit Lac des Allemands
Lake Boeuf
Bayou des Allemands
Raceland
Lake Salvador
Mathews
Gheens
N
U.S. ARMY CORPS
OF ENGINEERS
NEW ORLEANS DISTRICT
Engineering Office
Alternative Alignments
Alt 1: Hwy 90 - Seg 1 Extension
St. Charles Parish Levee
GNIS Placenames
Interstate Highways
US Highways
Louisiana Highways
Upper Barataria Study Area
Major Water Features
LOCATION MAP

Figure 2-38: Alternative 1 – U.S. Highway 90 – Segment 1 Extension

Figure 2-39: Alternative 2 – U.S. Highway 90 – Full Alignment

Figure 2-40: Alternative 3 – Des Allemands – Paradis Levee

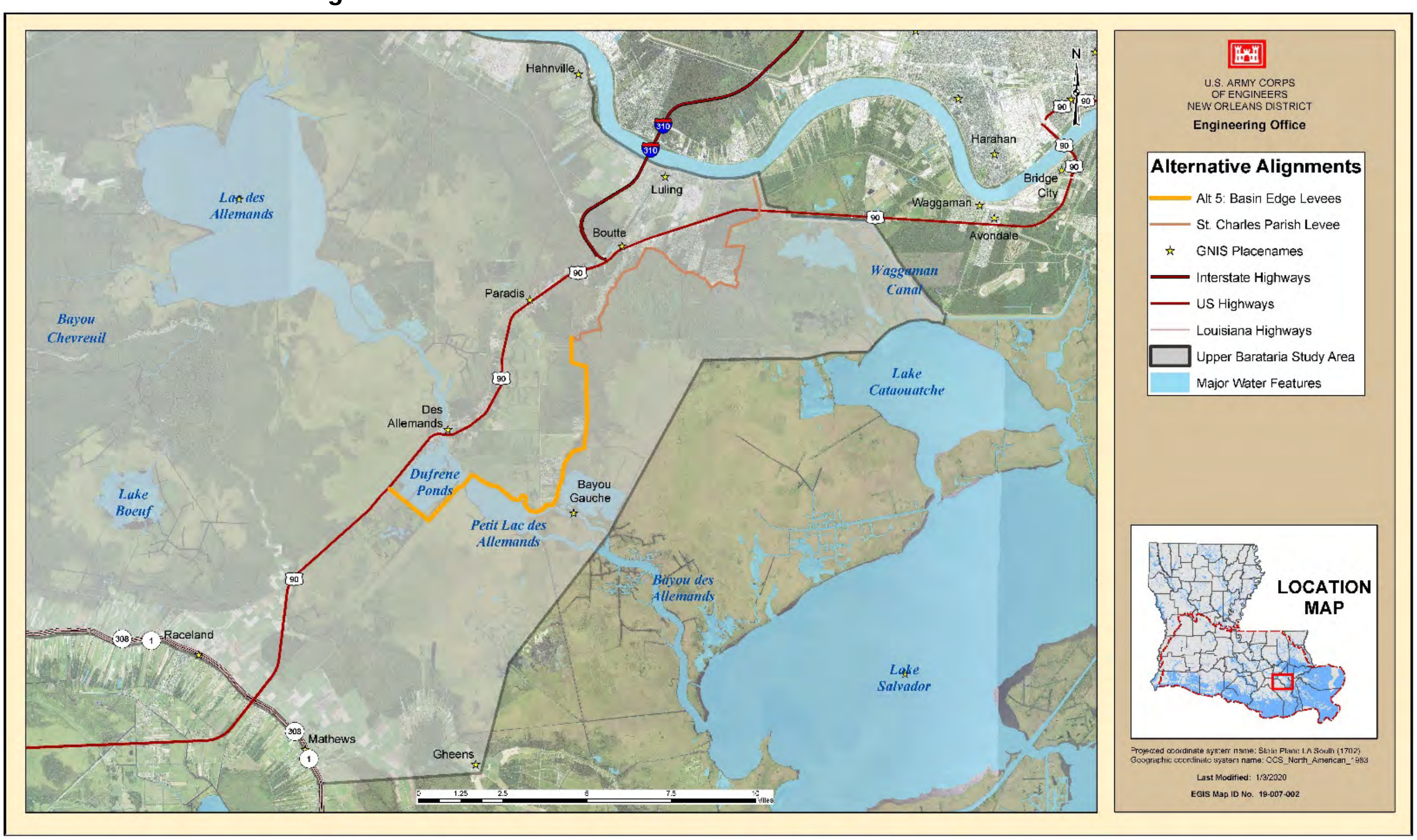


Figure 2-41: Alternative 5 – Basin Edge Levee

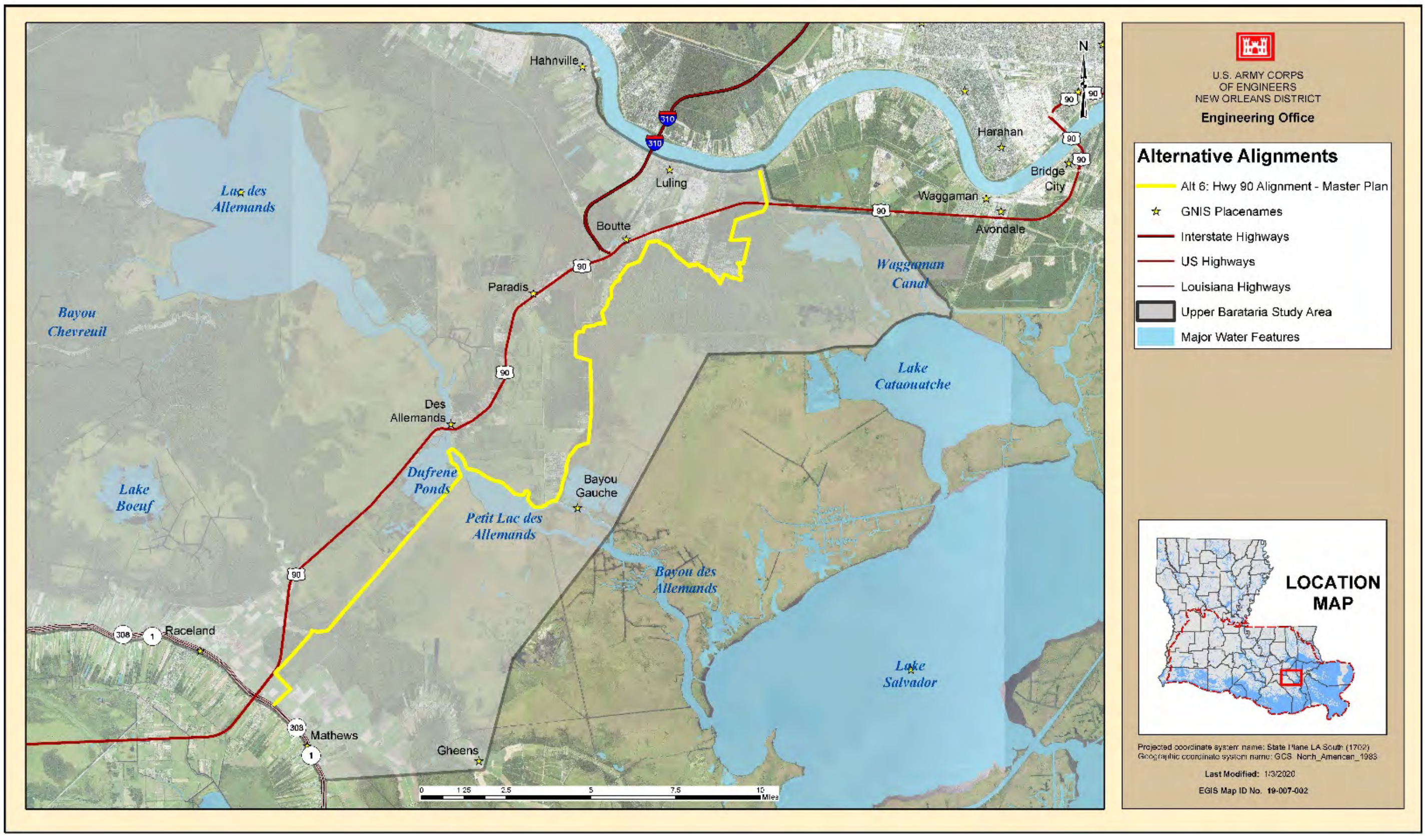


Figure 2-42: Alternative 6 – U.S. Highway 90 Alignment – State of LA Master Plan

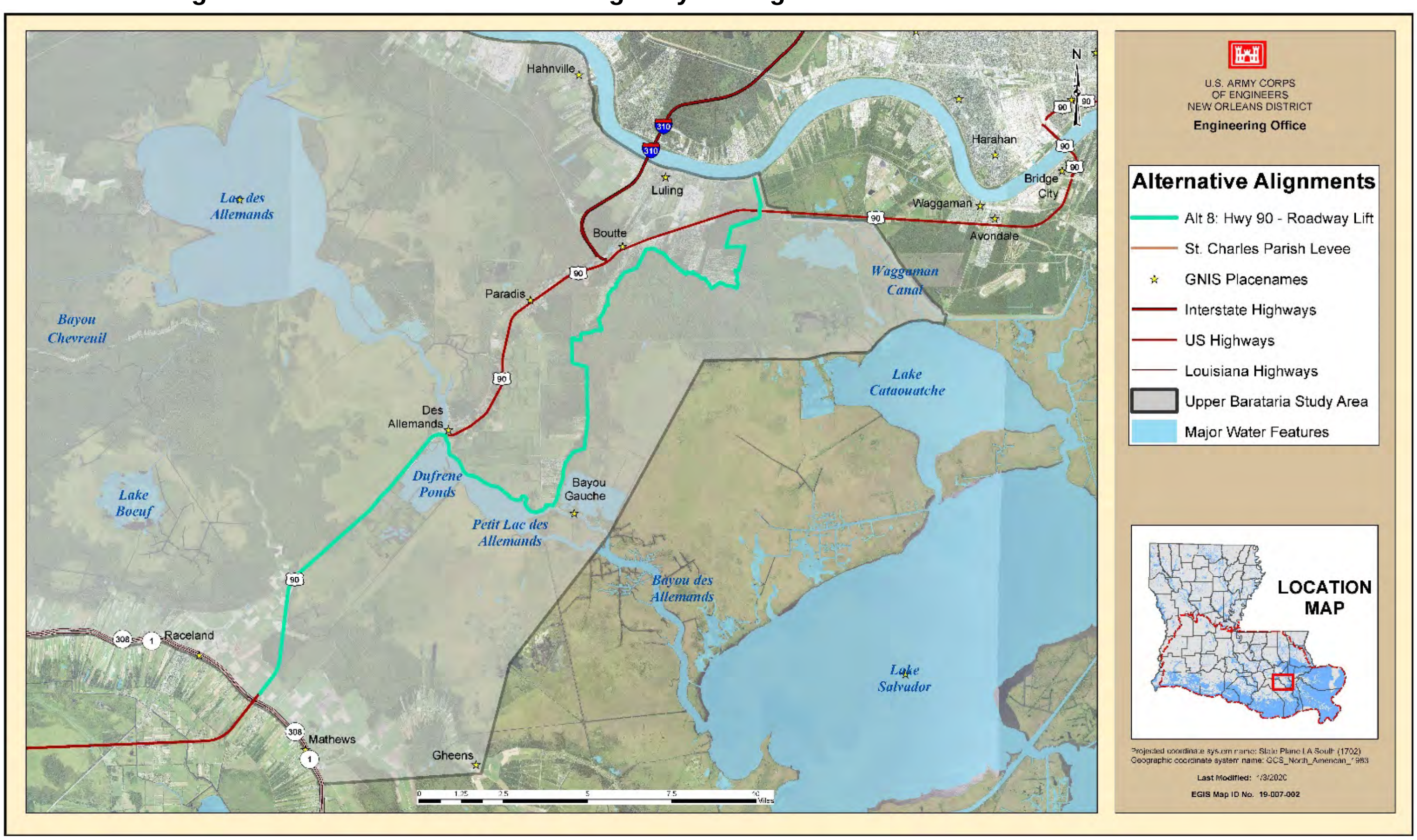


Figure 2-43: Alternative 8 – U.S. Highway 90 Lift Alignment

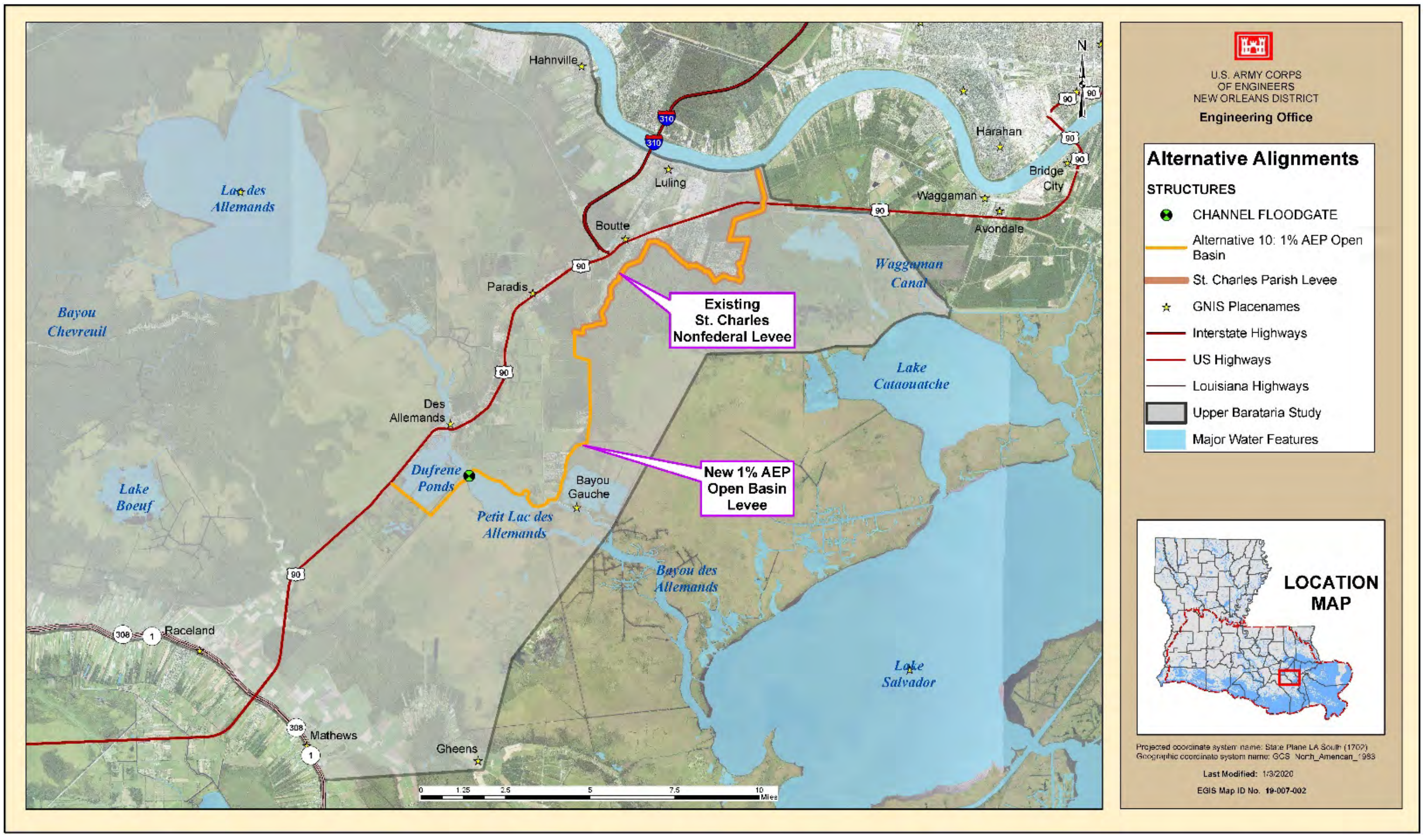


Figure 2-44: Alternative 10 – 1% AEP Open Basin Alternative

Methodology

The area investigated was analyzed using the HEC-RAS model version 5.0.6. The latest version of the River Analysis System (RAS) of the HEC-RAS model that was available at the time of model development was used for hydraulic modeling. HEC-RAS is designed to perform one- and two-dimensional hydraulic calculations for a full network of natural and constructed channels. This component of the HEC-RAS modeling system is capable of simulating one-dimensional, two-dimensional and combined one/two-dimensional unsteady flow through a full network of open channels, floodplains and alluvial fans. The unsteady flow component can be used to perform subcritical, supercritical and mixed-flow regime (subcritical, supercritical, hydraulic jumps and draw-downs) calculations in the unsteady flow computations module.

A 24-hour rainfall duration was used for the precipitation input. The HEC-RAS model was conducted using a 3-day simulation time window and a computation interval of 1 minute, with a mesh containing 32,620 cells.

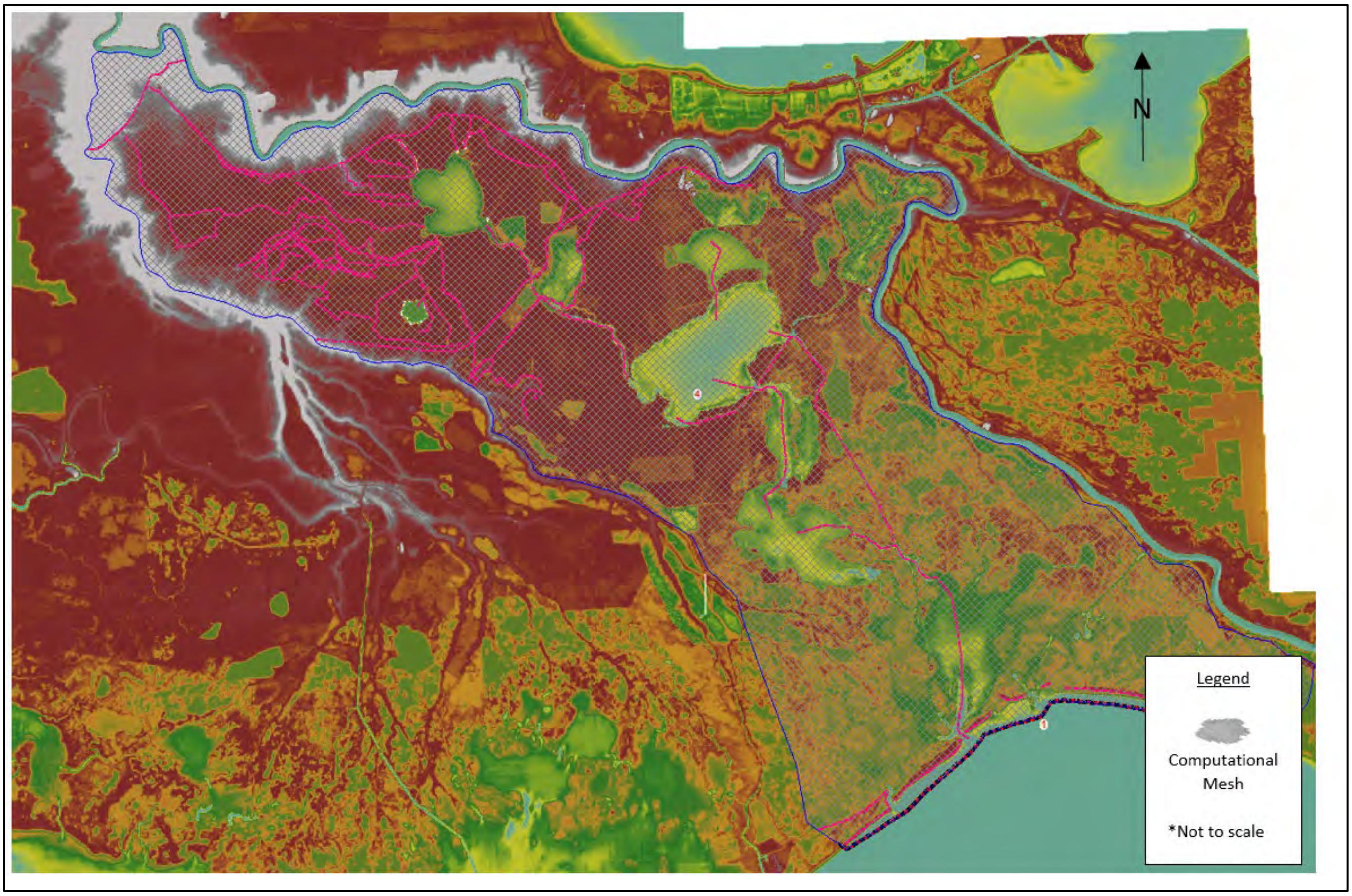


Figure 2-45: HEC-RAS Computational Mesh

The NOAA Atlas 14 precipitation frequency estimates were used for rainfall point precipitation estimates. Figure 2-46 below shows these estimates.

Point precipitation frequency estimates (inches)										
NOAA Atlas 14 Volume 9 Version 2										
Data type: Precipitation depth										
Time series type: Partial duration										
Project area: Southeastern States										
Location name (ESRI Maps): None										
Station Name: None										
Latitude: 29.8005°										
Longitude: -90.3760°										
Elevation (USGS): None None										
PRECIPITATION FREQUENCY ESTIMATES										
by duratic	1	2	5	10	25	50	100	200	500	1000
5-min:	0.549	0.637	0.781	0.903	1.07	1.21	1.34	1.48	1.66	1.81
10-min:	0.804	0.932	1.14	1.32	1.57	1.77	1.96	2.17	2.44	2.64
15-min:	0.981	1.14	1.4	1.61	1.92	2.15	2.39	2.64	2.97	3.22
30-min:	1.49	1.74	2.15	2.5	2.99	3.36	3.74	4.13	4.64	5.04
60-min:	2.01	2.32	2.88	3.39	4.16	4.81	5.5	6.25	7.31	8.17
2-hr:	2.53	2.9	3.61	4.28	5.34	6.26	7.26	8.38	9.98	11.3
3-hr:	2.85	3.25	4.04	4.84	6.13	7.29	8.59	10	12.2	14
6-hr:	3.42	3.9	4.87	5.87	7.51	9	10.7	12.6	15.4	17.7
12-hr:	4.02	4.64	5.85	7.03	8.9	10.5	12.4	14.4	17.3	19.8
24-hr:	4.67	5.47	6.92	8.27	10.3	12.1	13.9	16	18.9	21.3
2-day:	5.42	6.36	8.04	9.57	11.9	13.8	15.9	18.1	21.2	23.8
3-day:	5.9	6.93	8.77	10.4	12.9	15.1	17.3	19.7	23.2	26
4-day:	6.27	7.35	9.28	11	13.7	15.9	18.3	20.9	24.6	27.6
7-day:	7.2	8.32	10.3	12.2	15.1	17.5	20.1	22.9	27	30.3
10-day:	8.1	9.26	11.4	13.3	16.2	18.7	21.4	24.3	28.4	31.8
20-day:	11	12.4	14.8	16.9	20	22.6	25.2	28	31.9	35
30-day:	13.4	15.1	17.8	20.2	23.5	26.1	28.7	31.5	35.1	38
45-day:	16.5	18.5	21.7	24.4	28	30.8	33.6	36.3	39.9	42.5
60-day:	19	21.3	25	28	32	35	37.9	40.7	44.4	47.1
Date/time (GMT): Wed Feb 27 23:36:44 2019										
pyRunTime: 0.0250720977783										

Figure 2-46: NOAA Atlas 14 Precipitation Frequency Estimates

The model was calibrated against the August 2017 storm, which was associated with Hurricane Harvey, using the following Coastal Reference Monitoring System (CRMS) gage stations shown on Figure 2-47 below.

Figure 2-47: Coastal Reference Monitoring System (CRMS) Gages

The observed stages versus modeled stages were compared for each CRMS gage. The difference between the observed stages and the modeled stages ranged from approximately 0.5 ft to 1.0 ft, as shown on Figures 2-48 and 2-49 below.

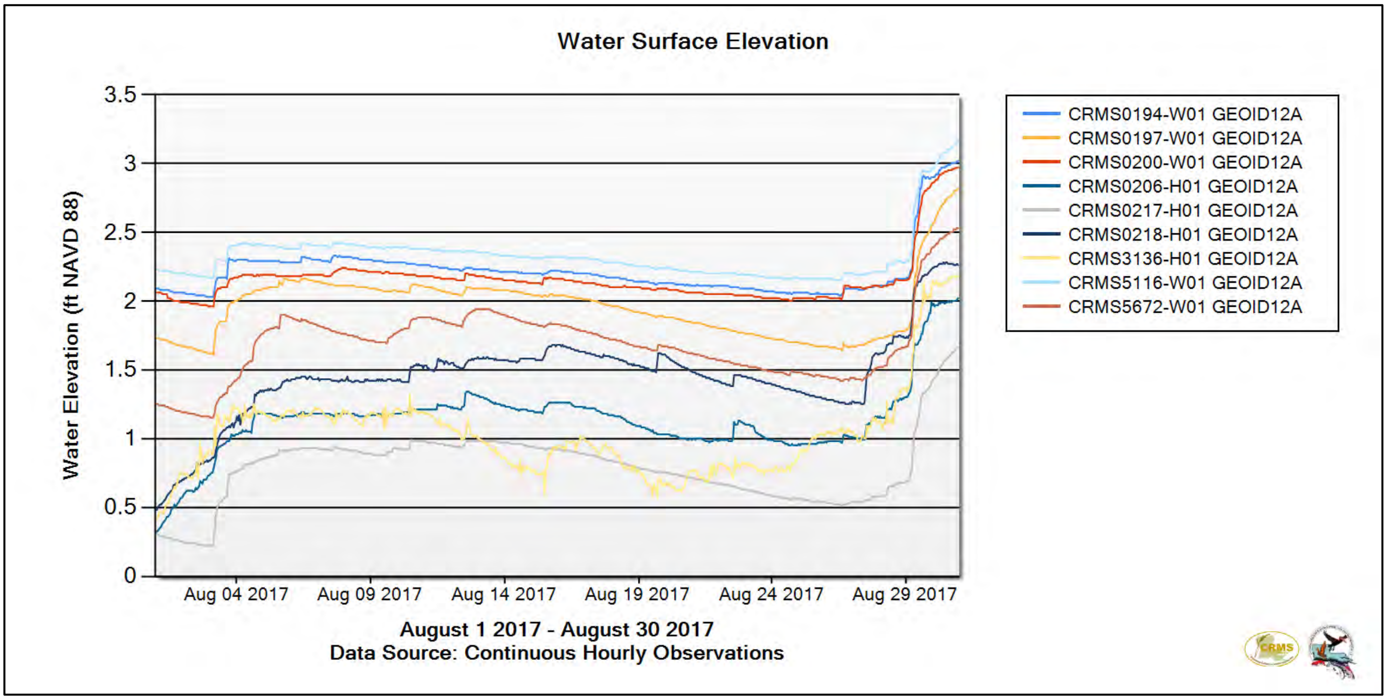


Figure 2-48: CRMS Gages Water Elevations for August 2017

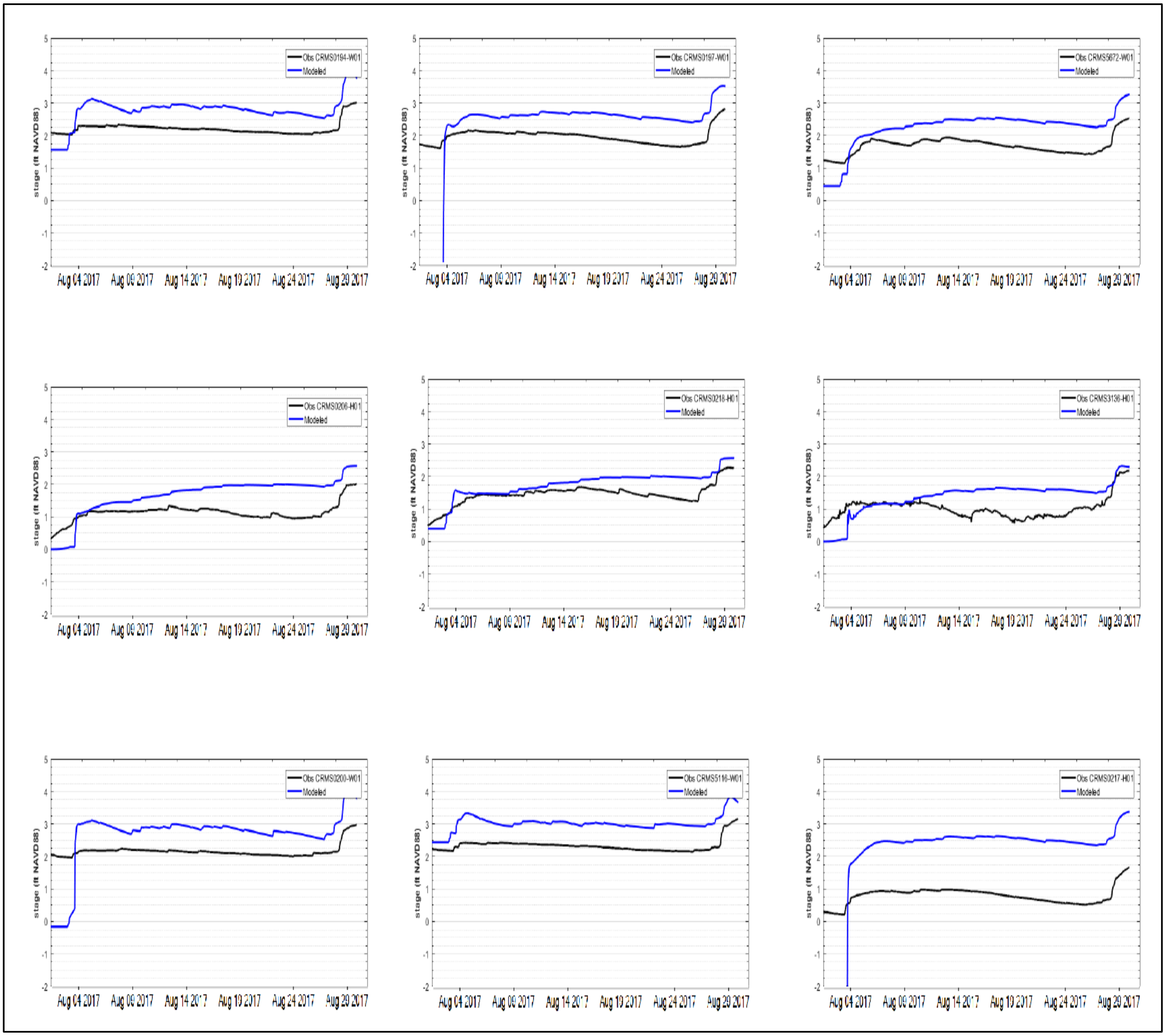


Figure 2-49: CRMS Gages Observed versus HEC-RAS Modeled Stages

Results

The geometries for each alternative and a sample snapshot of the associated output attribute table results, containing 3,258 output points, are shown on Figures 2-50 through 2-58 below. The full attribute tables can be obtained from the referenced shape files. In the attribute tables, the water elevations are shown in ft for each of the 8 rainfall frequencies for the existing without-project and future without-project conditions, along with the 0.2%, 0.5%, 1% and 2% surge values for each output point. The shape files and attribute tables were used by Economics to determine the flood risk reduction benefits associated with each alternative. Refer to Annex 6 for more information.

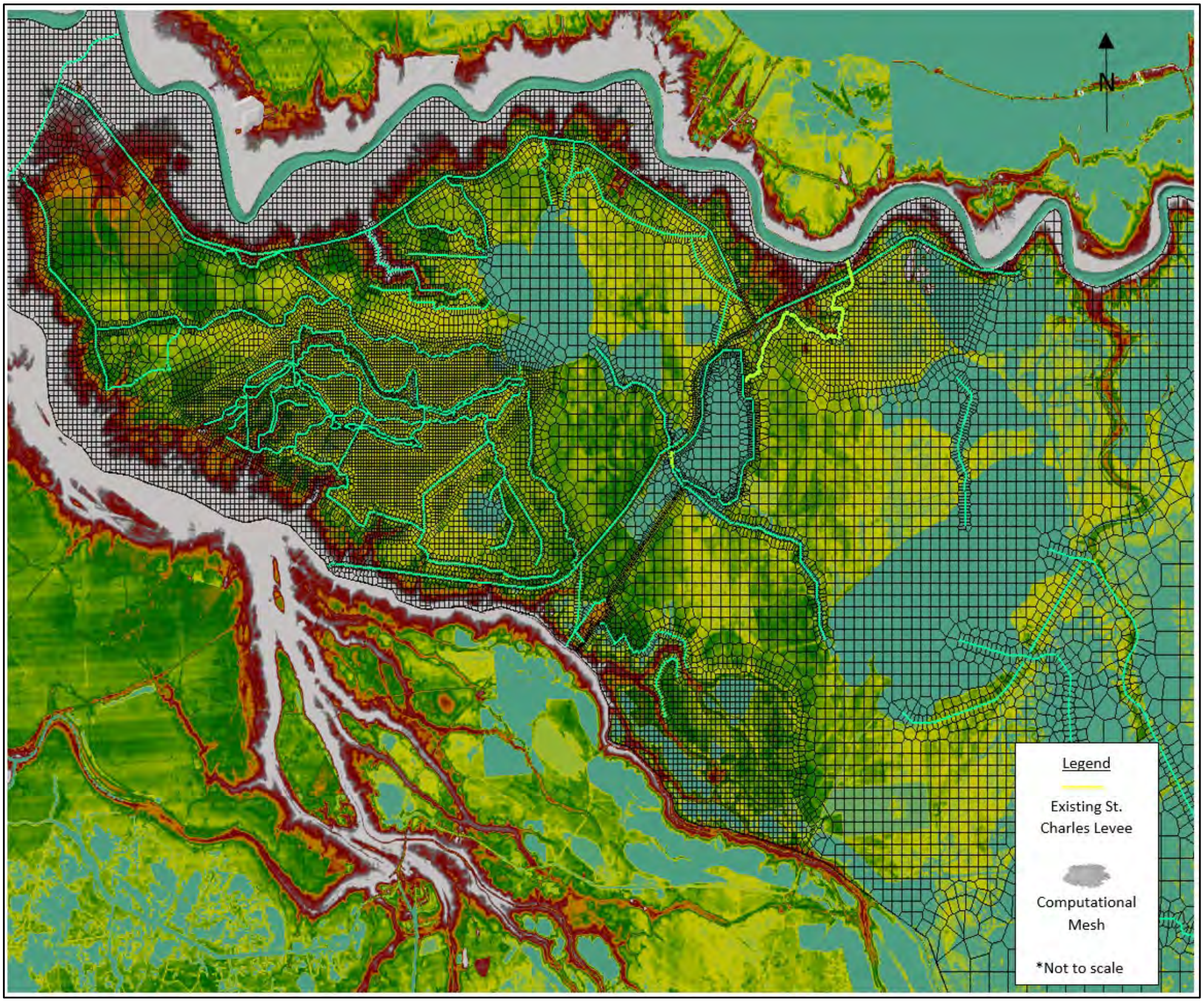


Figure 2-50: Existing and Future Without Project Geometry

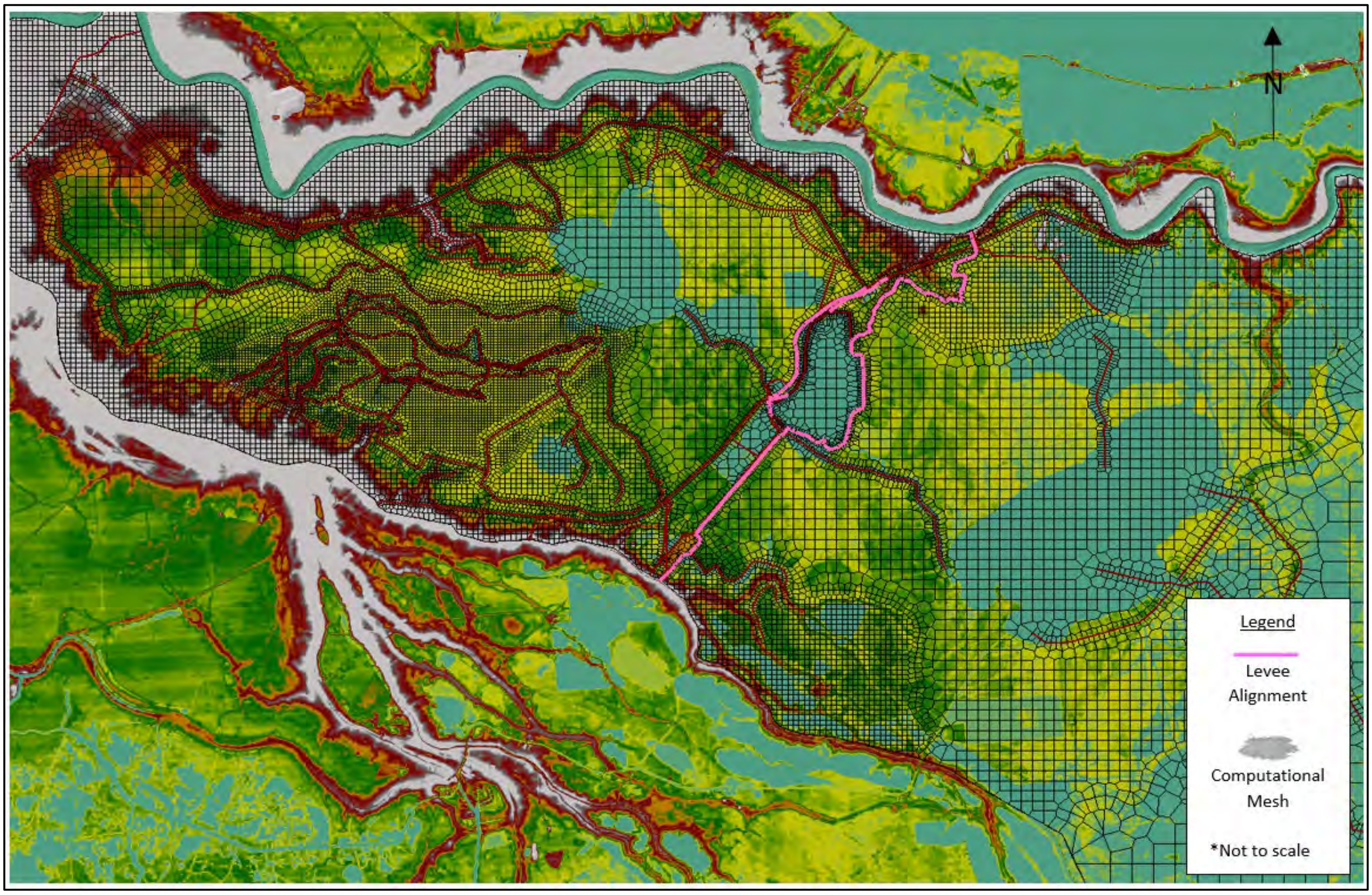


Figure 2-51: Alternative 1 (U.S. Highway 90 – Segment 1 Extension) Geometry

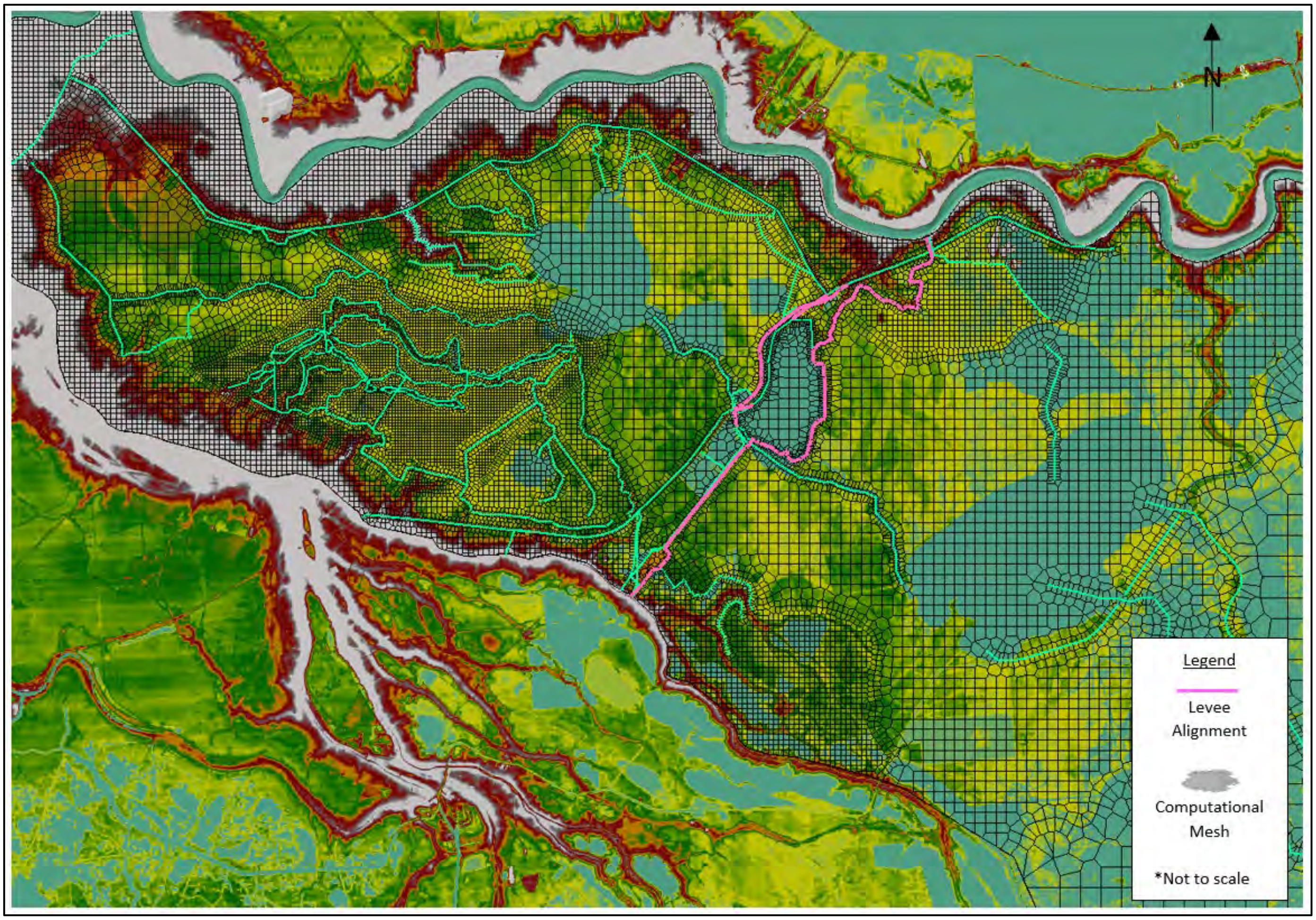


Figure 2-52: Alternative 2 (U.S. Highway 90 – Full Alignment) Geometry

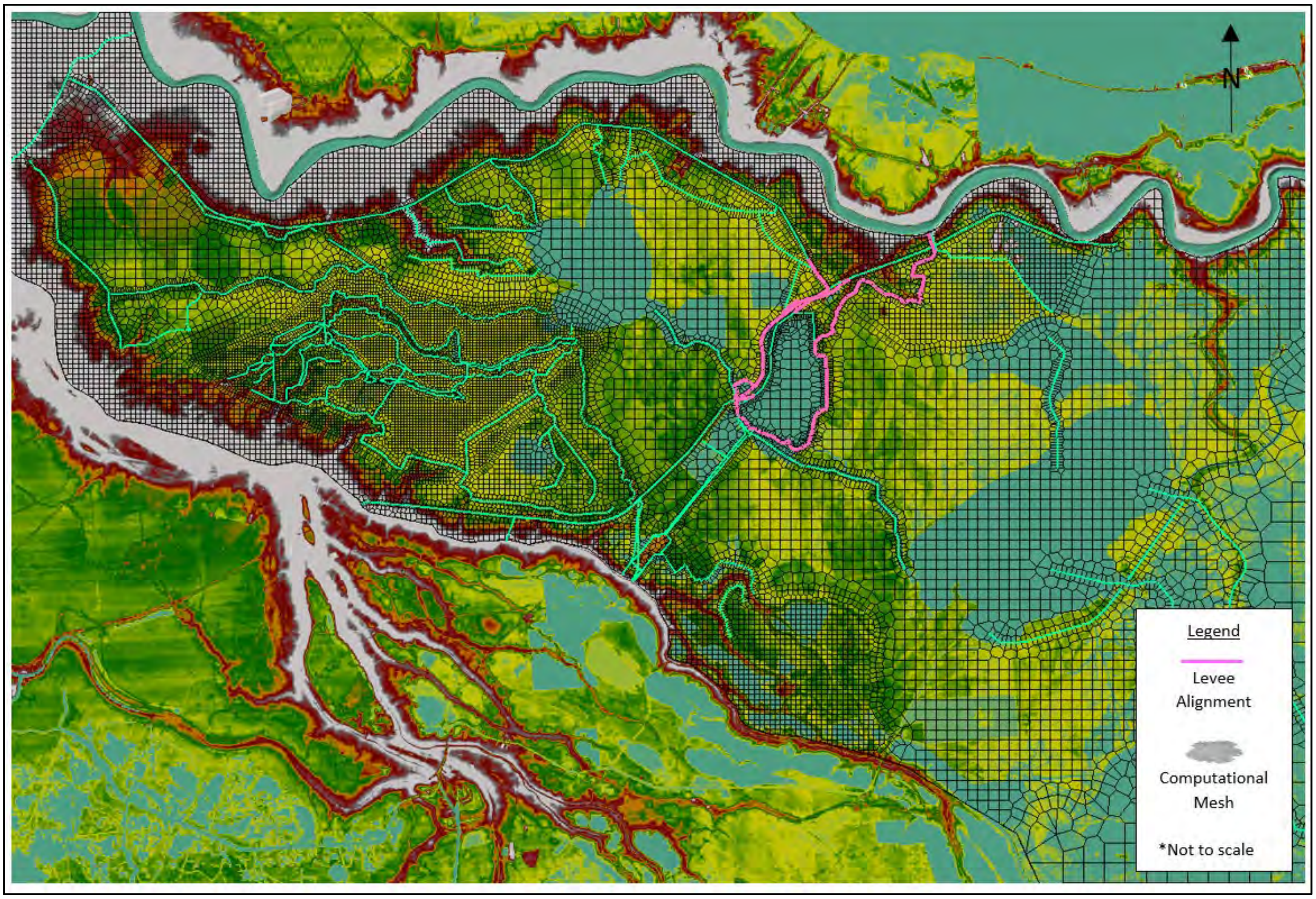


Figure 2-53: Alternative 3 (Des Allemands – Paradis Levee) Geometry

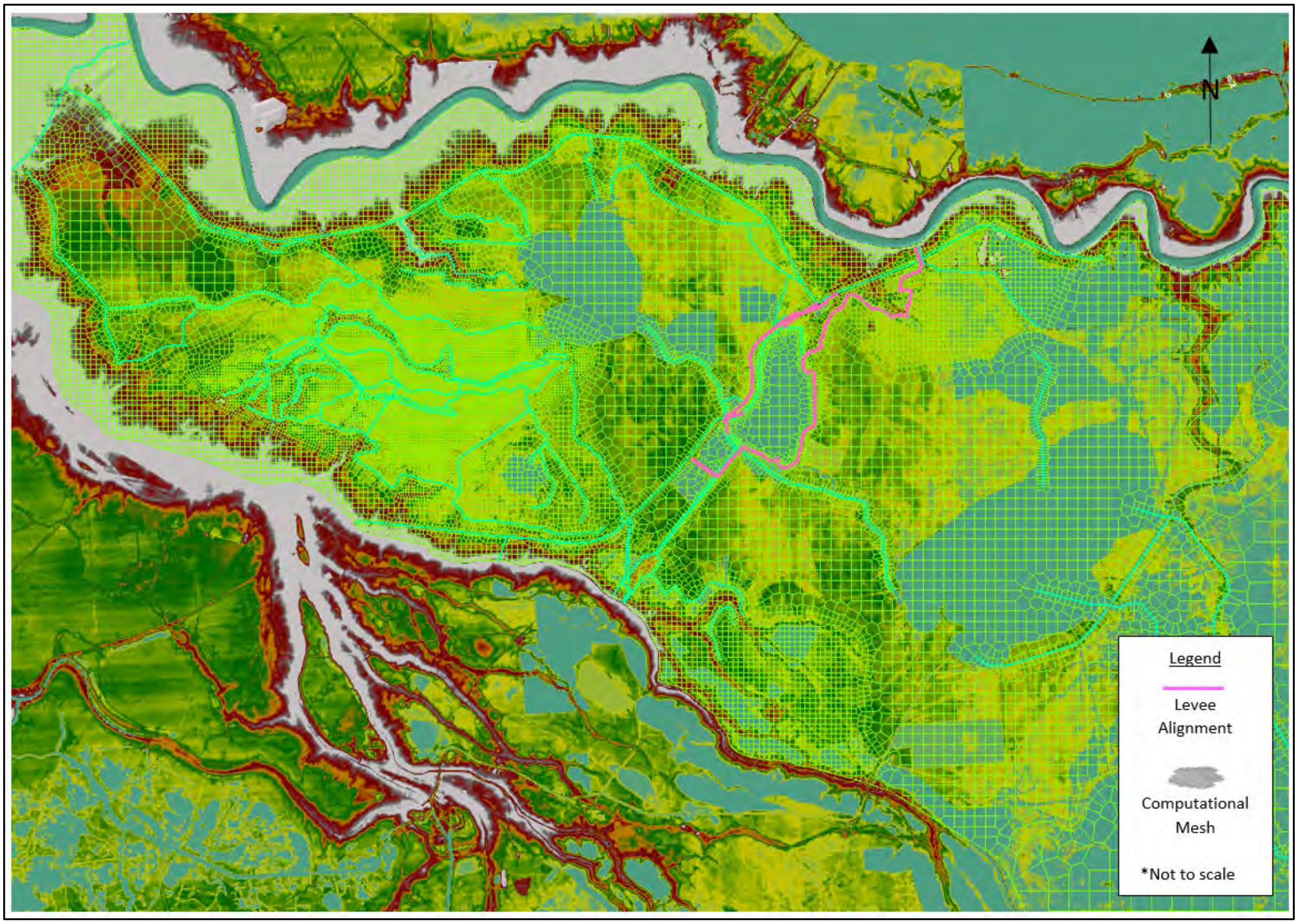


Figure 2-54: Alternative 5 (Basin Edge Levee) Geometry

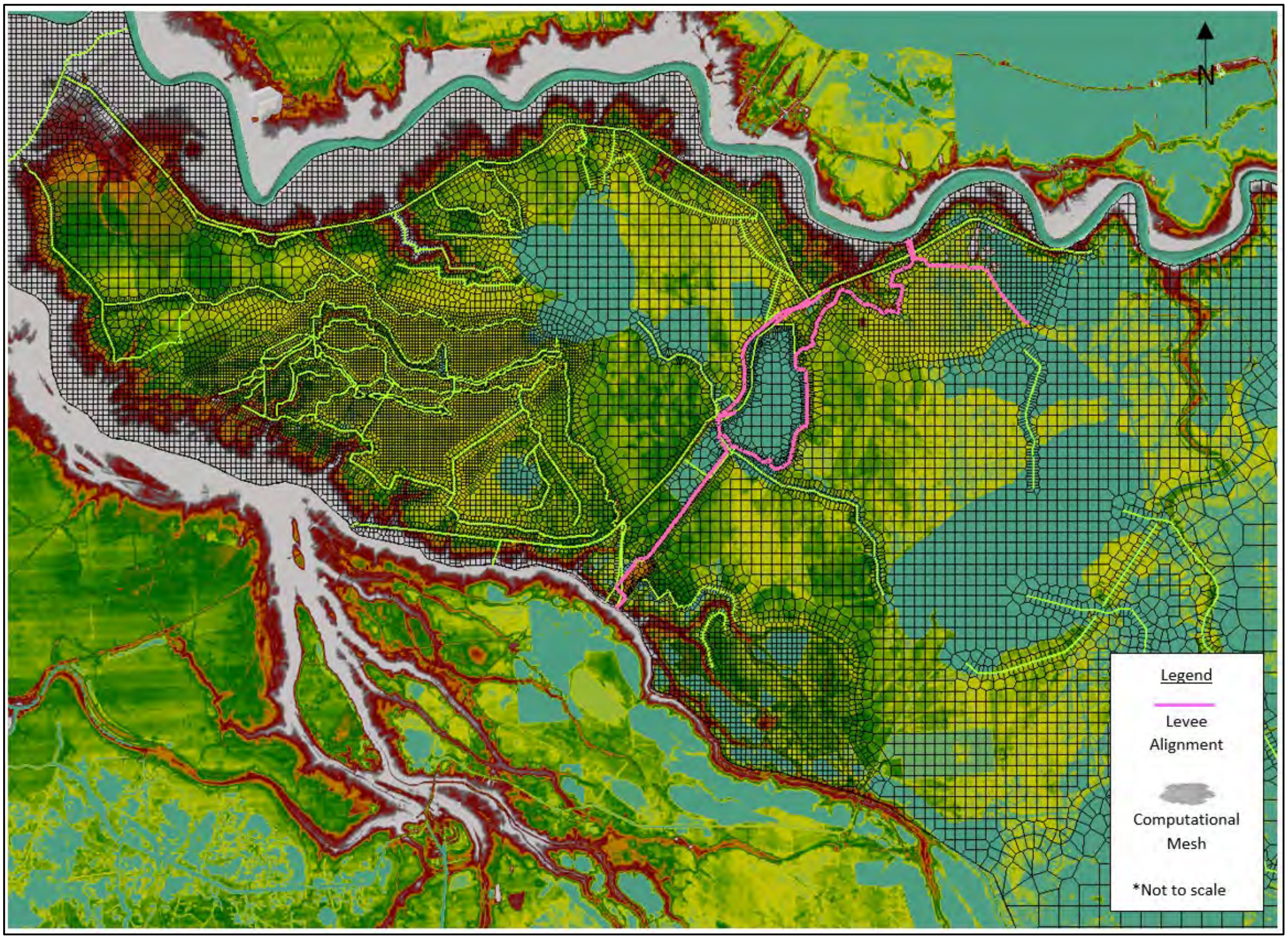


Figure 2-55: Alternative 6 (U.S. Highway 90 Alignment – State of LA Master Plan) Geometry

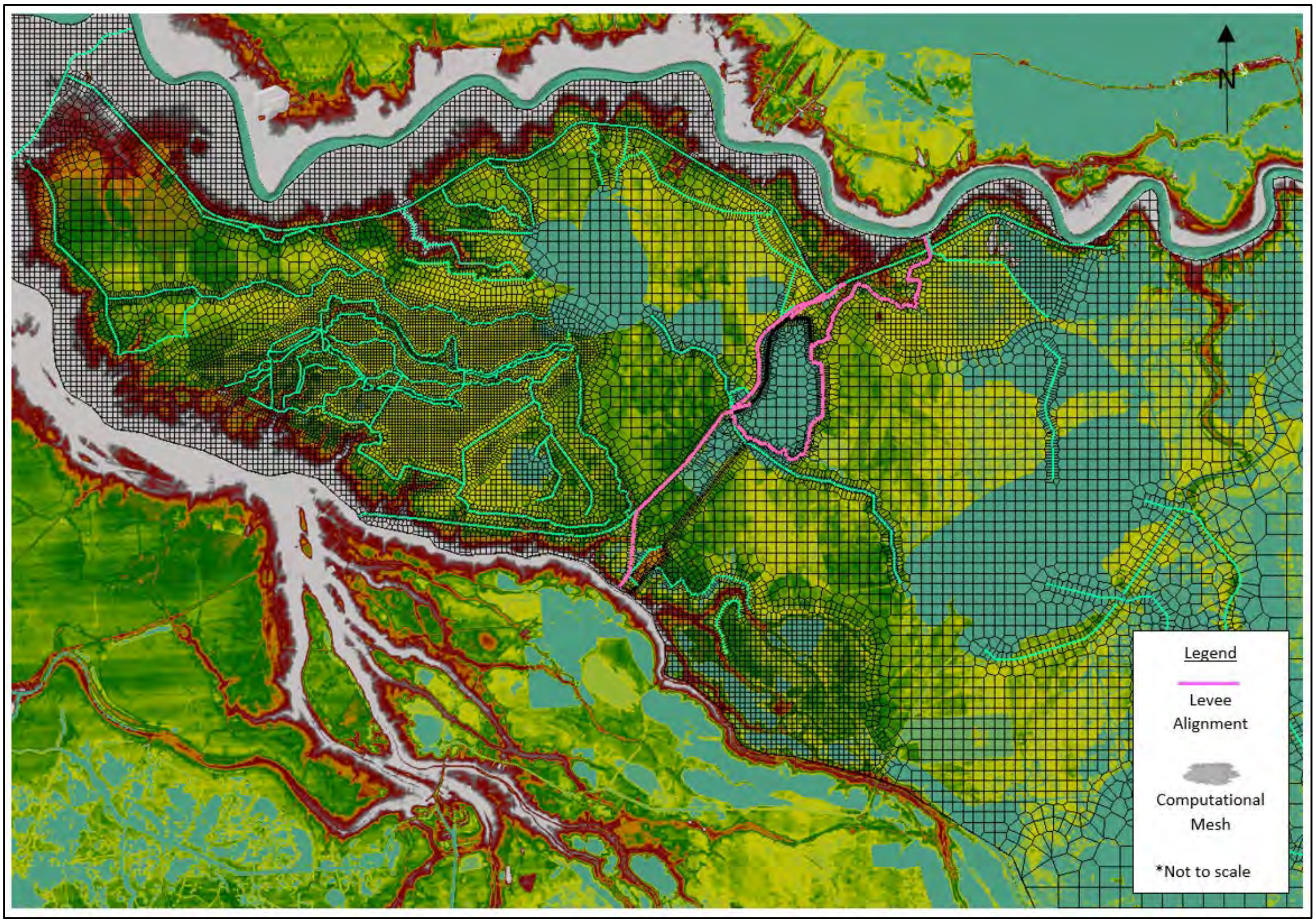


Figure 2-56: Alternative 8 (U.S. Highway 90 Lift Alignment) Geometry

Sample snapshots of the associated output attribute table results, which contains 3,258 output points, are shown on Figures 2-57 and 2-58 below. The attribute table provides the stages at each output point for rainfall for the eight rainfall frequencies analyzed (50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.2% AEP) and the 4 surge frequencies analyzed (2%, 1%, 0.5% and 0.2% AEP), along with comparison columns that show the highest stage at that point due to rain or surge. The complete raw dataset of the attribute tables for each alignment is available at the referenced location (refer to Annex 6).

FID	Shape *	EC_100yr_r	EC_10yr_ra	EC_200yr_r	EC_25yr_ra	EC_2yr_rai	EC_500yr_r	EC_50yr_ra	EC_5yr_rai	FWOP_100yr	FWOP_10yr_	FWOP_200yr	FWOP_25yr_	FWOP_2yr_r	FWOP_500yr	FWOP_50yr_	FWOP_5yr_r
0	Polygon ZM	2.46946	1.946071	2.662326	2.130646	1.688864	2.938912	2.293191	1.820457	4.577807	4.131712	4.748951	4.287194	3.939299	4.996824	4.425566	4.035604
1	Polygon ZM	2.468627	1.94581	2.661464	2.130355	1.6887	2.937957	2.292478	1.820259	4.576725	4.131243	4.747689	4.286531	3.93904	4.995192	4.424728	4.035247
2	Polygon ZM	2.469281	1.946004	2.662165	2.130575	1.688819	2.938738	2.293028	1.820405	4.57773	4.131673	4.748884	4.287154	3.939276	4.996716	4.425505	4.035573
3	Polygon ZM	2.469652	1.9461	2.662525	2.130683	1.688878	2.939057	2.293392	1.820477	4.577745	4.131722	4.748856	4.287203	3.939314	4.99665	4.425547	4.035617
4	Polygon ZM	2.516171	1.984656	2.708349	2.178395	1.715667	2.976271	2.347026	1.854687	4.580982	4.133296	4.752432	4.289385	3.940227	5.000903	4.428191	4.036842
5	Polygon ZM	5.440672	4.989972	5.577954	5.173529	4.66571	5.752549	5.303221	4.841285	5.514344	5.019182	5.661963	5.21453	4.694327	5.850046	5.368128	4.870011
6	Polygon ZM	2.454845	1.938708	2.645338	2.122006	1.684256	2.918197	2.282417	1.814746	4.558749	4.121776	4.726526	4.274127	3.933064	4.969275	4.409754	4.027554
7	Polygon ZM	2.451074	1.936459	2.640751	2.119398	1.682828	2.912277	2.279303	1.812989	4.55345	4.118765	4.720358	4.270314	3.931061	4.961844	4.405232	4.025043
8	Polygon ZM	2.45231	1.937188	2.642268	2.120252	1.683287	2.914259	2.280329	1.813553	4.555275	4.119799	4.722489	4.271623	3.931751	4.964386	4.406786	4.025906
9	Polygon ZM	2.442271	1.93132	2.629877	2.113267	1.679622	2.89783	2.271886	1.809026	4.541915	4.111879	4.70712	4.261764	3.926353	4.946119	4.395237	4.019228
10	Polygon ZM	2.316506	1.836931	2.493243	2.006776	1.608042	2.748484	2.154736	1.726493	4.484032	4.071943	4.643835	4.214781	3.897986	4.876465	4.342698	3.984253
11	Polygon ZM	2.302472	1.82748	2.478073	1.995537	1.601318	2.732206	2.142005	1.718329	4.477532	4.067437	4.636736	4.209492	3.89521	4.868599	4.33679	3.980321
12	Polygon ZM	2.223439	1.770803	2.392415	1.930258	1.561832	2.638443	2.0695	1.668538	4.44096	4.041809	4.597013	4.179338	3.880973	4.824835	4.303336	3.9604
13	Polygon ZM	2.214429	1.765327	2.382131	1.923497	1.558934	2.626399	2.061612	1.66392	4.434127	4.037679	4.589458	4.173866	3.878709	4.816307	4.297177	3.957428
14	Polygon ZM	2.222101	1.771194	2.39032	1.930195	1.562346	2.635324	2.06886	1.669161	4.438811	4.040633	4.594535	4.177792	3.880293	4.821917	4.3015	3.959498
15	Polygon ZM	2.210394	1.762791	2.377638	1.920393	1.557613	2.621335	2.058006	1.661772	4.431403	4.036124	4.586423	4.171725	3.877824	4.812857	4.294744	3.956299
16	Polygon ZM	2.205521	1.759845	2.372101	1.916708	1.556202	2.614863	2.053708	1.659308	4.427291	4.033833	4.581865	4.16844	3.876509	4.807686	4.291042	3.954667
17	Polygon ZM	2.199094	1.755674	2.36493	1.91166	1.554167	2.606694	2.047942	1.655805	4.422498	4.031249	4.576559	4.164606	3.874964	4.801683	4.286725	3.952803
18	Polygon ZM	2.213049	1.764312	2.380554	1.922498	1.558128	2.624657	2.060436	1.662939	4.433774	4.037528	4.588992	4.17374	3.878559	4.815716	4.296951	3.957244
19	Polygon ZM	2.207022	1.760306	2.373899	1.917646	1.556111	2.617137	2.054967	1.659505	4.429318	4.034934	4.584092	4.170117	3.877114	4.810211	4.292902	3.955419
20	Polygon ZM	2.199006	1.755178	2.365074	1.911243	1.553801	2.607214	2.047677	1.655309	4.42372	4.031821	4.577948	4.165549	3.875285	4.803322	4.287806	3.953198
21	Polygon ZM	2.194555	1.75252	2.36002	1.907903	1.552638	2.601315	2.043752	1.653221	4.419863	4.029823	4.573672	4.162463	3.874069	4.798465	4.28433	3.951731
22	Polygon ZM	2.191043	1.750488	2.356018	1.905297	1.551857	2.596624	2.04066	1.651699	4.416713	4.028247	4.570172	4.159953	3.873086	4.794477	4.281497	3.950546
23	Polygon ZM	2.181812	1.744104	2.345887	1.897754	1.548838	2.585307	2.032219	1.646736	4.410435	4.025146	4.563258	4.154889	3.871042	4.786692	4.27581	3.948099
24	Polygon ZM	2.189427	1.747064	2.354972	1.902601	1.549322	2.596476	2.038565	1.648324	4.4189	4.029155	4.572689	4.161612	3.873591	4.797515	4.283418	3.951187
25	Polygon ZM	2.185277	1.745611	2.350006	1.900038	1.549137	2.590365	2.035151	1.647662	4.41438	4.026951	4.567667	4.158003	3.872203	4.791787	4.279349	3.949505
26	Polygon ZM	2.182345	1.74428	2.346566	1.898046	1.548735	2.586199	2.032662	1.646827	4.411201	4.025469	4.564119	4.155487	3.871239	4.787715	4.2765	3.948338
27	Polygon ZM	2.176071	1.740085	2.33978	1.892784	1.546664	2.578883	2.026835	1.643609	4.407055	4.023524	4.559553	4.152241	3.869901	4.782572	4.27274	3.946738
28	Polygon ZM	2.168591	1.735097	2.332063	1.886399	1.543895	2.570824	2.020021	1.639702	4.402789	4.021573	4.554879	4.149034	3.868487	4.77735	4.268855	3.945054
29	Polygon ZM	2.154092	1.724062	2.318374	1.873001	1.536238	2.557776	2.006417	1.630684	4.39959	4.019655	4.551662	4.146304	3.866966	4.774265	4.265757	3.943318
30	Polygon ZM	2.160913	1.729569	2.324633	1.879578	1.540218	2.563544	2.012952	1.635284	4.400499	4.020292	4.552499	4.147174	3.8675	4.774935	4.266694	3.943911
31	Polygon ZM	2.157897	1.727705	2.321475	1.877244	1.538937	2.560048	2.010415	1.633758	4.397676	4.019113	4.549345	4.145273	3.866656	4.771305	4.264165	3.942891
32	Polygon ZM	2.149926	1.722474	2.313491	1.870675	1.535038	2.551676	2.003469	1.62935	4.392563	4.01684	4.543736	4.141839	3.864982	4.765019	4.259511	3.940901
33	Polygon ZM	2.140273	1.716309	2.304034	1.863172	1.530225	2.541573	1.99553	1.623815	4.385606	4.0137	4.536131	4.137406	3.862657	4.756557	4.253164	3.938143
34	Polygon ZM	2.133193	1.711214	2.296359	1.857317	1.526404	2.533163	1.98903	1.619318	4.378106	4.010372	4.527879	4.133008	3.860211	4.747291	4.246521	3.935233
35	Polygon ZM	2.149208	1.721444	2.313096	1.869499	1.534382	2.551761	2.00245	1.628499	4.394223	4.017354	4.545655	4.142724	3.865315	4.767368	4.260972	3.941329
36	Polygon ZM	2.148448	1.721758	2.311905	1.869574	1.534794	2.549959	2.002178	1.62887	4.391445	4.016248	4.542508	4.141028	3.864545	4.76368	4.258517	3.940385
37	Polygon ZM	2.143464	1.718997	2.306623	1.865997	1.532744	2.544022	1.998159	1.626462	4.3865	4.014114	4.537036	4.137971	3.862994	4.75748	4.254052	3.938528
38	Polygon ZM	2.134997	1.712863	2.298187	1.859039	1.527809	2.535016	1.99079	1.620866	4.37961	4.011036	4.529492	4.133871	3.860719	4.749061	4.247835	3.935828
39	Polygon ZM	2.128184	1.707508	2.290995	1.853095	1.523605	2.527255	1.984369	1.616035	4.373099	4.008124	4.522367	4.130248	3.858563	4.741124	4.242403	3.933272
40	Polygon ZM	2.128797	1.708144	2.291539	1.85375	1.52415	2.527679	1.985011	1.616635	4.372385	4.007895	4.521515	4.129951	3.858415	4.74006	4.241888	3.933082
41	Polygon ZM	2.127977	1.707277	2.290749	1.852932	1.523402	2.526577	1.984103	1.615802	4.370088	4.006969	4.51898	4.128877	3.85774	4.737234	4.240144	3.932272
42	Polygon ZM	2.143526	1.718508	2.306923	1.865524	1.532272	2.54467	1.997865	1.625973	4.387427	4.014438	4.538058	4.138457	3.863216	4.758659	4.254909	3.938805
43	Polygon ZM	2.140283	1.716952	2.303294	1.863432	1.531229	2.540399	1.995355	1.624673	4.382892	4.012518	4.532988	4.135789	3.861839	4.752842	4.250857	3.937145
44	Polygon ZM	2.127161	1.706905	2.28984	1.852351	1.523134	2.526026	1.983513	1.615494	4.371992	4.007603	4.521097	4.129602	3.858192	4.739641	4.241506	3.932826
45	Polygon ZM	2.123758	1.704626	2.286035	1.849651	1.521516	2.52162	1.980437	1.613536	4.366714	4.005364	4.515216	4.126926	3.856612	4.732922	4.237523	3.930883
46	Polygon ZM	2.124263	1.705173	2.286472	1.850209	1.522018	2.521862	1.980968	1.614071	4.36578	4.005058	4.51412	4.126546	3.856424	4.731574	4.236906	3.930628
47	Polygon ZM	2.124097	1.705054	2.286281	1.850071	1.52194	2.521614	1.980809	1.613973	4.36538	4.00491	4.513671	4.126374	3.856326	4.731058	4.236634	3.930499
48	Polygon ZM	2.121475	1.7032	2.283389	1.847923	1.520584	2.518274	1.978398	1.612363	4.361169	4.00318	4.508924	4.124292	3.855187	4.725557	4.233701	3.929007
49	Polygon ZM	2.13873	1.715881	2.301707	1.862167	1.530379	2.538663	1.993995	1.6237	4.381054	4.011728	4.530913	4.134723	3.86127	4.750437	4.249237	3.936462
50	Polygon ZM	2.137192	1.715121	2.299956	1.861189	1.52987	2.536511	1.992814	1.623066	4.378054	4.010498	4.527522	4.133085	3.860398	4.746484	4.24665	3.935405
51	Polygon ZM	2.121397	1.703382	2.283174	1.848043	1.520679	2.518052	1.978484	1.612494	4.361039	4.002986	4.508781	4.124042	3.855048	4.725421	4.233482	3.928838
52	Polygon ZM	2.117819	1.701025	2.279202	1.845222	1.519044	2.513526	1.975257	1.61049	4.355327	4.00057	4.50239	4.121157	3.853518	4.718085	4.229665	3.926744
53	Polygon ZM	2.113574	1.698346	2.274414	1.841977	1.517209	2.507734	1.9715	1.608228	4.348446	3.997609	4.494609	4.11763	3.851732	4.709176	4.225296	3.924172
54	Polygon ZM	2.102631	1.691628	2.261827	1.833758	1.512587	2.493078	1.961914	1.602543	4.334569	3.990505	4.476478	4.109204	3.847657	4.688593	4.215718	3.918144
55	Polygon ZM	2.099632	1.689783	2.258372	1.831508	1.511309	2.488995	1.95929	1.600977	4.330745	3.988302	4.470854	4.106581	3.846405	4.682029	4.212749	3.916441
56	Polygon ZM	2.134181	1.713097	2.296802	1.858862	1.528318	2.533064	1.990243	1.621262	4.375021	4.009143	4.52417	4.131373	3.859404	4.742711	4.244081	3.934222
57	Polygon ZM	2.129096	1.709876	2.291196	1.855066	1.525912	2.526544	1.985914	1.618441	4.367522	4.005933	4.515811	4.12746	3.8571	4.733158	4.23822	3.931436
58	Polygon ZM	2.118847	1.702157	2.280049	1.846402	1.519923	2.514109	1.976424	1.611509	4.355447	4.00063	4.502483	4.121208	3.853562	4.718138	4.229728	3.926804
59	Polygon ZM	2.104766	1.693003	2.264303	1.835377	1.513581	2.496125	1.963776	1.603735	4.339184	3.992894	4.483122	4.112083	3.848982	4.696334	4.219015	3.920073
60	Polygon ZM	2.100658	1.690449	2.259575	1.832287	1.511802	2.490559	1.960186	1.601561	4.333219	3.989684	4.474602	4.108243	3.847169	4.686532	4.214647	3.917494
61	Polygon ZM	2.099234	1.689563	2.257915	1.831222	1.51117	2.488489	1.958948	1.600797	4.330396	3.988121	4.47036	4.106351	3.846304	4.681387	4.212474	3.916309
62	Polygon ZM	2.096794	1.688036	2.255107	1.829378	1.510103	2.485126	1.956809	1.59949	4.326889	3.986041	4.465294	4.103848	3.84514	4.674794	4.209612	3.914783
63	Polygon ZM	2.09046	1.683938	2.247942	1.824461	1.507362	2.476761	1.951176	1.595983	4.319672	3.981391	4.455367	4.098276	3.842525	4.660444	4.203265	3.911567
64	Polygon ZM	2.139348	1.715248	2.302916	1.86182	1.529501	2.540819	1.993992	1.622921	4.383868	4.012828	4.533992	4.136214	3.862048	4.753931	4.251839	3.937412

Figure 2-57: Existing and Future Without Project Attribute Table for Rainfall Sample Snapshot

Ht50_Mean	Ht100_Mean	Ht400_Mean	Ht500_Mean	Ht1000_Mea	FHt50_Mean	FHt100_Mea	FHt200_Mea	FHt400_Mea	FHt500_Mea	FHt1000_Me	interp200	compEC50	compEC100	compEC200	compEC500	compF50	compF100	compF200	compF500
0	0	0	0	0	0	0	0	0	0	0	0	2.293191	2.46946	2.662326	2.938912	4.425566	4.577807	4.748951	4.996824
0	0	0	0	0	0	0	0	0	0	0	0	2.292478	2.468627	2.661464	2.937957	4.424728	4.576725	4.747689	4.995192
0	0	0	0	0	0	0	0	0	0	0	0	2.293028	2.469281	2.662165	2.938738	4.425505	4.57773	4.748884	4.996716
0	0	0	0	0	0	0	0	0	0	0	0	2.293392	2.469652	2.662525	2.939057	4.425547	4.577745	4.748856	4.99665
0	0	0	0	0	0	0	0	0	0	0	0	2.347026	2.516171	2.708349	2.976271	4.428191	4.580982	4.752432	5.000903
0	0	0	0	0	0	0	0	0	0	0	0	5.303221	5.440672	5.577954	5.752549	5.368128	5.514344	5.661963	5.850046
0	0	0	0	0	0	0	0	0	0	0	0	2.282417	2.454845	2.645338	2.918197	4.409754	4.558749	4.726526	4.969275
0	0	0	0	0	0	0	0	0	0	0	0	2.279303	2.451074	2.640751	2.912277	4.405232	4.55345	4.720358	4.961844
0	0	0	0	0	0	0	0	0	0	0	0	2.280329	2.45231	2.642268	2.914259	4.406786	4.555275	4.722489	4.964386
0	0	0	0	0	0	0	0	0	0	0	0	2.271886	2.442271	2.629877	2.89783	4.395237	4.541915	4.70712	4.946119
0	0	0	0	0	0	0	0	0	0	0	0	2.154736	2.316506	2.493243	2.748484	4.342698	4.484032	4.643835	4.876465
6.6	8.16	11.386667	11.893333	13.313333	0	0	0	0	0	0	9.235556	6.6	8.16	9.235556	11.893333	4.33679	4.477532	4.636736	4.868599
6.598039	8.141176	11.476471	12.003922	13.637255	0	0	0	0	0	0	9.252941	6.598039	8.141176	9.252941	12.003922	4.303336	4.44096	4.597013	4.824835
6.6	8.114085	11.383099	11.887324	13.332394	0	0	0	0	0	0	9.203756	6.6	8.114085	9.203756	11.887324	4.297177	4.434127	4.589458	4.816307
6.763107	8.531068	13.040777	13.995146	17.540777	9.29	10.98	12.07	14.25	14.7	16.28	10.034304	6.763107	8.531068	10.034304	13.995146	9.29	10.98	12.07	14.7
6.675	8.283333	11.925	12.533333	14.533333	0	0	0	0	0	0	9.497222	6.675	8.283333	9.497222	12.533333	4.294744	4.431403	4.586423	4.812857
6.596774	8.122581	11.467742	11.982258	13.456452	0	0	0	0	0	0	9.237634	6.596774	8.122581	9.237634	11.982258	4.291042	4.427291	4.581865	4.807686
6.621739	8.186957	11.643478	12.173913	13.678261	0	0	0	0	0	0	9.33913	6.621739	8.186957	9.33913	12.173913	4.286725	4.422498	4.576559	4.801683
6.722093	8.393798	12.656589	13.635271	17.110465	9.195238	10.754286	11.809048	13.918571	14.415238	15.875714	9.814729	6.722093	8.393798	9.814729	13.635271	9.195238	10.754286	11.809048	14.415238
6.930851	8.789362	13.5	14.437234	17.856383	0	0	0	0	0	0	10.359574	6.930851	8.789362	10.359574	14.437234	4.292902	4.429318	4.584092	4.810211
6.866667	8.622222	12.611111	13.277778	15.511111	0	0	0	0	0	0	9.951852	6.866667	8.622222	9.951852	13.277778	4.287806	4.42372	4.577948	4.803322
6.6	8.2	11.5	12	13.5	0	0	0	0	0	0	9.3	6.6	8.2	9.3	12	4.28433	4.419863	4.573672	4.798465
6.6875	8.3625	11.925	12.425	13.925	0	0	0	0	0	0	9.55	6.6875	8.3625	9.55	12.425	4.281497	4.416713	4.570172	4.794477
6.7	8.4	12	12.5	14	0	0	0	0	0	0	9.6	6.7	8.4	9.6	12.5	4.27581	4.410435	4.563258	4.786692
6.807643	8.395541	11.810191	12.366879	14.211465	9.265	10.845125	11.929917	14.0995	14.603	16.085625	9.533758	6.807643	8.395541	9.533758	12.366879	9.265	10.845125	11.929917	14.603
6.984615	8.8	12.746154	13.384615	15.515385	9.615	11.565	12.83	15.36	15.905	17.475	10.115385	6.984615	8.8	10.115385	13.384615	9.615	11.565	12.83	15.905
0	0	0	0	0	0	0	0	0	0	0	0	2.032662	2.182345	2.346566	2.586199	4.2765	4.411201	4.564119	4.787715
6.7	8.4	12	12.5	14	0	0	0	0	0	0	9.6	6.7	8.4	9.6	12.5	4.27274	4.407055	4.559553	4.782572
6.7	8.4	12	12.5	14	0	0	0	0	0	0	9.6	6.7	8.4	9.6	12.5	4.268855	4.402789	4.554879	4.77735
6.893798	8.415504	11.450388	11.936822	13.36938	9.305323	10.880376	11.909122	13.966613	14.454946	15.870591	9.427132	6.893798	8.415504	9.427132	11.936822	9.305323	10.880376	11.909122	14.454946
6.936	8.564	11.784	12.3	13.744	9.423636	11.160455	12.299091	14.576364	15.126364	16.656818	9.637333	6.936	8.564	9.637333	12.3	9.423636	11.160455	12.299091	15.126364
0	0	0	0	0	0	0	0	0	0	0	0	2.010415	2.157897	2.321475	2.560048	4.264165	4.397676	4.549345	4.771305
0	0	0	0	0	0	0	0	0	0	0	0	2.003469	2.149926	2.313491	2.551676	4.259511	4.392563	4.543736	4.765019
0	0	0	0	0	0	0	0	0	0	0	0	1.99553	2.140273	2.304034	2.541573	4.253164	4.385606	4.536131	4.756557
0	0	0	0	0	0	0	0	0	0	0	0	1.98903	2.133193	2.296359	2.533163	4.246521	4.378106	4.527879	4.747291
6.859816	8.341411	11.18589	11.62454	12.918712	9.250927	10.783578	11.762588	13.720607	14.174217	15.508083	9.289571	6.859816	8.341411	9.289571	11.62454	9.250927	10.783578	11.762588	14.174217
6.875862	8.406897	11.382759	11.841379	13.213793	9.308333	10.915556	11.952037	14.025	14.513333	15.917778	9.398851	6.875862	8.406897	9.398851	11.841379	9.308333	10.915556	11.952037	14.513333
0	0	0	0	0	0	0	0	0	0	0	0	1.998159	2.143464	2.306623	2.544022	4.254052	4.3865	4.537036	4.75748
0	0	0	0	0	0	0	0	0	0	0	0	1.99079	2.134997	2.298187	2.535016	4.247835	4.37961	4.529492	4.749061
0	0	0	0	0	0	0	0	0	0	0	0	1.984369	2.128184	2.290995	2.527255	4.242403	4.373099	4.522367	4.741124
0	0	0	0	0	0	0	0	0	0	0	0	1.985011	2.128797	2.291539	2.527679	4.241888	4.372385	4.521515	4.74006
0	0	0	0	0	0	0	0	0	0	0	0	1.984103	2.127977	2.290749	2.526577	4.240144	4.370088	4.51898	4.737234
6.820219	8.303279	11.191257	11.651366	13.054372	9.175167	10.679787	11.631348	13.534468	13.962553	15.239119	9.265938	6.820219	8.303279	9.265938	11.651366	9.175167	10.679787	11.631348	13.962553
6.941538	8.54	12.010769	12.683077	14.881538	9.187037	10.697778	11.659012	13.581481	14.000741	15.263704	9.696923	6.941538	8.54	9.696923	12.683077	9.187037	10.697778	11.659012	14.000741
0	0	0	0	0	0	0	0	0	0	0	0	1.983513	2.127161	2.28984	2.526026	4.241506	4.371992	4.521097	4.739641
0	0	0	0	0	0	0	0	0	0	0	0	1.980437	2.123758	2.286035	2.52162	4.237523	4.366714	4.515216	4.732922
0	0	0	0	0	0	0	0	0	0	0	0	1.980968	2.124263	2.286472	2.521862	4.236906	4.36578	4.51412	4.731574
0	0	0	0	0	0	0	0	0	0	0	0	1.980809	2.124097	2.286281	2.521614	4.236634	4.36538	4.513671	4.731058
0	0	0	0	0	0	0	0	0	0	0	0	1.978398	2.121475	2.283389	2.518274	4.233701	4.361169	4.508924	4.725557
6.763456	8.238244	11.111331	11.572238	13.003683	9.095472	10.572345	11.49873	13.351498	13.762769	14.978762	9.19594	6.763456	8.238244	9.19594	11.572238	9.095472	10.572345	11.49873	13.762769
6.864948	8.443299	11.756701	12.374227	14.448454	9.101961	10.608039	11.545033	13.41902	13.829412	15.037843	9.547766	6.864948	8.443299	9.547766	12.374227	9.101961	10.608039	11.545033	13.829412
0	0	0	0	0	0	0	0	0	0	0	0	1.978484	2.121397	2.283174	2.518052	4.233482	4.361039	4.508781	4.725421
7.3	9	12.1	12.5	13.7	9.75	11.26	12.176667	14.01	14.365	15.43	10.033333	7.3	9	10.033333	12.5	9.75	11.26	12.176667	14.365
7.5875	9.375	12.625	13.0625	14.3375	10.15125	11.7775	12.764167	14.7375	15.13625	16.29875	10.458333	7.5875	9.375	10.458333	13.0625	10.15125	11.7775	12.764167	15.13625
7.6	9.4	12.666667	13.1	14.383333	10.155	11.781667	12.766111	14.735	15.126667	16.29	10.488889	7.6	9.4	10.488889	13.1	10.155	11.781667	12.766111	15.126667
0	0	0	0	0	0	0	0	0	0	0	0	1.95929	2.099632	2.258372	2.488995	4.212749	4.330745	4.470854	4.682029
6.708951	8.149105	10.860102	11.272123	12.491304	9.057493	10.518886	11.428886	13.248886	13.657855	14.843231	9.052771	6.708951	8.149105	9.052771	11.272123	9.057493	10.518886	11.428886	13.657855
6.765432	8.25679	11.149383	11.601235	13.017284	9.096129	10.586613	11.526129	13.405161	13.825161	15.052258	9.220988	6.765432	8.25679	9.220988	11.601235	9.096129	10.586613	11.526129	13.825161
7.25	8.875	11.875	12.3	13.475	9.6625	11.1	11.983333	13.75	14.125	15.1625	9.875	7.25	8.875	9.875	12.3	9.6625	11.1	11.983333	14.125
7.28	8.933333	11.98	12.393333	13.58	9.724	11.197333	12.101556	13.91	14.278667	15.333333	9.948889	7.28	8.933333	9.948889	12.393333	9.724	11.197333	12.101556	14.278667
7.445455	9.172727	12.336364	12.754545	13.981818	9.985455	11.563636	12.527879	14.456364	14.839091	15.959091	10.227273	7.445455	9.172727	10.227273	12.754545	9.985455	11.563636	12.527879	14.839091
7.5	9.3	12.5	12.95	14.2	10.085	11.755	12.745	14.725	15.14	16.3	10.366667	7.5	9.3	10.366667	12.95	10.085	11.755	12.745	15.14
0	0	0	0	0	0	0	0	0	0	0	0	1.956809	2.096794	2.255107	2.485126	4.209612	4.326889	4.465294	4.674794
0	0	0	0	0	0	0	0	0	0	0	0	1.951176	2.09046	2.247942	2.476761	4.203265	4.319672	4.455367	4.660444
6.645087	7.930636	10.191329	10.524855	11.536994	8.860651	10.138047	10.884753	12.378166	12.706213	13.691302	8.6842	6.645087	7.930636	8.6842	10.524855	8.860651	10.138047	10.884753	12.706213

Figure 2-58: Existing and Future Without Project Attribute Table for Surge Sample Snapshot

Conclusion

The following inundation maps show the existing without project and future without project conditions for the 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.2% AEP annual rainfall frequency events. These conditions are shown on Figures 2-59 through 2-74 below.

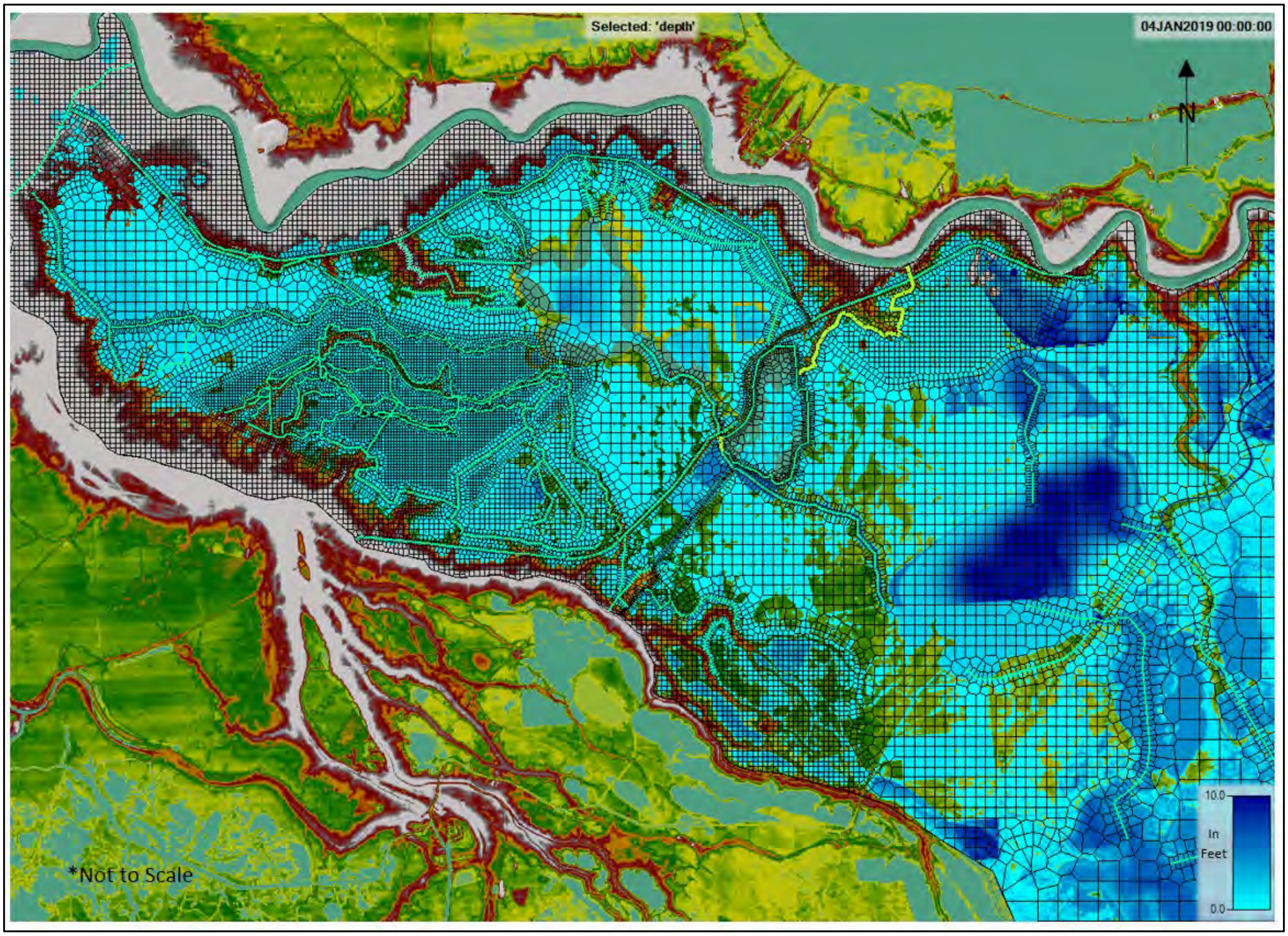


Figure 2-59: Inundation Map for the 50% AEP Rainfall Frequency Event (Existing Without Project Condition)

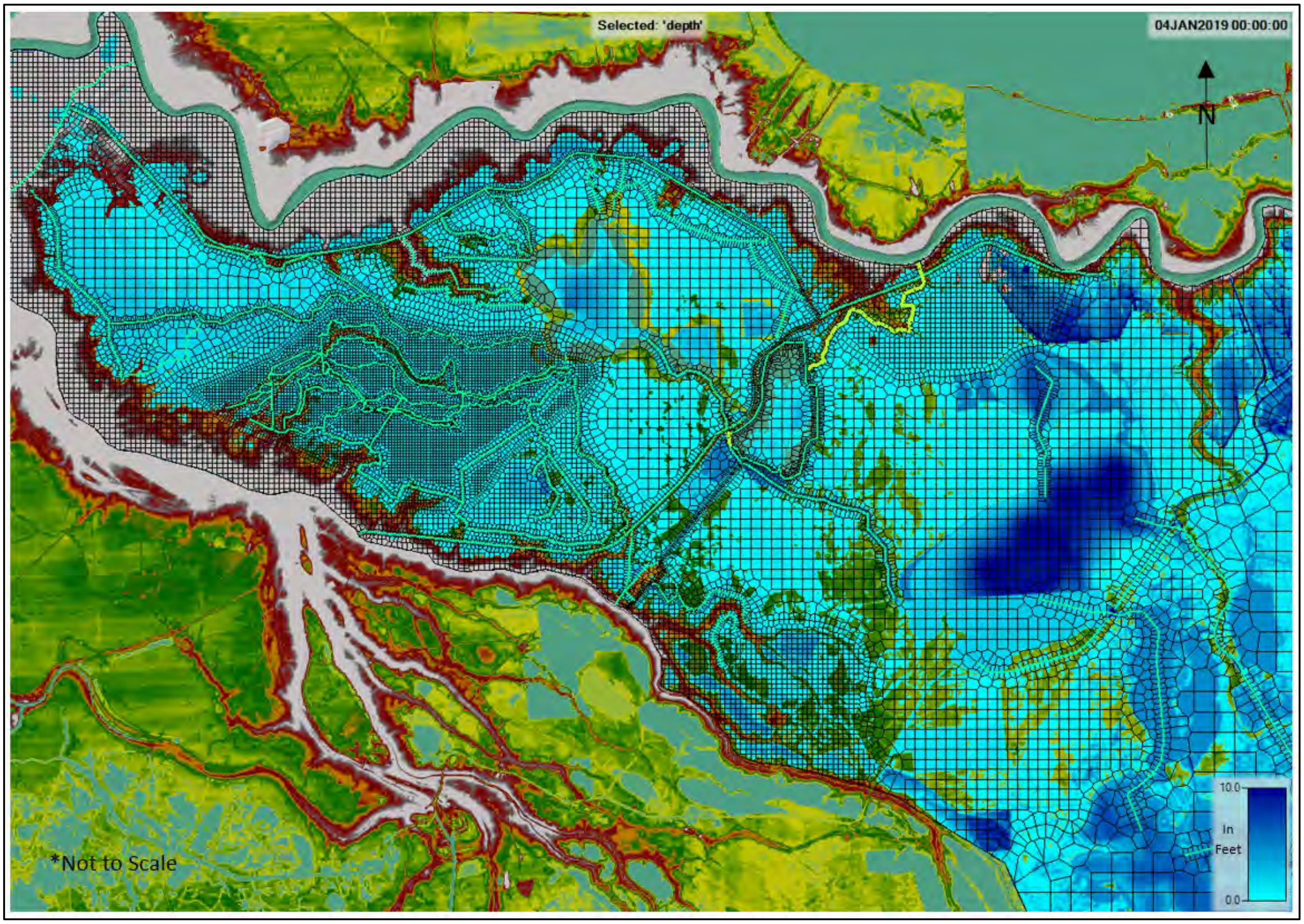


Figure 2-60: Inundation Map for the 20% AEP Rainfall Frequency Event (Existing Without Project Condition)

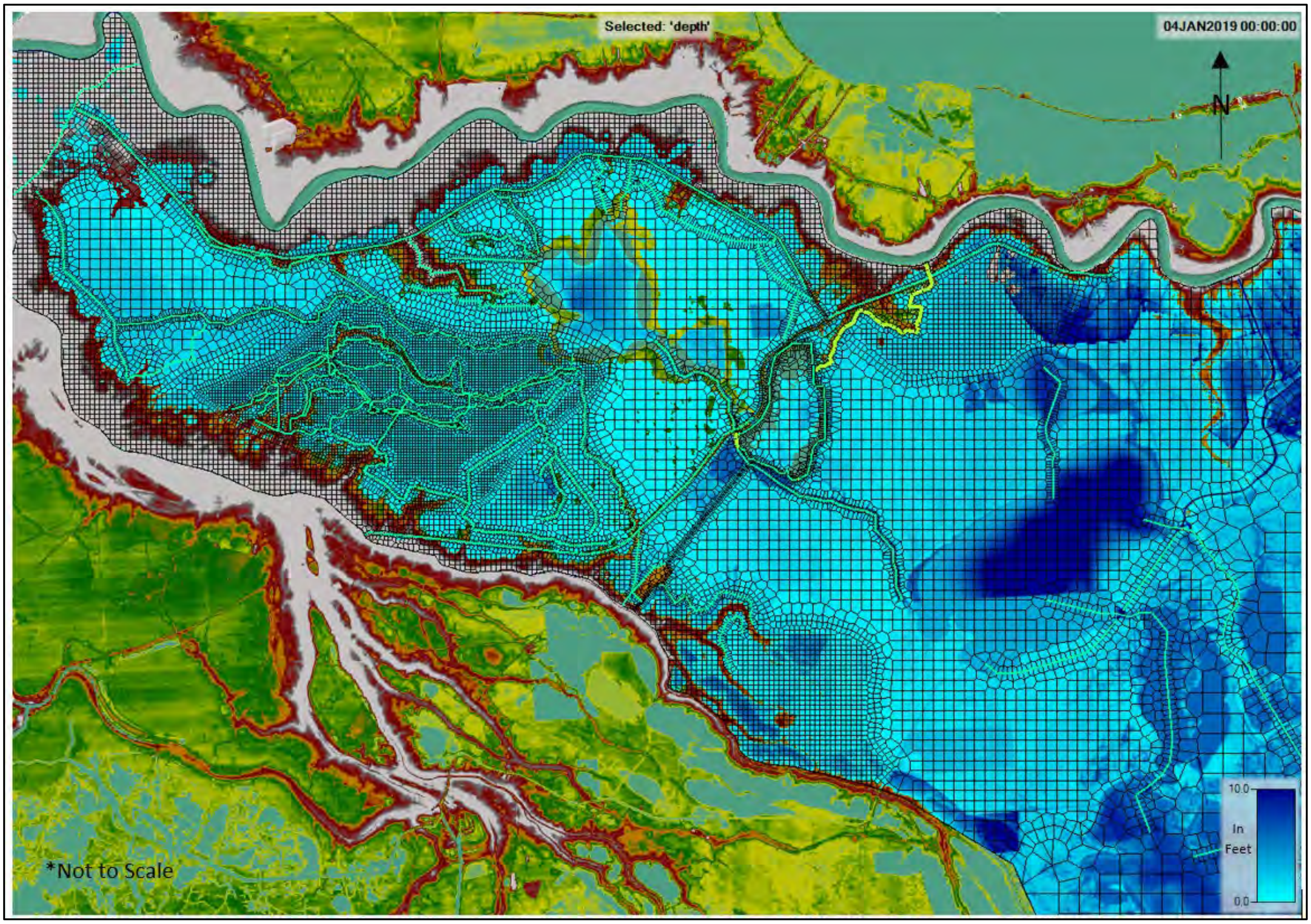


Figure 2-61: Inundation Map for the 10% AEP Rainfall Frequency Event (Existing Without Project Condition)

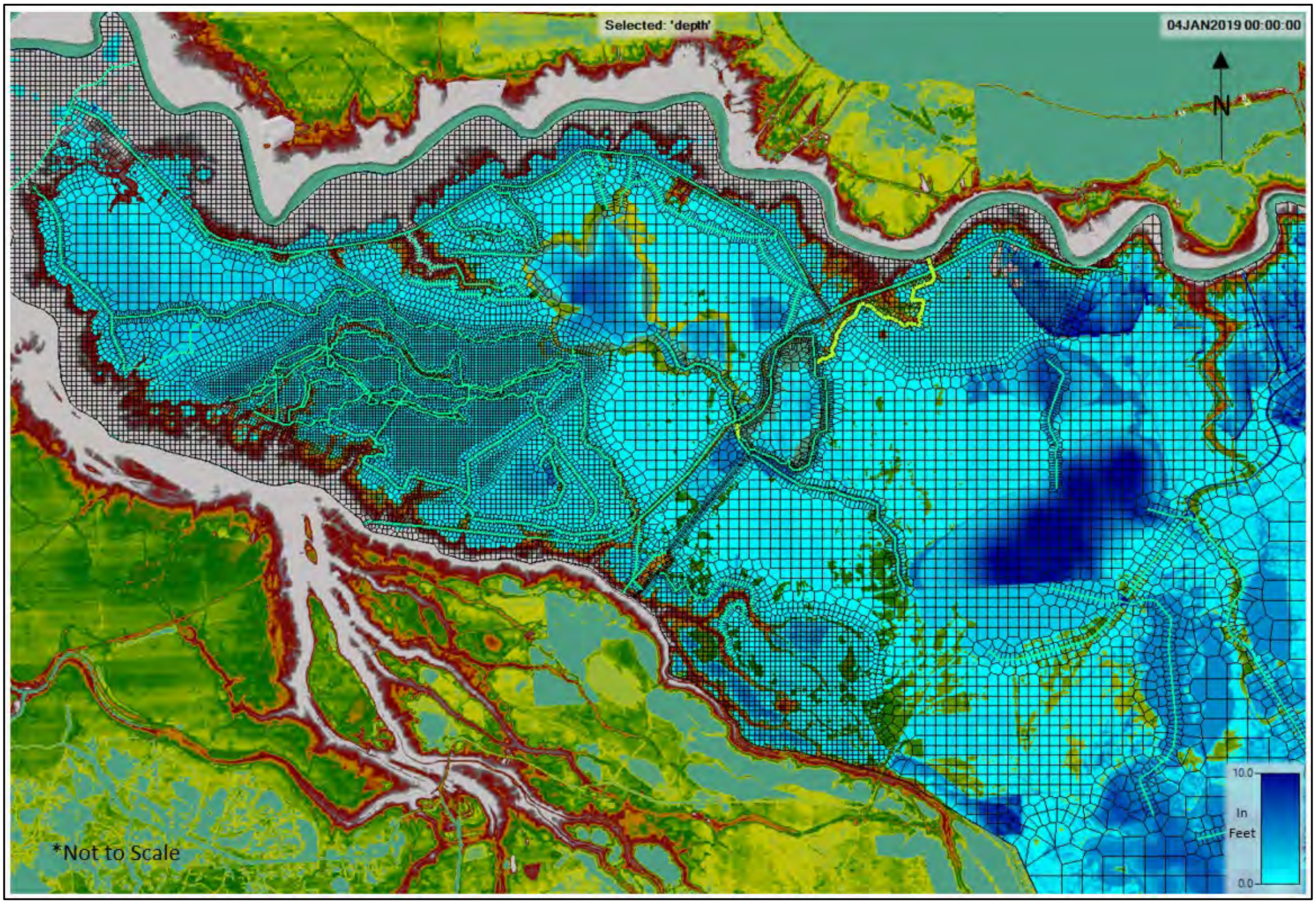


Figure 2-62: Inundation Map for the 4% AEP Rainfall Frequency Event (Existing Without Project Condition)

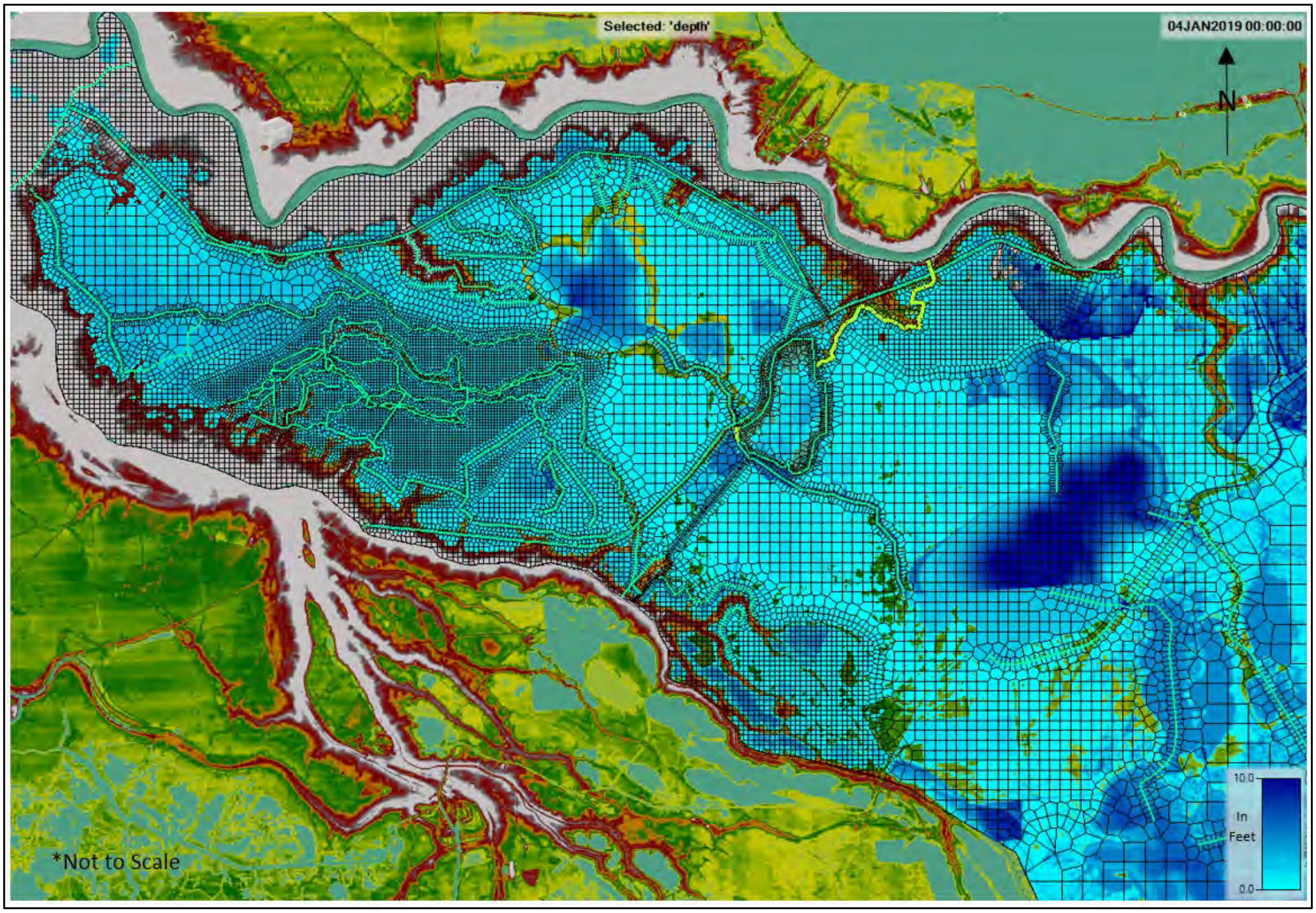


Figure 2-63: Inundation Map for the 2% AEP Rainfall Frequency Event (Existing Without Project Condition)

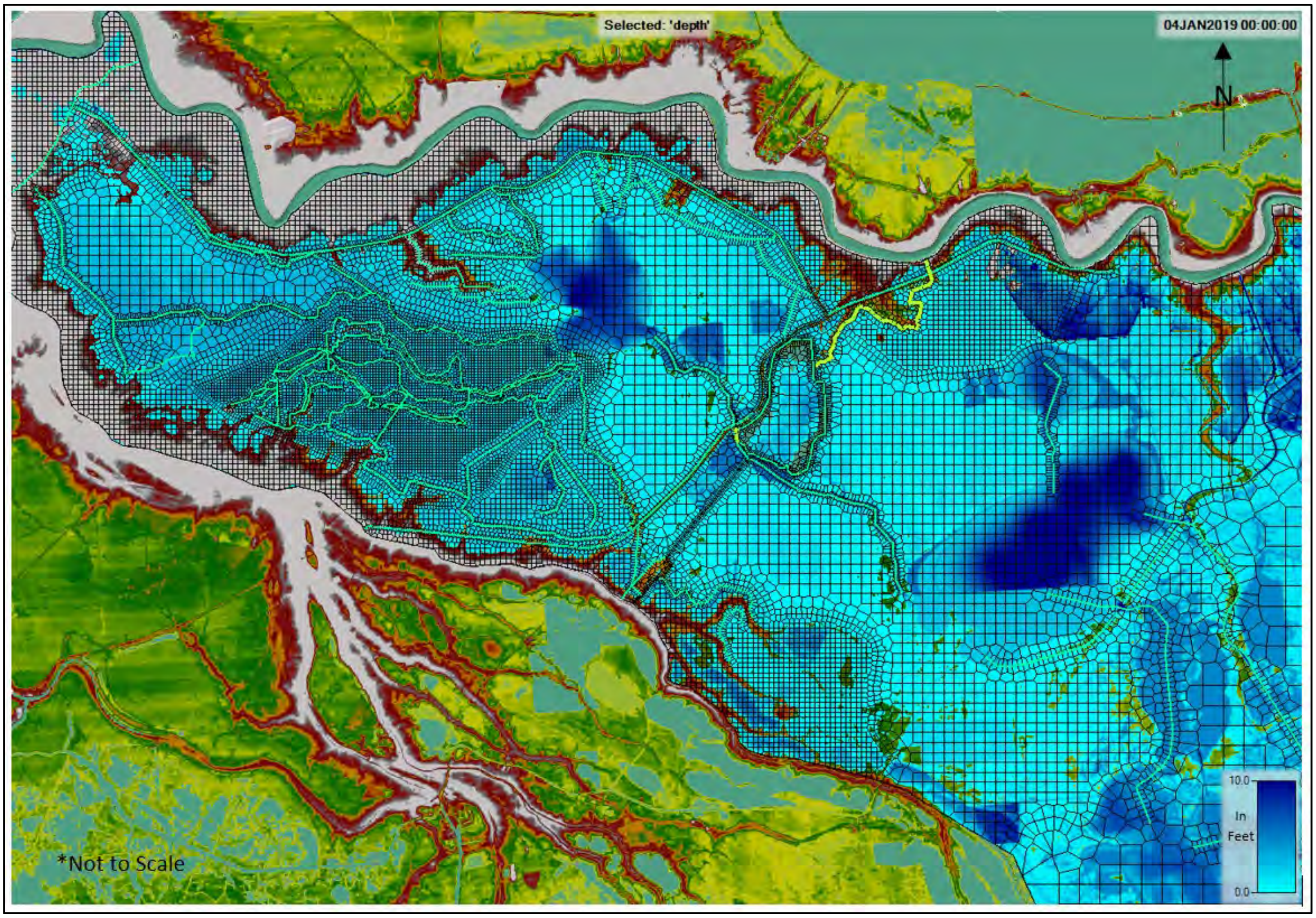


Figure 2-64: Inundation Map for the 1% AEP Rainfall Frequency Event (Existing Without Project Condition)

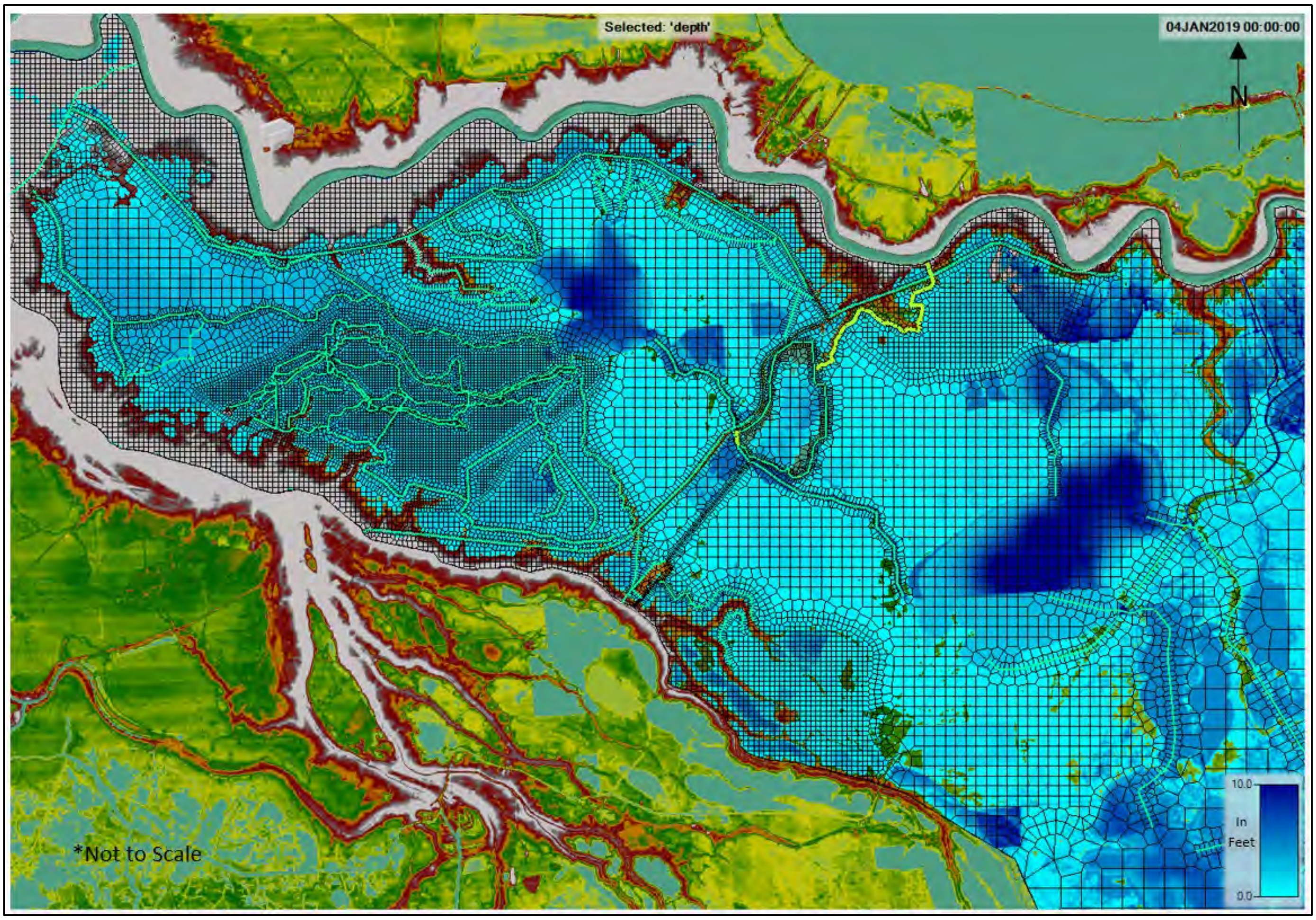


Figure 2-65: Inundation Map for the 0.5% AEP Rainfall Frequency Event (Existing Without Project Condition)

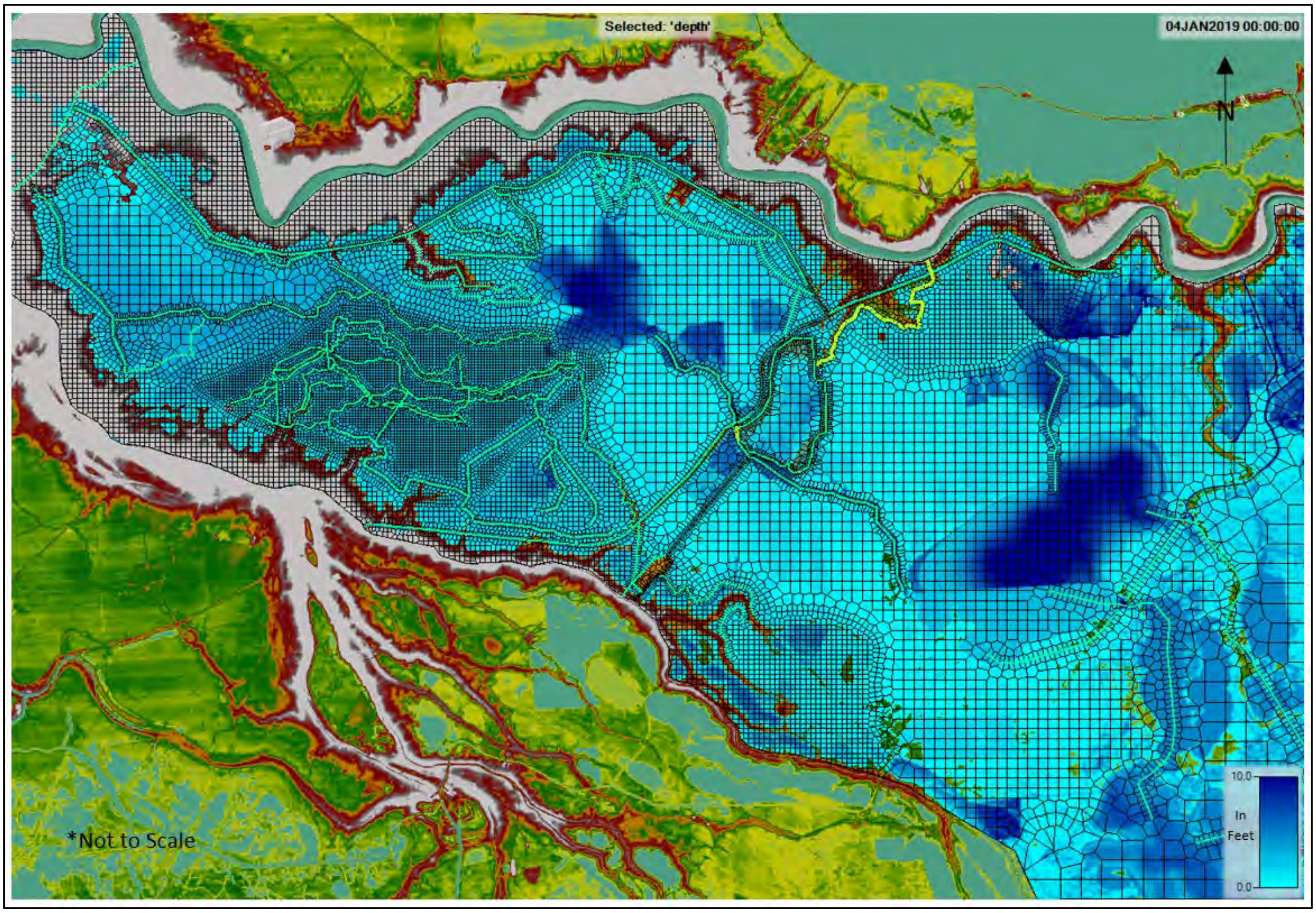


Figure 2-66: Inundation Map for the 0.2% AEP Rainfall Frequency Event (Existing Without Project Condition)

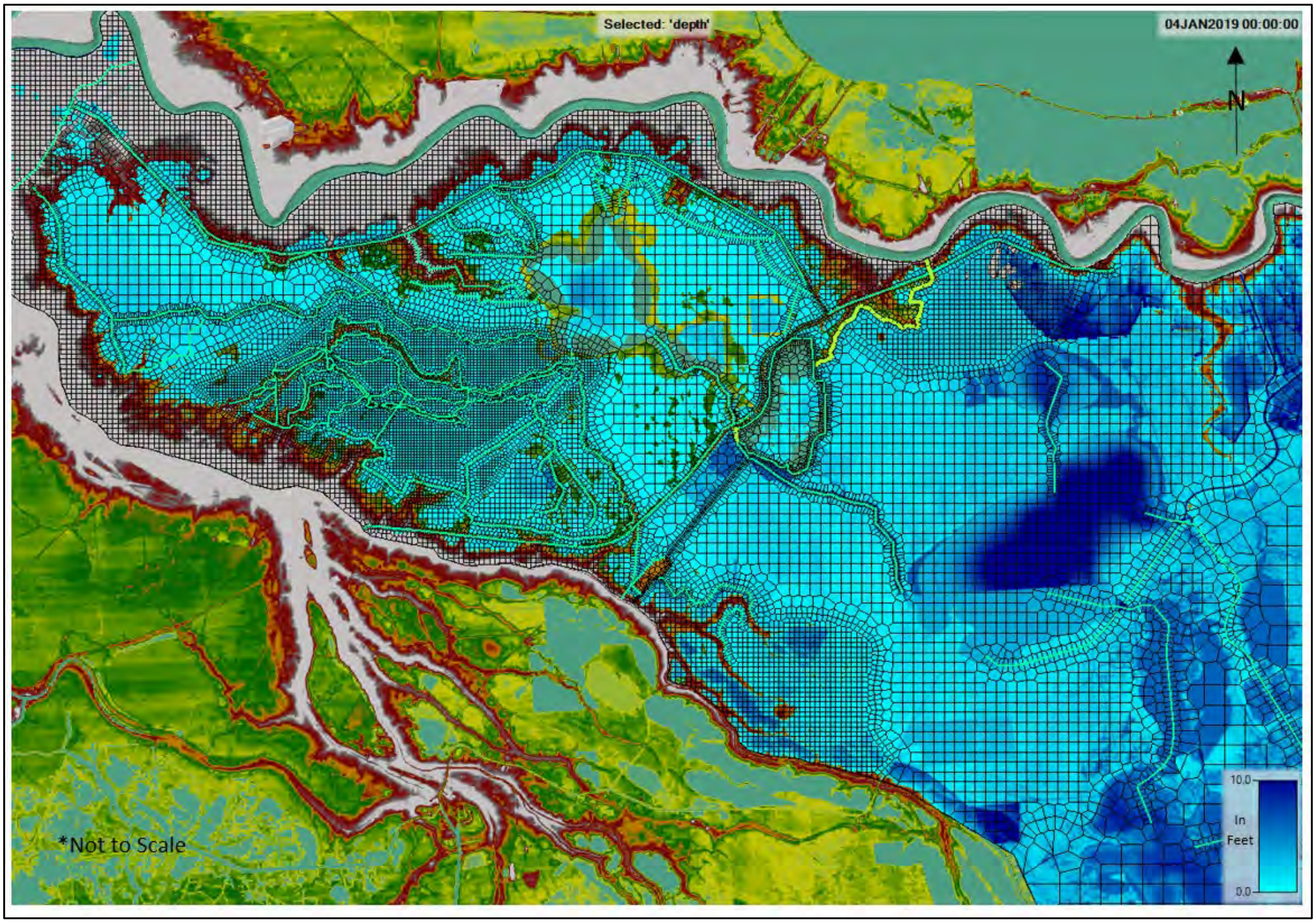


Figure 2-67: Inundation Map for the 50% AEP Rainfall Frequency Event (Future Without Project Condition)

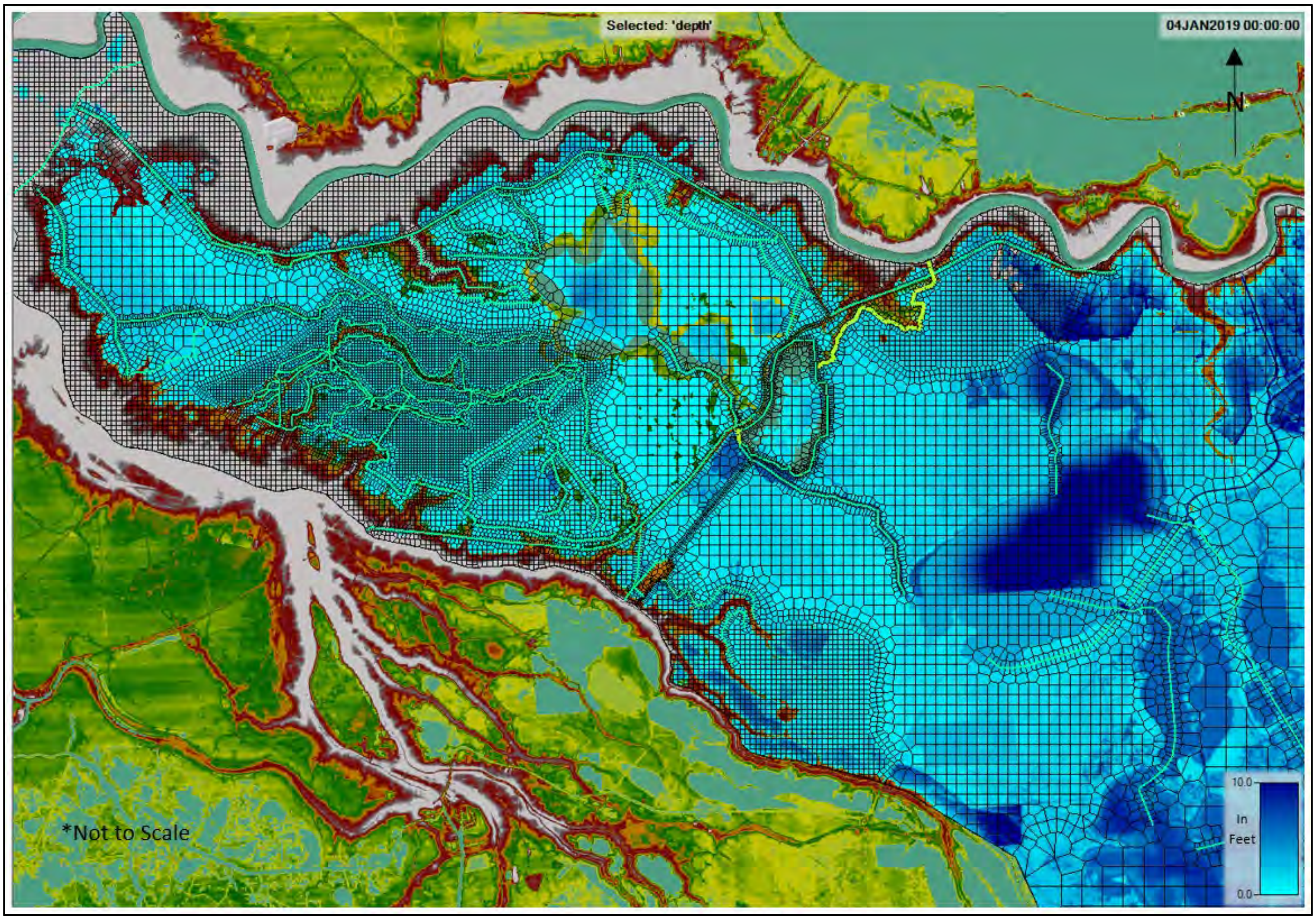


Figure 2-68: Inundation Map for the 20% AEP Rainfall Frequency Event (Future Without Project Condition)

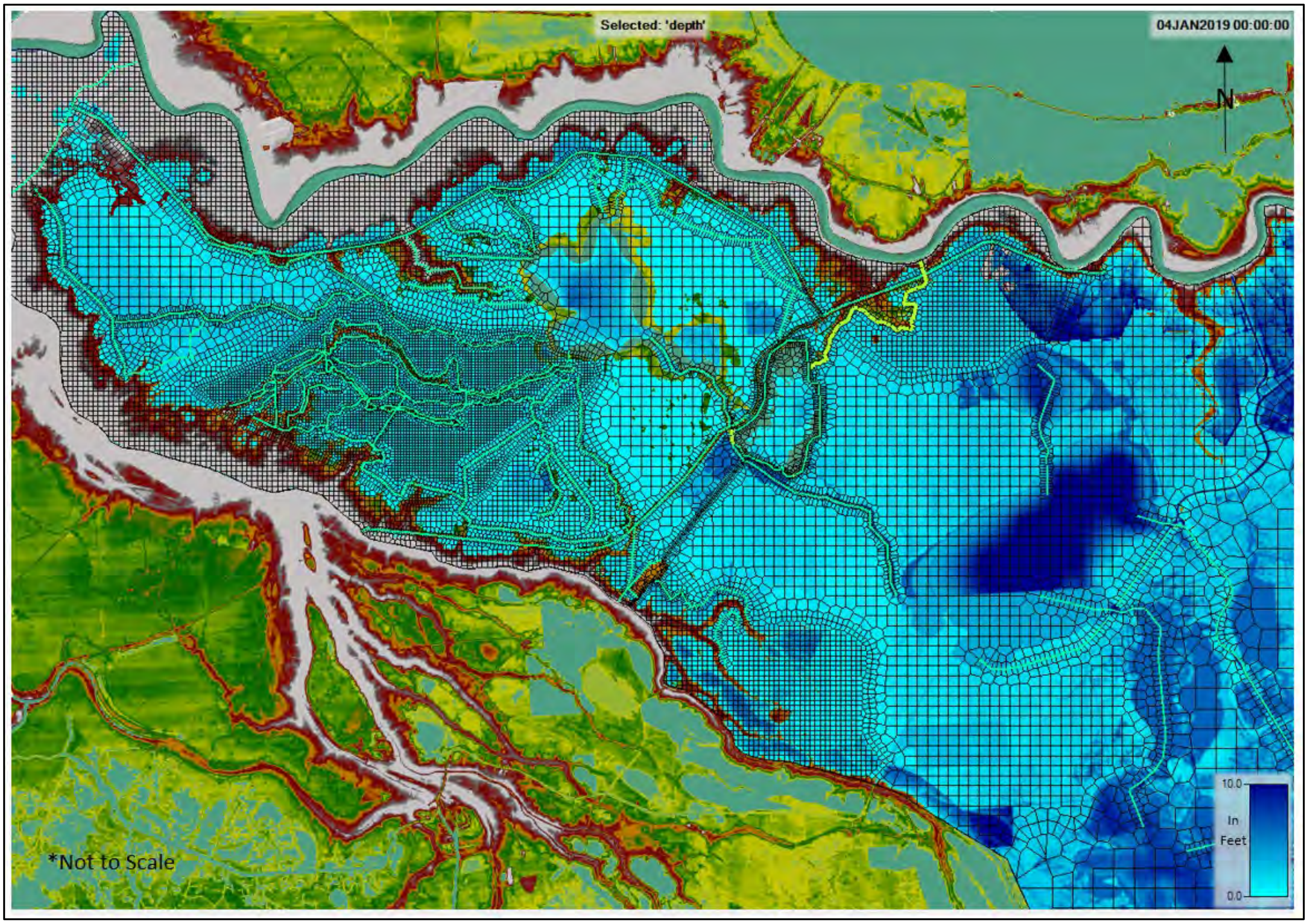


Figure 2-69: Inundation Map for the 10% AEP Rainfall Frequency Event (Future Without Project Condition)

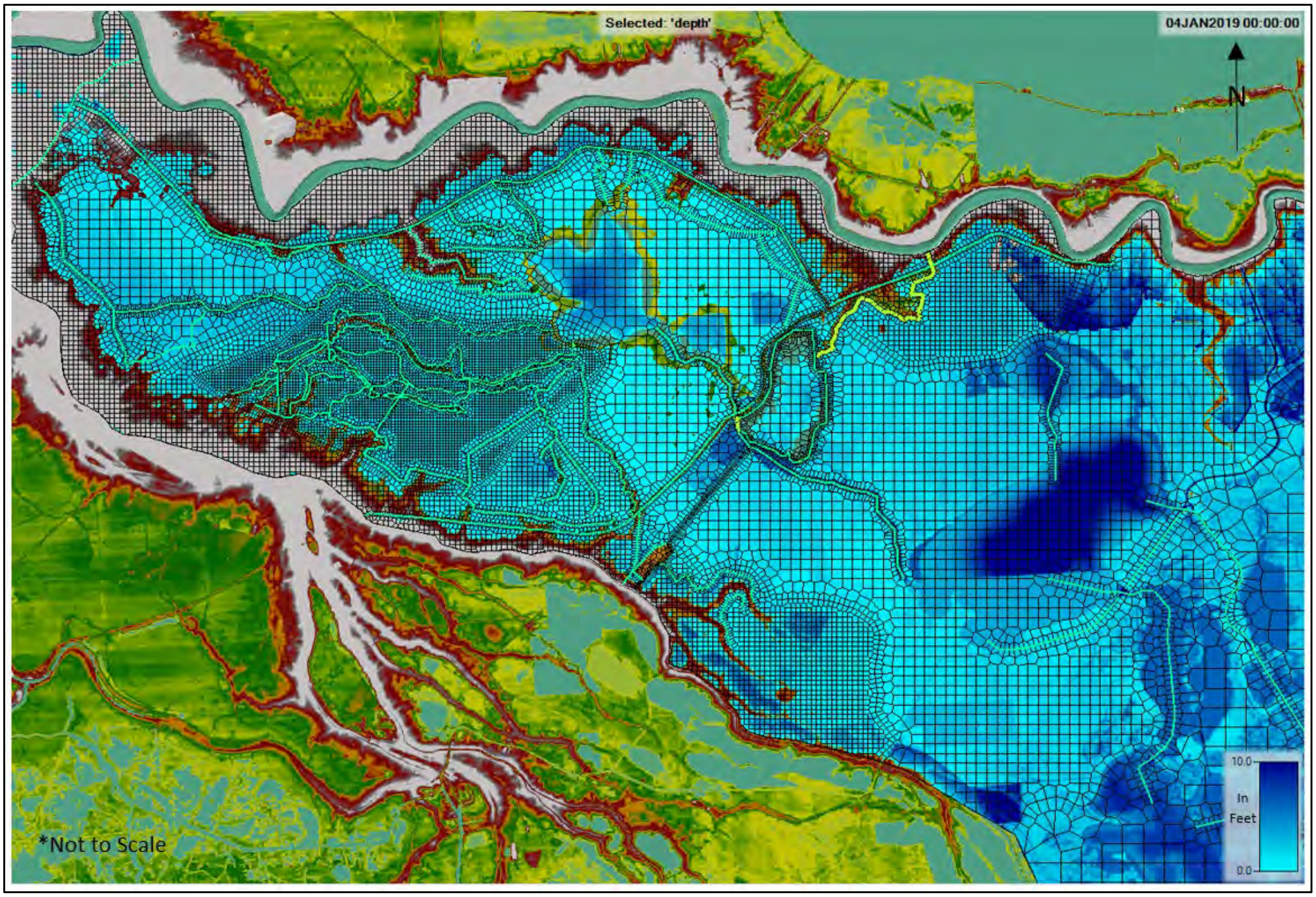


Figure 2-70: Inundation Map for the 4% AEP Rainfall Frequency Event (Future Without Project Condition)

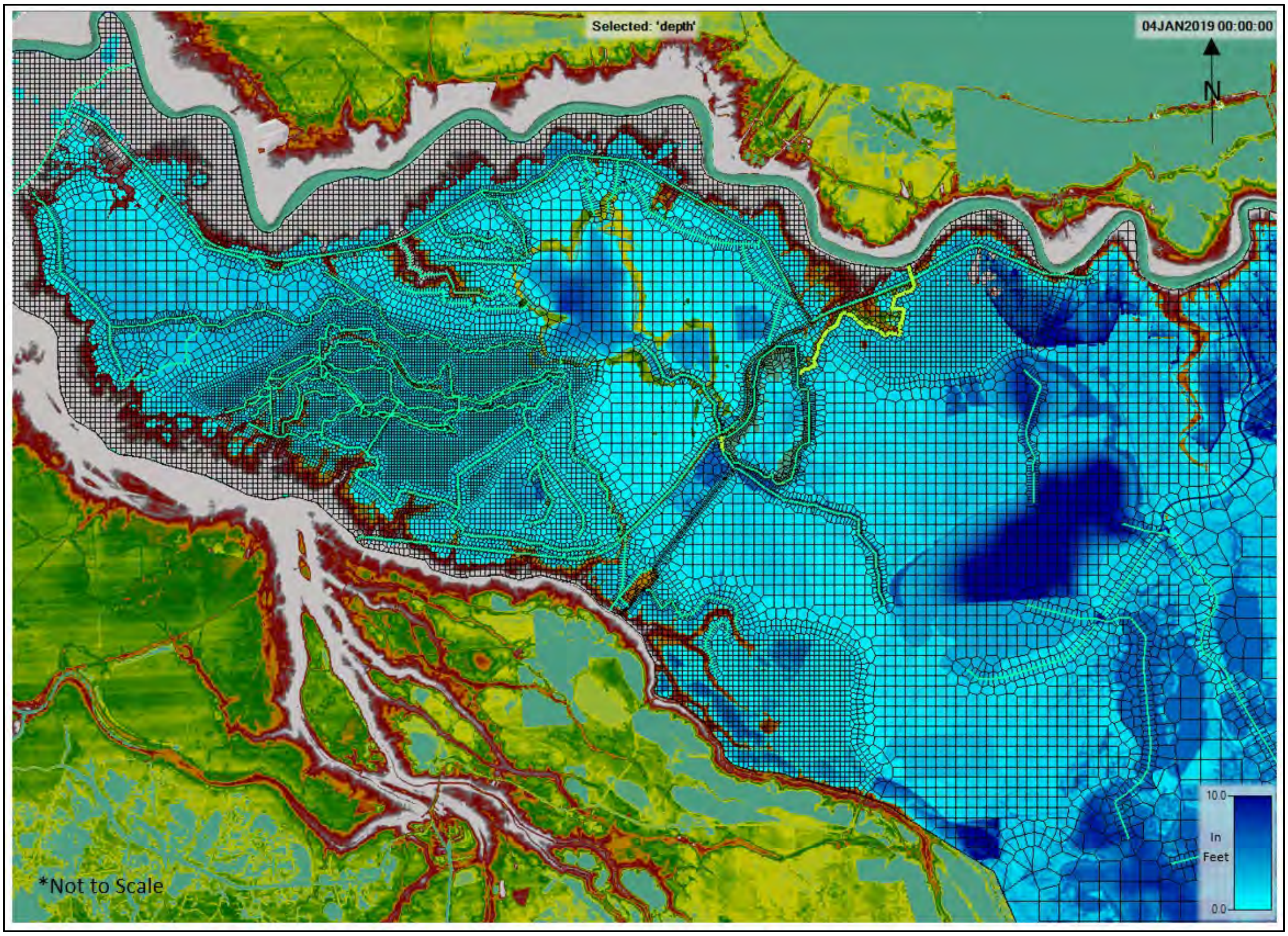


Figure 2-71: Inundation Map for the 2% AEP Rainfall Frequency Event (Future Without Project Condition)

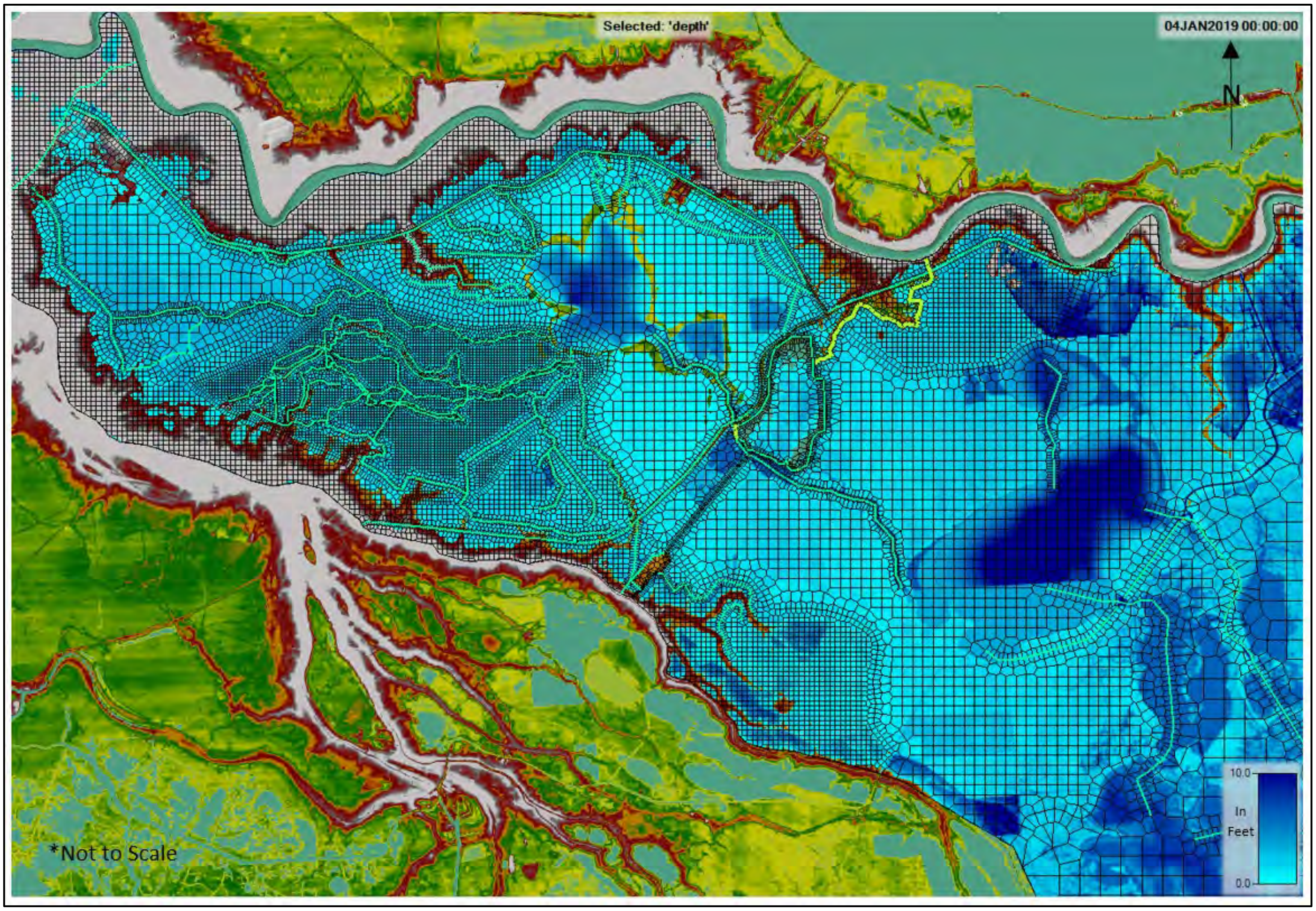


Figure 2-72: Inundation Map for the 1% AEP Rainfall Frequency Event (Future Without Project Condition)

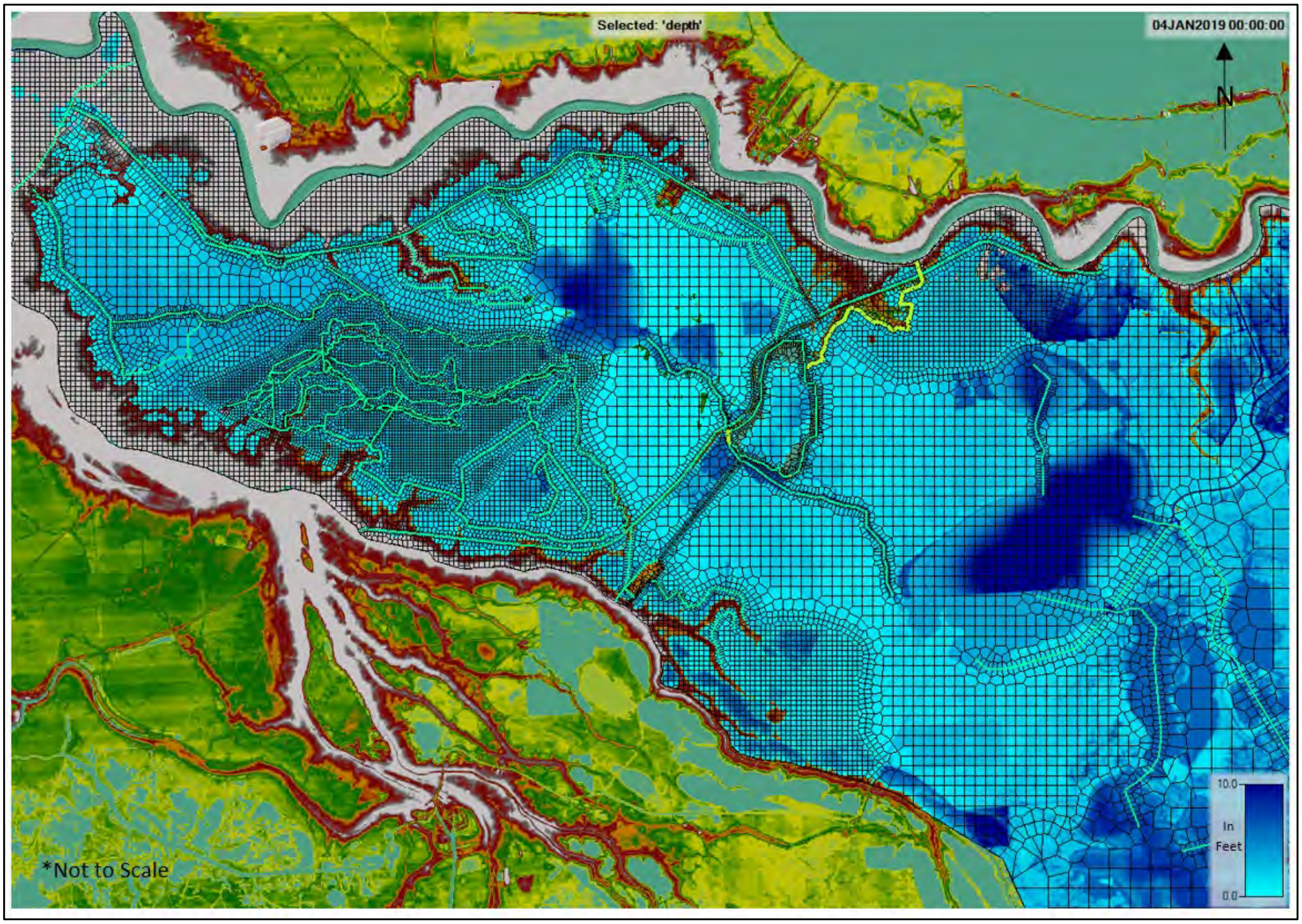


Figure 2-73: Inundation Map for the 0.5% AEP Rainfall Frequency Event (Future Without Project Condition)

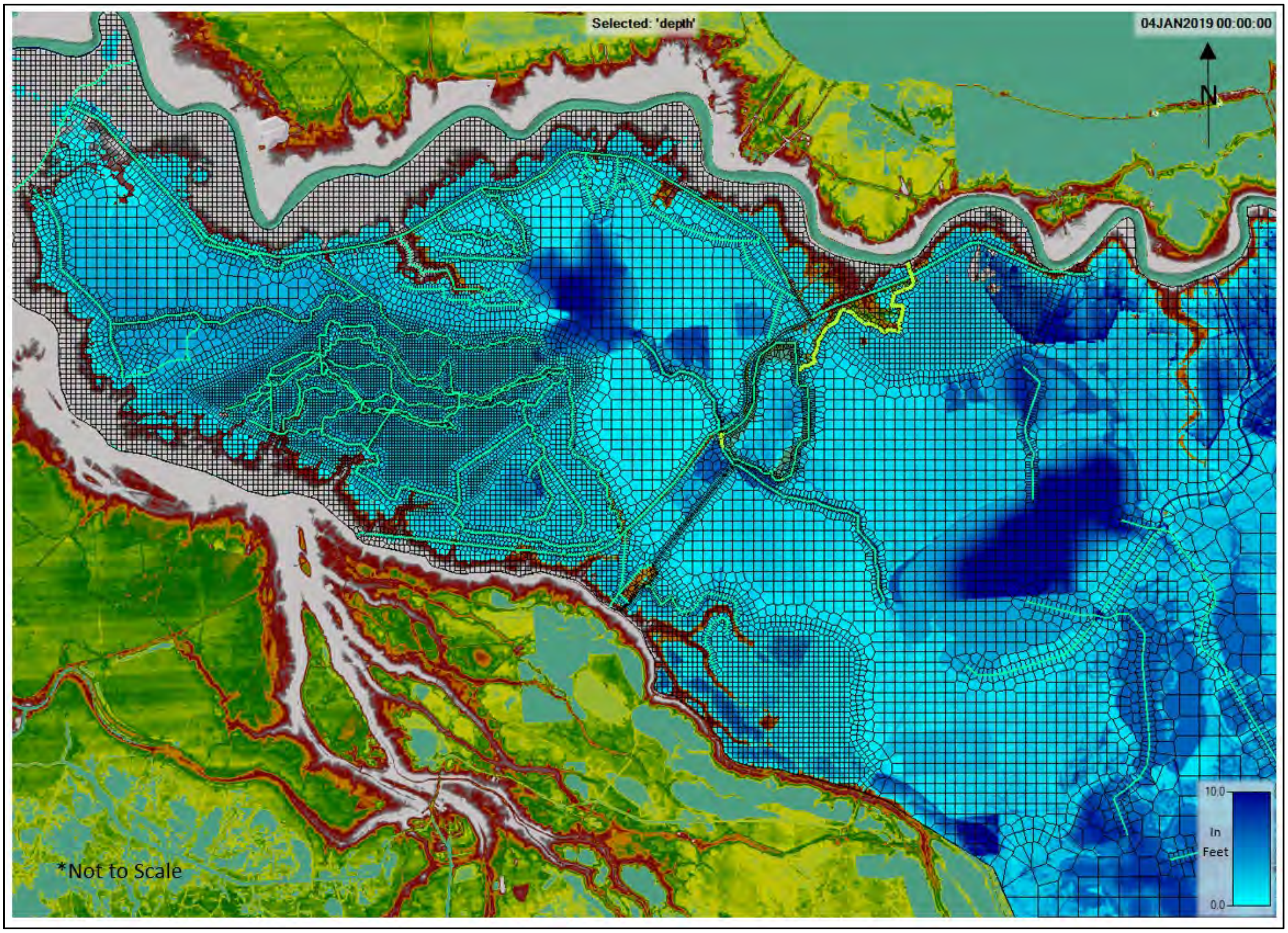


Figure 2-74: Inundation Map for the 0.2% AEP Rainfall Frequency Event (Future Without Project Condition)

2.12 Geotechnical

2.12.1 Background

Earthwork stability templates, settlement and lift schedule predictions were prepared for cost estimating purposes only. The templates and lift schedules were used for the elimination of alternatives and to determine a TSP.

The process to complete the scoping-level engineering effort started with the geotechnical evaluation of the different alignments. The geotechnical evaluation consisted of reviewing existing soil boring data, preparation of earthwork stability templates by stability analyses, settlement predictions and preparation of a lift schedule.

Geotechnical data was used to develop soil design parameters for the proposed alignments. By a comparison of the available soil properties in the project area, it was determined that the properties used in the Magnolia Ridge (a local risk-reduction project constructed by St. Charles Parish) geotechnical report, provided to the PDT by the local levee district, yielded a good general representation of the general project area. This report is relevant to this study because it is the geotechnical design for the levee on the same alignment as the study area. Soil properties from the Magnolia Ridge geotechnical report were used in the stability and settlement analyses. All elevations are referenced to the NAVD88 datum.

2.12.2 Furnished Information

One hundred and forty-three borings along the proposed alignment were available from the USACE New Orleans District database. Seven of the borings were applicable to Alternative 1, while all 143 of the borings were applicable to Alternative 2.

Local levee districts provided geotechnical reports about local levees including Willowridge, Ellington, Magnolia Ridge and Sunset. These geotechnical reports contained boring information, stability analyses and some settlement analyses. These reports can be available upon request.

2.12.3 Soil Design Reaches

Alternative 1 has five hydraulic reaches: D, E, F, G and H (see Figure 2-12 of this appendix). Hydraulic analyses were performed to determine the design levee elevations at each of these reaches. One general soils reach was used in the stability analyses and settlement predictions. Hydraulic reach D corresponds to the local Magnolia Ridge and Sunset levee reaches. Hydraulic reach E is a portion of the local Sunset levee reach. A portion of hydraulic reach F overlaps the local Sunset levee reach, while the remainder of the hydraulic reach does not correspond to any of the levee reaches.

Alternative 2 has eight hydraulic reaches: A, B, C, D, E, F, G and H (see Figure 2-13 of this appendix). A small portion of hydraulic reach A overlaps the local Willowridge levee reach. Hydraulic reach B overlaps the local Willowridge and Ellington reaches. Hydraulic reach C overlaps the local Ellington and Magnolia Ridge reaches. The locations where hydraulic reaches D, E and F overlap the local levee reaches are described above. Hydraulic reaches G and H are south of the existing St. Charles Parish Levees (there were no USACE borings available in the New Orleans District (CEMVN) database for these reaches). The Upper Barataria Basin Risk Reduction 10% Conceptual Design Report, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018, only contained two soil borings and six CPTs in hydraulic reaches G and H (which each extend for about ten miles). This lack of subsurface information was reflected in the risk register.

Alternative 10 includes four hydraulic reaches: D, E, F and G (see Figure 2-19 of this appendix), which are described above.

2.12.4 Methodology and Assumptions

The analyses were performed in accordance with the HSDRRS Design Guidelines dated 23 October 2007, with the geotechnical section updated on 14 June 2012. It should be noted that the scope of this study does not include all cases required by the HSDRRS guidelines. The scope of this study only includes an evaluation of the Q-case (i.e., undrained) parameters for the TOL, Still Water Level (SWL) and the Low Water Level (LWL). It was assumed that the SWL was two feet below the top of levee elevation, while the actual SWL will be used in the analysis after a TSP is chosen. It is assumed that the S-case (i.e., drained) parameters will be analyzed after the TSP is selected.

2.12.5 Design Information

The levee was analyzed with a crown elevation of 8.5 ft for Alternatives 1, 2, 3 and 5. The levee was analyzed for Alternatives 6, 8 and 10 with various crown elevations, including elevations of 15.0 ft, 17.0 ft, 19.0 ft, 21.0 ft and 21.5 ft. These heights were analyzed to ensure the required elevation that is needed in the year 2073 could be reached. A weighted average of all of the required hydraulic elevations was used to determine the levee elevation needed in 2073, which is elevation 18.82 ft (rounded to 19.0 ft).

Locations of the borings used in the analyses can be found in the geotechnical drawings of Annex 2 (sheets 7 through 9). Subsoil profiles of the borings used in the analyses can be found in Annex 2 geotechnical drawings (sheets 10 through 12). Design parameters used in the stability analyses can be found in Annex 2 (sheet 13). Design parameters used in the settlement calculations can be found in Annex 2 (sheets 14 and 15).

The analyses presented in the Upper Barataria Basin Risk Reduction 10% Conceptual Design Report, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018, were used to develop typical sections to compare to a floodwall option that was not selected. This report is available upon request.

2.12.6 Stability Analyses

The stability of the earthen levees was determined using soil properties from the Magnolia Ridge geotechnical report. This report was used because it appeared to be a good representation of the general soil properties in the area. The program SLOPE/W version 7.23, Build 5099 from the GeoStudio Suite of programs used the Spencer Method to determine typical levee cross sections to be used in the cost estimate. A Method of Planes analysis will be conducted after the TSP has been selected.

The earthen levees generally consist of a 10 ft-wide levee crown with 1V:4H side slopes. A simplifying assumption that the SWL was two ft below the top of the levee was used in each analysis. Stability analyses for Alternative 6 can be found in the geotechnical drawings of Annex 2 (sheets 19 through 27). Stability analyses for Alternative 8 can be found in Annex 2 (sheets 28 through 39).

One option in Alternative 10 consisted of a floodwall instead of an earthen levee. A geotechnical levee section was provided based on Section 2 of the Upper Barataria Basin Risk Reduction 10% Conceptual Design Report, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018, which corresponds to the alignment in Alternative 10 that was used for cost estimating purposes. The typical section shown on page 13 of 71 of Appendix 8 – Plan Drawings in the Upper Barataria Basin Risk Reduction 10% Conceptual Design Report, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018, was used, and can be found in Annex 2 (sheet 9). This report is available upon request.

2.12.7 Settlement Analyses

The Settle3D Version 4.013 Build date: Nov 24 2017 13:21:12, by Rocscience Inc., was used for the settlement analysis for Alternatives 1, 3, 5, 6 and 8. Embankment loads were used to model the typical levee sections found in the stability analyses. Soil properties from the Magnolia Ridge project were used to model the soil for the entire reach. This assumption was based upon the limited data available in the study area. The soil properties found in the Magnolia Ridge report were similar to available boring data in the area. It was assumed the soil was normally to slightly over-consolidated in this reach. The settlement parameters used in the settlement calculations can be found in the geotechnical drawings of Annex 2 (sheet 14). The amount of settlement was determined for each levee height. The amount of settlement was used to develop a lift schedule for Alternatives 1, 3, 5, 6 and 8. Calculations were provided for each levee lift shown on the lift schedules, since the elevation needed to be increased each time the levee was lifted so that the levee reached the required grade in the year 2073. Alternative 2 used the section and lift curve from Alternative 1 to determine the cost. Alternative 4 was eliminated from further consideration due to a lack of damages; therefore analyses were not needed. Alternative 7 consists of nonstructural features.

The lift schedule for Alternative 10 was created with a family of settlement curves based on CEMVN's experience with soft soils in southeastern Louisiana. This lift schedule was compared to several lift schedules for the HSDRRS, including but not limited to the contracts WBV-16.2 and WBV-72, near the project sites and should have similar geologic properties. The lift schedules for hydraulic reaches A, B and C used Curve 7 from the family of curves. This curve was chosen because the existing levees in this area have been there for many years and any settlement should be minimal. The lift schedules for hydraulic reaches D, E and F use Curve 5 in the year 2023, Curve 5 in the year 2038, Curve 6 in the year 2053 and Curve 7 in the year 2064. A plot of the family of settlement curves is included in Annex 2.

2.12.8 Results and Conclusions

Stability analyses and settlement calculations were used to develop the lift schedules and typical cross sections for Alternatives 1, 3, 5, 6, 8 and 10. The results of the analysis in the Upper Barataria Basin Risk Reduction 10% Conceptual Design Report, prepared by Burk-Kleinpeter, Inc. for the State of Louisiana, dated December 2018 were used to estimate the typical sections for an option in Alternative 10, which used floodwalls instead of levees. Typical cross sections for Alternatives 1, 3 and 5 consisted of a levee with a 10 ft-wide crown at elevation 8.5 ft, with 1V:4H side slopes. Typical cross sections for Alternative 2 consisted of a levee with a 10 ft wide crown at elevation 9.5 ft, with 1V:4H side slopes. Typical cross sections for Alternative 10 consisted of a levee with a 10 ft-wide crown at elevation 13 ft, with 1V:4H side slopes. The lift schedules for Alternatives 1, 3, 5, 6, 8 and 10, as well as the typical cross sections for Alternatives 6, 8 and 10 are included in Annex 2.

2.13 Civil Design

For all of the levee structural alternatives, the side slopes used were 1V:4H. The base elevations ranged from 4.0 ft to (-) 4.0 ft so, for consistency, it was decided to use a weighted average across all reaches and alternatives of 1.5 ft. For the footprint width, an additional 15 ft was added to each side to account for the vegetative free zone for maintenance purposes. Another 25 ft was added to each side for fertilizing, seeding, clearing and grubbing. Therefore, an overall distance for the seeding, mulching, fertilizing, clearing and grubbing quantities is an additional 80 ft, added to the toe-to-toe width of the levee. For silt fence quantities, the reach length was doubled, with an additional 25% added for staging areas. Hydraulic reaches A, B and C have existing levees to elevation 7.5 ft. So, for the quantities on these reaches, the cross sectional area to 7.5 ft was subtracted from the new levee section. It is assumed that a straddle lift would be placed on top of the existing levees.

For Alternative 1, the levee design height used was 7.5 ft. The MVN geotechnical designer advised the addition of one ft for settlement. This resulted in a construction grade of 8.5 ft (which was also the basis for determining the quantities). There were no additional lifts or berms required for this alternative (only one lift was needed). For Alternative 2, the design elevation was 8.5 ft, resulting in a construction elevation of 9.5 ft. There were no additional lifts or berms required for this alternative (only one lift was needed). For Alternative 3, the design elevation was 7.5 ft, resulting in a construction elevation of 8.5. There were no additional lifts or berms required for this alternative (only one lift was needed). For Alternative 5, the design elevation was 7.5 ft, which resulted in a construction elevation of 8.5 ft. There were no additional lifts or berms required for this alternative (only one lift was needed). For Alternative 6, there were four lifts and berms required. For all hydraulic reaches of Alternative 6, the first lift was scheduled to 15.0 ft in the year 2023, the second lift was scheduled to 17.0 ft in the year 2036 for hydraulic reaches A, B and C, and to 17.0 ft in the year 2034 for hydraulic reaches D, E, F, G, I and H. The third lift was scheduled to 19.0 ft in the year 2049 for hydraulic reaches A, B and C, and to 19.0 ft in the year 2047 for hydraulic reaches D, E, F, G, I and H. The fourth lift was scheduled to 21.0 ft in the year 2062 for hydraulic reaches A, B and C, and to 21.0 ft in the year 2060 for hydraulic reaches D, E, F, G, I and H. For Alternative 8, reaches A through F, the same sections and assumptions were used as in Alternative 6. However, hydraulic reaches G, I and H for Alternative 6 have a 155 ft-wide crown. For all hydraulic reaches of Alternative 8, the first lift was scheduled to 15.0 ft in the year 2023, the second lift was scheduled to 17.0 ft in the year 2051, the third lift was scheduled to 19.0 ft in the year 2059 and the fourth lift was scheduled to 20.5 ft in the year 2067.

Additional Alternative 10 was also investigated. The alternative had a design elevation of 12.0 ft, with a construction elevation of 13.0 ft to account for settlement. The base elevation was also assumed to be 1.5 ft (similar to the other alternatives). Alternative 10 consisted of hydraulic reaches A, B, C, D, E, F and G. For the alternative, the quantity for the existing levee built to elevation 7.5 ft was subtracted to account for hydraulic reaches A, B and C. For the alternative, there were four scheduled lifts in years 2023, 2050, 2053 and 2064 for hydraulic reaches D through G. Hydraulic reaches A, B and C only required three lifts each in years 2023, 2033 and 2062.

Refer to Annex 1 for a table of quantities for the seven levee structural alternatives.

2.14 Structural Design

During the review of the array of alternatives, two alternatives were selected for further analysis:

- Alternative 6, “U.S. Highway 90 Alignment – State of LA Master Plan”, was selected to provide scoping level engineering estimates for the 1% future (2073) Hydraulic design elevation for each structure, with an additional two ft of structural superiority added to the computed design elevations.

- Alternative 1, “U.S. Highway 90 - Segment 1 Extension”, was selected to provide scoping level engineering estimates for a lower level of risk reduction for each structure, with an additional two ft. of structural superiority added to the computed design elevations.

Seven representative structures were selected by the PDT to update quantities for cost based on the UBB feasibility study alternatives. These representative structures were typical of most alignments in the study area. The seven representative structures are: (1) – Railroad gate near River Road; (2) - Pump station fronting protection at Davis Pond pump station; (3) - T-wall pipeline crossing (Davis Pond Pipeline No. 2); (4) - Roller gate (LA Highway 306, Bayou Gauche Rd); (5) – 270 ft-Barge Gate; (6) - Godchaux Canal Stoplog Gate; and (7) - 6 ft x 6 ft-Sluice Gate/Box Culvert (Hydraulic Structures).

Based on information available in the “Upper Barataria Risk Reduction Conceptual Design Report, Louisiana State Coastal Master Plan Project No. 002.HP.06, dated December 2018” (State Master Plan (SMP)) and the computed design elevations, the existing quantities from the SMP design report were scaled up and/or down to reach the required elevation. This report is available upon request.

2.15 Relocations

2.15.1 General

The Fifth Amendment to the Constitution of the United States provides that just compensation will be paid for the acquisition of private property for public use. This acquisition of an interest in real estate is necessary for the Federal Government to subordinate such interest in real estate. In publicly-owned roads and utility systems, the Federal Courts have held that the liability of the United States for such acquisition is the cost of providing substitute facilities where substitute facilities are, in fact, necessary. This is the basis of the facility and utility relocation process. Therefore, it was incumbent that an investigation of the existing public utilities and facilities located within the proposed project area was conducted, while accounting for the current design requirements for the TSP. In the event that such a facility, utility, cemetery or town would affect the construction, operation, maintenance, repair, replacement or rehabilitation of a USACE project, then the appropriate disposition of the impacted facility must be determined. Some facilities may require either a permanent or temporary physical adjustment or displacement to support project activities, engineering requirements and operation and maintenance needs.

Investigating, identifying and verifying public facilities and utilities located within Alternatives 1, 2, 3, 5, 6, 8 and 10 within the project area was performed. However, for the final array, Alternatives 1, 2 and 10 were selected (see Figures 2-2, 2-3 and 2-11). Database research included the National Pipeline Database, State Online Natural Resources Information System (SONRIS), Louisiana Department of Natural Resources (LADNR), HTST-IHS, Penwell and the National Pipeline Mapping System (NPMS) data.

Based on the research and investigations conducted as part of the study effort, multiple facilities or utilities located within the project area of the aforementioned alternatives are expected to be impacted. Refer to Annex 3 for maps of the various utilities in the project area of each alternative.

2.15.2 Methodology

A review of multiple pipeline databases was used to investigate the facilities located within the project areas of the three Alternatives. During this review, no other facilities were identified except for the pipelines and associated markers in the overall project area known as the Master Plan

(Alternatives 1 and 2 combined). A site visit had not been completed. The utilities located during the preliminary investigation were cross-referenced with utilities identified in the Upper Barataria Risk Reduction Conceptual Design Report dated December 2018. The facilities that could be potentially impacted by the project were the pipelines, overhead electrical transmission lines and electrical distribution lines shown in Annex 3. The status of each pipeline was identified as either Active, Inactive, Abandoned, Removed or Proposed, according to information in the pipeline databases.

The impacts on the pipelines were based on the assumption that the Upper Barataria Levee Project will use HSDRRS criteria, dated February 2007, which addresses the following as acceptable methods of pipeline crossings: directional drilling, structural elevated support, T-wall construction and direct contact. It was decided to use the T-wall and direct contact methods for this methodology.

The T-wall construction method focuses on passing the pipeline through the T-wall, with the existing pipeline remaining in place. This method consists of constructing a pile-founded, inverted T-wall flanked by a sheet pile wall on either side to provide seepage reduction for flood control. The T-wall is built around the in-situ pipeline. This method is more conducive for pipelines that are approximately 20 ft. or less apart and are unable to bypass their right-of-way on a temporary basis. There are 3 areas in Alternative 1 and 6 areas in Alternative 2 that were identified as requiring T-walls.

With the direct contact method, the pipeline owner has the option of placing the pipeline in direct contact with the surface of the newly-constructed hurricane levee. This will require the owner to relocate the pipeline when the levee is raised because of settlement of change in design grade. The owners must also determine that the pipeline can sustain the settlement and resulting stresses that are associated with it. Slope pavement or other approved methods must be installed over the pipeline throughout the transition area. This method was assumed for single or dual pipelines that have enough space to bypass or re-route up-and-over the new levee design section.

Electric Transmission Lines in this area are assumed to meet the minimum clearance criteria over the proposed levee crossings, which is 22 ft at 50 kV, plus 0.4 inches for every 1.0 kV above 50 kV.

2.15.3 Results

The results of the facility relocations investigations shown in Table 2-2 for Alternative 1, Table 2-3 for Alternative 2 and Table 2-4 for Alternative 10 below, which includes a description of the only facilities located within the respective project areas of Alternatives 1, 2 and 10.

The estimated costs for utility relocations are as follows: For Alternative 1, $32,201,000; for Alternative 2, $43,258,000; and for Alternate 10, $28,507,000. The furnished information included the utility owner, type of utility, size, location and the number of utilities. All estimated costs for relocations are at October 2019 price levels and include a percentage of 31% for risk contingencies.

Table 2-2: Utilities within Alternative 1

	Owner	Diameter	Material	Product	Station*	
Segment 2.1						
	Bridgeline	22 in.	Steel	Natural gas	24+50	
Segment 2.5						
	Boardwalk	18 in.	Steel	Natural gas	230+00	
	Bellsouth	12 in.	Steel	Conduit	305+00	
	St. Charles Parish	4 in.	Steel	Water	305+00	
Segment 2.6						
	Chevron	6 in.	Steel	Natural gas	339+60	
	Chevron	6 in.	Steel	Natural gas liquid	339+80	
	William Energy	10 in.	Steel	Natural gas liquid	340+00	
	Chevron	14 in.	Steel	Natural gas	340+20	
	Chevron	20 in.	Steel	Liquified Petroleum Gas	340+40	
	Bridgeline	30 in.	Steel	Natural gas	340+60	
Segment 3						
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 32+13	
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 32+13	
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 32+13	
	Shell	9 in.	Steel	Crude Oil	10+00 to 32+13	
	Boardwalk	(2) 10 in.	Steel	Natural gas	10+00 to 32+13	
	Entergy	N/A	N/A	Electric Transmission	10+00 to 32+13	
Segment 4						
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 85+00	93+00
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 85+00	93+20
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 85+00	90+00
	Shell	9 in.	Steel	Crude Oil	10+00 to 85+00	91+50
	Boardwalk	(2) 10 in.	Steel	Natural gas	10+00 to 85+00	93+40
	Castex	6 in.	Steel	Unknown	10+00 to 85+00	

	Owner	Diameter	Material	Product	Station*	
	Entergy	N/A	N/A	Electric Transmission	10+00 to 85+00	91+00
Segment 5						
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 215+00	
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 215+00	
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 215+00	
	Shell	9 in.	Steel	Crude Oil	10+00 to 215+00	
	Boardwalk	12 in.	Steel	Natural gas	248+00	
	Castex	6 in.	Steel	Unknown	Unknown	
	Phillip 66	8 in.	Steel	Ethane/Propylene	92+50	
	Entergy	N/A	N/A	Overhead Electric Transmission	10+00 to 215+00	
	Transcontinental	10 in.	Steel	Gas	242+00	
	Boardwalk	12 in.	Steel	Natural gas	251+00	
	Boardwalk	10 in.	Steel	Natural gas	251+20	
	Abandoned	6.5 in.	Steel	N/A	N/A	
	Entergy	N/A	N/A	Overhead Transmission	296+00	
	Entergy	N/A	N/A	Overhead Transmission	256+00	
	Spectra	36 in.	Steel	Natural gas	337+00	
	LOOP	48 in.	Steel	Crude Oil	339+00	
	Exxon	12 in.	Steel	Crude Oil	394+90	
	Exxon	16 in.	Steel	Crude Oil	395+10	
	Entergy	N/A	N/A	Overhead Distribution	404+00	

***Stations are based on stationing used in the Upper Barataria Risk Reduction Conceptual Design Report**

Table 2-3: Utilities within Alternative 2

	Owner	Diameter	Material	Product	Station*	
Segment 1-a						
	Bridgeline	12 in.	Steel	Natural gas	77+00	
	Bridgeline	16 in.	Steel	Natural gas	76+80	
	Enterprise	10 in.	Steel	Natural gas liquids	160+20	
	Shell	24 in.	Steel	Liquid crude	159+80	
	Shell	20 in.	Steel	Liquid crude	160+00	
	Enterprise	26 in.	Steel	Natural gas	170+80	
	Boardwalk	16 in.	Steel	Natural gas	170+20	
	Evangeline	24 in.	Steel	Natural gas	Unknown	
	Nu-star	6 in.	Steel	Anhydrous ammonia	170+60	
	Atmos	24 in.	Steel	Gas	184+00	
	Quest	6 in.	Steel	Conduit	Unknown	
Segment 1-b						
	No Utilities					
Segment 1-c						
	Atmos	24 in.	Steel	Gas	10+00 to 15+00	
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 68+25	
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 68+25	
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 68+25	
	Chevron	14 in.	Steel	Liquid carbon dioxide	101+00 to 102+50	
	Columbia	16 in.	Steel	Natural gas	101+00 to 102+50	
	Bridgeline	8 in.	Steel	Natural gas	101+00 to 102+50	
	Bridgeline	14 in.	Steel	Natural gas	101+00 to 102+50	
	Bridgeline	12 in.	Steel	Natural gas	135+00	
	St. Charles Parish	20 in.	Steel	Water	147+08 to 152+00	
	St. Charles Parish	12 in.	Steel	Water	147+08 to 152+00	
	St. Charles Parish	8 in.	Steel	Water	147+08 to 152+00	
Segment 1-d						
	Bridgeline	16 in.	Steel	Natural gas	95+99 to 97+35	

	Owner	Diameter	Material	Product	Station*	
	Columbia	16 in.	Steel	Natural gas	95+99 to 97+35	
	Chevron	14 in.	Steel	Liquid carbon dioxide	95+99 to 97+35	
Segment 2.1						
	Bridgeline	22 in.	Steel	Natural gas	24+50	
Segment 2.5						
	Boardwalk	18 in.	Steel	Natural gas	230+00	
	Bellsouth	12 in.	Steel	Conduit	305+00	
	St. Charles Parish	4 in.	Steel	Water	305+00	
Segment 2.6						
	Chevron	6 in.	Steel	Natural gas	339+60	
	Chevron	6 in.	Steel	Natural gas liquid	339+80	
	William Energy	10 in.	Steel	Natural gas liquid	340+00	
	Chevron	14 in.	Steel	Natural gas	340+20	
	Chevron	20 in.	Steel	Liquified petroleum gas	340+40	
	Bridgeline	30 in.	Steel	Natural gas	340+60	
Segment 3						
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 32+13	
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 32+13	
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 32+13	
	Shell	9 in.	Steel	Crude oil	10+00 to 32+13	
	Boardwalk	(2) 10 in.	Steel	Natural gas	10+00 to 32+13	
	Entergy	N/A	N/A	Electric Transmission	10+00 to 32+13	
Segment 4						
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 85+00	
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 85+00	
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 85+00	
	Shell	9 in.	Steel	Crude oil	10+00 to 85+00	
	Boardwalk	(2) 10 in.	Steel	Natural gas	10+00 to 85+00	

	Owner	Diameter	Material	Product	Station*	
	Castex	6 in.	Steel	Unknown	10+00 to 85+00	
	Entergy	N/A	N/A	Electric Transmission	10+00 to 85+00	
Segment 5						
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 215+00	
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 215+00	
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 215+00	
	Shell	9 in.	Steel	Crude oil	10+00 to 215+00	
	Boardwalk	12 in.	Steel	Natural gas	248+00	
	Castex	6 in.	Steel	Unknown	Unknown	
	Phillip 66	8 in.	Steel	Ethane/Propylene	92+50	
	Entergy	N/A	Steel	Overhead Electric Transmission	10+00 to 215+00	
	Transcontinental	10 in.	Steel	Gas	242+00	
	Boardwalk	12 in.	Steel	Natural gas	251+00	
	Boardwalk	10 in.	Steel	Natural gas	251+20	
	Abandoned	6.5 in.	Steel	N/A	N/A	
	Entergy	N/A	Steel	Overhead Transmission	296+00	
	Entergy	N/A	Steel	Overhead Transmission	256+00	
	Spectra	36 in.	Steel	Natural gas	337+00	
	LOOP	48 in.	Steel	Crude oil	339+00	
	Exxon	12 in.	Steel	Crude oil	394+90	
	Exxon	16 in.	Steel	Crude oil	395+10	
	Entergy	N/A	N/A	Overhead Distribution	404+00	

***Stations are based on stationing used in the Upper Barataria Risk Reduction Conceptual Design Report**

Table 2-4: Utilities within Alternative 10

	Owner	Diameter	Material	Product	Station*
Segment 1-a					
	Bridgeline	12 in.	Steel	Natural gas	77+00
	Bridgeline	16 in.	Steel	Natural gas	76+80
	Enterprise	10 in.	Steel	Natural gas liquids	160+20
	Shell	24 in.	Steel	Liquid crude	159+80
	Shell	20 in.	Steel	Liquid crude	160+00
	Enterprise	26 in.	Steel	Natural gas	170+80
	Boardwalk	16 in.	Steel	Natural gas	170+20
	Evangeline	24 in.	Steel	Natural gas	Unknown
	Nu-star	6 in.	Steel	Anhydrous ammonia	170+60
	Atmos	24 in.	Steel	Gas	184+00
	Quest	6 in.	Steel	Conduit	Unknown
Segment 1-b					
	No Utilities				
Segment 1-c					
	Atmos	24 in.	Steel	Gas	10+00 to 15+00
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 68+25
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 68+25
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 68+25
	Chevron	14 in.	Steel	Liquid carbon dioxide	101+00 to 102+50
	Columbia	16 in.	Steel	Natural gas	101+00 to 102+50
	Bridgeline	8 in.	Steel	Natural gas	101+00 to 102+50
	Bridgeline	14 in.	Steel	Natural gas	101+00 to 102+50
	Bridgeline	12 in.	Steel	Natural gas	135+00
	St. Charles Parish	20 in.	Steel	Water	147+08 to 152+00
	St. Charles Parish	12 in.	Steel	Water	147+08 to 152+00
	St. Charles Parish	8 in.	Steel	Water	147+08 to 152+00
Segment 1-d					
	Bridgeline	16 in.	Steel	Natural gas	95+99 to 97+35
	Columbia	16 in.	Steel	Natural gas	95+99 to 97+35
	Chevron	14 in.	Steel	Liquid carbon dioxide	95+99 to 97+35
Segment 2.1					
	Bridgeline	22 in.	Steel	Natural gas	24+50
	Owner	**Diameter**	**Material**	**Product**	**Station***

Segment 2.5						
	Boardwalk	18 in.	Steel	Natural gas	230+00	
	Bellsouth	12 in.	Steel	Conduit	305+00	
	St. Charles Parish	4 in.	Steel	Water	305+00	
Segment 2.6						
	Chevron	6 in.	Steel	Natural gas	339+60	
	Chevron	6 in.	Steel	Natural gas liquid	339+80	
	William Energy	10 in.	Steel	Natural gas liquid	340+00	
	Chevron	14 in.	Steel	Natural gas	340+20	
	Chevron	20 in.	Steel	Liquified petroleum gas	340+40	
	Bridgeline	30 in.	Steel	Natural gas	340+60	
Segment 3						
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 32+13	
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 32+13	
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 32+13	
	Shell	9 in.	Steel	Crude oil	10+00 to 32+13	
	Boardwalk	(2) 10 in.	Steel	Natural gas	10+00 to 32+13	
	Entergy	N/A	N/A	Electric transmission	10+00 to 32+13	
Segment 4						
	Boardwalk	12 in.	Steel	Natural gas	10+00 to 85+00	
	Boardwalk	16 in.	Steel	Natural gas	10+00 to 85+00	
	Boardwalk	30 in.	Steel	Natural gas	10+00 to 85+00	
	Shell	9 in.	Steel	Crude oil	10+00 to 85+00	
	Boardwalk	(2) 10 in.	Steel	Natural gas	10+00 to 85+00	
	Castex	6 in.	Steel	Unknown	10+00 to 85+00	
	Entergy	N/A	N/A	Electric transmission	10+00 to 85+00	

***Stations are based on stationing used in the Upper Barataria Risk Reduction Conceptual Design Report**

2.15.4 Pipeline Owners

There are multiple pipelines within the project area of the alternatives mentioned above. These pipelines cross project access corridors or run parallel to the proposed flood risk reduction alignments, as described in the general description of Section 2.15.1. Refer to Tables 2-2, 2-3 and 2-4, as well as Annex 3 for more information.

2.15.5 Conclusions

Based on the preliminary findings of the relocations investigation, it was determined that the existing pipelines within the project area of these alternatives **will** be impacted, either requiring relocation of the utilities affected, or requiring pipeline protection over the affected utilities during construction. In such situations, CEMVN will incorporate the relocations process towards compensability and coordinate with utility owners throughout the design and development of the plans and specifications.

2.16 Cost Estimates (Final Array of Alternatives)

2.16.1 Cost Estimate Development

Cost estimates for the final array of structural alternatives (Alternatives 1, 2 and 10) were developed at a Class 4 Level of effort using largely parametric unit prices from sources such as historical Government and Commercial bid data, Architect/Engineer (A/E) cost estimates available from design reports, the 2019 Gordian/RS Means Cost Data Books and other available historical cost data. For developing costs for certain levee construction items such as "Clearing and Grubbing" and "Embankment, Compacted Fill", the standard approaches for developing a feasibility cost regarding cost elements such as labor, equipment, materials, crews, unit prices, subcontractor and prime contractor markups were used. The Lafourche Basin Levee District Upper Barataria Risk Reduction Conceptual Design Report (LBLDDR), dated December 2018, was very useful to the feasibility study in developing costs for structural features of work. The LBLDDR had already developed 10% conceptual designs for all structures in an alignment that would span from the Mississippi River to Raceland, LA and mimic very closely the alignment paths of the final array of structural alternatives, but used a higher design elevation for the structures of 14.5 ft. It was decided by the Project Delivery Team (PDT) that any LBLDDR structure type that was within the same path along the alternatives' alignments would also be included in that alternative alignment. The A/E cost estimates from the LBLDDR included itemized quantities in sufficient detail as to be useful in prorating the quantities for eight representative structures (Davis Pond Pump Station Fronting Protection, Union Pacific Railroad Gate, Tidal Exchange Structure #1, 270 ft Barge Gate, 45 ft Roller Gate, 20 ft Stop Log Gate, Large Hydraulic Structure and Davis Pond Diversion Pipeline #2 T-wall) at the new design elevation for each alternative. Unit costs for the representative structures were reviewed for reasonableness and applied to the revised quantities to develop new total costs for the representative structures. The cost factor differential for each representative structure was applied to other similar structures within each alignment. In the final step, the cost of each structure was escalated to 4th quarter 2019 pricing to develop new costs for all structures. There are eight pump station structures included in the LBLDDR alignment (Davis Pond, Willowdale, Willowridge, Cousins, Kellogg, Ellington, Magnolia Ridge and Crawford Canal) which are all located within St. Charles Parish, LA. Seven of these pump stations are existing, and the Magnolia Ridge Pump Station is presently being constructed. The hydraulics designer determined no new pump stations will be required for any of the final array of alternatives, but costs for new fronting protection for these pump stations will be included where necessary based upon the design elevation requirement for each alternative.

The cost estimates for the non-structural alternative (Alternative 7) were developed by the PDT economist and the cost engineer. These estimates are discussed in Section 2.7 of this appendix, as well as the Main Report and the Economics Appendix.

Refer to Cost Appendix H for detailed information regarding cost estimate development for each alternative in the final array (including assumptions and methodologies).

2.16.2 Cost Estimates

Tables 2-5 through 2-7 show the baseline project cost for each structural alternative in the final array. All costs are at October 2019 price levels.

***Table 2-5: Alternative 1 – U.S. Highway 90 – Segment 1 Extension**

Feature	Cost	Contingency	Total
01 Lands and Damages	$3,907,000	$977,000	$4,884,000
02 Relocations	$21,434,000	$6,587,000	$28,021,000
06 Fish and Wildlife Facilities	$57,557,000	$17,689,000	$75,246,000
11 Levees and Floodwalls	$140,569,000	$43,201,000	$183,770,000
15 Floodway Control and Diversion Structures	$86,519,000	$26,590,000	$113,109,000
18 Cultural Resources Preservation	$682,000	$210,000	$892,000
30 Planning, Engineering and Design	$50,947,000	$15,658,000	$66,605,000
31 Construction Management	$27,337,000	$8,402,000	$35,739,000
TOTAL	$388,952,000	$119,314,000	**$508,266,000**

***Table 2-6: Alternative 2 – U.S. Highway 90 – Full Alignment**

Feature	Cost	Contingency	Total
01 Lands and Damages	$4,743,000	$1,186,000	$5,929,000
02 Relocations	$29,226,000	$9,001,000	$38,277,000
06 Fish and Wildlife Facilities	$75,818,000	$23,350,000	$99,168,000
11 Levees and Floodwalls	$196,480,000	$60,510,000	$256,990,000
15 Floodway Control and Diversion Structures	$95,748,000	$29,488,000	$125,236,000
18 Cultural Resources Preservation	$694,000	$214,000	$908,000
30 Planning, Engineering and Design	$65,898,000	$20,295,000	$86,193,000
31 Construction Management	$35,360,000	$10,890,000	$46,250,000
TOTAL	$503,967,000	$154,934,000	**$658,901,000**

***Table 2-7: Alternative 10 – 1% AEP Open Basin**

Feature	Cost	Contingency	Total

01 Lands and Damages	$5,365,000	$1,341,000	$6,706,000
02 Relocations	$19,270,000	$5,916,000	$25,186,000
06 Fish and Wildlife Facilities	$55,920,000	$17,167,000	$73,087,000
11 Levees and Floodwalls	$371,317,000	$113,994,000	$485,311,000
15 Floodway Control and Diversion Structures	$88,383,000	$27,134,000	$115,517,000
18 Cultural Resources Preservation	$853,000	$262,000	$1,115,000
30 Planning, Engineering and Design	$98,189,000	$30,144,000	$128,333,000
31 Construction Management	$52,687,000	$16,175,000	$68,862,000
TOTAL	$691,984,000	$212,133,000	**$904,117,000**

* All costs for Tables 2-5 through 2-7 above do not include costs for armoring.

The total baseline project cost for the nonstructural alternative (Alternative 7) is $1,568,912,000.

2.17 Final Array of Alternatives

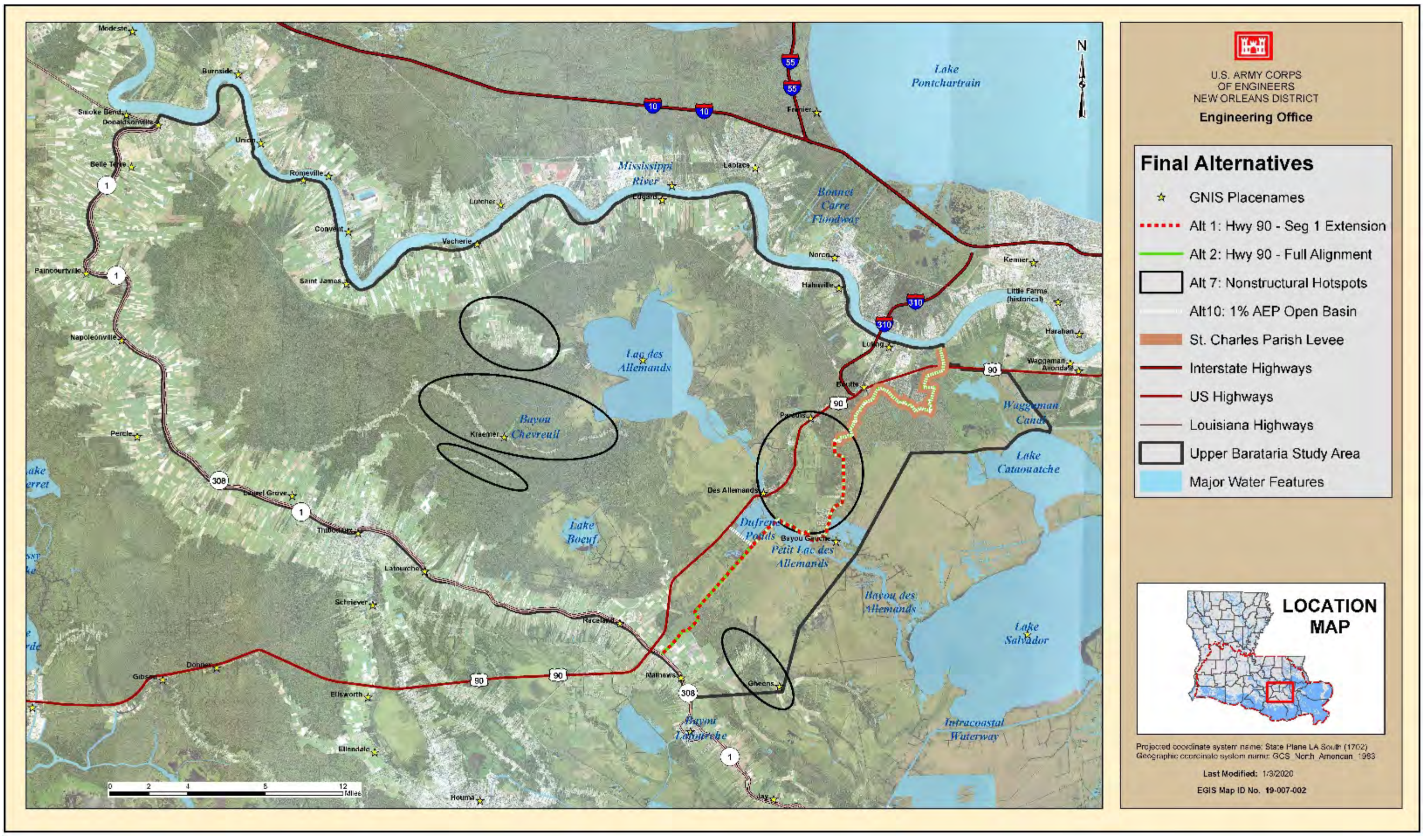


Figure 2-75: Final Array of Alternatives

The final array of alternatives, from which a TSP was selected, consisted of Alternatives 1, 2, 7, 10 and the future without project conditions.

The final array of alternatives were compared based on a variety of factors such as input from economics, hydraulic impacts and non-Federal sponsor coordination. Alternatives 1 and 2 were found to have positive net benefits. Alternatives 3, 4, 5, 6, 8 and 9 were eliminated from the detailed analysis. Alternative 7 (the nonstructural alternative) was not economically justified as a standalone alternative. Alternative 10 was eliminated from consideration due to a further economic adjustment, which yielded a B/C ratio of less than 1.0. Alternative 1, the U.S. Highway 90 Alignment – Segment 1 Extension, was selected from the final array to be the TSP due to higher positive net benefits than Alternative 2.

Refer to Cost Appendix H for detailed information regarding armoring costs of the TSP (including the existing St. Charles Parish levee).

Refer to Section 1 of this appendix for more information regarding the TSP, including optimization during Feasibility-Level design, in conjunction with new hydraulic information from Future With Project (FWP) Conditions, along with associated overtopping conditions, and the possible use of nonstructural measures in specific targeted populated areas.