UPPER BARATARIA BASIN, LOUISIANA

DRAFT FEASIBILITY REPORT

AND

INTEGRATED ENVIRONMENTAL IMPACT STATEMENT

ENGINEERING

APPENDIX A

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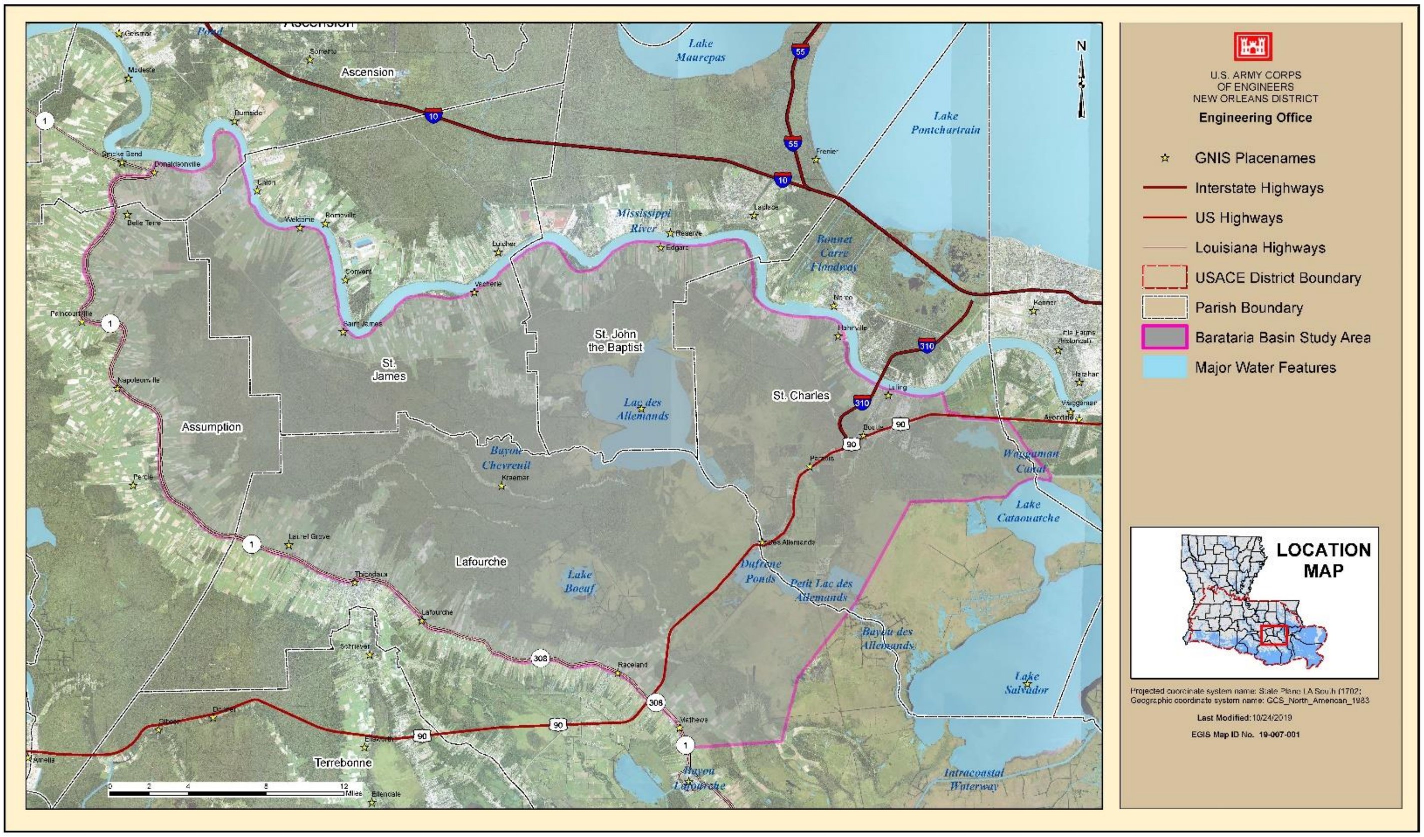
ANNEXES

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). The Engineering Appendix is presented in two sections: Section 1 describes the TSP, including details that will be developed during further design analysis, 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 TENTATIVELY SELECTED PLAN (TSP)

Information provided herein describes the details of the TSP. The TSP provides approximately a 2% Annual Exceedance Probability (AEP) level of risk reduction in the Baseline Year of 2023. 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 2023 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.

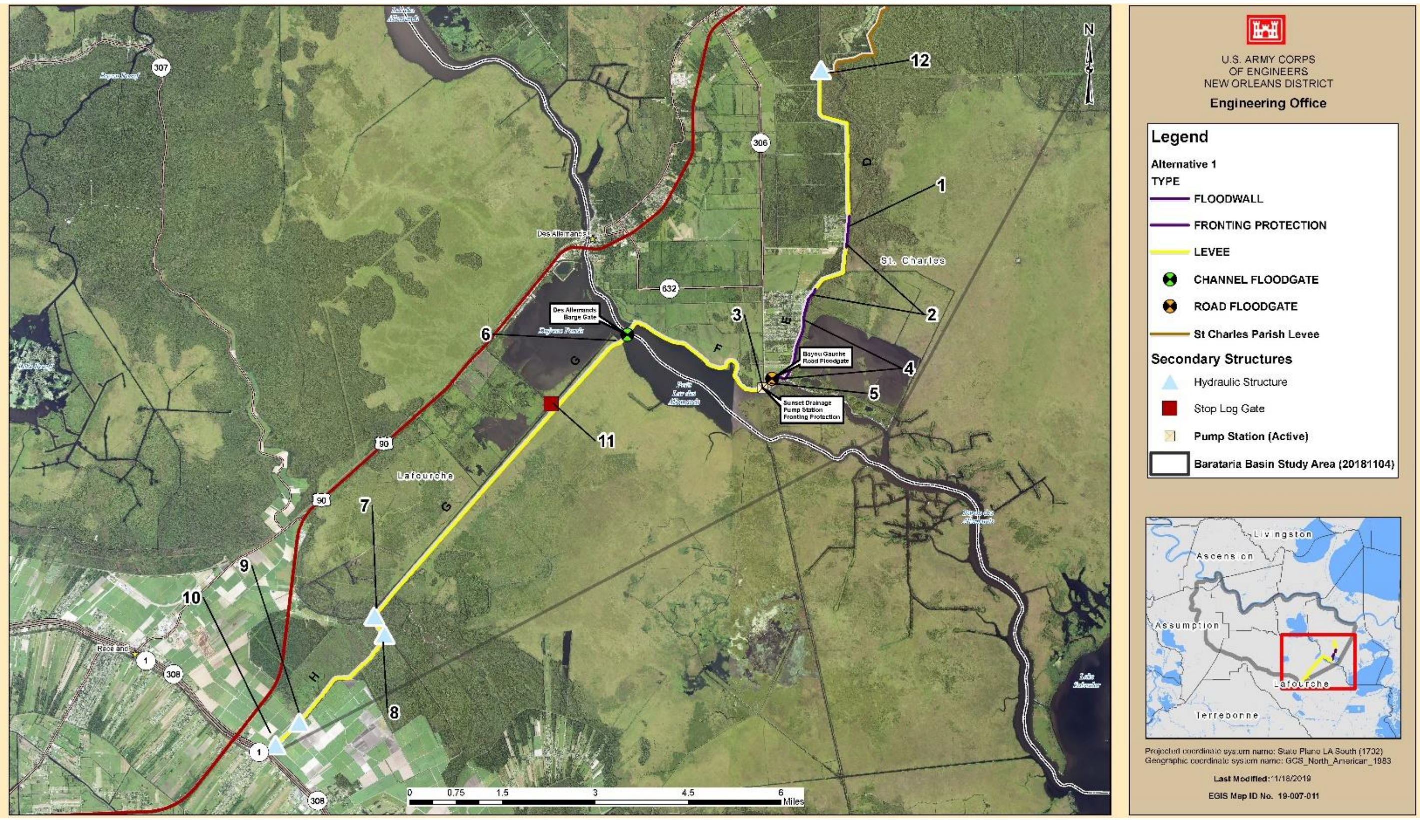


Figure 1-1: Overview of TSP (Alternative 1)

Table 1-1 (Features Listed in Figure 1-1 – Overview Map of TSP)

Numbered Feature on Map	Feature Description
1	Floodwall Section in Hydraulic Reach D
2	Floodwall Section in Hydraulic Reaches D and E
3	Crawford Canal Pump Station Fronting Protection
4	Floodwall Section in Hydraulic Reaches E and F
5	45 ft. Bayou Gauche Roller Gate
6	270 ft. Barge Gate Crossing Bayou Des Allemands
7	Drainage Structure – (4) 6 ft. x 6 ft. Reinforced Concrete Box Culverts with Sluice Gates
8	Drainage Structure – (4) 6 ft. x 6 ft. Reinforced Concrete Box Culverts with Sluice Gates
9	Drainage Structure – (2) 84 in. Diameter Reinforced Concrete Pipe Culverts with Sluice Gates
10	Drainage Structure – (1) 60 in. Diameter Reinforced Concrete Pipe Culvert with Sluice Gates
11	Stop Log Gate at Godchaux Canal (Using Access Road)
12	Paradis Control Structure

The TSP (known as Alternative 1 – U.S. Highway 90 - Segment 1 Extension) for the UBB study includes the construction of an approximately 15.94 mile (approximately 84,158 linear ft) levee system near the communities of Boutte, Paradis, Des Allemands and Raceland. This system also includes the construction of localized flood risk reduction measures in various places throughout the UBB. An overview of the TSP is shown in Figure 1-1.

All elevations are referenced to the North American Vertical Datum of 1988 (NAVD 88 (2004.65)), unless otherwise noted.

1.1 Levee System

The earthen 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 construction of the structural levee component of the project, hereafter referred to as the "levee system", would be based on approximately a 2% AEP level of risk reduction and a year 2023 intermediate Relative Sea Level Rise (RSLR) condition. The levee was 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 consisted of earthen levees, including 1 Vertical on 4 Horizontal (1V:4H) side slopes and a 10 ft-wide crown, with a design elevation of 7.5 ft (the construction grade elevation would be 8.5 ft, to allow for settlement) along the alignment. An average ground surface elevation of 1.5 ft was used to calculate the required earthen embankment quantity, needed for levee construction, of 1,086,096 cubic yards (CY).

Available borrow source sites were estimated to be within 15 miles of where U.S. Highway 90 crosses Bayou Des Allemands. Potential borrow sites were also 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. One of these sites is known as the Raceland Raw Sugar Borrow Pits.

1.2 Floodwalls and Floodgates

Floodwalls (T-walls), comprising a total of 12,253 linear ft, east of Des Allemands along the Paradis Canal, 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. Structural superiority will be followed and applied where applicable along the alignment.

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.

1.3 Pump Stations

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

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.

Hydrologic connectivity would be maintained to the extent practicable through water control structures, except during closure for hurricanes or tropical storms. The risk reduction system is only authorized to address storm surge caused by hurricane and tropical storm events. It is not authorized to mitigate for or reduce impacts caused by higher day-to-day water levels brought about by increases in sea level rise. Rainfall events and high tides could still cause significant flooding of the swamps within the levee-enclosed 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 NEPA documentation and/or permit approvals.

1.5 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.

1.6 Armoring

Armoring will consist of the typical High Performance Turf Reinforcement Mat (HPTRM), similar to that used in the HSDRRS standards, that will be anchored in a 1 ft-deep trench on the flood side slope, extending across the crown and down the land side slope, extending past the levee toe by 15 ft, where it will be anchored in a 1 ft-deep trench. The HPTRM will then be covered by Bermuda sod. Concrete armoring may need to be laid in the areas of highest risk.

1.7 Nonstructural Measures

Inclusion of nonstructural measures in the TSP will be investigated in the design phase.

1.8 Hydrology and Hydraulics

Refer to Section 2.11 of this appendix for information regarding the exterior and interior analysis for the levee design. Figure 1-2 shows the levee hydraulic reaches that applied to the TSP.

1.9 Geotechnical

Refer to Section 2.12 of this appendix for information regarding the analysis for the levee design.

1.10 Civil Design

Refer to Section 2.13 of this appendix for information regarding the analysis for the levee design.

1.11 Structural Design

Refer to Section 2.14 of this appendix for information regarding the analysis for the structures design.

1.12 Relocations

Refer to Section 2.15 of this appendix for information regarding relocations.

1.13 Cost Estimates

Refer to Section 2.16 of this appendix for information regarding cost estimates.

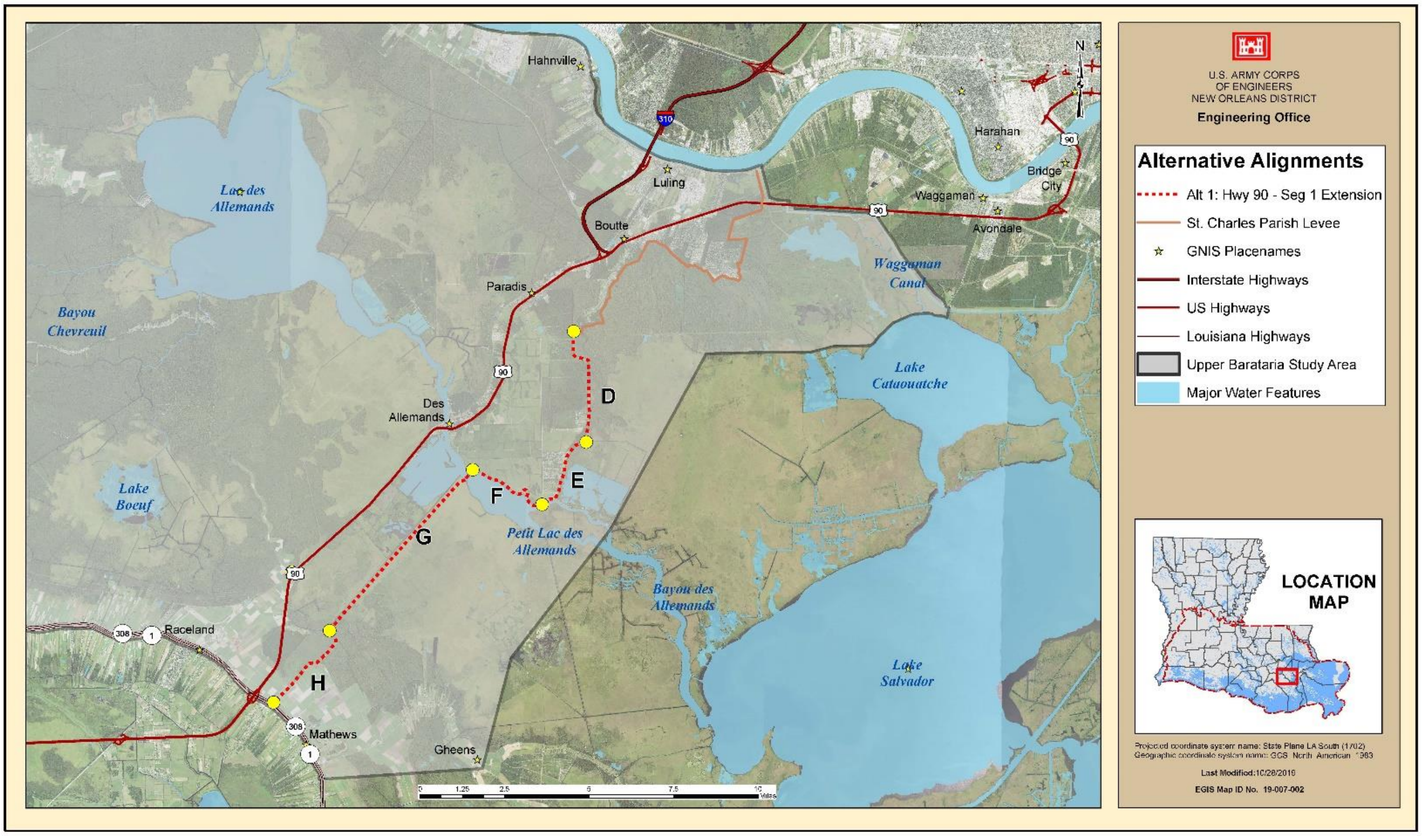


Figure 1-2: TSP (Alternative 1) Levee Hydraulic Reaches

1.14 Access for Construction

Figure 1-3: Levee Access Road No. 1

Reach H and a portion of Reach G will be accessed using Amerada Hess Road.

Reach G will be accessed from U.S. Highway 90 by constructing a permanent access route (7,925 ft long) to the alignment just southwest of Dufrene Ponds (the red route in Figure 1-3 above).

Reach F will be accessed by constructing an 8,293 ft-long temporary access route from 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 red route in Figure 1-4 below).

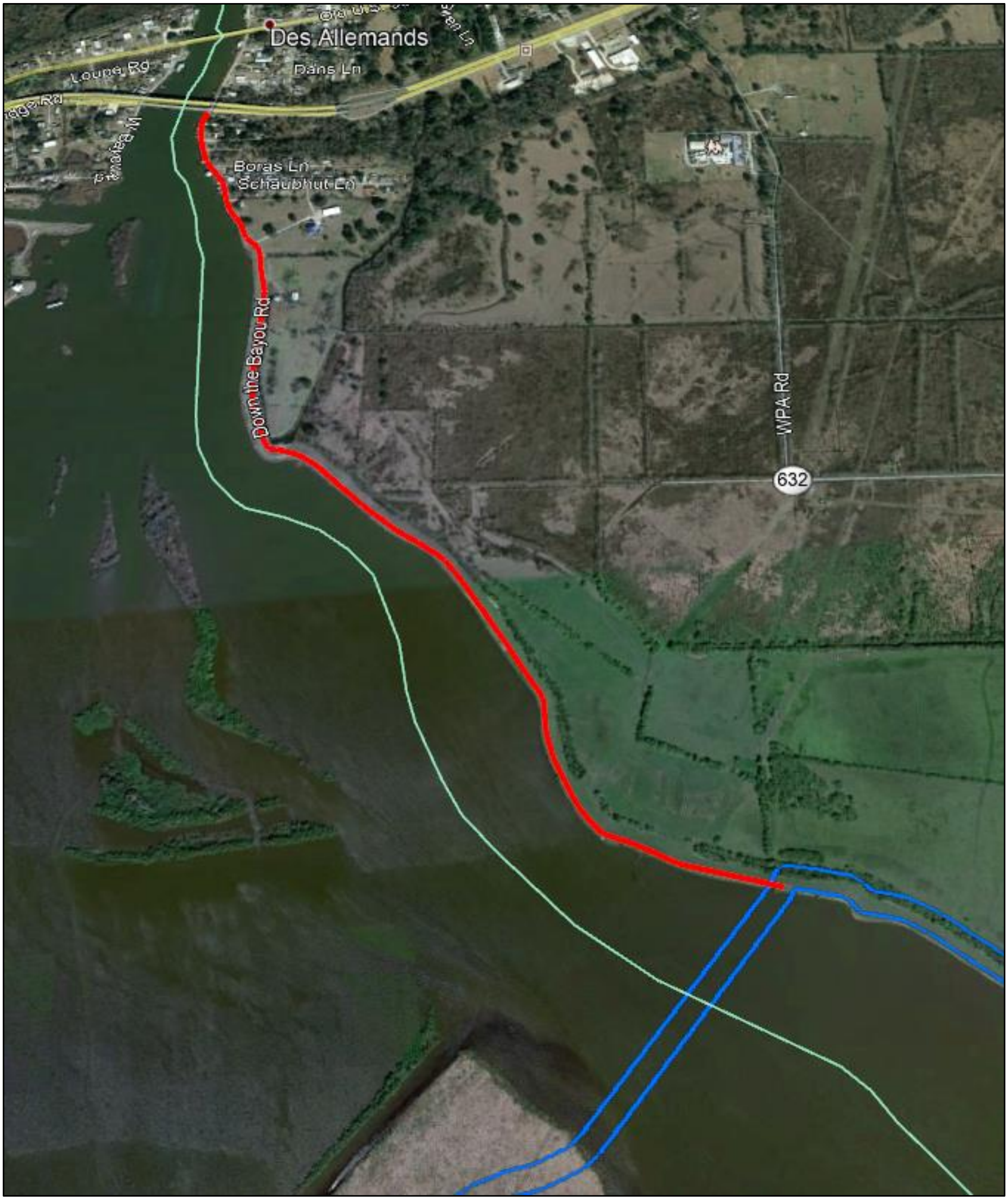


Figure 1-4: Levee Access Road No. 2

Reach E will be accessed from Highway 306 (Bayou Gauche Road).

Reach D will be accessed using a temporary access route (1,527 linear ft long), located between Highway 632 and the Paradis Canal (the red route in Figure 1-5 below).

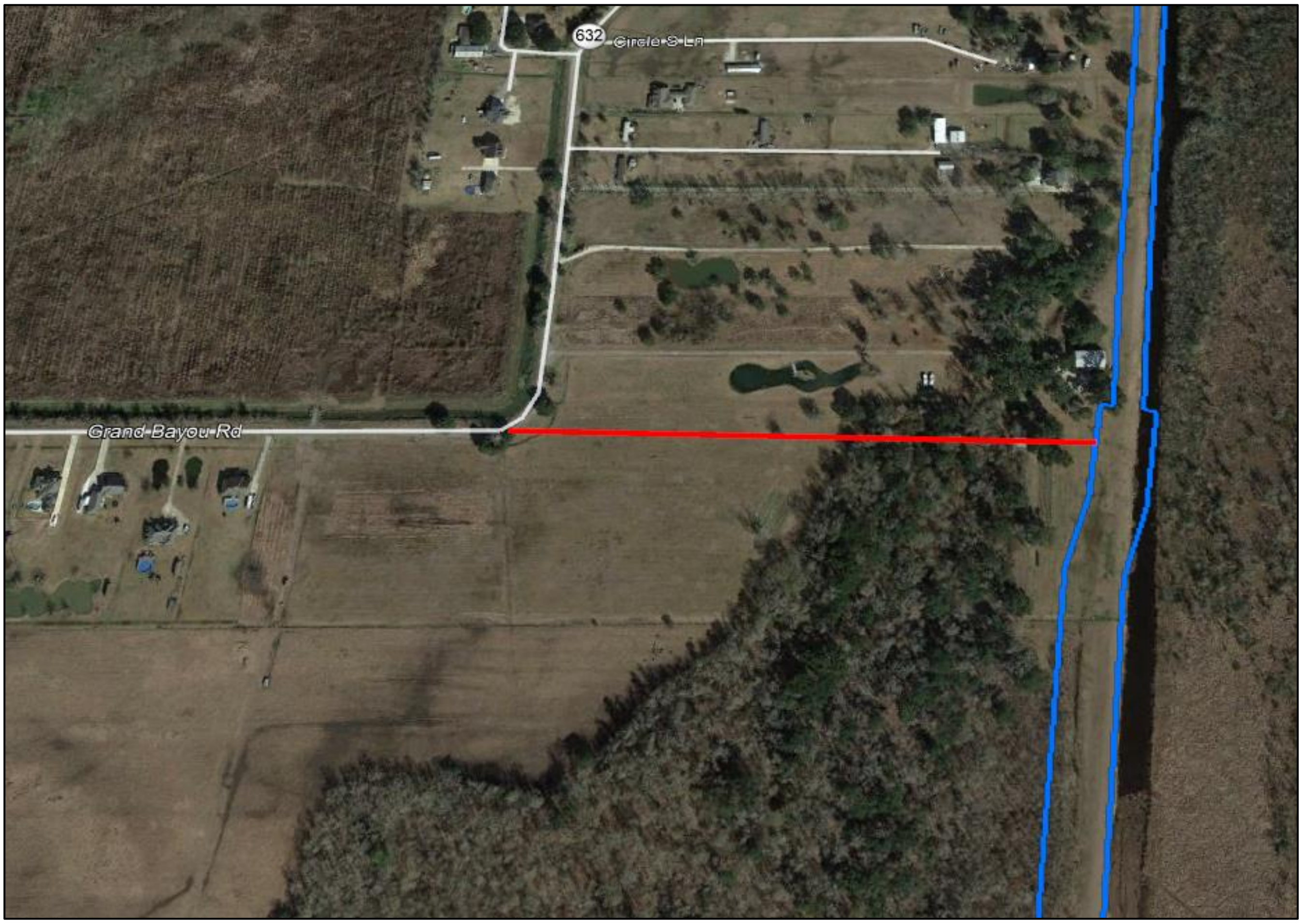


Figure 1-5: Levee Access Road No. 3

Staging area details will be finalized in the design phase.

Type of Equipment: Construction equipment details will be finalized in the design phase.

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).

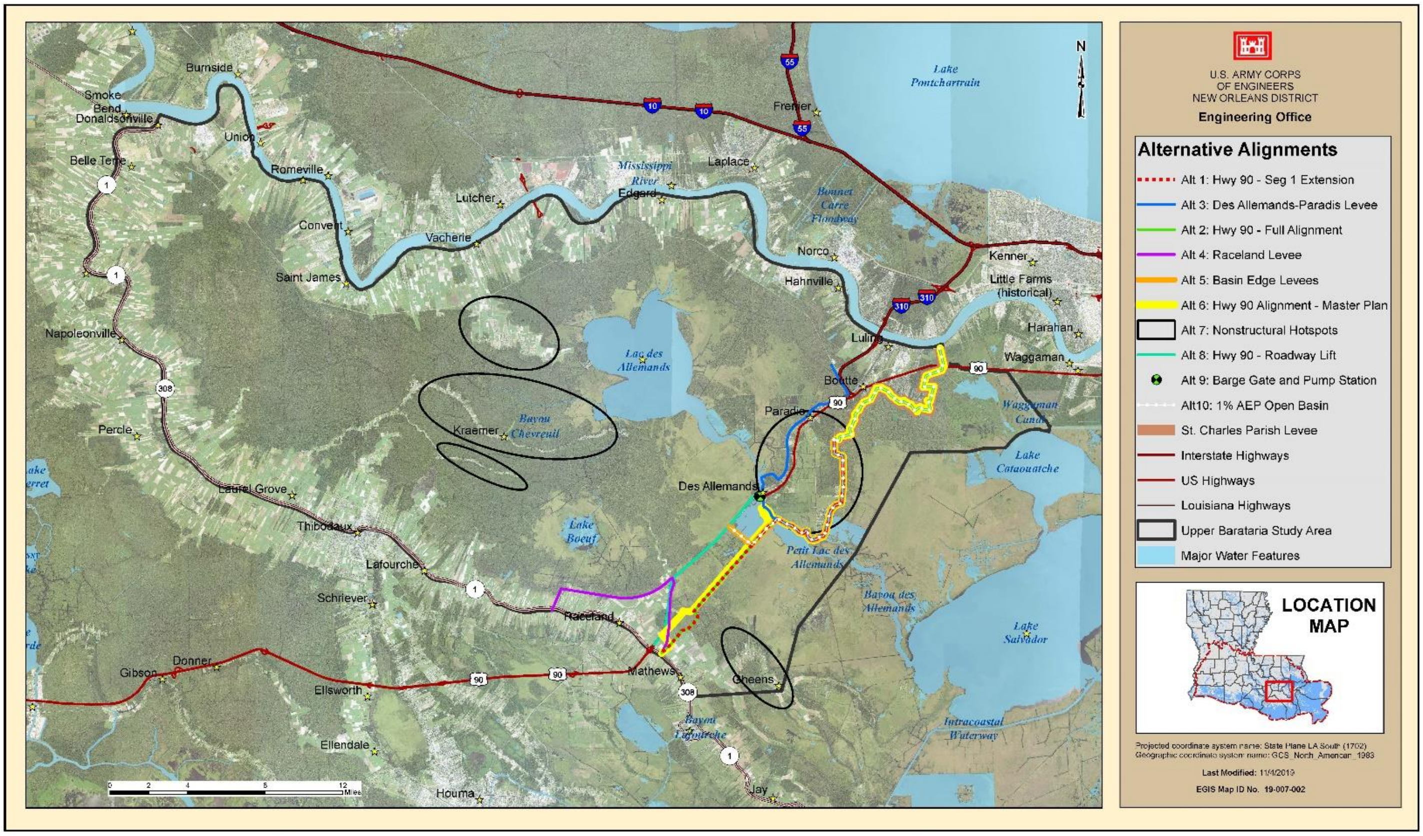


Figure 2-1: The Ten Alternative Alignments

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 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

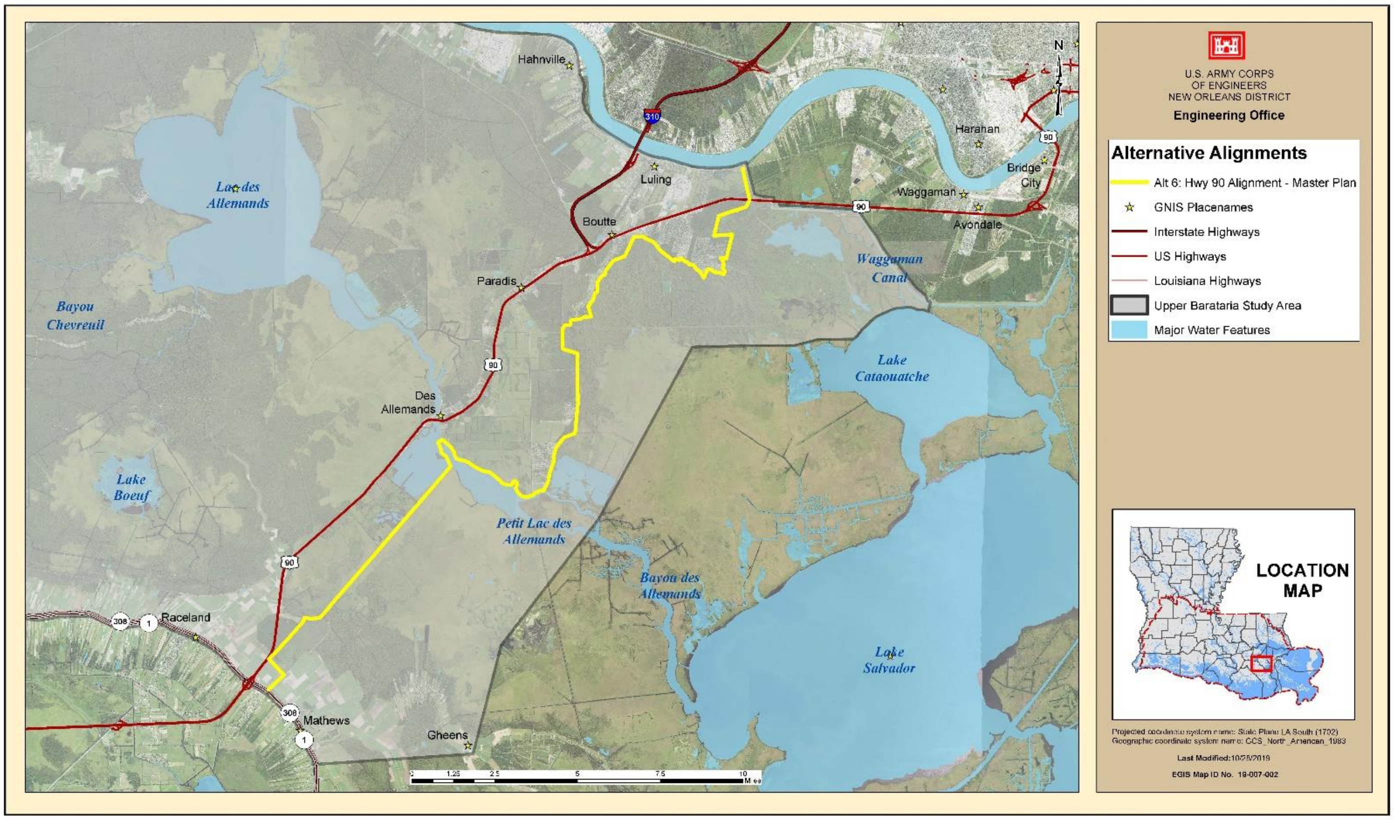


Figure 2-7: Alternative 6 – U.S. Highway 90 Alignment – State of LA Master Plan

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

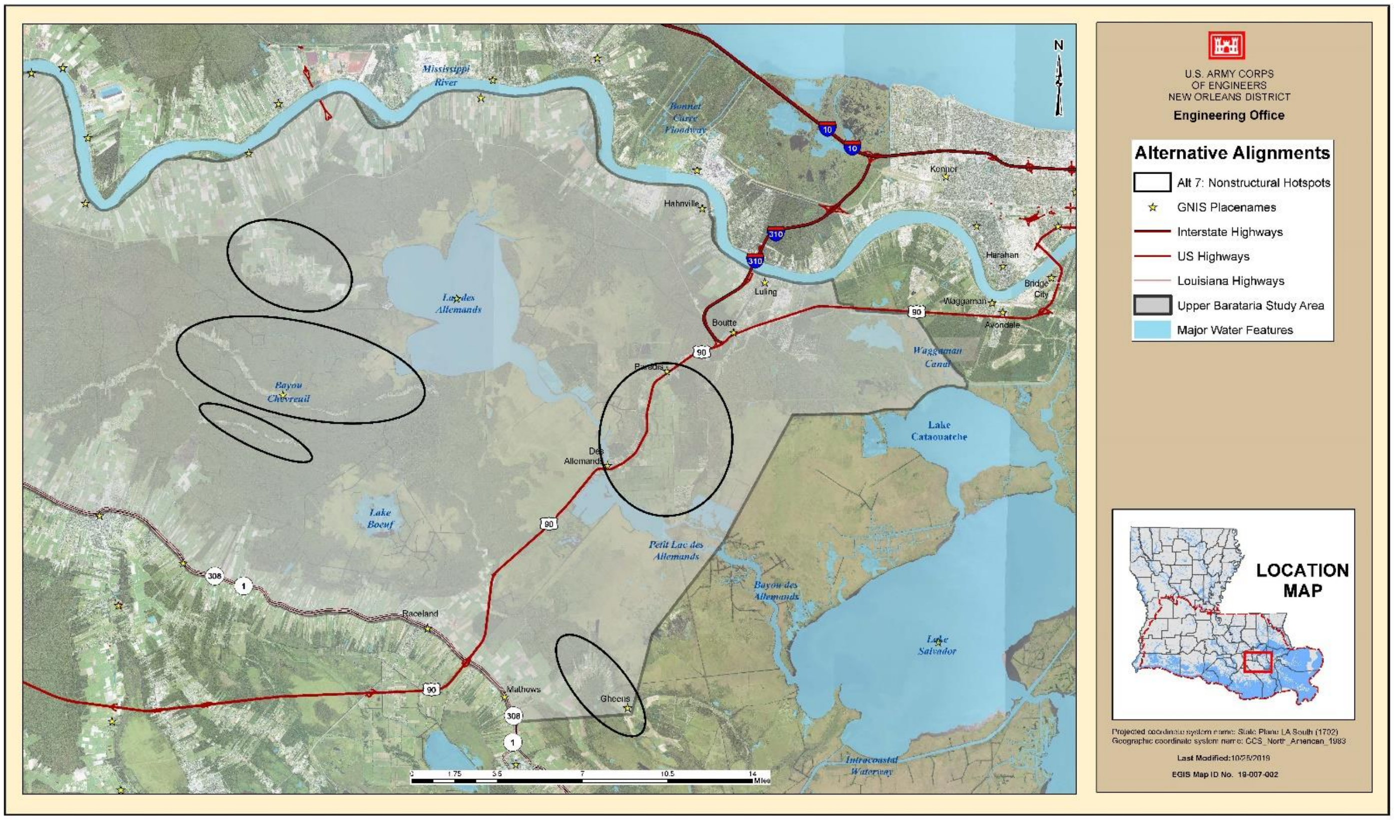


Figure 2-8: Alternative 7 – Nonstructural Measures (Hotspots)

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 $10,000 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 $10,000 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

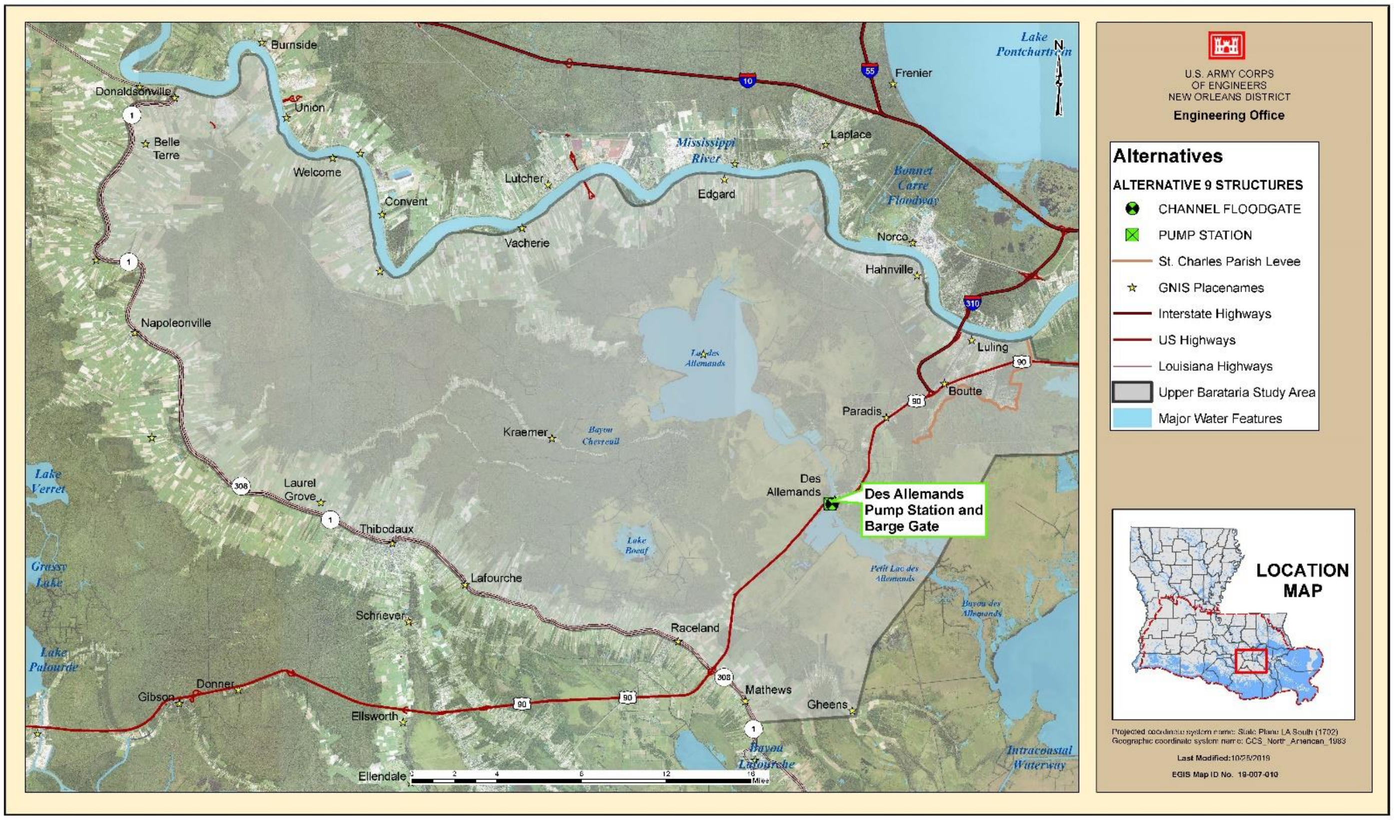


Figure 2-10: Alternative 9 – Basin Rainfall Alternative

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

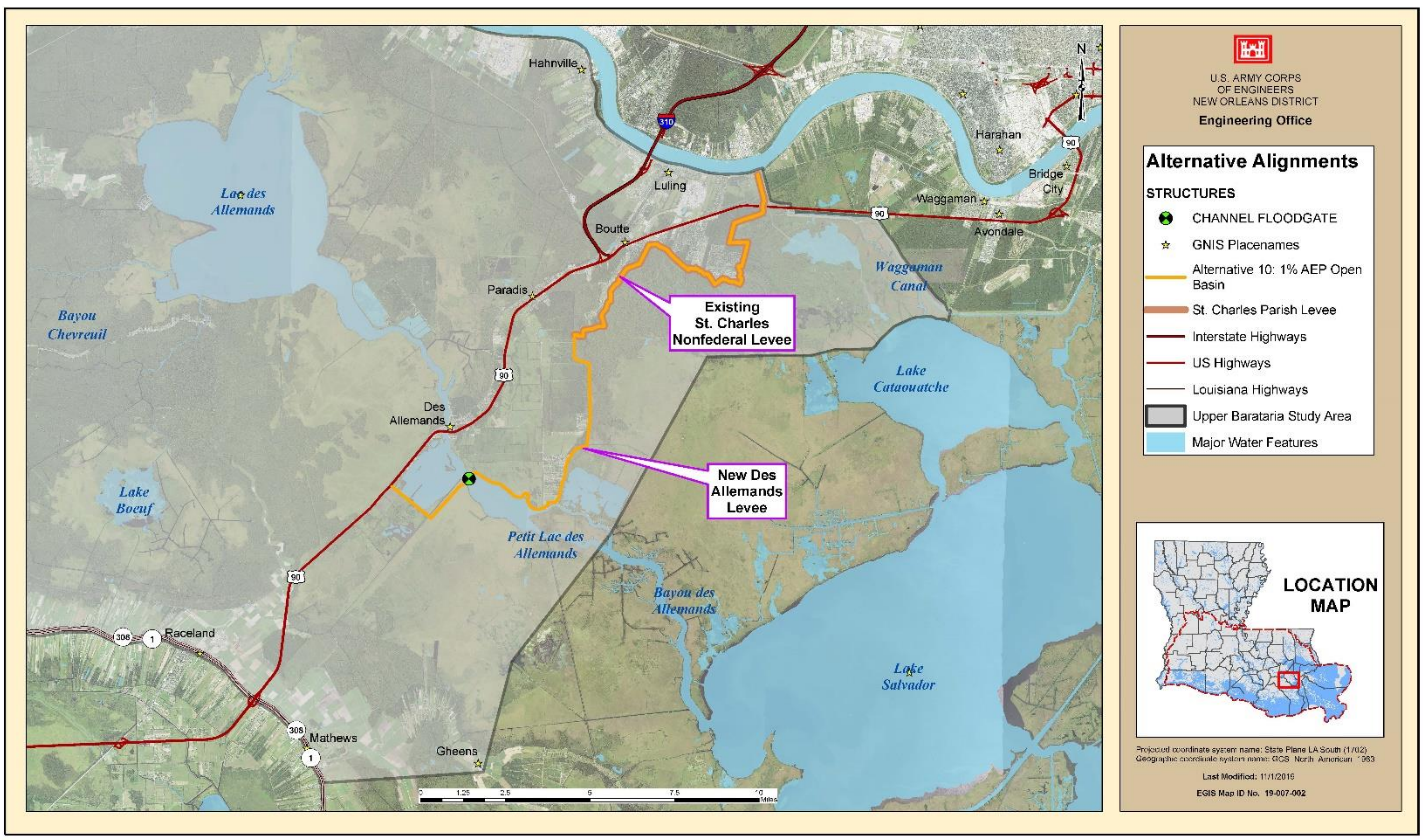


Figure 2-11: Alternative 10 – 1% AEP Open Basin Alternative

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.

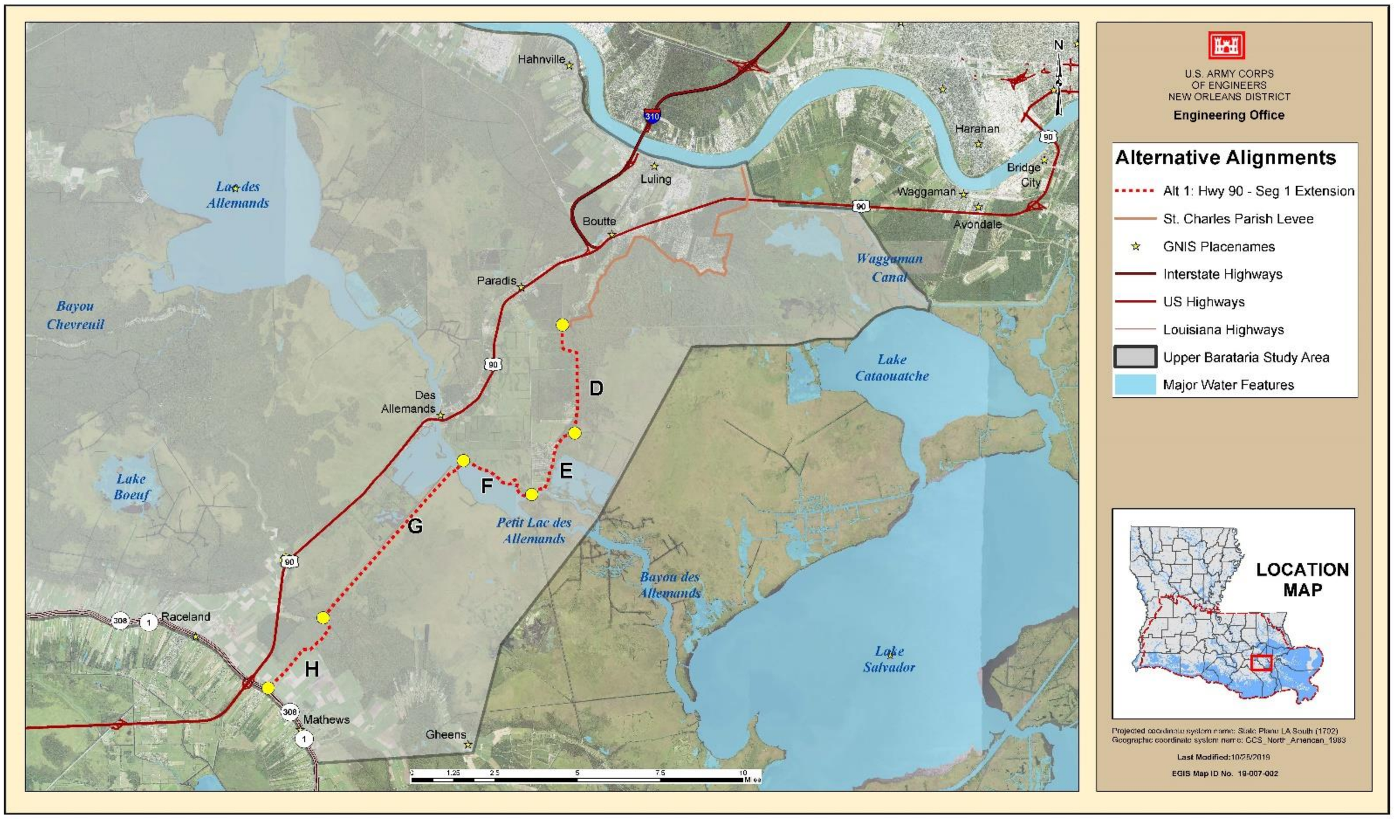


Figure 2-12: Alternative 1 – U.S. Highway 90 – Segment 1 Extension – With Hydraulic Reaches

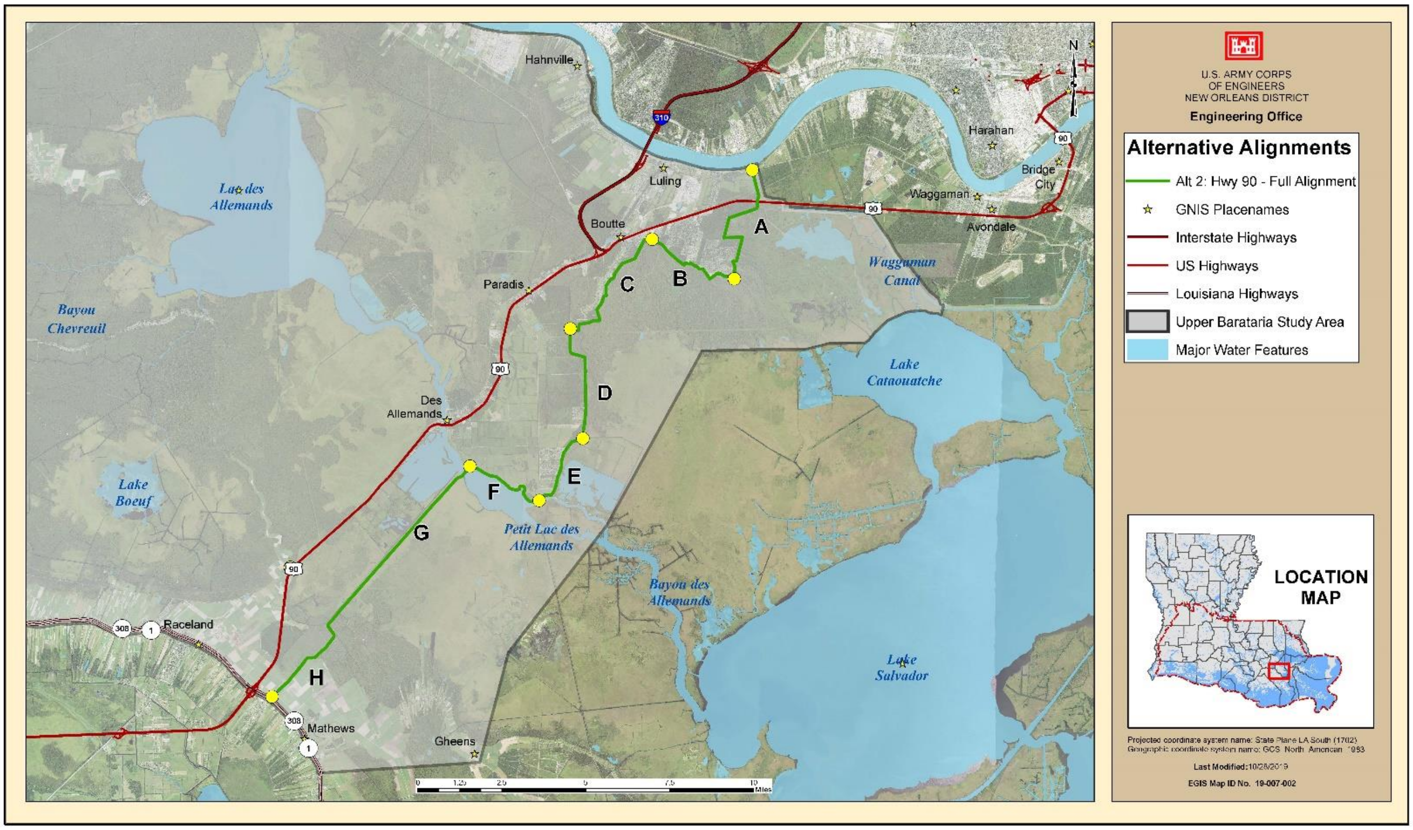


Figure 2-13: Alternative 2 – U.S. Highway 90 – Full Alignment – With Hydraulic Reaches

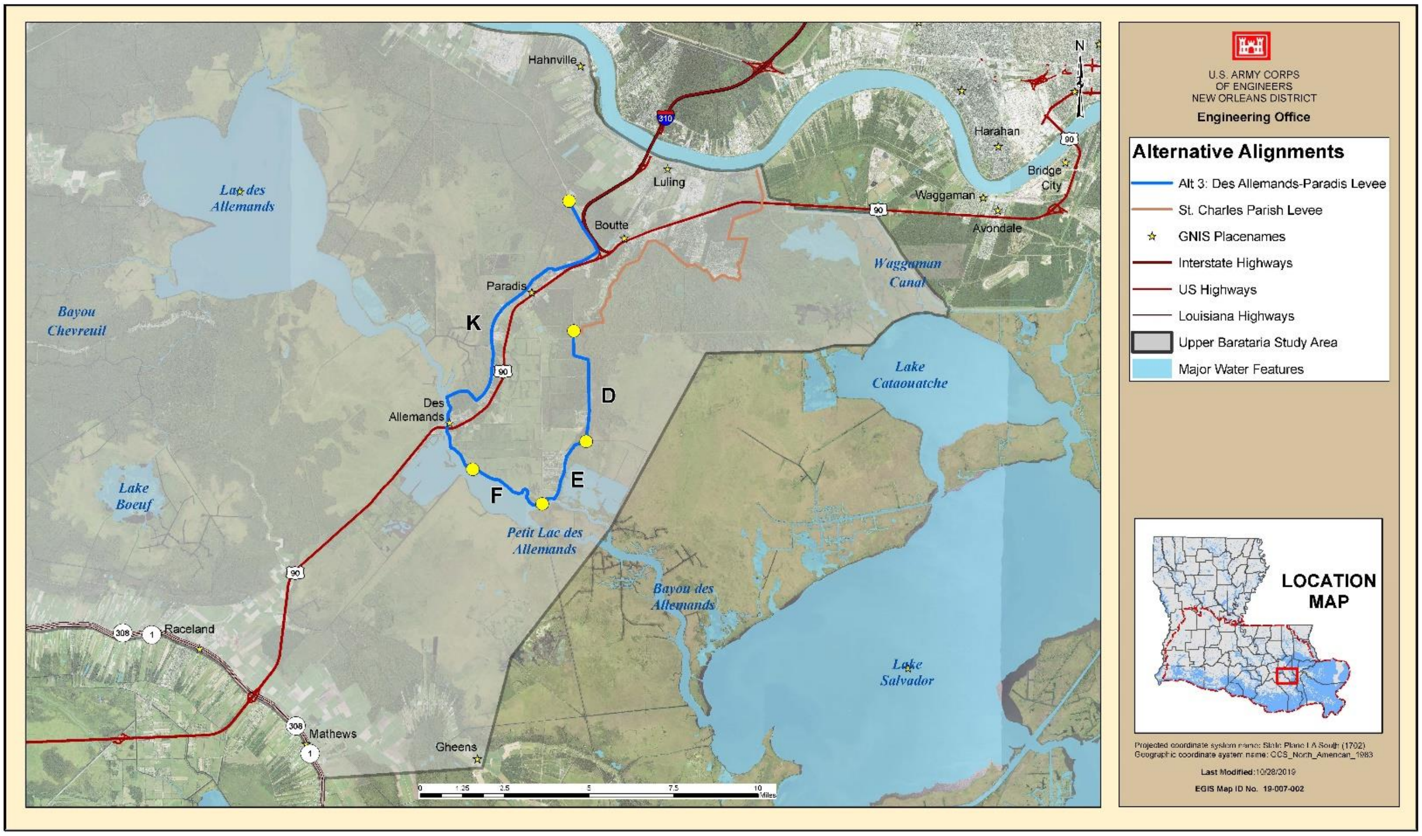


Figure 2-14: Alternative 3 – Des Allemands – Paradis Levee – With Hydraulic Reaches

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

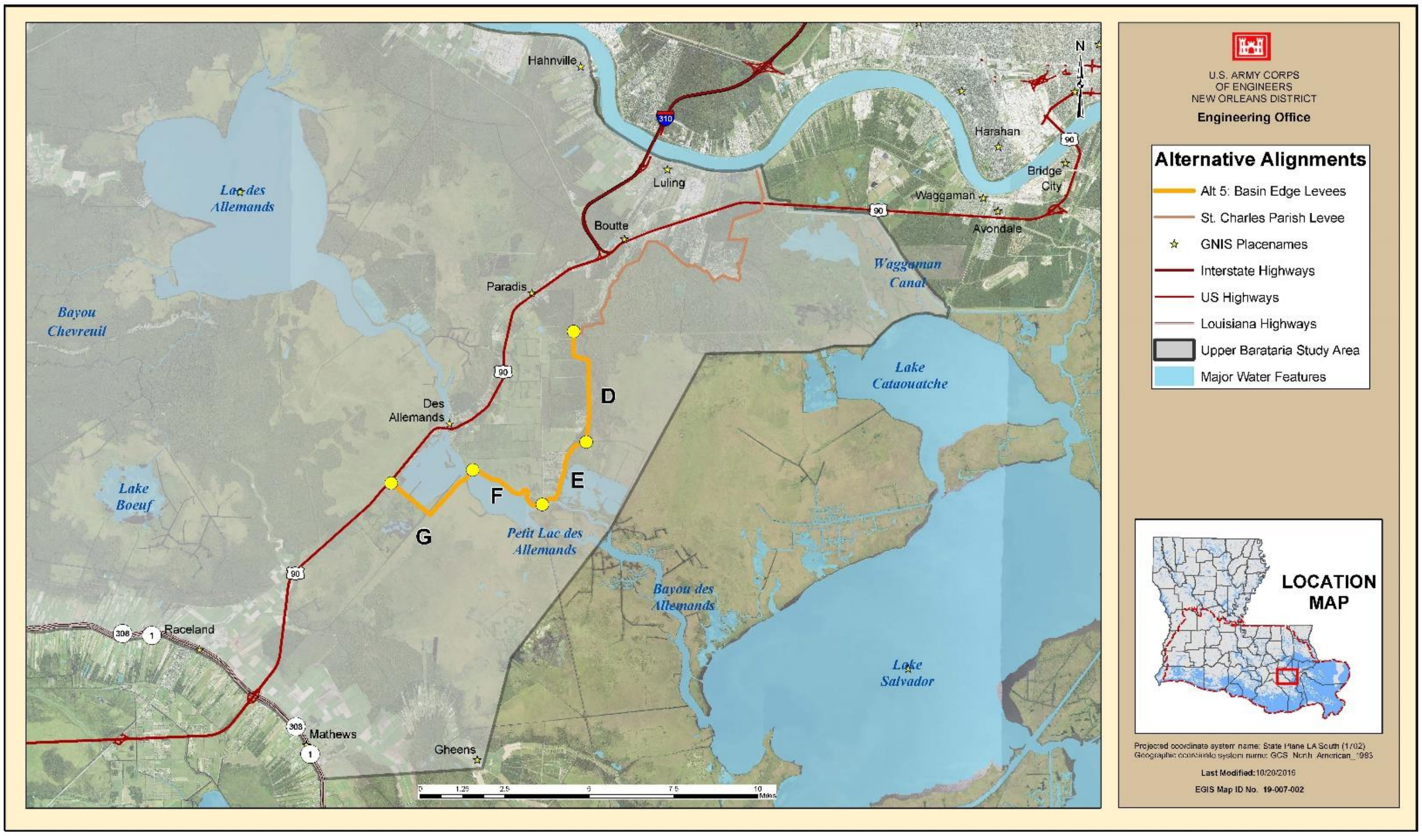


Figure 2-16: Alternative 5 – Basin Edge Levee – With Hydraulic Reaches

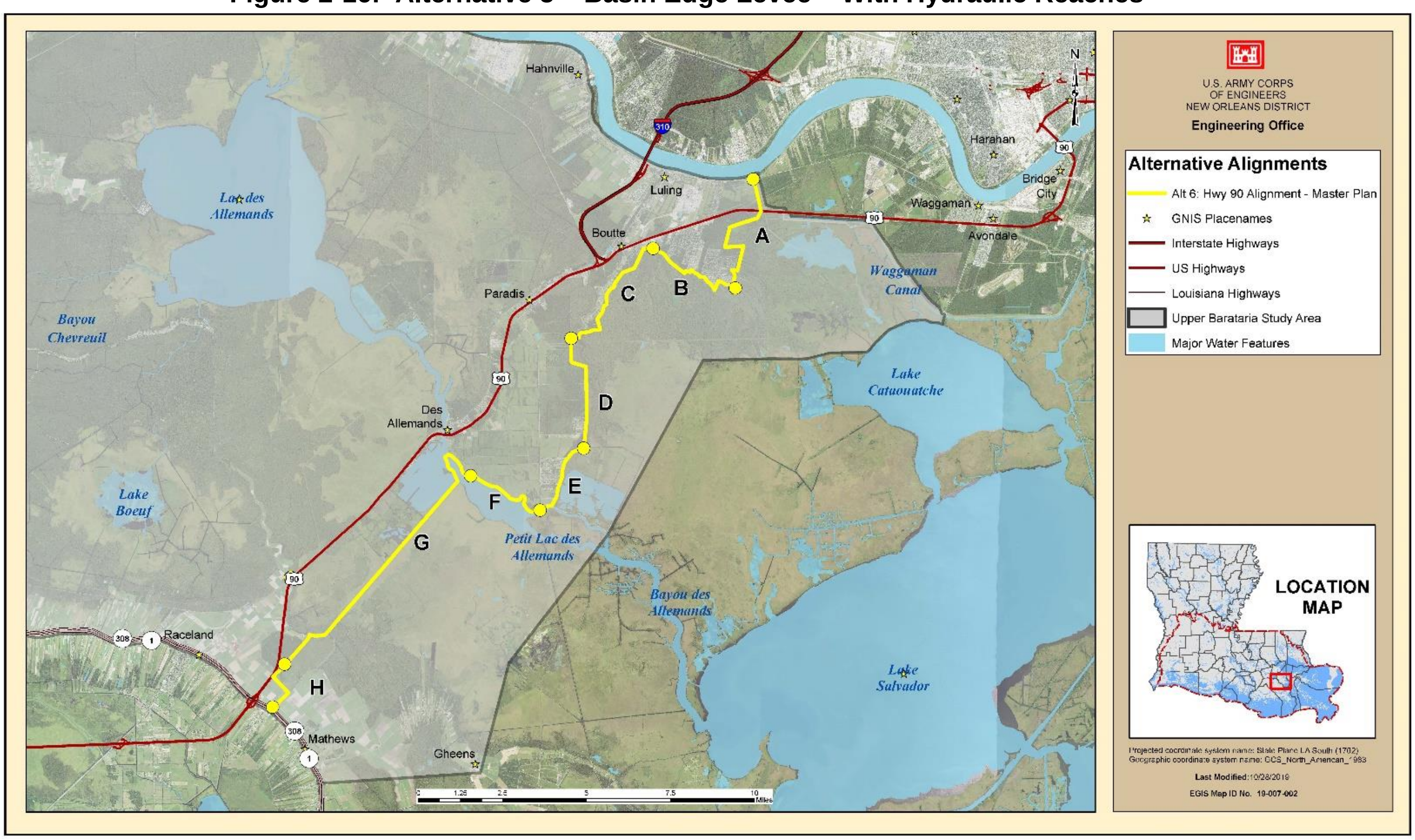


Figure 2-17: Alternative 6 – U.S. Highway 90 Alignment – State of LA Master Plan – With Hydraulic Reaches

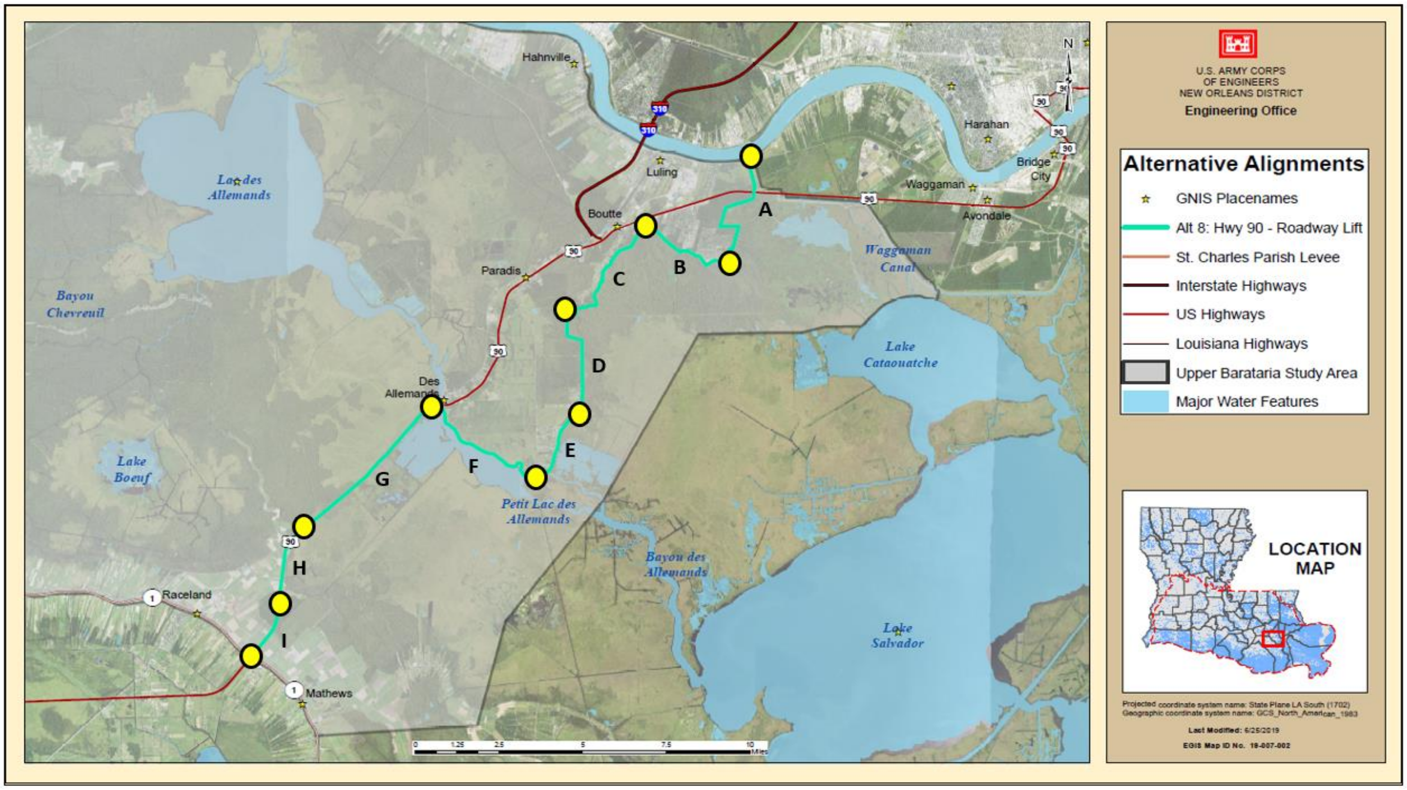


Figure 2-18: Alternative 8 – U.S. Highway 90 Lift Alignment – With Hydraulic Reaches

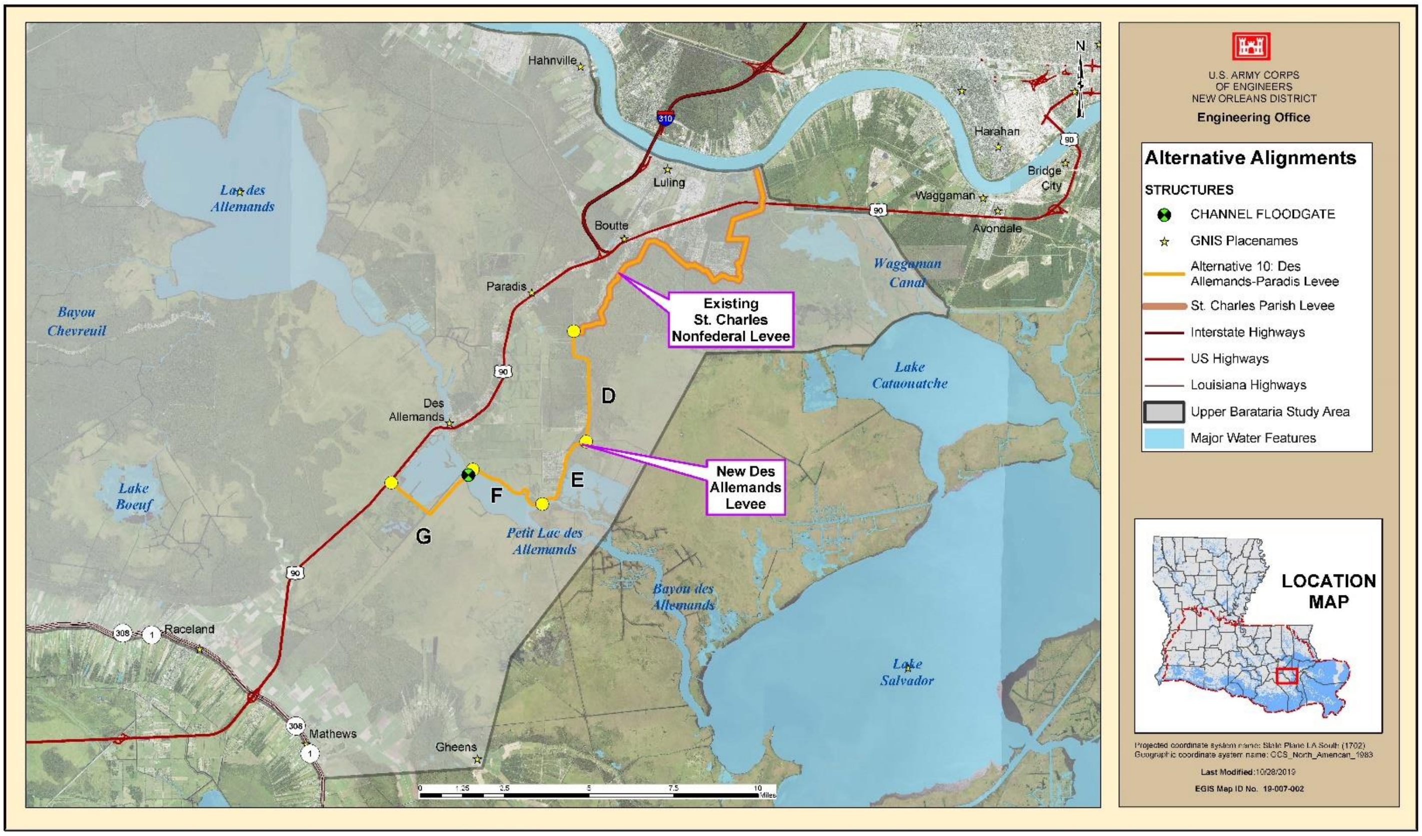


Figure 2-19: Alternative 10 – 1% AEP Open Basin

Methodology

The hydraulic boundary conditions for each hydraulic reach for the 2%, 1%, 0.5% and 0.2% annual exceedance probabilities for the years 2023 and 2073 were obtained from the 2017 Coastal Protection and Restoration Authority (CPRA) ADCIRC model runs and are tabulated in 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.

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 $s0 = 2\pi H_{m0} / (g T_{m-10}^2)$. 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:

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

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).

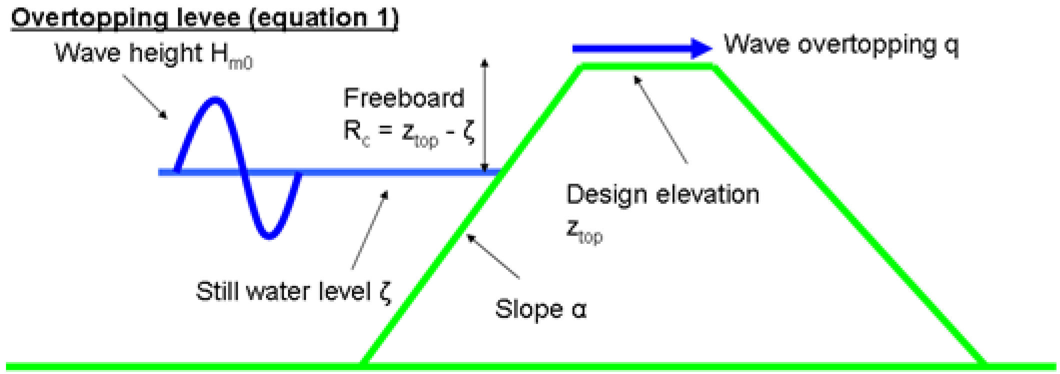


Figure 2-28 – Definitions for Overtopping of a Levee

The Monte Carlo Analysis is executed as follows:

1. Draw a random number between 0 and 1 to set the exceedence probability (p).
2. Compute the water elevation from a normal distribution using the mean 1% surge elevation and standard deviation as parameters and with an exceedence probability (p).
3. Draw a random number between 0 and 1 to set the exceedence probability (p).
4. Compute the wave height and wave period from a normal distribution using the mean 1% wave height/wave period and the associated standard deviation and with an exceedence probability (p).
5. Repeat 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 the textbox).
7. Repeat Steps 1 through 5 a large number of times. (N)
8. Compute the 50% and 90% confidence limit of the overtopping rate. (i.e. q_{50} and q_{90})

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.

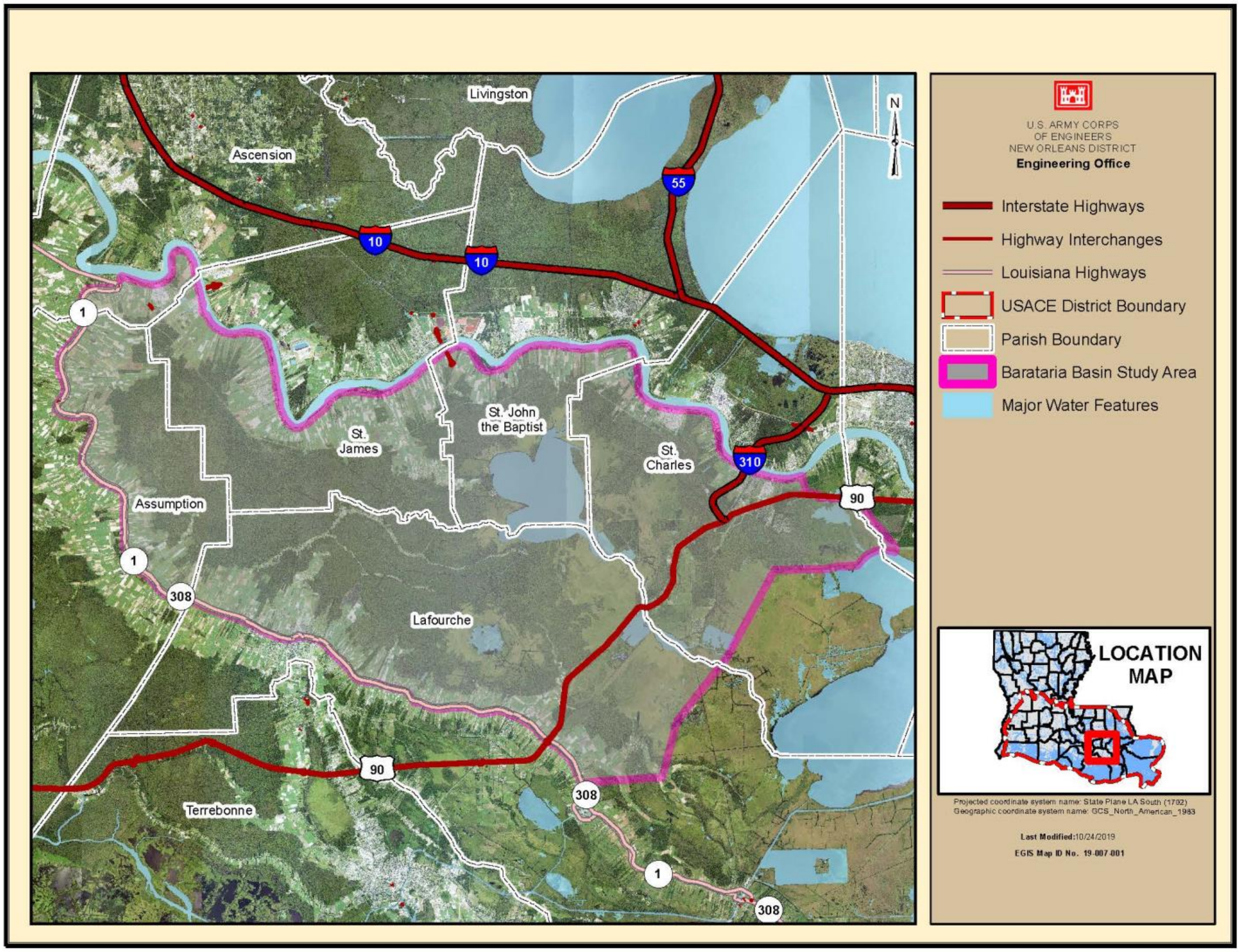


Figure 2-37: Upper Barataria Basin Study Area

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

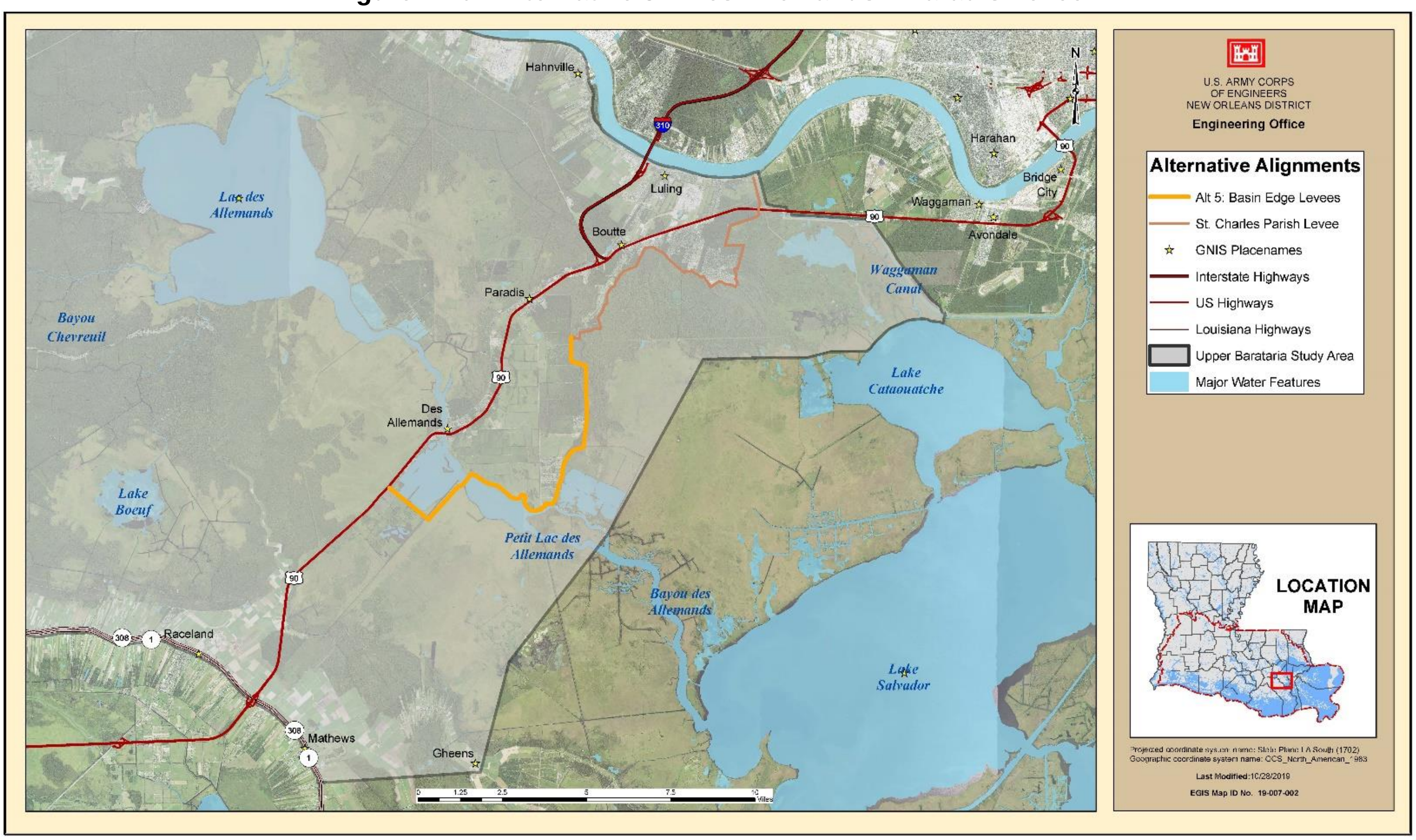


Figure 2-41: Alternative 5 – Basin Edge Levee

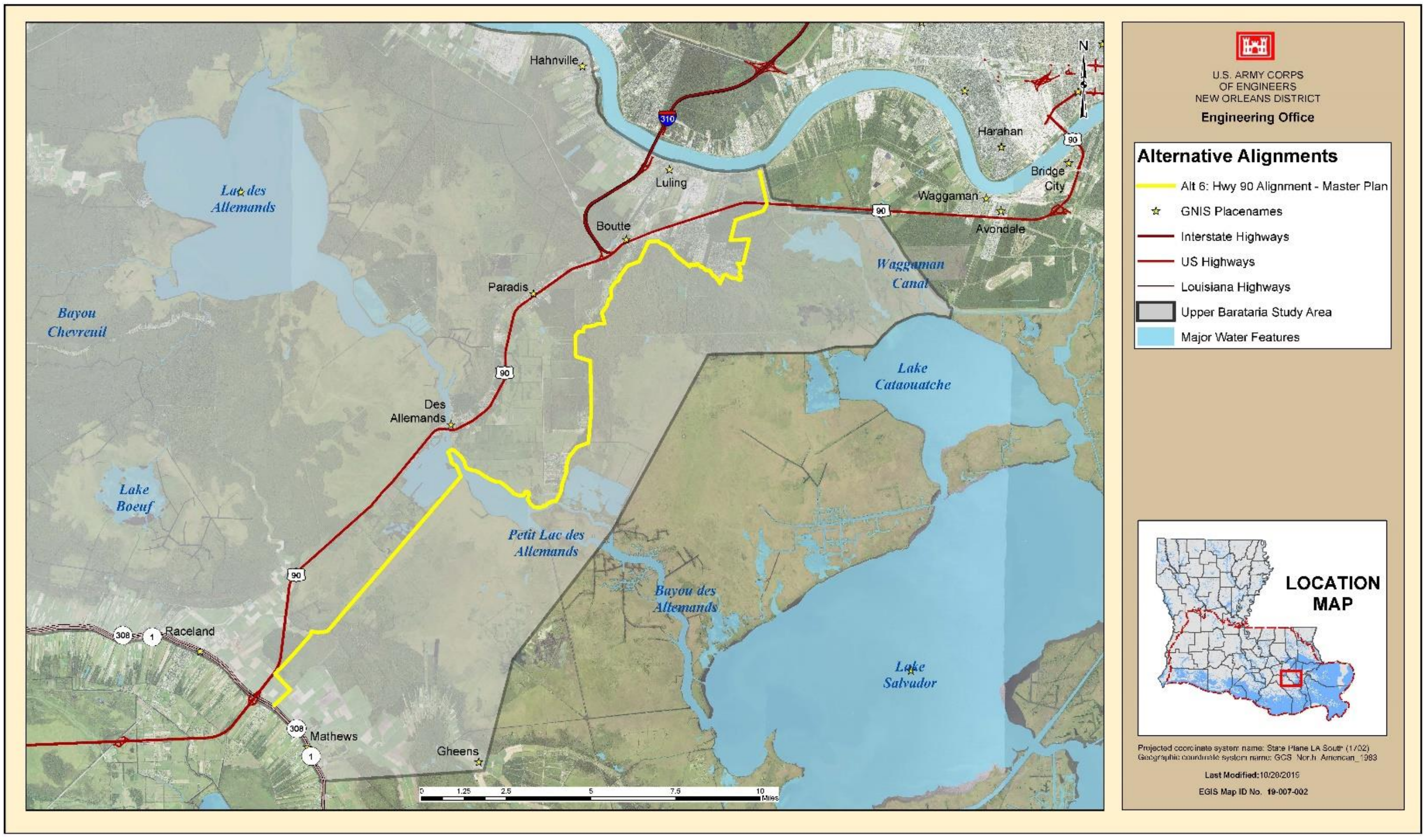


Figure 2-42: Alternative 6 – U.S. Highway 90 Alignment – State of LA Master Plan

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

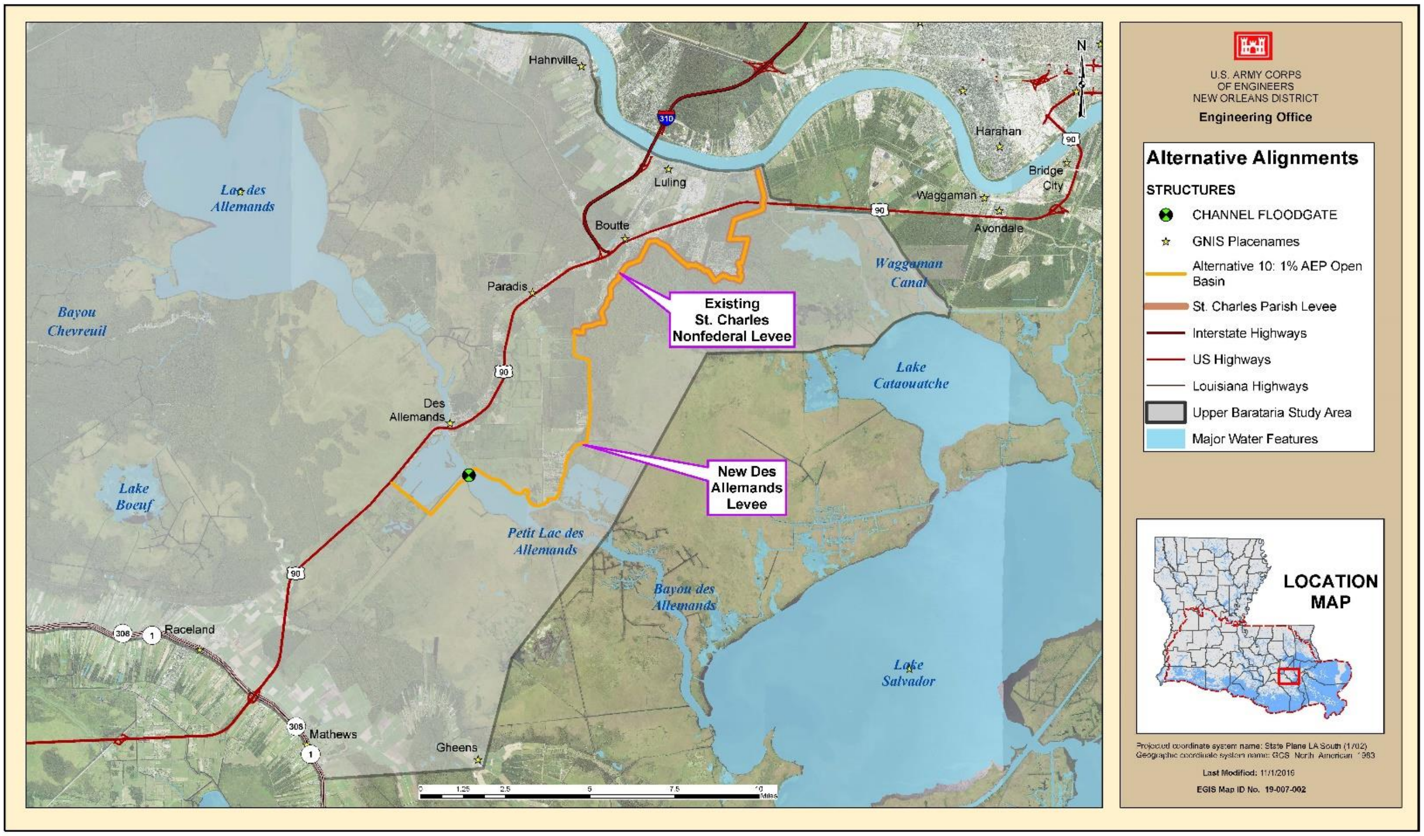


Figure 2-44: Alternative 10 – 1% AEP Open Basin Alternative

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.

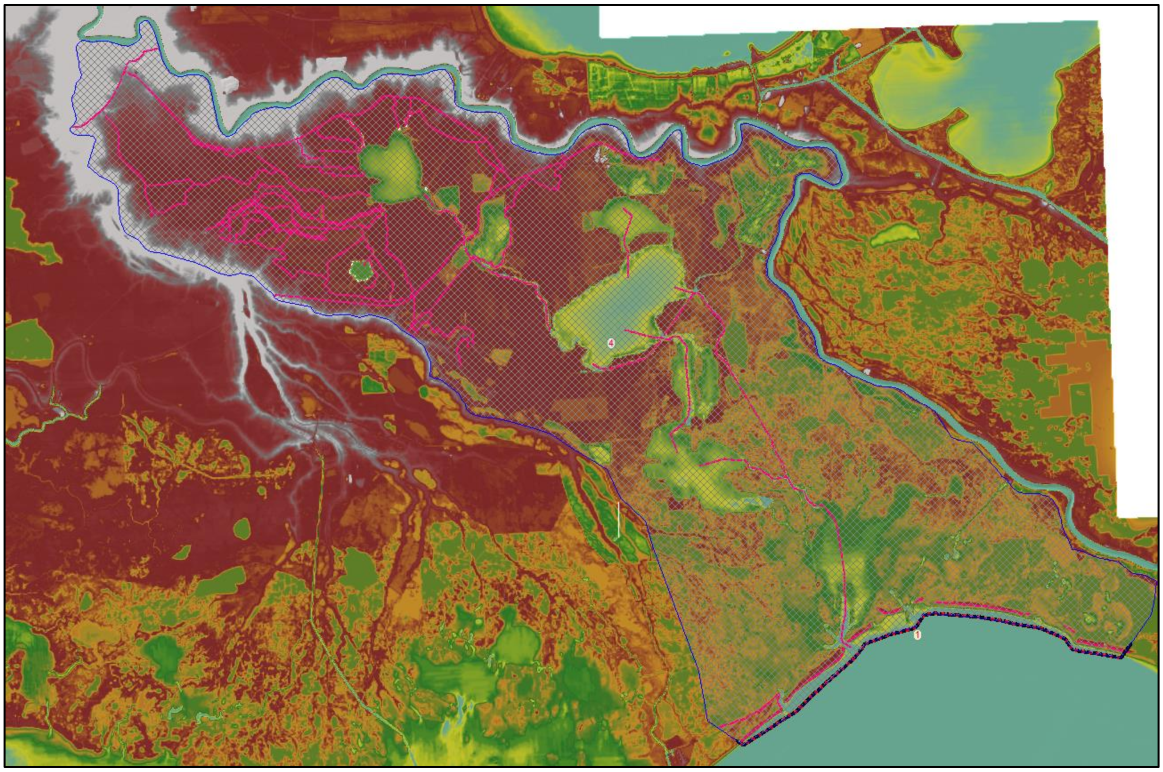


Figure 2-45: HEC-RAS Computational Mesh

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 in 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 in Figure 2-48 below.

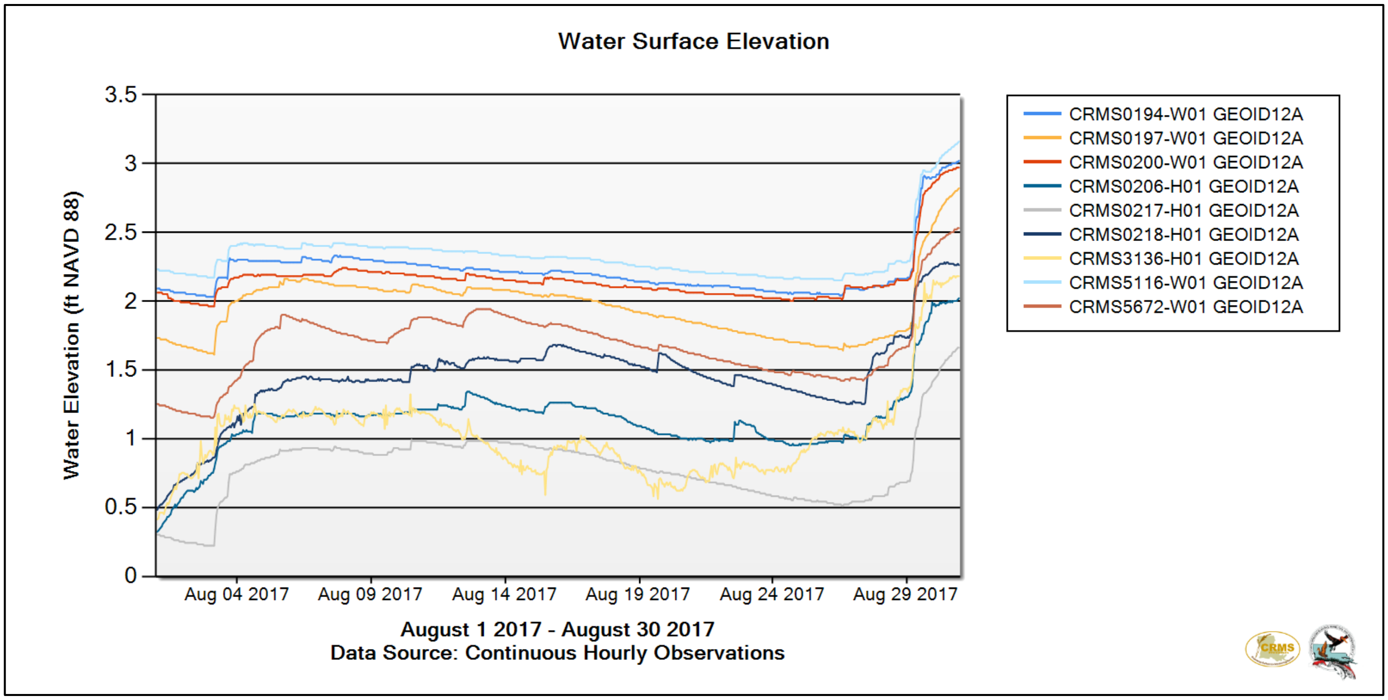


Figure 2-48: CRMS Gages Water Elevations for August 2017

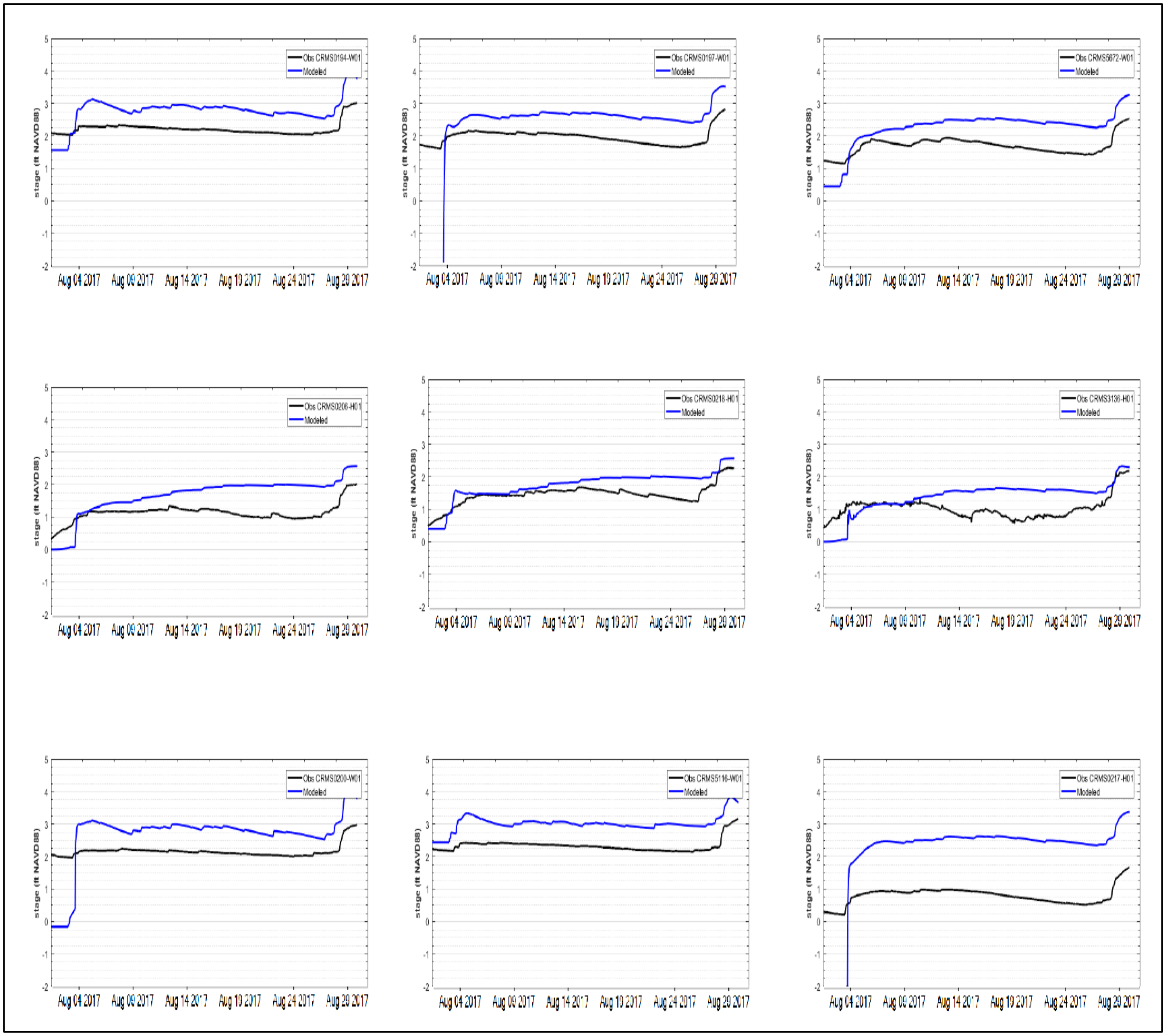


Figure 2-49: CRMS Gages Observed versus HEC-RAS Modeled Stages

Results

The geometries for each alternative and a sample snapshot of the associated output attribute table results, containing 3,258 output points, are shown in 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.

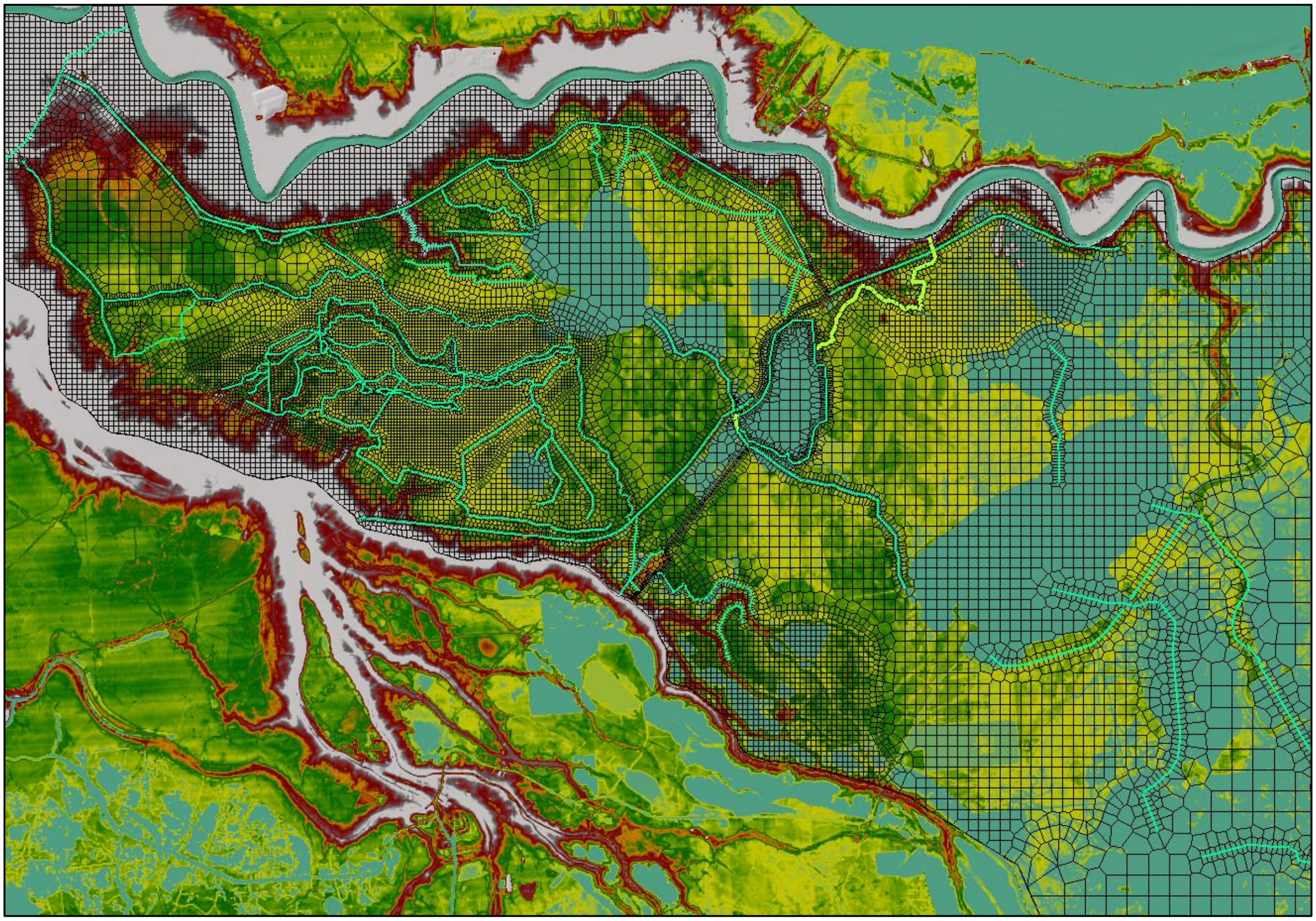


Figure 2-50: Existing and Future Without Project Geometry

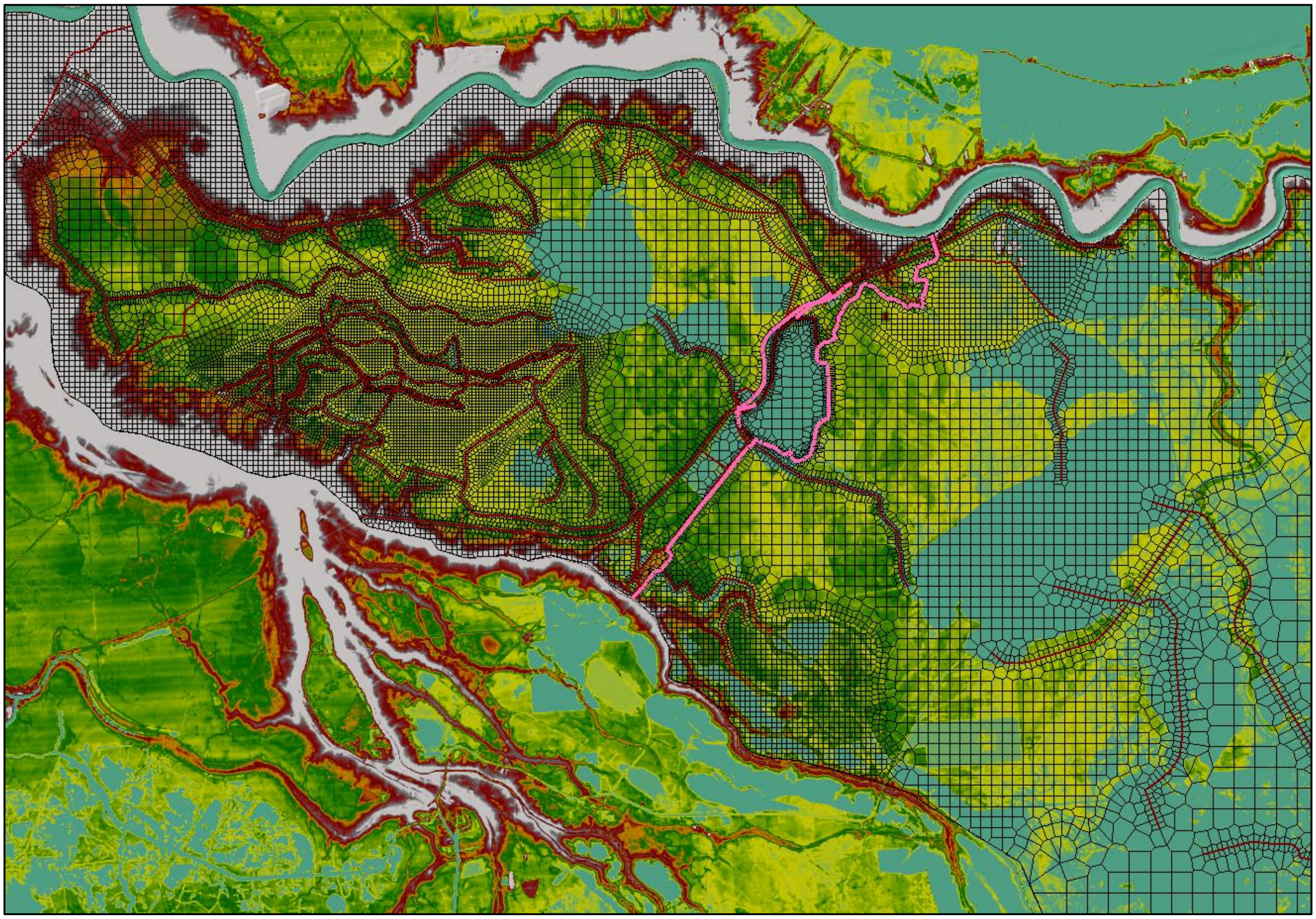


Figure 2-51: Alternative 1 (U.S. Highway 90 – Segment 1 Extension) Geometry

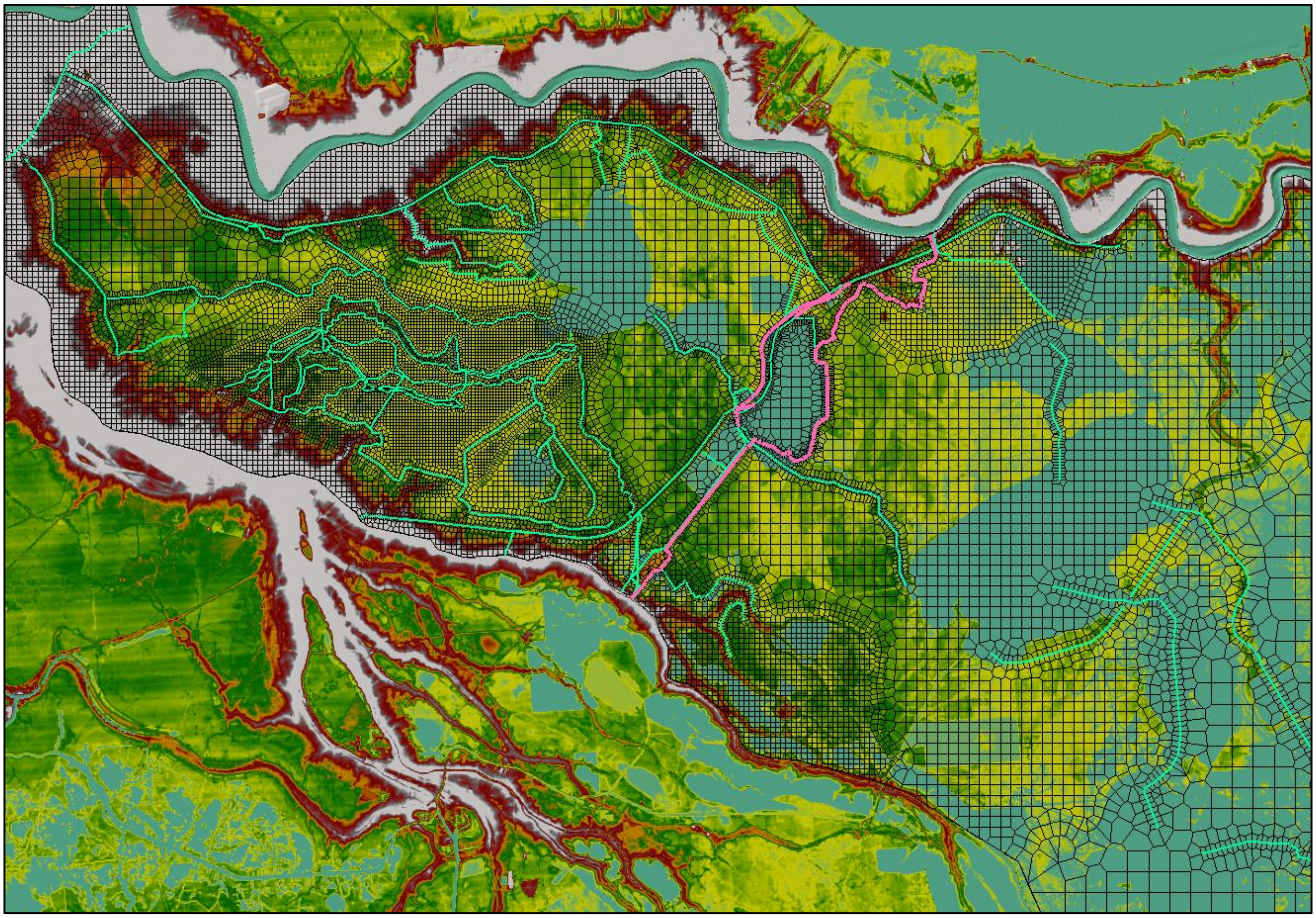


Figure 2-52: Alternative 2 (U.S. Highway 90 – Full Alignment) Geometry

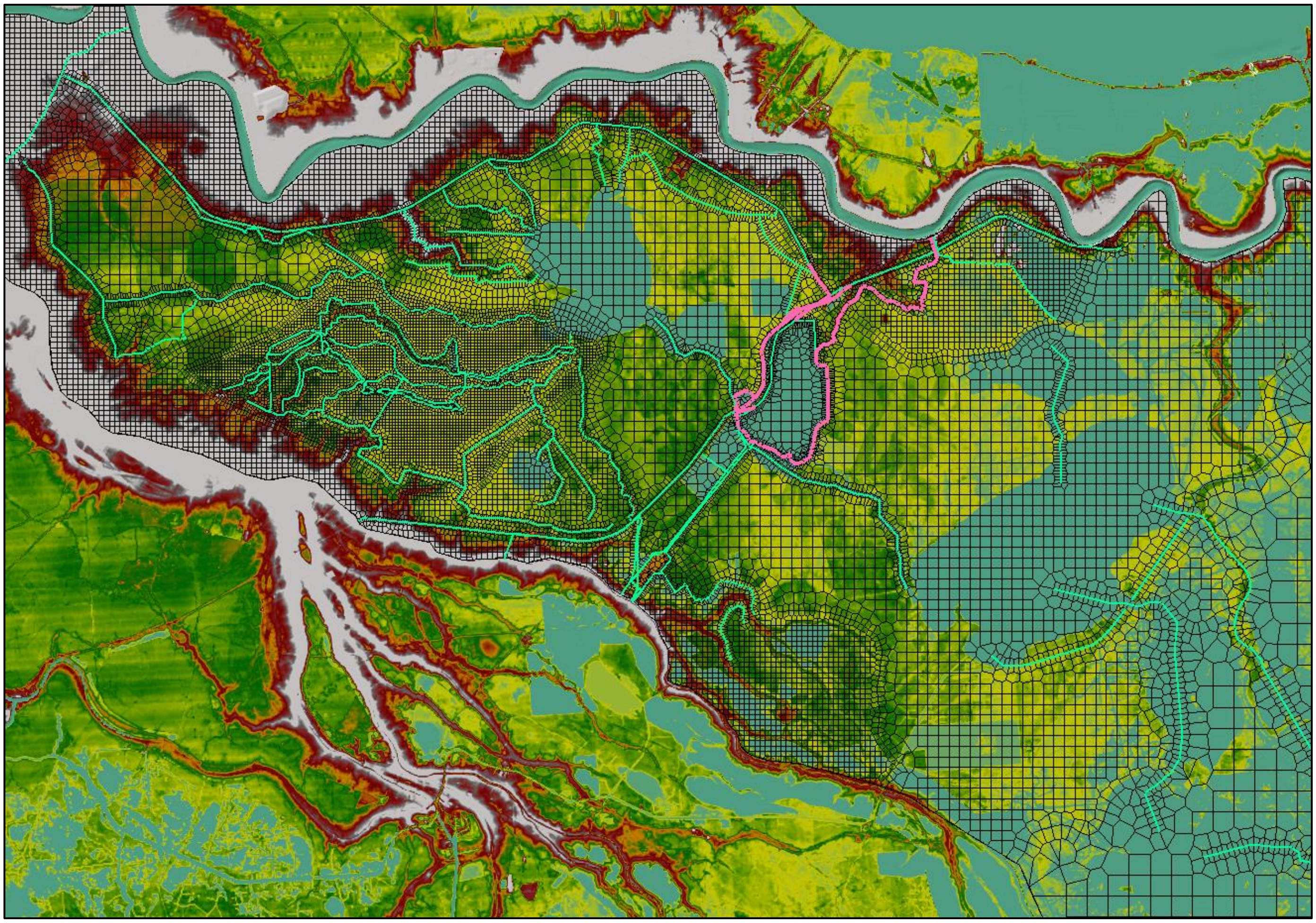


Figure 2-53: Alternative 3 (Des Allemands – Paradis Levee) Geometry

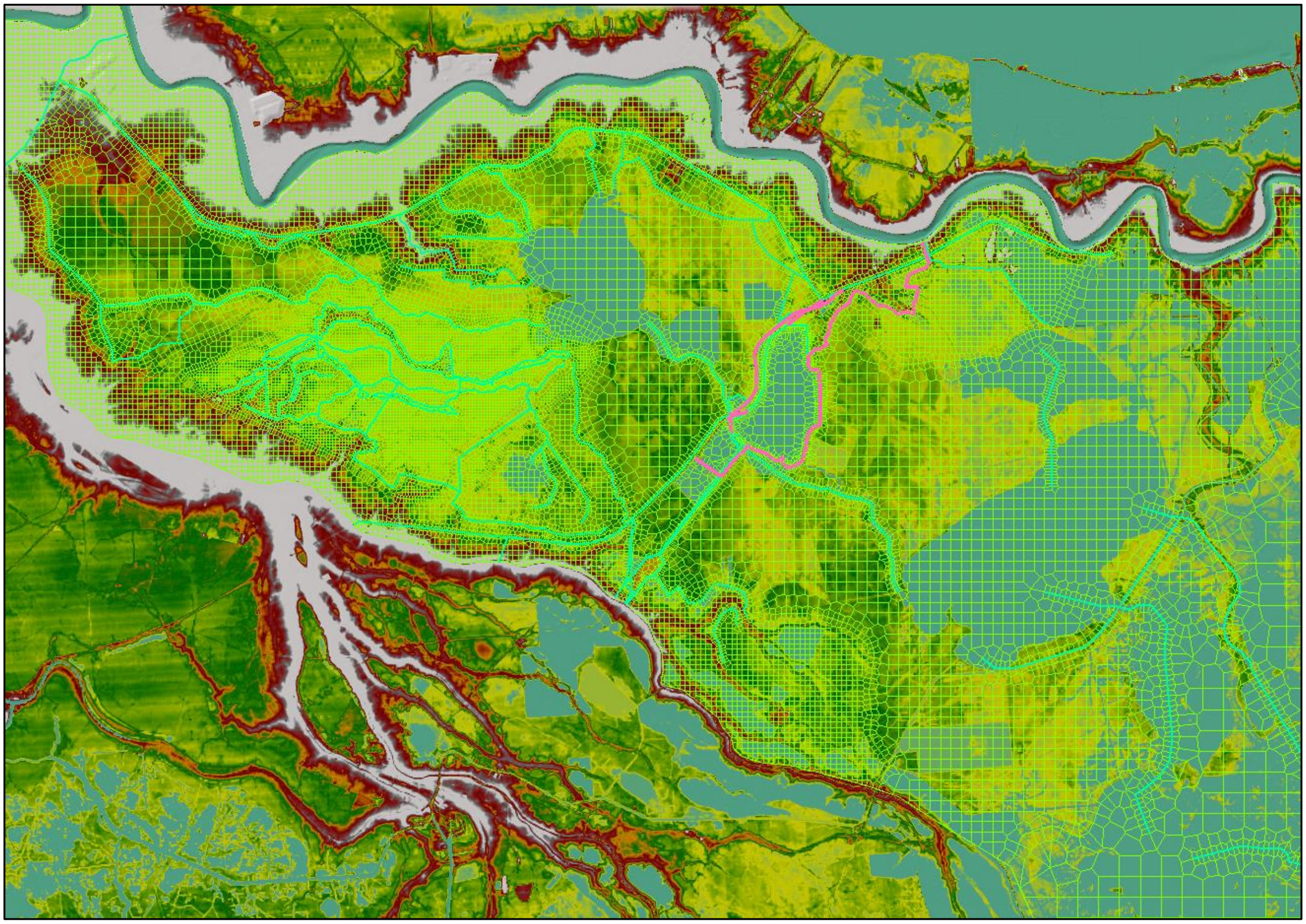


Figure 2-54: Alternative 5 (Basin Edge Levee) Geometry

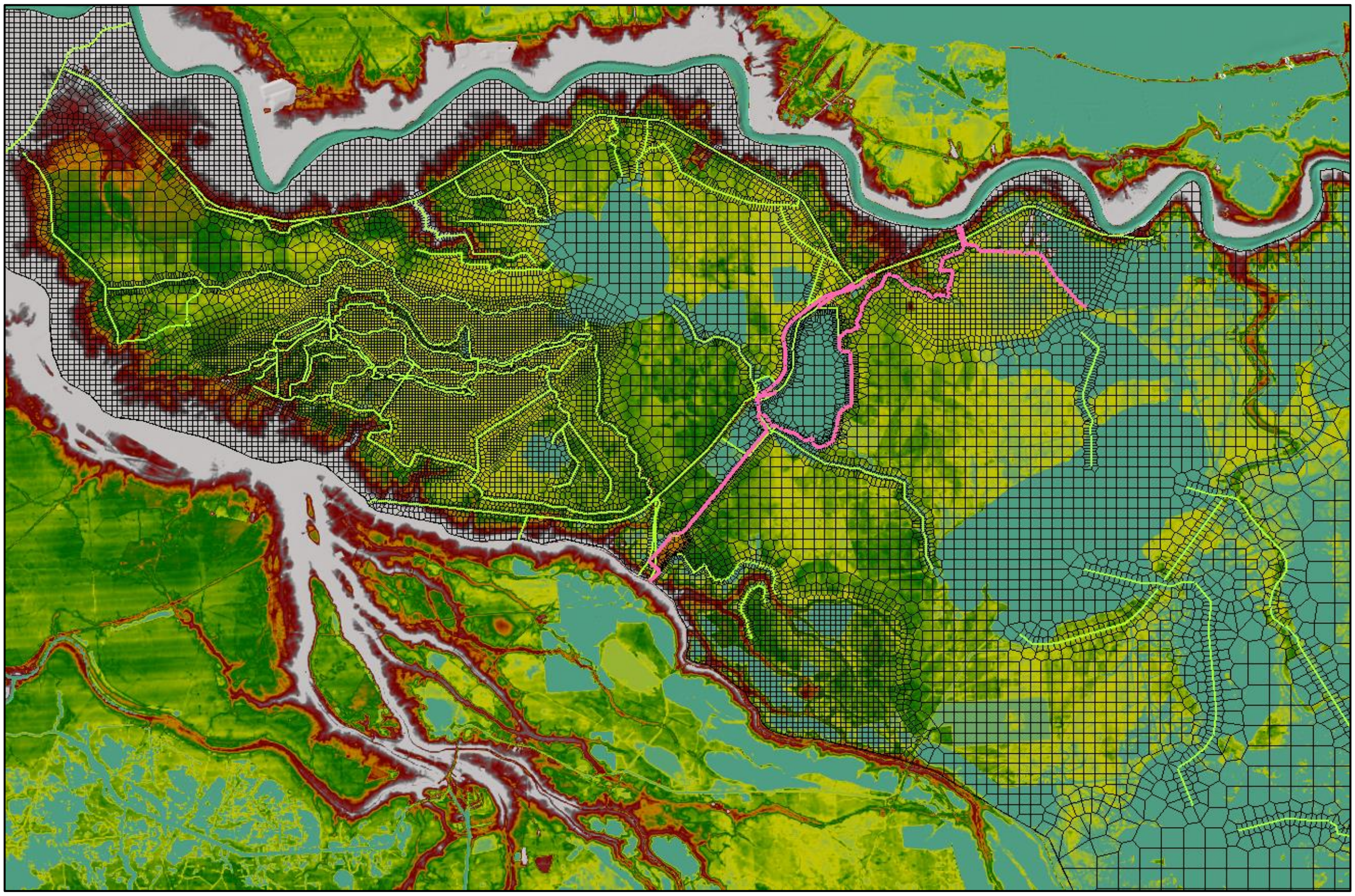


Figure 2-55: Alternative 6 (U.S. Highway 90 Alignment – State of LA Master Plan) Geometry

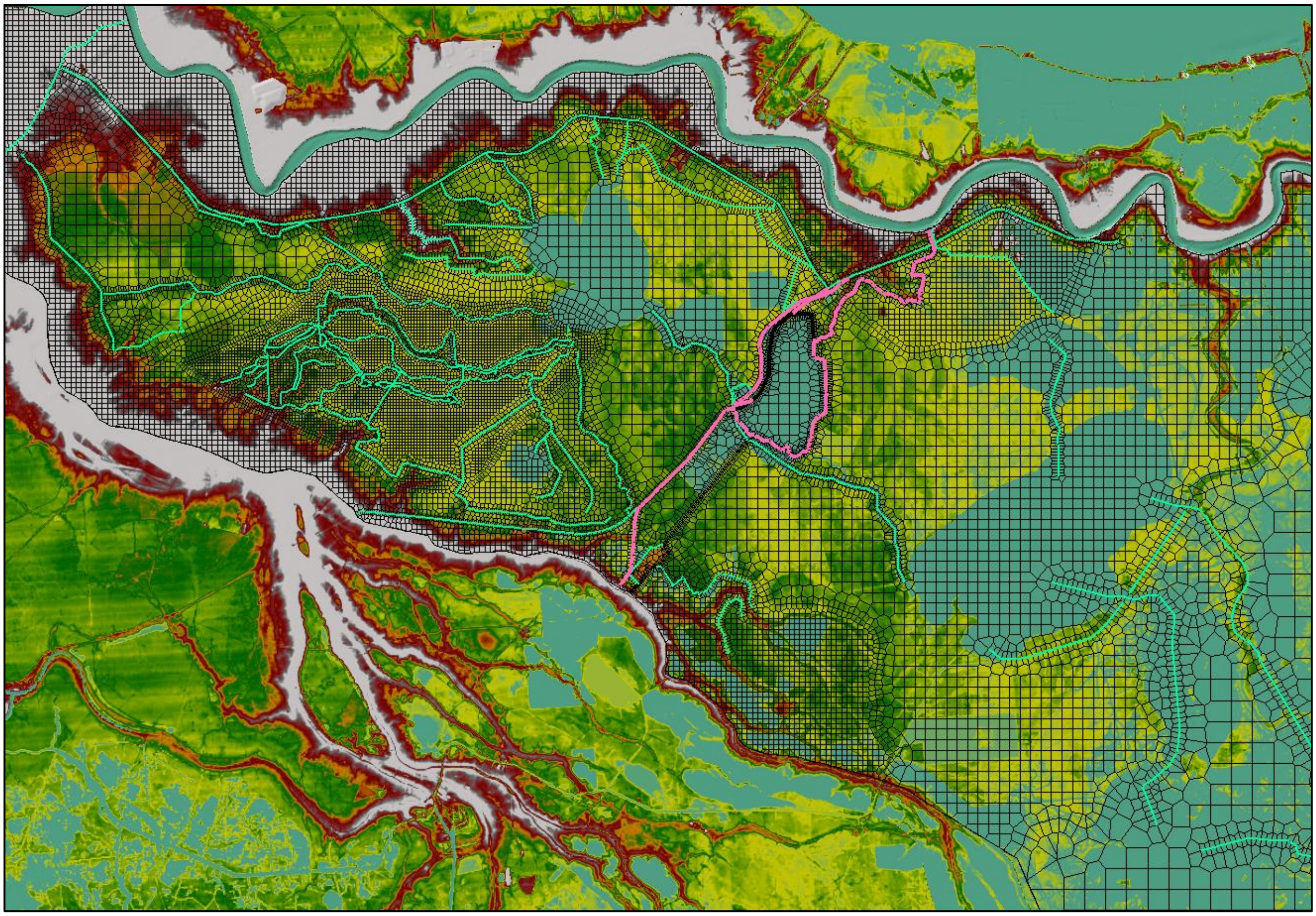


Figure 2-56: Alternative 8 (U.S. Highway 90 Lift Alignment) Geometry

Sample snapshots of the associated output attribute table results, which contains 3,258 output points, are shown in 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 in Figures 2-59 through 2-74 below.

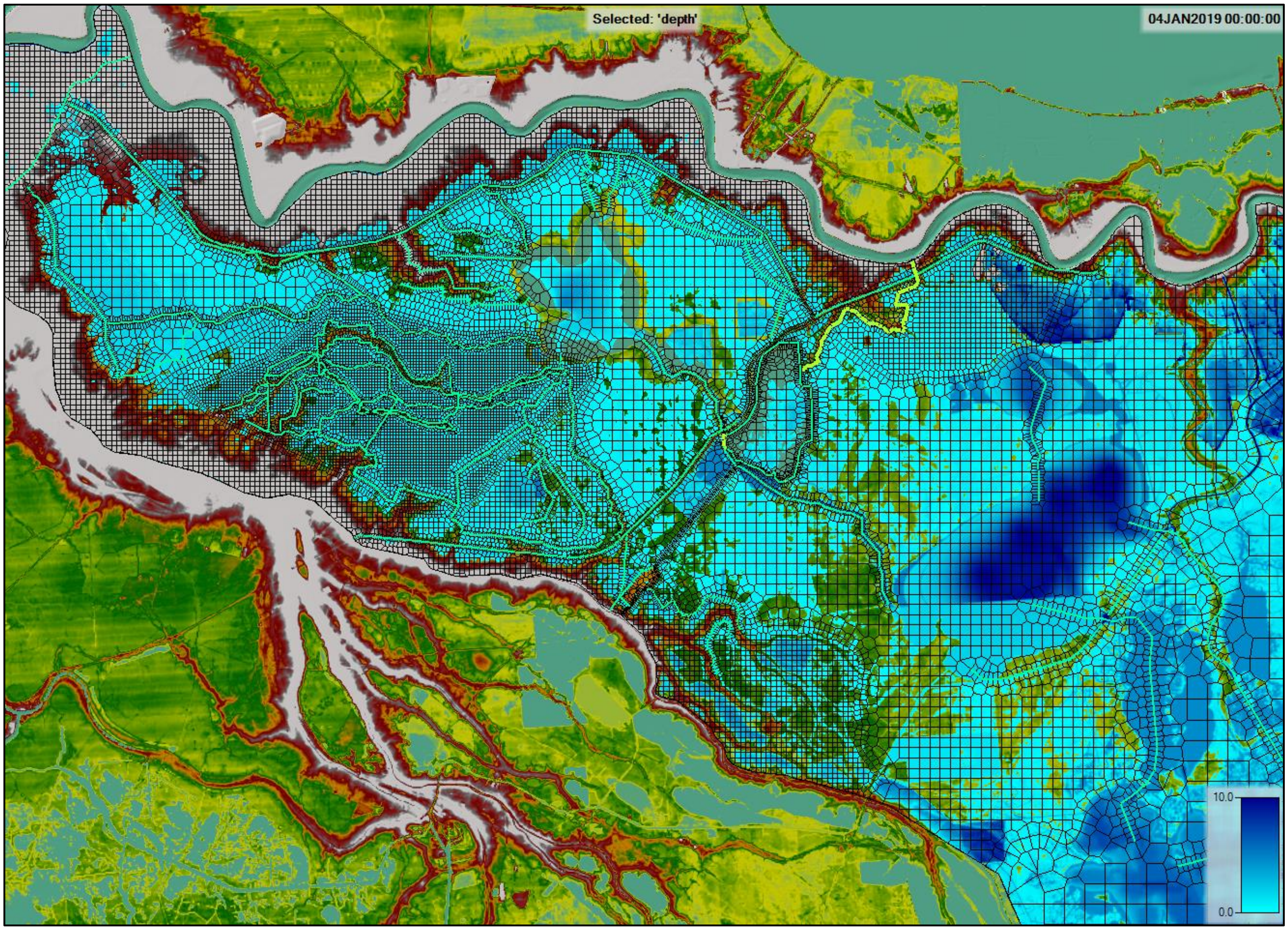


Figure 2-59: Inundation Map for the 50% AEP Rainfall Frequency Event (Existing Without Project Condition)

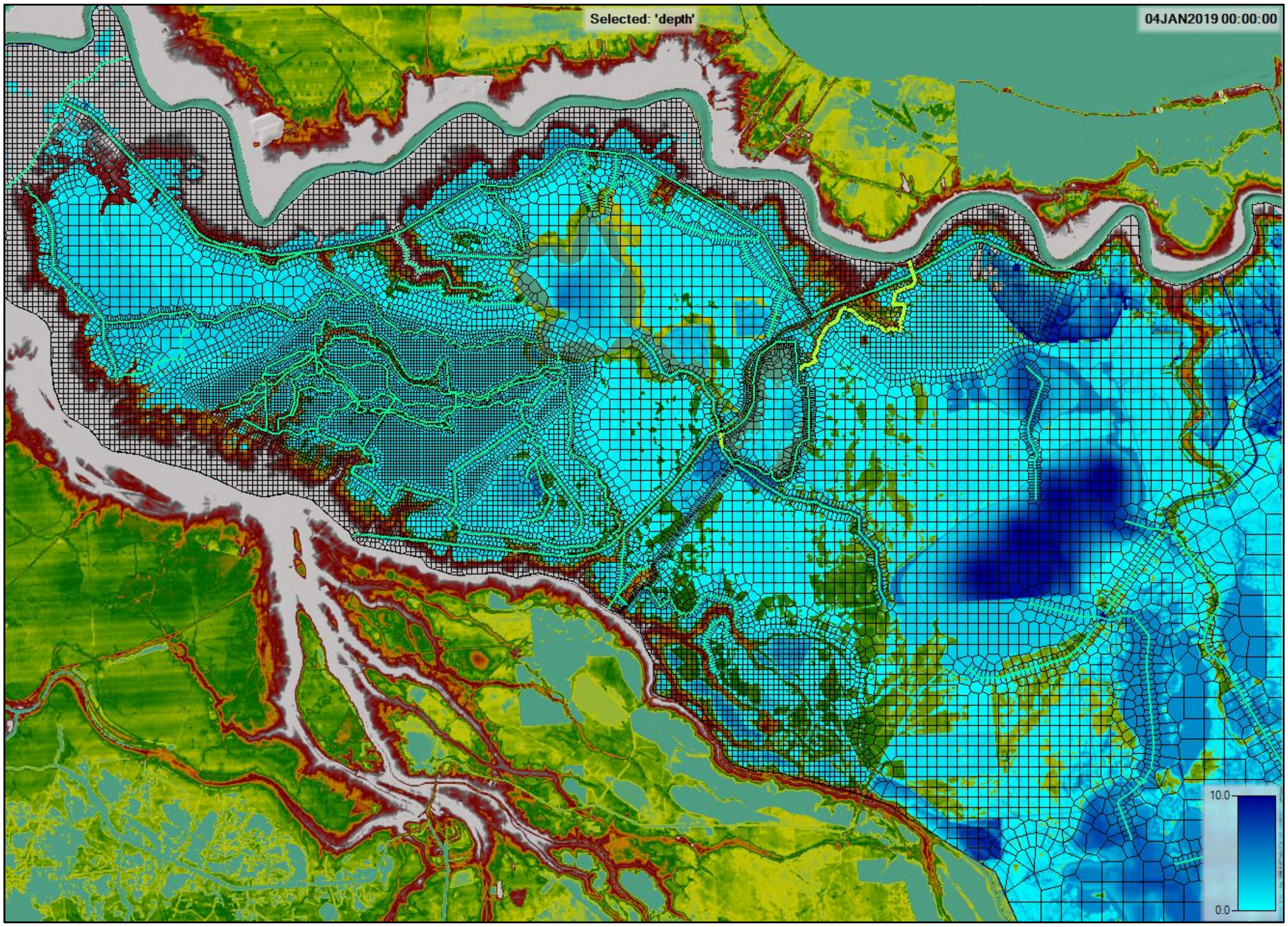


Figure 2-60: Inundation Map for the 20% AEP Rainfall Frequency Event (Existing Without Project Condition)

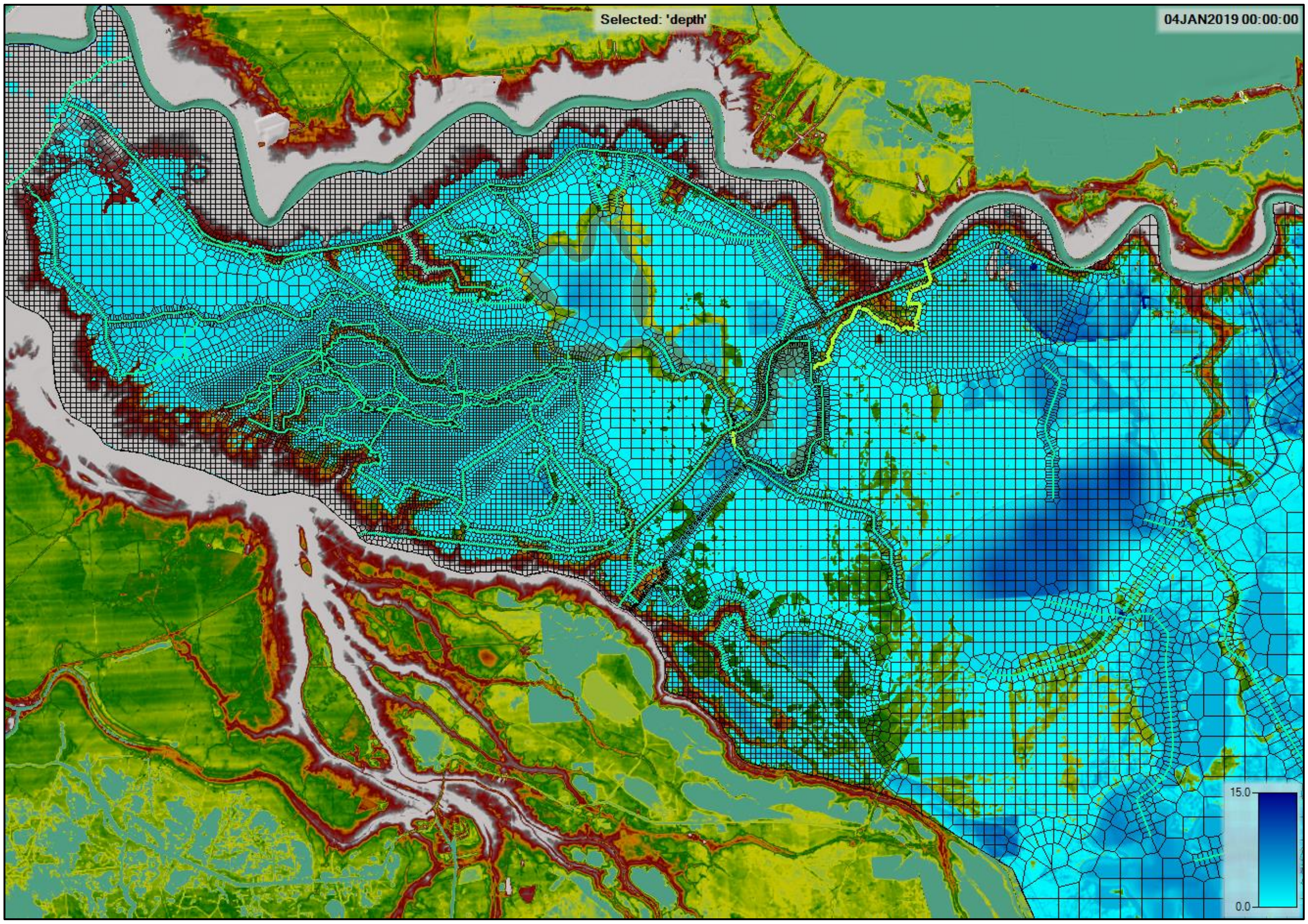


Figure 2-61: Inundation Map for the 10% AEP Rainfall Frequency Event (Existing Without Project Condition)

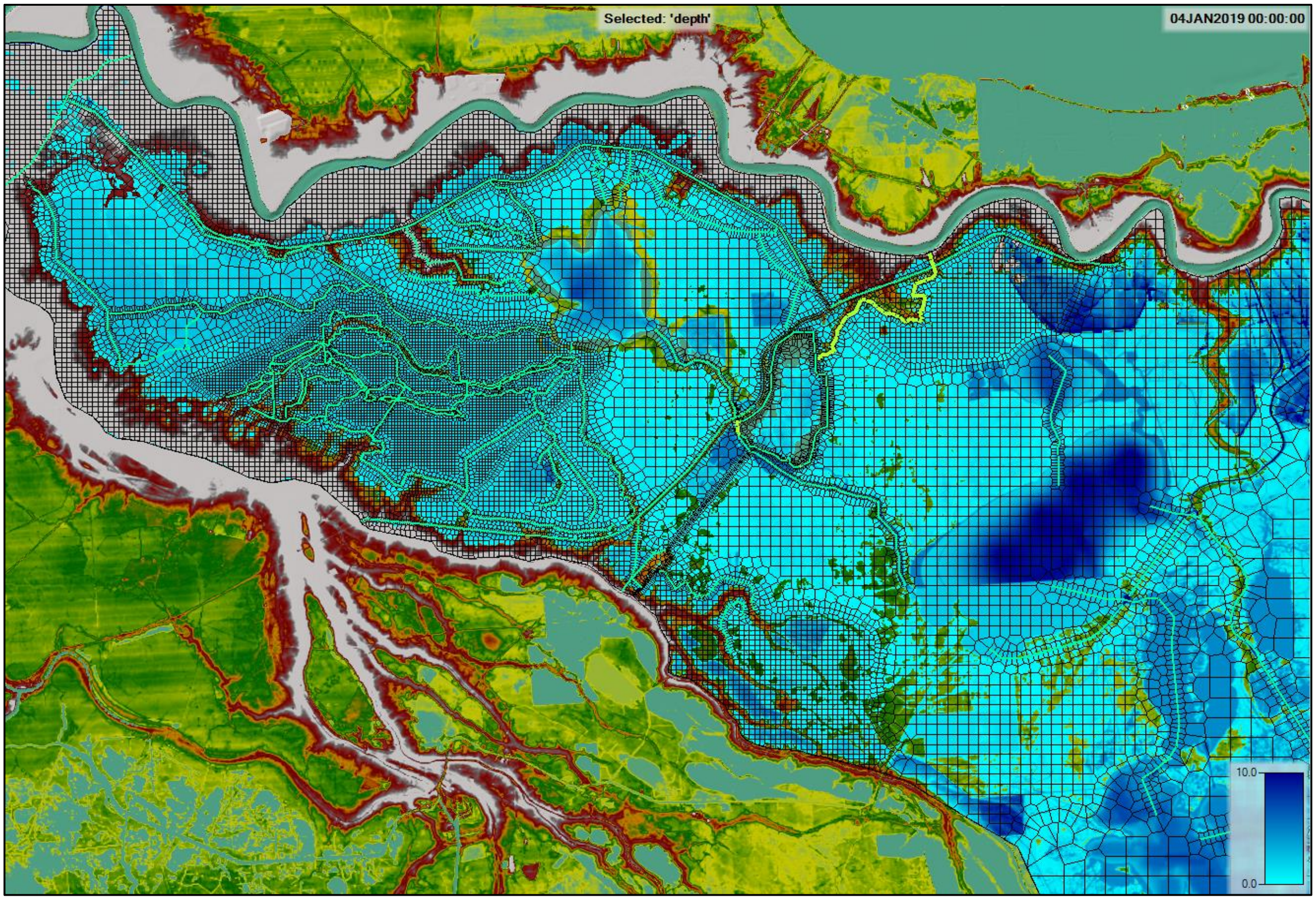


Figure 2-62: Inundation Map for the 4% AEP Rainfall Frequency Event (Existing Without Project Condition)

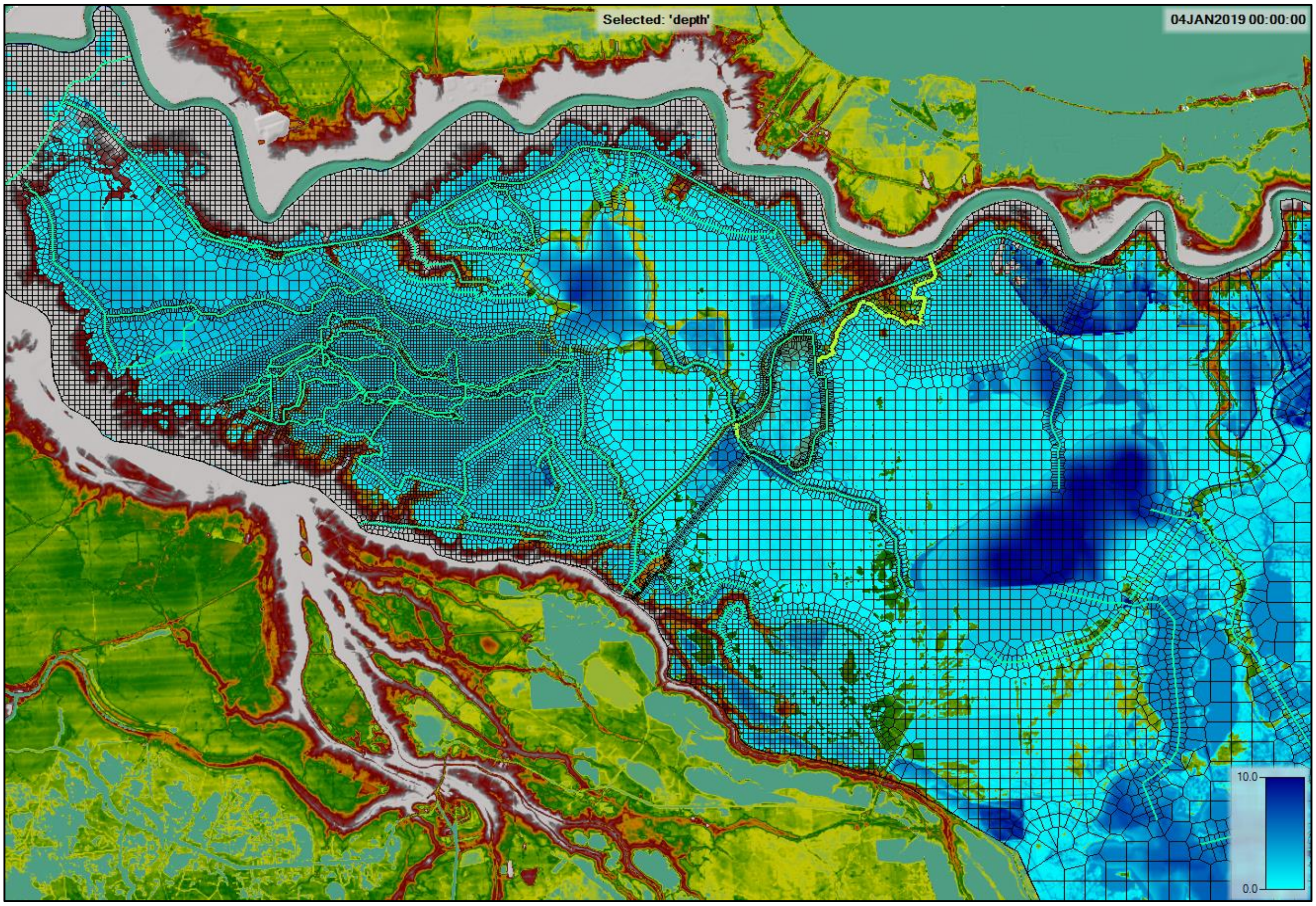


Figure 2-63: Inundation Map for the 2% AEP Rainfall Frequency Event (Existing Without Project Condition)

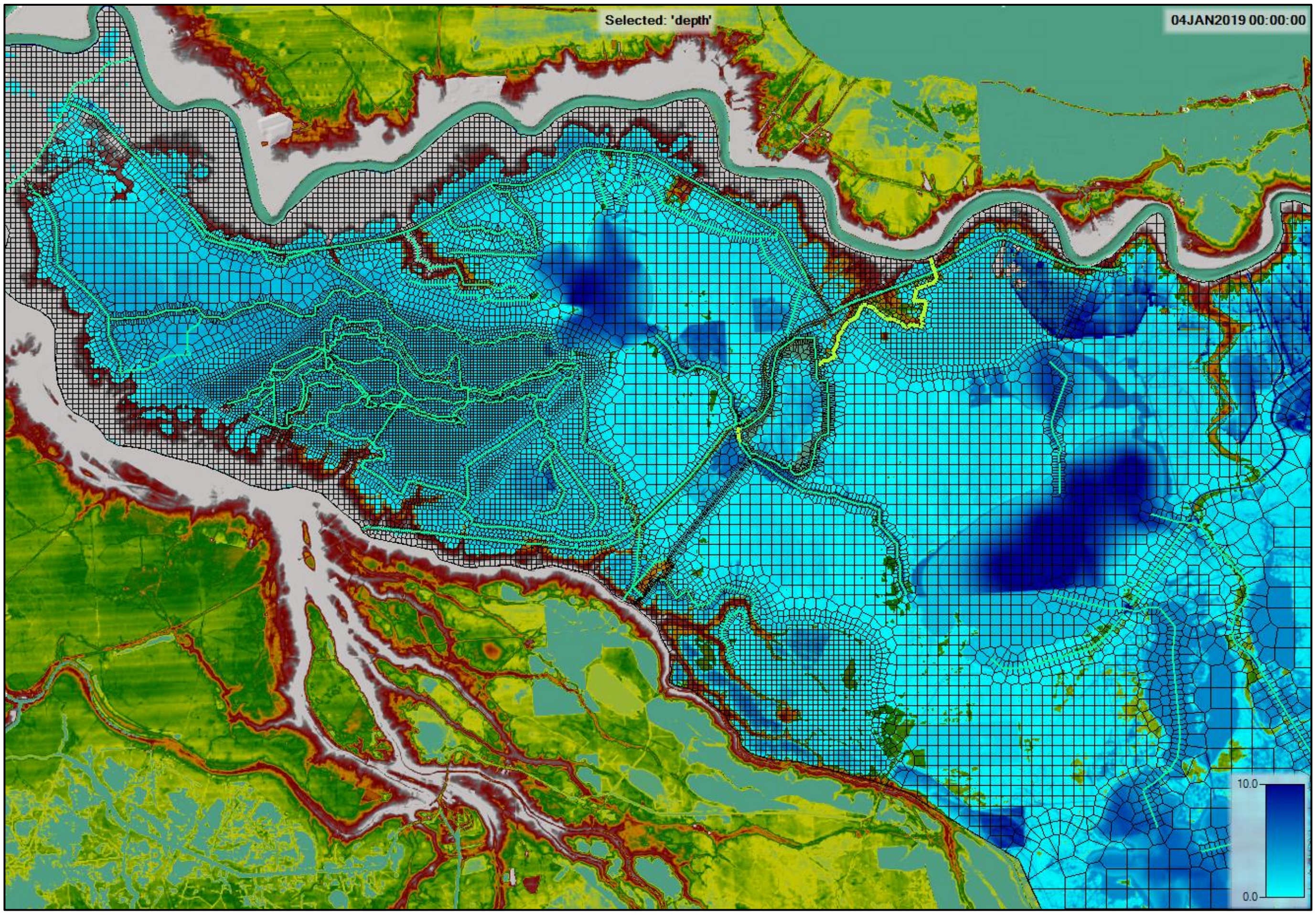


Figure 2-64: Inundation Map for the 1% AEP Rainfall Frequency Event (Existing Without Project Condition)

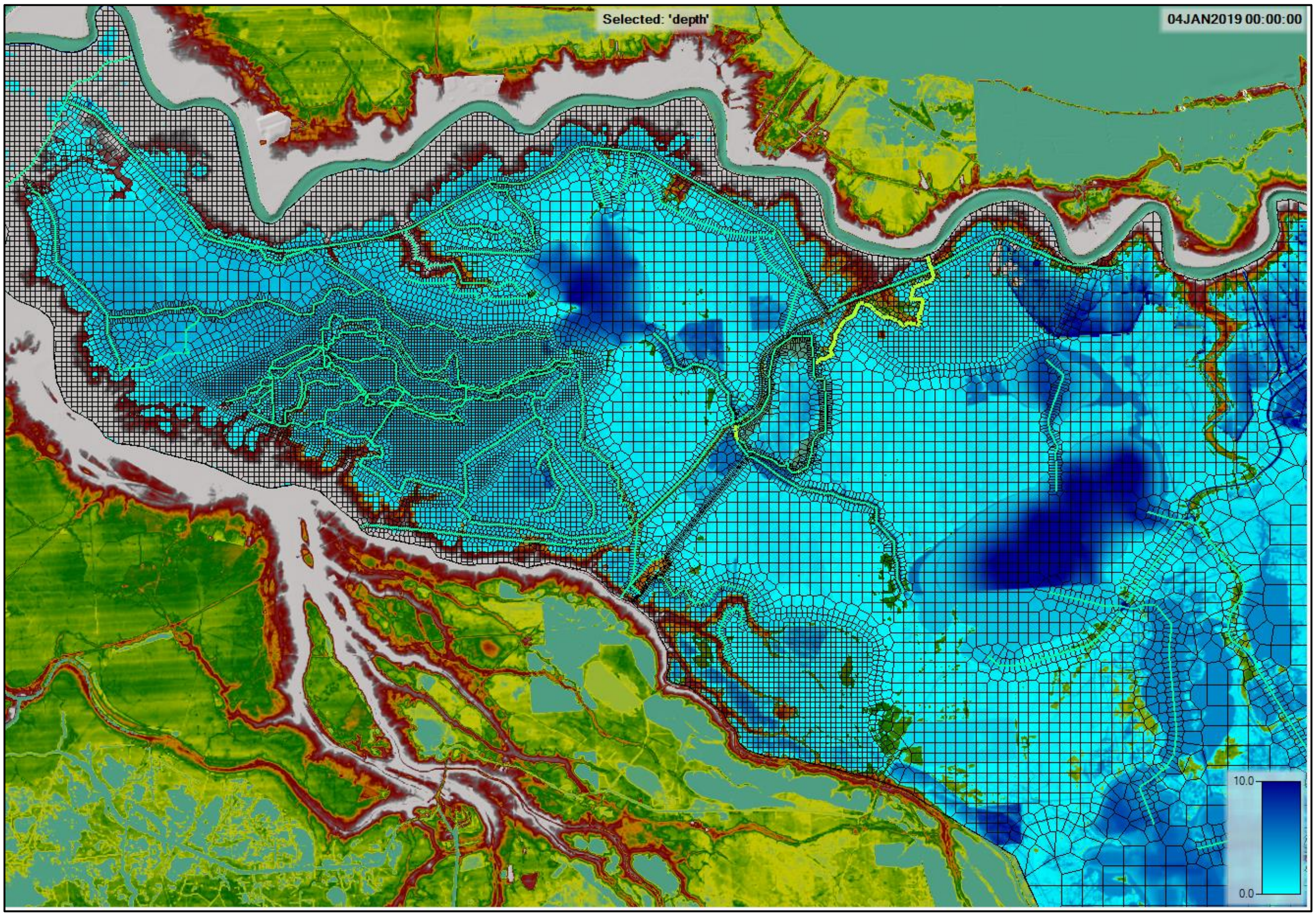


Figure 2-65: Inundation Map for the 0.5% AEP Rainfall Frequency Event (Existing Without Project Condition)

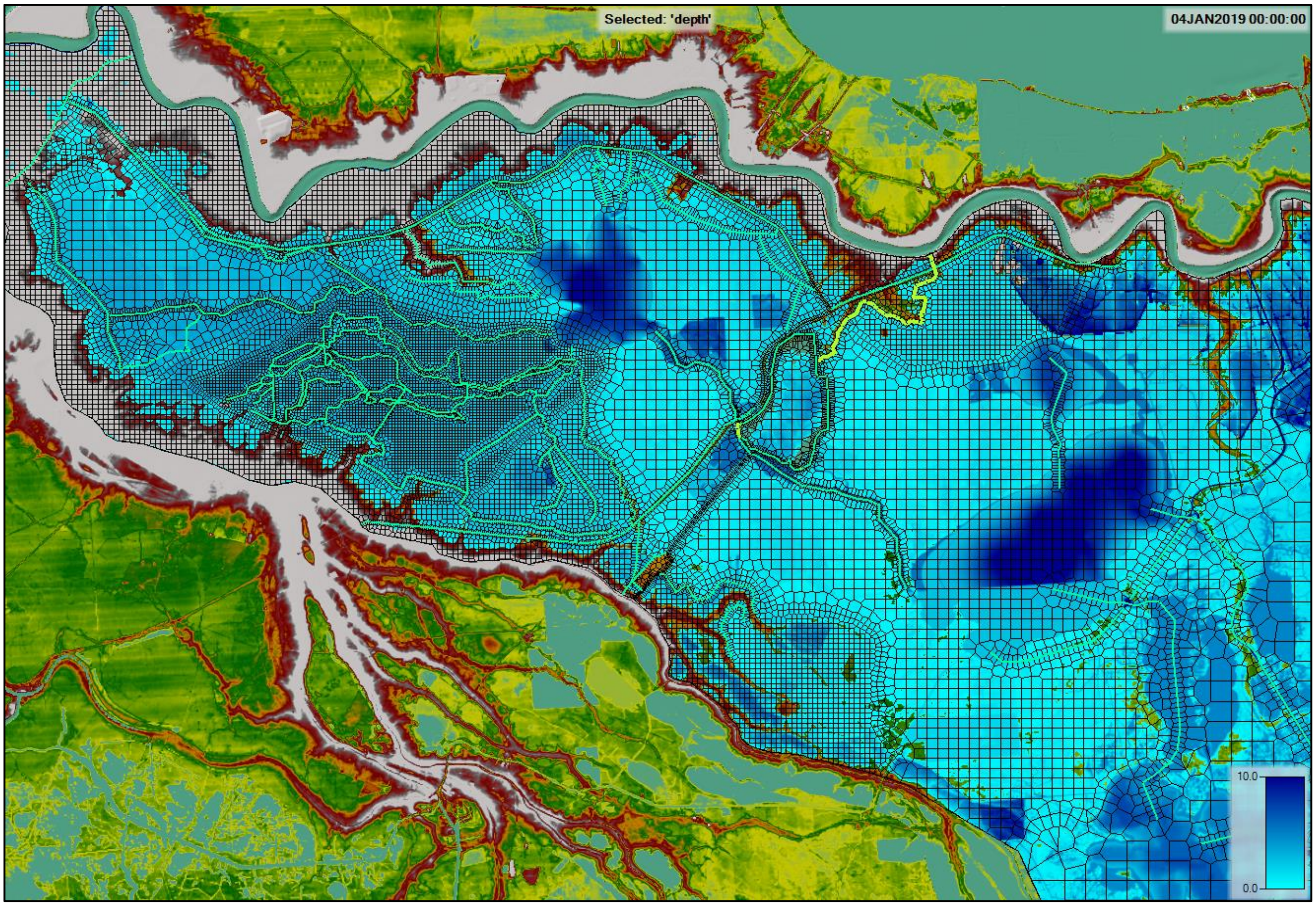


Figure 2-66: Inundation Map for the 0.2% AEP Rainfall Frequency Event (Existing Without Project Condition)

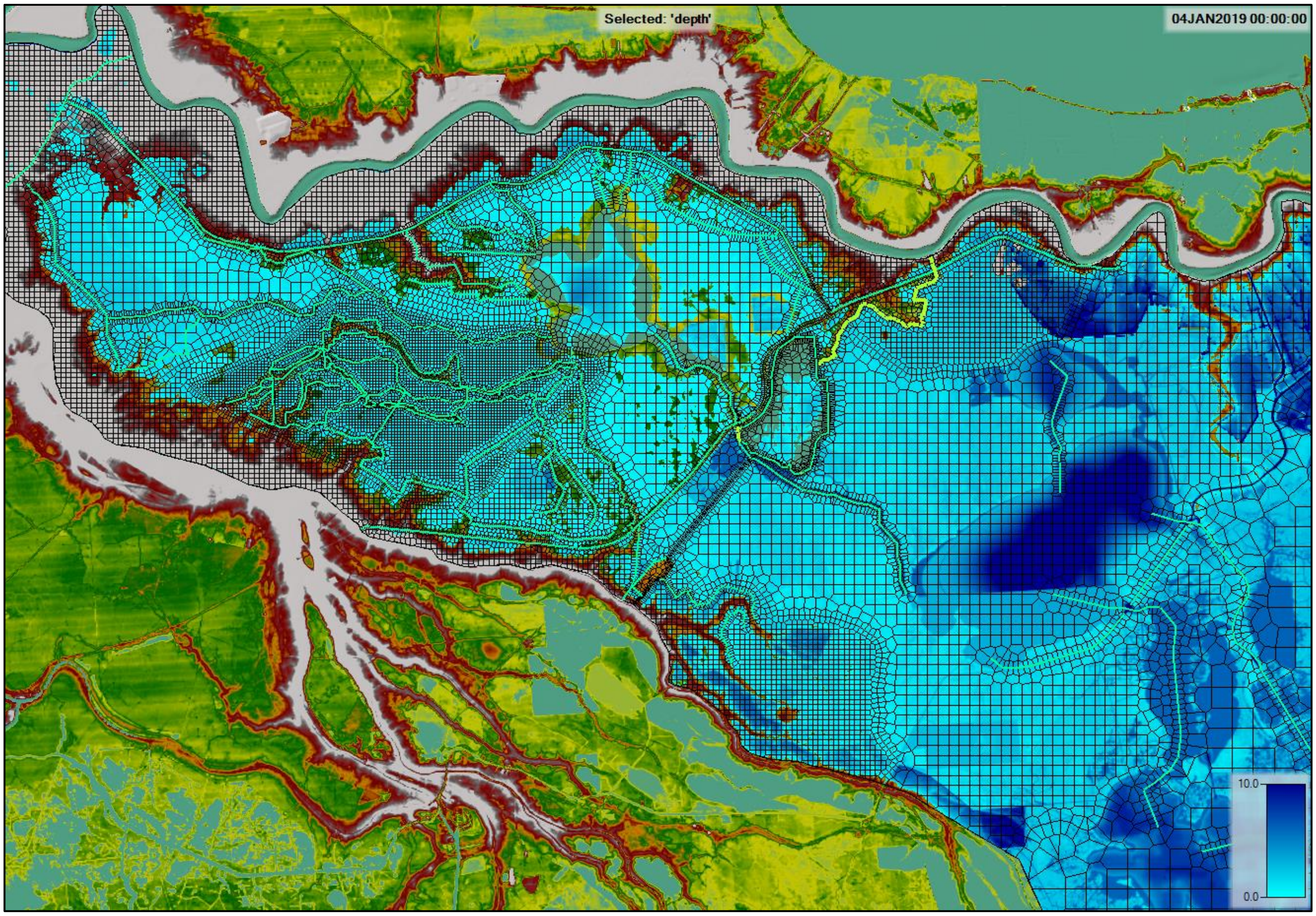


Figure 2-67: Inundation Map for the 50% AEP Rainfall Frequency Event (Future Without Project Condition)

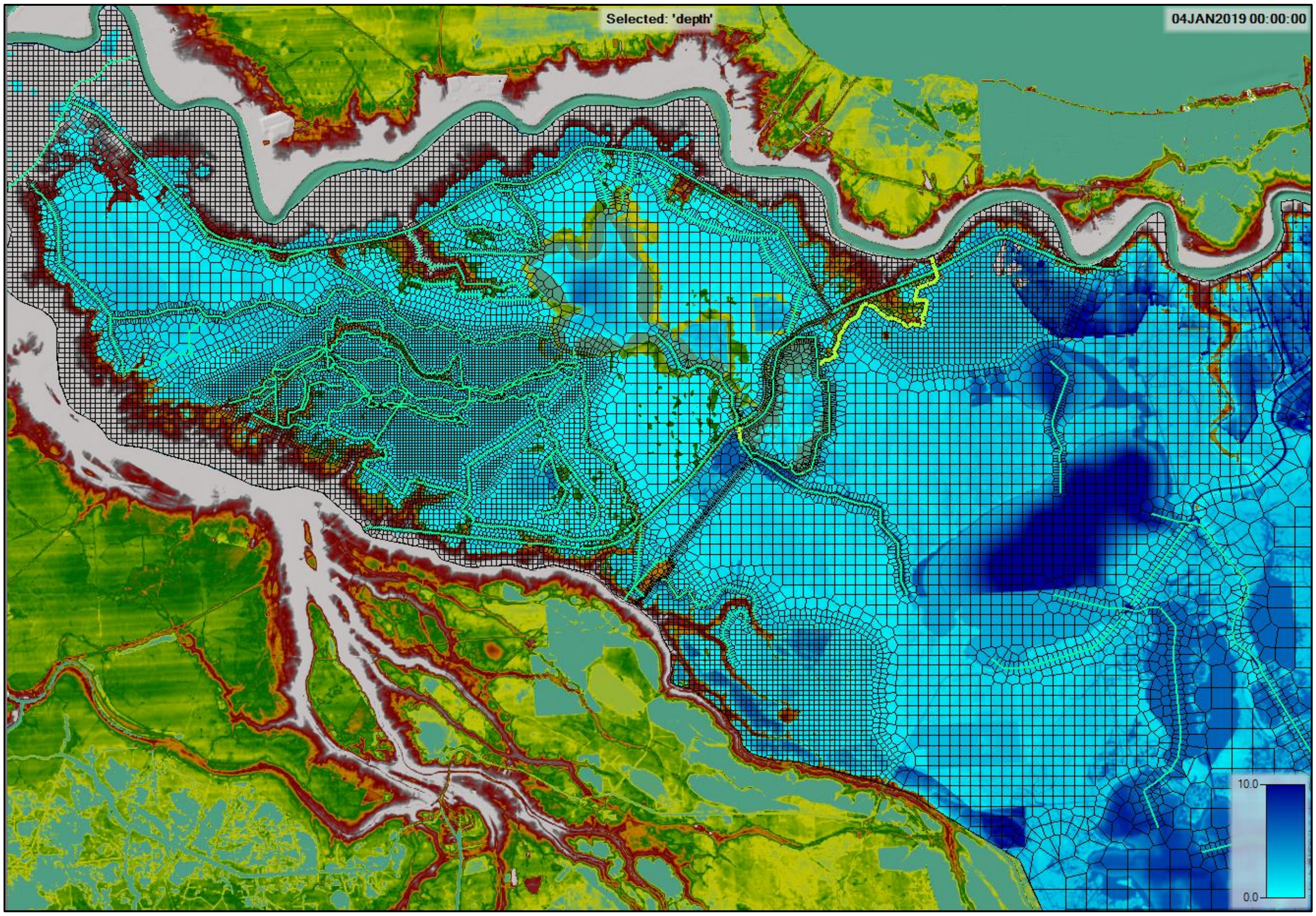


Figure 2-68: Inundation Map for the 20% AEP Rainfall Frequency Event (Future Without Project Condition)

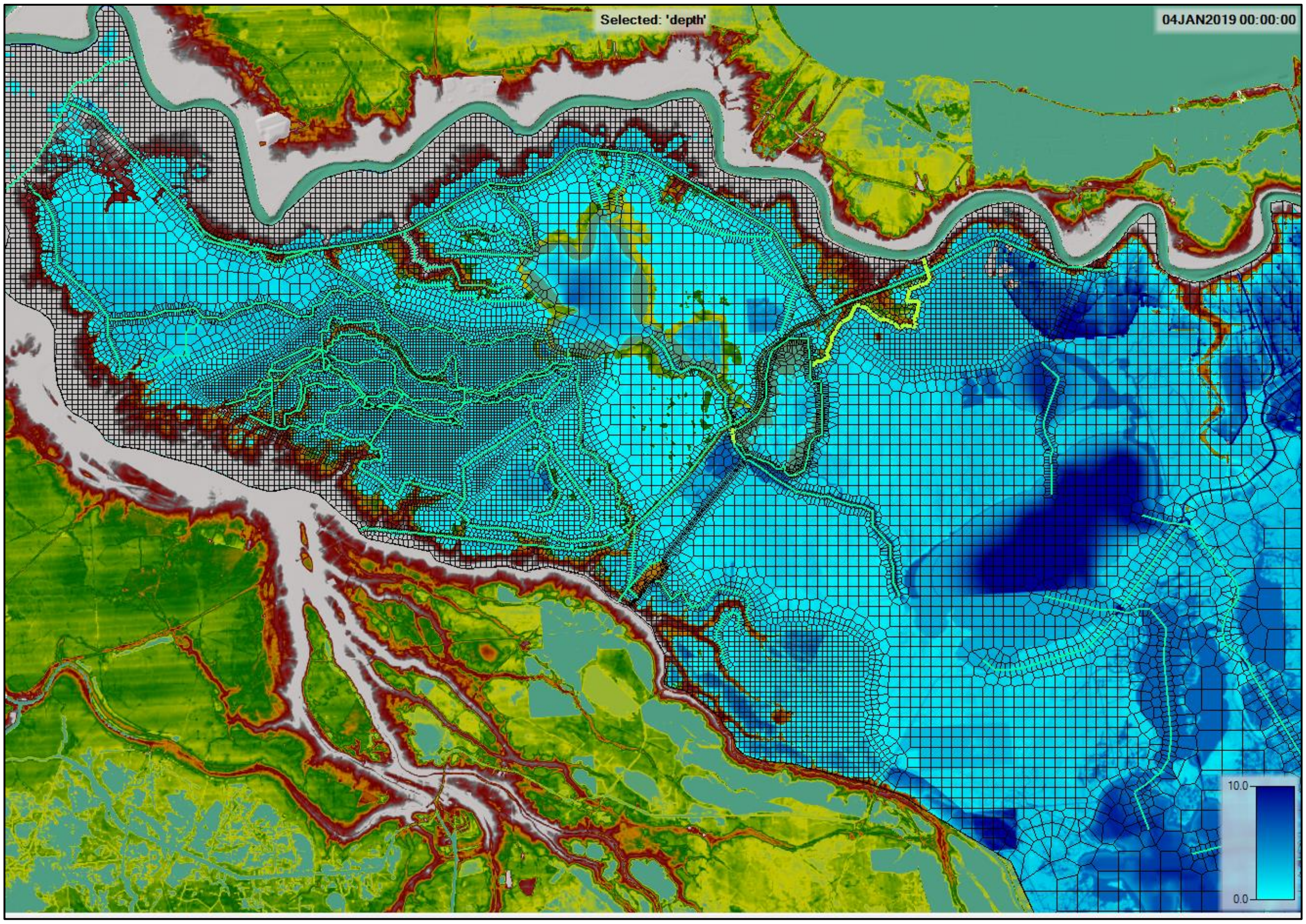


Figure 2-69: Inundation Map for the 10% AEP Rainfall Frequency Event (Future Without Project Condition)

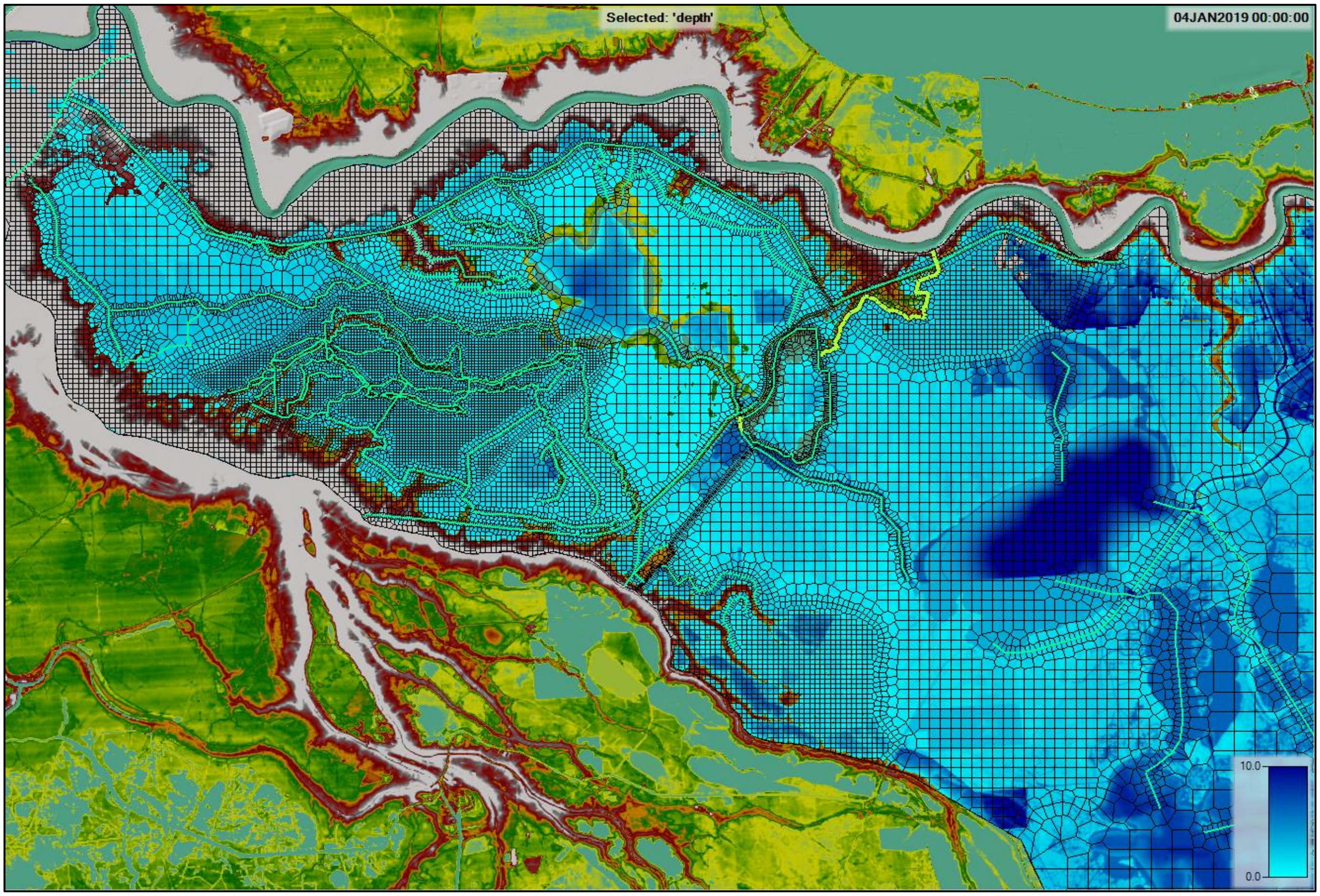


Figure 2-70: Inundation Map for the 4% AEP Rainfall Frequency Event (Future Without Project Condition)

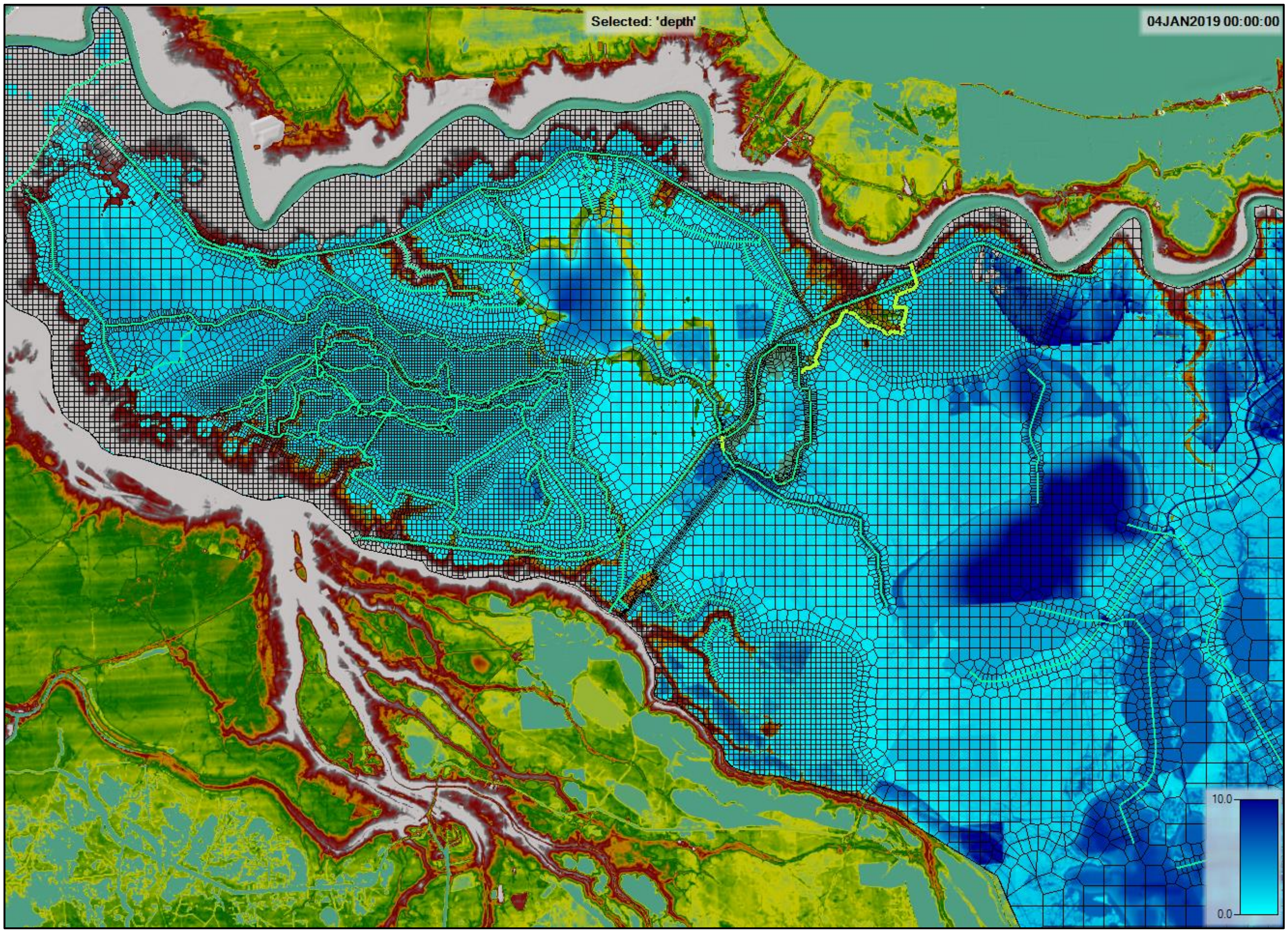


Figure 2-71: Inundation Map for the 2% AEP Rainfall Frequency Event (Future Without Project Condition)

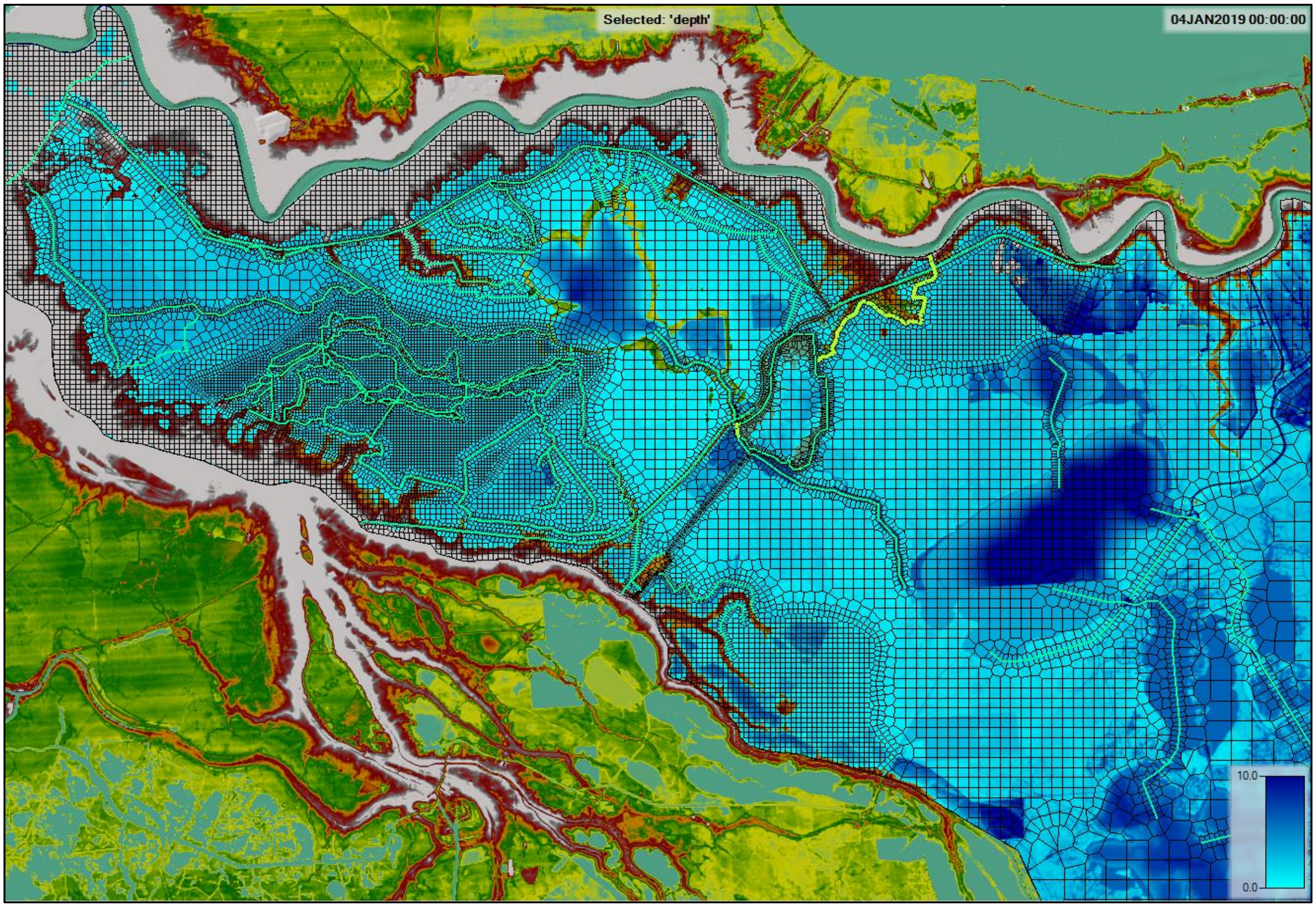


Figure 2-72: Inundation Map for the 1% AEP Rainfall Frequency Event (Future Without Project Condition)

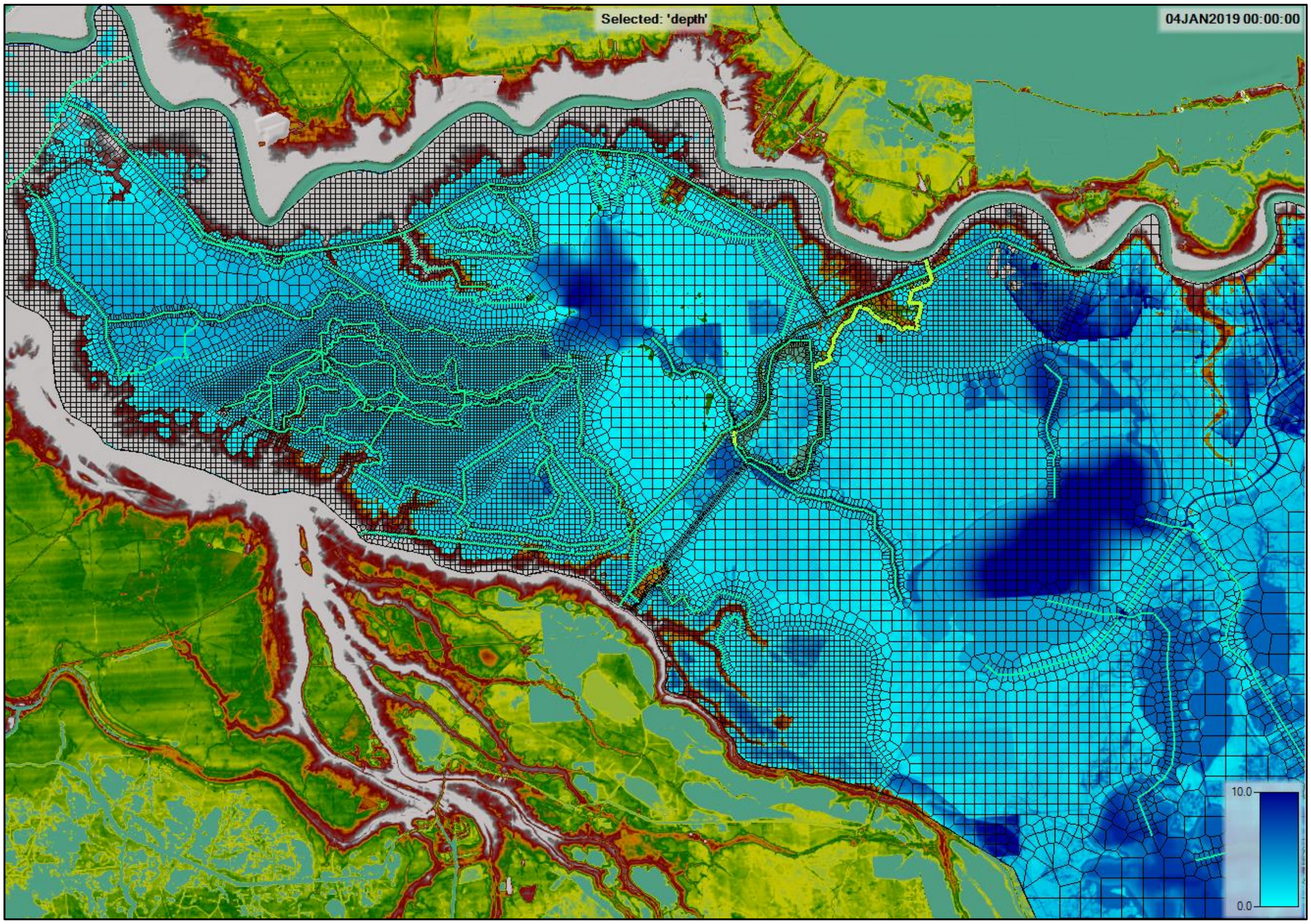


Figure 2-73: Inundation Map for the 0.5% AEP Rainfall Frequency Event (Future Without Project Condition)

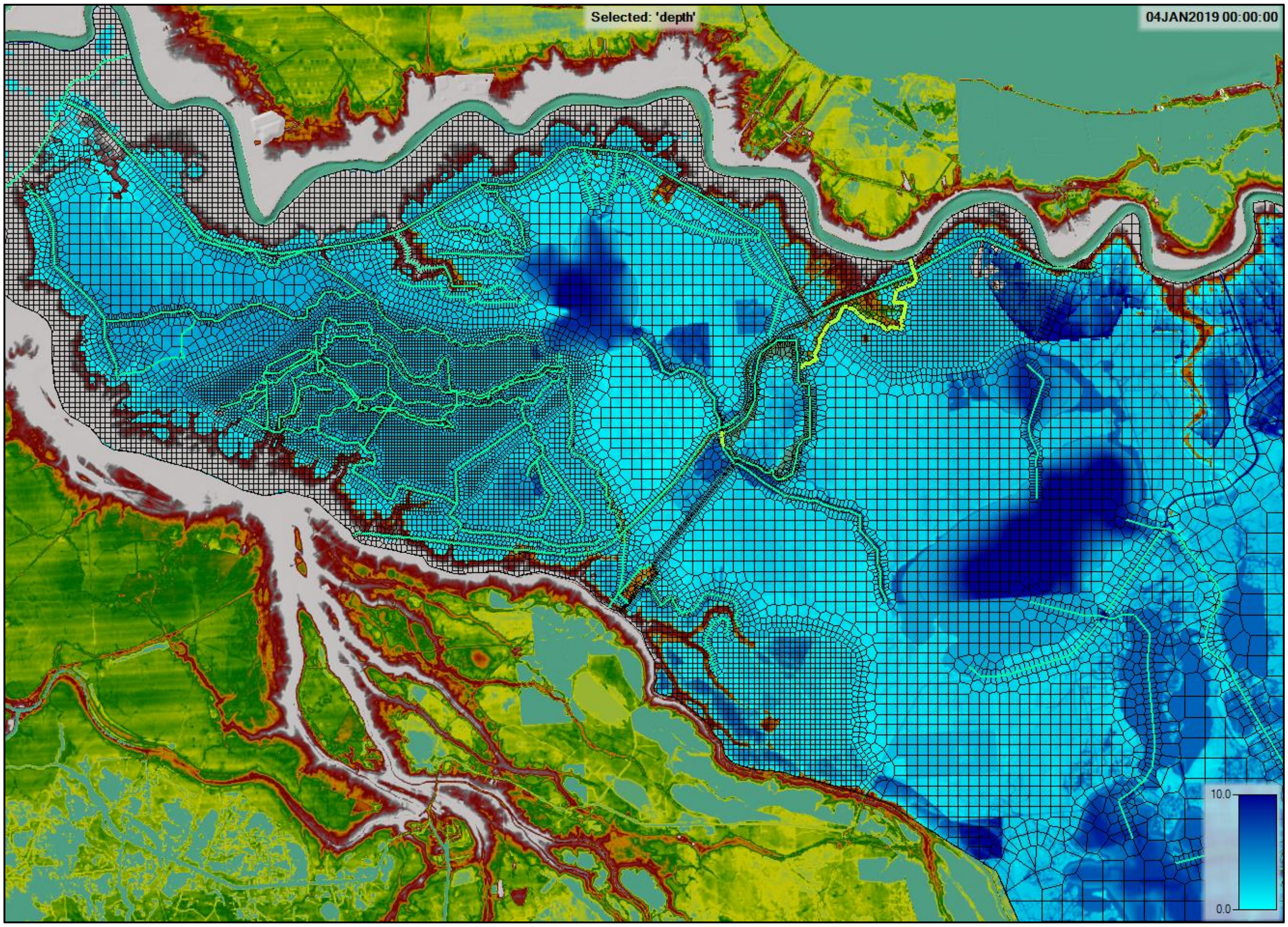


Figure 2-74: Inundation Map for the 0.2% AEP Rainfall Frequency Event (Future Without Project Condition)

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 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:3H 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 once the TSP has been selected.

2.16 Cost Estimates

2.16.1 Cost Estimate Development

Cost estimates for the structural alternatives were developed at a Class 4 Level of effort utilizing parametric costs, historical costs or the latest TRACES MII cost estimating software. The cost estimate used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes and subcontractor and prime contractor markups. This philosophy was taken wherever practical. This process was supplemented with estimating information from other sources where necessary such as quotes, bid data and Architect/Engineer (A/E) firm estimates. The A/E cost estimates provided in the Lafourche Basin Levee District Upper Barataria Risk Reduction Conceptual Design Report, dated December 2018, were developed from minimum 10% conceptual designs, and had quantities itemized in sufficient detail as to be useful in developing final costs for all structures contained within each of the alternatives. The intent was to provide or convey a “fair and reasonable” estimate which depicts the local market conditions. The estimates assumed a typical application of tiers of subcontractors. 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 accessible from land. Site access is easily provided from various local highways.

The cost estimates for the non-structural alternative (Alternative 7) were developed by the CEMVN Economist, and are discussed in Section 2.7 of this appendix and the Main Report (along with the Economics Appendix).

2.16.2 Estimate Structure

The estimates have been subdivided by alternative and USACE feature codes.

2.16.3 Bid Competition

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

2.16.4 Contract Acquisition Strategy

There is no declared contract acquisition plan/type at this time. It is assumed that the contract acquisition strategy will be similar to past projects with some negotiated contracts, focus and preference of small business/8(a) and large, unrestricted design/bid/build contracts.

2.16.5 Labor Shortages

It is assumed there will be a normal labor market.

2.16.6 Labor Rates

Local labor market wages are above the local Davis-Bacon Wage Determination, so actual rates have been used. Local payroll information was not available. Therefore, regional gulf coast information was used from the CEMVN construction representatives and estimators with experience in past years.

2.16.7 Materials

Cost quotes are used on major construction items when available. Recent cost quotes may include concrete, steel and concrete piling, HPTRM, sod, rock, gravel and sand. The assumption is that materials will be purchased as part of the construction contract. The estimate does not anticipate government furnished materials, except for borrow material. Prices include delivery of materials.

All borrow material is assumed to be government furnished. Specific sources for borrow material have not yet been established. There is considerable farmland and commercial borrow sites (e.g., Raceland Raw Sugars and River Birch) within a 15 mile radius of the project. Therefore, an assumed average one-way haul distance of 15 miles was used until a committed borrow source has been confirmed to be available. Haul speeds are estimated using a 35 mph average speed, given the rural access roads and highways that exist in the area.

The borrow quantity calculations followed the CEMVN Geotechnical guidance as follows: for hauled levee material, 10 bank cubic yards (BCY) of borrow material = 12 loose cubic yards (LCY) hauled = 8 embankment cubic yards (ECY) compacted.

2.16.8 Quantities

Quantities were provided by the civil and structural designers for the various alternatives.

2.16.9 Equipment

Rates used were based on the latest version of USACE EP-1110-1-8, Region III. Adjustments were incorporated for fuel, filters, oil and grease prices and facility capital cost of money (FCCM). Judicious use of owned or rental rates was considered based on typical contractor usage and local equipment availability. Only a few select pieces of marine/marsh equipment were considered for rent. The full FCCM rate was the latest available. The MII program takes the recommended discount from USACE EP-1110-1-8, Region III, with no other adjustments incorporated in the FCCM. Equipment was selected based on historical knowledge of similar projects.

2.16.10 Severe Rates

Severe equipment rates were used (where applicable) for various pieces of equipment in hydraulic dredging crews, where they may encounter a harsh environment.

Rental rates were used (where applicable) for various pieces of marine and marsh equipment, where rental of equipment is typical (such as marsh backhoes, for example).

2.16.11 Fuels

Fuels (e.g., gasoline and diesel fuel) were based on local market averages for the gulf coast area. It was discovered that fuels fluctuate irrationally, which is why an average was used.

2.16.12 Crews

Major crew and productivity rates were developed and studied by senior USACE estimators familiar with the type of work. All of the work is typical to the gulf coast area and CEMVN cost engineers. The crews and productivities were checked by local CEMVN estimators, discussions with contractors and comparisons with historical cost data. Major crews included those needed for hauling, earthwork placement, piling, concrete placement and hydraulic dredging.

Most crew work hours were assumed to be 10 hrs. per day at 6 days per week, which is typical to the area. Marine-based bucket excavation/dredging operations were assumed to work two 12-hour shifts at 7 days per week.

A 10% markup on labor for weather delay was selectively applied to the labor in major earthwork-placing detail items, and associated items that would be affected by the weather, creating unsafe or difficult conditions to operate (e.g., trying to run dump trucks on a wet levee) or would be detrimental/non-compliant to the work being performed (such as trying to place/compact material in the rain). The 10% markup was to cover the common practice of paying for labor “showing up” to the job site and then being sent home due to minor weather conditions, which is part of known average weather impacts as reflected within the standard contract specifications. The markup was not applied to small quantities where this can be rescheduled.

2.16.13 Unit Prices

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

2.16.14 Relocation Costs

Relocation costs are defined as the relocation of public roads, bridges, railroads and utilities required for project purposes. In cases where potential significant impacts were known, relocation costs were included within the cost estimate.

2.16.15 Mobilization

Contractor mobilization (mob.) and demobilization (demob.) are based on the assumption that most of the contractors will be coming from within the gulf coast/southern region. Mob./demob. costs are based on historical studies of detailed government estimates for mob./demob., which are in the range of 3% to 5% of the construction costs. With undefined acquisition strategies and assumed individual project limits, the estimate utilizes a slightly more comprehensive (approximately 4%) value (as a minimum) applied at each contract rather than risking minimizing the mob./demob. costs by detailing costs based on an assumed number of contracts. This value also matches well with values previously prescribed by the USACE Walla Walla District, which has studied historical rates.

2.16.16 Field Office Overhead

The estimate used a field office overhead rate of 12% for the prime contractors. Based on historical studies and experience, the USACE Walla Walla District has recommended typical rates ranging from 9% to 11% for large civil works projects. However, the 9% to 11% rates do not consider possible incentives such as camps, allowances, travel trailers, meals, etc., which have been used previously to facilitate large or remote projects. With undefined acquisition strategies and assumed individual project limits, the estimate uses a more comprehensive percentage-based approach applied at each contract rather than risking minimizing overhead costs by detailing costs based on an assumed number of contracts. The applied rates were previously discussed among numerous USACE District cost engineers, including Walla Walla, Vicksburg, Norfolk, Huntington, St. Paul and New Orleans Districts.

2.16.17 Overhead Assumptions

Overhead assumptions may include costs for the superintendent, the office manager, pickup trucks, periodic travel costs, communications, temporary offices (contractor and Government), office furniture, office supplies, computers and software, as-built drawings and minor designs, tool trailers, staging setup, camp/facility/kitchen maintenance and utilities, utility service, toilets, safety equipment, security and fencing, small hand and power tools, project signs, traffic control, surveys, temporary fuel tank station, generators, compressors, lighting and minor miscellaneous.

2.16.18 Home Office Overhead

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

2.16.19 Taxes

Local taxes will be applied based on the parishes that contain the work. Reference the tax rate website for Louisiana: http://www.salestaxstates.com.

2.16.20 Bond

The Bond interest rate was assumed to be 1%, applied against the prime contractor, assuming large contracts. There was no differentiation between large and small businesses.

2.16.21 Planning, Engineering and Design (PED)

The PED cost included such costs as project management, engineering, planning, designs, investigations, studies, reviews, value engineering (VE) and engineering during construction. Historically, a rate of approximately 12% for Engineering and Design (E&D), plus small percentages for other support features, is applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis have reported values ranging from 10% to 15% for E&D. Additional support features might include project management, engineering, planning, designs, investigations, studies, reviews and VE. An E&D rate of 12% was applied for this project.

2.16.22 Supervision and Administration (S&A)

Historically, a range from 5% to 15%, depending on project size and type, has been applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis report values ranging from 7.5% to 10%. Consideration includes that a portion of the Supervision and Administration (S&A) effort could be performed by contractors. An S&A rate of 11% was applied for this project.

2.16.23 Contingencies

Contingencies for the final array of structural alternatives were developed using the USACE Abbreviated Cost Risk Analysis (ARA) program. An ARA is a qualitative approach used by the PDT to address key risk concerns for major features of work and their impact to cost and schedule drivers such as Project Scope Growth, Acquisition Strategy, Construction Elements, Quantities, Specialty Fabrication or Equipment, Cost Estimate Assumptions and External Project Risks. A separate ARA was conducted for Alternatives 1 and 2, with each analysis resulting in a composite risk contingency of approximately 31%. The same 31% composite risk contingency was applied to Alternative 10, since each of the three structural alternatives had the same features of work and very similar risk concerns. It should be noted Real Estate, PED and S&A costs were not included in formulating the composite risk contingency.

2.16.24 Escalation

The escalation used was based upon the latest version of the USACE Engineering Manual (EM) 1110-2-1304, "Civil Works Construction Cost Index System (CWCCIS)".

2.16.25 Hazardous, Toxic and Radioactive Waste (HTRW)

The estimates do not include costs for any potential HTRW, however, these costs will be applied as appropriate following feasibility design.

2.16.26 Schedule

The project schedule for each structural alternative was developed based on the construction line items for each feature of work. A generic construction schedule was applied to all of the alternatives for comparison purposes.

The expected construction duration for each of the structural alternatives is three years (from year 2020 through year 2023).

2.16.27 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	$24,649,000	$7,552,000	$32,201,000
06 Fish and Wildlife Facilities	$57,557,000	$17,634,000	$75,191,000
11 Levees and Floodwalls	$140,569,000	$43,068,000	$183,637,000
15 Floodway Control and Diversion Structures	$86,519,000	$26,508,000	$113,027,000
18 Cultural Resources Preservation	$682,000	$209,000	$891,000
30 P.E.D (Engineering and Design)	$51,606,000	$15,811,000	$67,417,000
31 Construction Management	$27,691,000	$8,484,000	$36,175,000
TOTAL	$393,180,000	$120,243,000	**$513,423,000**

***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	$33,095,000	$10,163,000	$43,258,000
06 Fish and Wildlife Facilities	$75,818,000	$23,283,000	$99,101,000
11 Levees and Floodwalls	$196,480,000	$60,336,000	$256,816,000
15 Floodway Control and Diversion Structures	$95,748,000	$29,403,000	$125,151,000
18 Cultural Resources Preservation	$694,000	$213,000	$907,000
30 P.E.D (Engineering and Design)	$66,691,000	$20,480,000	$87,171,000
31 Construction Management	$35,786,000	$10,989,000	$46,775,000
TOTAL	$509,055,000	$156,053,000	**$665,108,000**

***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	$21,811,000	$6,696,000	$28,507,000
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 P.E.D (Engineering and Design)	$98,710,000	$30,304,000	$129,014,000
31 Construction Management	$52,966,000	$16,261,000	$69,227,000
TOTAL	$695,325,000	$213,159,000	**$908,484,000**

* 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

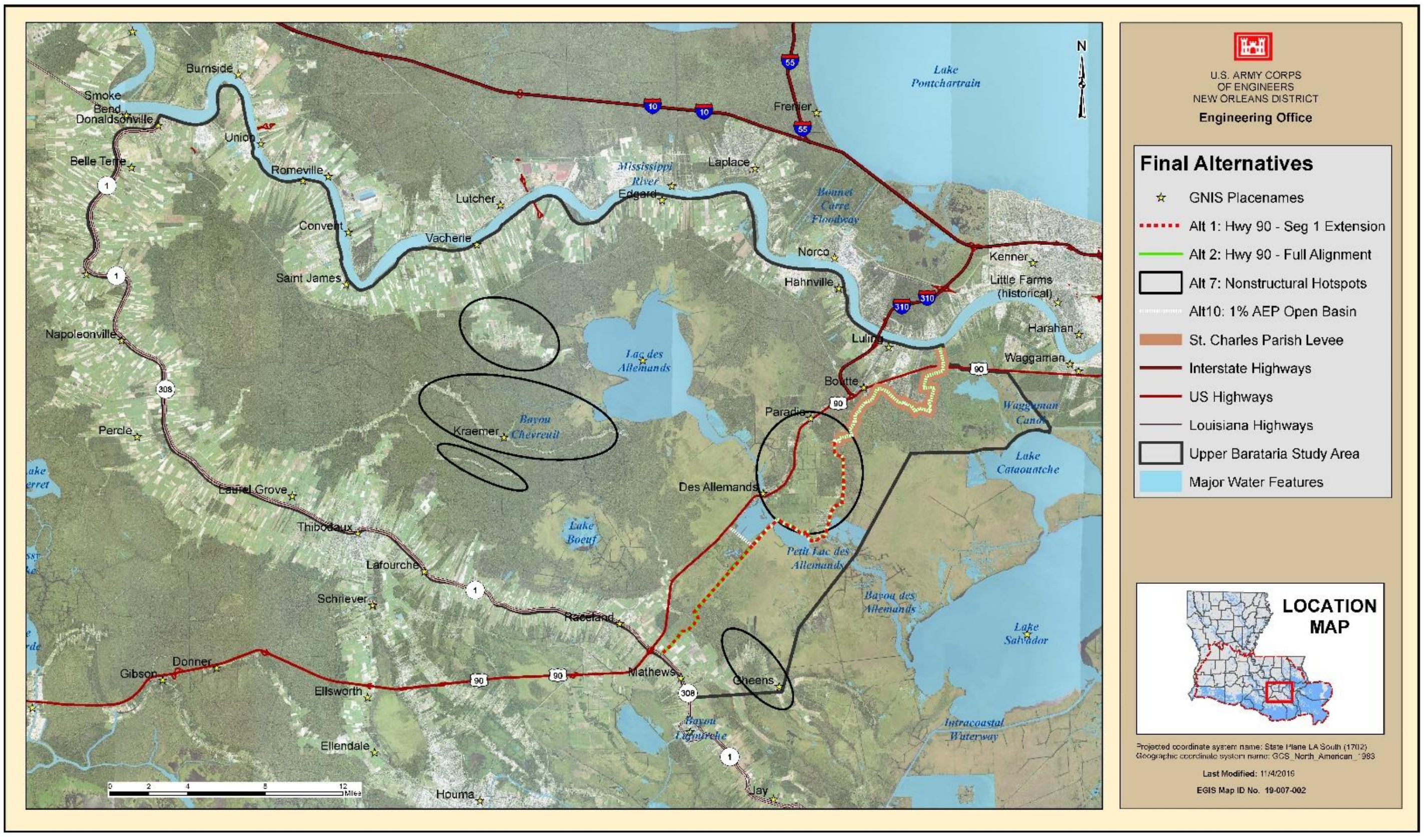


Figure 2-75: Final Array of Alternatives

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 Section 1 of this appendix for more information regarding the TSP.