

**Summary of the
MORGANZA TO THE GULF OF MEXICO, LOUISIANA
Final Post Authorization Change Report
May 2013**

Purpose of the Post-Authorization Change Report

The Morganza to the Gulf of Mexico, Louisiana (Morganza to the Gulf) project authorized by the Water Resources Development Act (WRDA) of 2007 was developed well before Hurricane Katrina's devastating impact on the New Orleans hurricane levees in August 2005. Implementation of more robust Hurricane and Storm Damage Risk Reduction System (HSDRRS) design standards and other changes since project authorization caused the Morganza to the Gulf project to exceed the 20 percent cost increase limit specified in WRDA 1986, Section 902. The purpose of this Post Authorization Change (PAC) report is to seek re-authorization of the Morganza to the Gulf project. Once all required technical, legal, and policy reviews are complete, the report will ultimately be reviewed by the Assistant Secretary of the Army (Civil Works) and coordinated with the Office of Management and Budget as appropriate for submission to Congress.

Authority

The Morganza to the Gulf project was authorized by WRDA 2007 (PL 110-114, Sec 1001) at a total cost of \$886.7 million as follows:

*“(24) MORGANZA TO THE GULF OF MEXICO, LOUISIANA.—
(A) IN GENERAL.—The project for hurricane and storm damage reduction, Morganza to the Gulf of Mexico, Louisiana: Reports of the Chief of Engineers dated August 23, 2002, and July 22, 2003, at a total cost of \$886,700,000, with an estimated Federal cost of \$576,355,000 and an estimated non-Federal cost of \$310,345,000.
(B) OPERATION AND MAINTENANCE.—The operation, maintenance, repair, rehabilitation, and replacement of the Houma Navigation Canal lock complex and the Gulf Intracoastal Waterway floodgate features of the project described in subparagraph (A) that provide for inland waterway transportation shall be a Federal responsibility in accordance with section 102 of the Water Resources Development Act of 1986 (33 U.S.C. 2212).”*

In accordance with the 2002 and 2003 reports of the Chief of Engineers, the Morganza project is authorized as a feature of the Mississippi River and Tributaries (MR&T).

Description of Authorized Project

The authorized MR&T project, Morganza to the Gulf, is designed to provide hurricane and storm damage reduction benefits while ensuring navigational passage and tidal exchange. The project is located about 60 miles southwest of New Orleans, LA, and includes Terrebonne Parish and the portion of Lafourche Parish between the eastern boundary of Terrebonne Parish and Bayou Lafourche. The 2002 and 2003 Chief of Engineers reports recommended a plan to reduce

hurricane and storm damages by providing a 100-year, or 1 percent annual exceedance probability (1% AEP), level of risk reduction including the features shown in figure S-1.

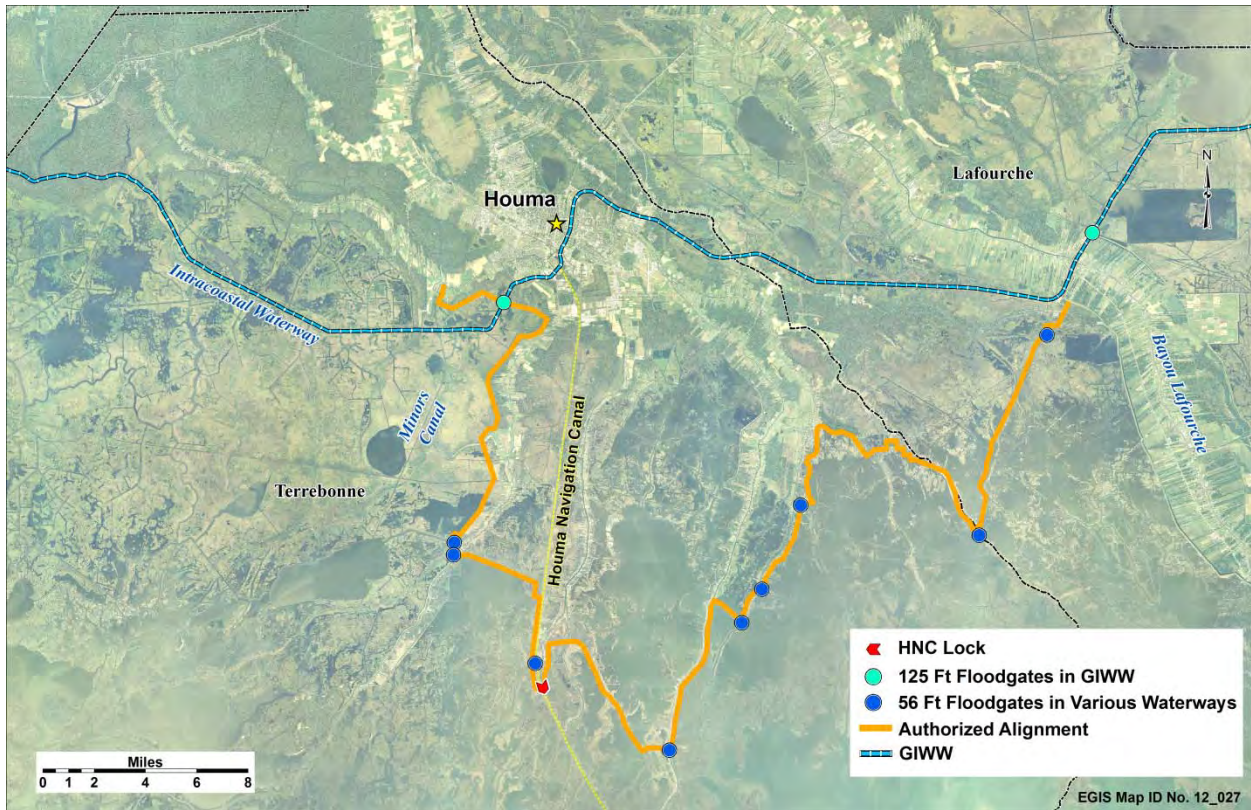


Figure S-1. Authorized Project Features

Project Purpose

The primary project purpose as described in the authorization is hurricane and storm damage reduction. The post-authorization plan does not include any changes in project purpose from the authorized plan. The purpose of the earthen levee system is to stop or slow down surge inundation. Floodgates provide storm damage reduction during tropical storms and allow currently navigable waterways to remain open to navigation during non-storm conditions. The purpose of the lock is to control saltwater intrusion at the Houma water treatment plant while allowing for navigation. Environmental control structures (box culverts) through the levee allow tidal ebb and flow.

Non-Federal Sponsor

The Louisiana Coastal Protection and Restoration Authority Board (LACPRAB) and the Terrebonne Levee and Conservation District (TLCD) have expressed their intent to be non-Federal co-sponsors for the Morganza to the Gulf project (hereafter referred to as the non-Federal sponsor). In a letter dated December 21, 2012, the non-Federal sponsor expressed commitment and understanding of non-Federal cost share responsibilities for construction and operation and maintenance, repair, replacement and rehabilitation (OMRR&R). Section 1001(24) of WRDA 2007 specifies Federal responsibility for OMRR&R of the Houma

Navigation Canal (HNC) lock complex and the Gulf Intracoastal Waterway (GIWW) floodgate features that provide for inland waterway transportation in accordance with Section 102 of WRDA 1986, as amended. The non-Federal sponsor is responsible for OMRR&R of all other project features. Additional responsibilities of the non-Federal sponsor are listed in section 8.3 of this report.

Funding Since Authorization

The Energy and Water Appropriations Act of 1998 (PL105-62) included funds to initiate design on the HNC lock feature of the Morganza to the Gulf project, which initiated the Preconstruction Engineering and Design (PED) phase for the HNC lock feature in advance of completing the Feasibility Report (2002) and signing of Chief's report (also 2002). The USACE and non-Federal sponsor signed a Design Agreement for the HNC lock in January 2000, and the non-Federal sponsor first contributed matching funds for PED in 2000. The first non-Federal contributions to the overall Morganza to the Gulf project were in September 2002.

Approximately \$61,650,000 has been allocated for the Morganza to the Gulf PED phase, which includes the PAC report. Most of the PED funds have been spent on engineering design and geotechnical investigations rather than on the PAC feasibility-level analysis.

Per U.S. Army Corps of Engineers (USACE) guidance, study costs for the PAC report are being cost shared 75 percent Federal and 25 percent non-Federal. The PAC study is cost shared under a Design Agreement originally executed on May 22, 2002 and amended on March 24, 2005 and January 11, 2011. While the Design Agreement provides for 75/25 cost share during design, WRDA 1986 (PL99-662), Section 105(c), stipulates that the non-Federal share of the cost of design is the same percentage as the non-Federal share for construction, which in this case is 35 percent. The design cost is shared per the percentage of construction cost with 25 percent being collected from the non-Federal sponsor during the Design Agreement and the remaining 10 percent collected in the first year after the Project Partnership Agreement is executed. Pending re-authorization, the construction cost share would be 65 percent Federal and 35 percent non-Federal. No Federal funds have been appropriated for construction of the Morganza to the Gulf project.

Project History Since Authorization

In 2008, a reconnaissance-level planning analysis and detailed programmatic cost estimate was completed for the purpose of determining whether or not there would still be a Federal interest in the project with post-Hurricane Katrina design criteria incorporated and whether a feasibility-level PAC report should be initiated. The 2008 analysis determined that the Morganza to the Gulf project updated with the HSDRRS criteria would still be economically justified, and the PAC re-evaluation study was initiated in early 2009.

Design Criteria Changes Since Authorization

Several policy, procedural, and design criteria changes have been made since the 2002 Morganza to the Gulf Feasibility Report was completed. Lessons learned from Hurricane Katrina and other recent storms have been incorporated into new HSDRRS design guidelines. These peer-reviewed guidelines were developed in response to recommendations made by the Interagency Performance Evaluation Task force (IPET), a team composed of members from USACE,

industry and academia that evaluated the Greater New Orleans levee system after Hurricane Katrina. In accordance with Assistant Secretary of the Army (Civil Works) direction, USACE is applying the HSDRRS guidelines to all hurricane levee system work in the New Orleans District, including the Morganza to the Gulf PAC project. The HSDRRS guidelines provide a comprehensive collection of best practices and were developed to provide redundancy, resiliency, and robustness of the interfaces between structures, materials, and members of the hurricane risk reduction system for the desired level of risk reduction.

The HSDRRS guidelines include some criteria that are more stringent than required for other USACE structures. Changes leading to larger designs and higher costs for the Morganza to the Gulf post-authorization project include the following:

- **Increase in Hydraulic Design Elevations** – Storm surge modeling in the 2002 report was based on only 17 tropical storms and did not consider relative sea level rise in the model. New storm surge modeling predicts water levels based on 115 theoretical storms and incorporates the effects of relative sea level rise within the model. In addition, the 2002 1% AEP water levels were based on the 50 percent confidence values, which have a 50 percent chance of being under-predicted. The new design guidelines require levees to be designed based on the 90 percent confidence values, which have only a 10 percent chance of being under-predicted. All of these factors result in prediction of higher surge and waves, and wave run up used to set levee elevations.
- **Change from I-Walls to T-Walls** – In the 2002 report, floodwalls could be based on I-wall designs. Under the new guidelines, I-walls are not permitted in most cases and have been replaced with more robust and more expensive T-walls.
- **Increase in Geotechnical Stability Factor of Safety** – The analysis method for global stability changed, leading to a higher factor of safety, resulting in taller and wider levees and cost increases.
- **Addition of Structural Superiority** – All new structures that are difficult to construct because of disruptions to navigation or traffic, large utility crossings, or requiring cofferdams must be designed with a minimum of 2 ft of additional wall height resulting in cost increases.

These increases in project size and costs resulted in the project exceeding the WRDA 1986 Section 902 limit.

Post-Authorization Change Alternatives

The PAC study considered two primary hurricane and storm damage reduction alternatives in detail: a 3% AEP system (pre-Katrina 100-yr alternative) and a 1% AEP system (post-Katrina 100-yr alternative). The 3% AEP and 1% AEP alternatives both follow the same levee alignment, which is based on the authorized alignment, but with some modifications that have occurred since authorization. Of the two alternatives, the 1% AEP alternative has the greater net benefits, lower residual risk, and greater adaptability to future sea level rise.

Description of the 1% AEP Post-Authorization Project

The post-authorization 1% AEP Morganza to the Gulf hurricane and storm damage risk reduction system based on post-Katrina HSDRRS criteria consists of 98 miles of grass-covered earthen levees tying into US 90 near the town of Gibson in Terrebonne Parish and Hwy 1 near Lockport, LA in Lafourche Parish (see figure S-2). Levee elevations for base conditions (2035) range from 10.5 to 24 ft NAVD88, and final levee elevations (2085) range from 15 to 26.5 ft NAVD88 with final levee widths from 282 to 725 ft.

Structures include a lock on the HNC, 22 floodgates on navigable waterways (3 on Federally-maintained navigation channels and 19 on other canals and bayous), 23 environmental water control structures, 9 road gates, and fronting protection for 4 existing pumping stations.

Structures on Federally-maintained navigation channels include the HNC lock and floodgate (250-ft sector gate) and two floodgates on the GIWW (i.e. GIWW East, a 125-ft sector gate east of Bayou Lafourche, and GIWW West, a 125-ft sector gate west of Houma). Fourteen 56-ft sector gates and five 20- to 30-ft stop log gates are located on various waterways that cross the levee system. Structure elevations range from 17 to 33 ft NAVD88.

Levees would be covered in grass to increase resilience in the case of wave overtopping. All of the transitions between levees and floodwalls would be armored with reinforced concrete scour protection.

Changes in Location of Project

Figure S-2 shows the location of both the authorized and post-authorization (current) alignments. A few reaches in the authorized project were refined during PED (reaches A, G, H, J, and L), and the original alignment had to be extended to the west (Barrier Reach) and to the east (Larose reaches) because surge modeling now indicates that with projected sea level rise, the 1% AEP surge may be able to cross the Bayou Black and Lafourche ridges. Surge modeling for the 2002 feasibility report produced lower stages, which indicated that surge would not cross the ridges. Some levee reach footprints are also wider because of the higher post-Katrina design elevations and the HSDRRS increase in Geotechnical Stability Factor of Safety.

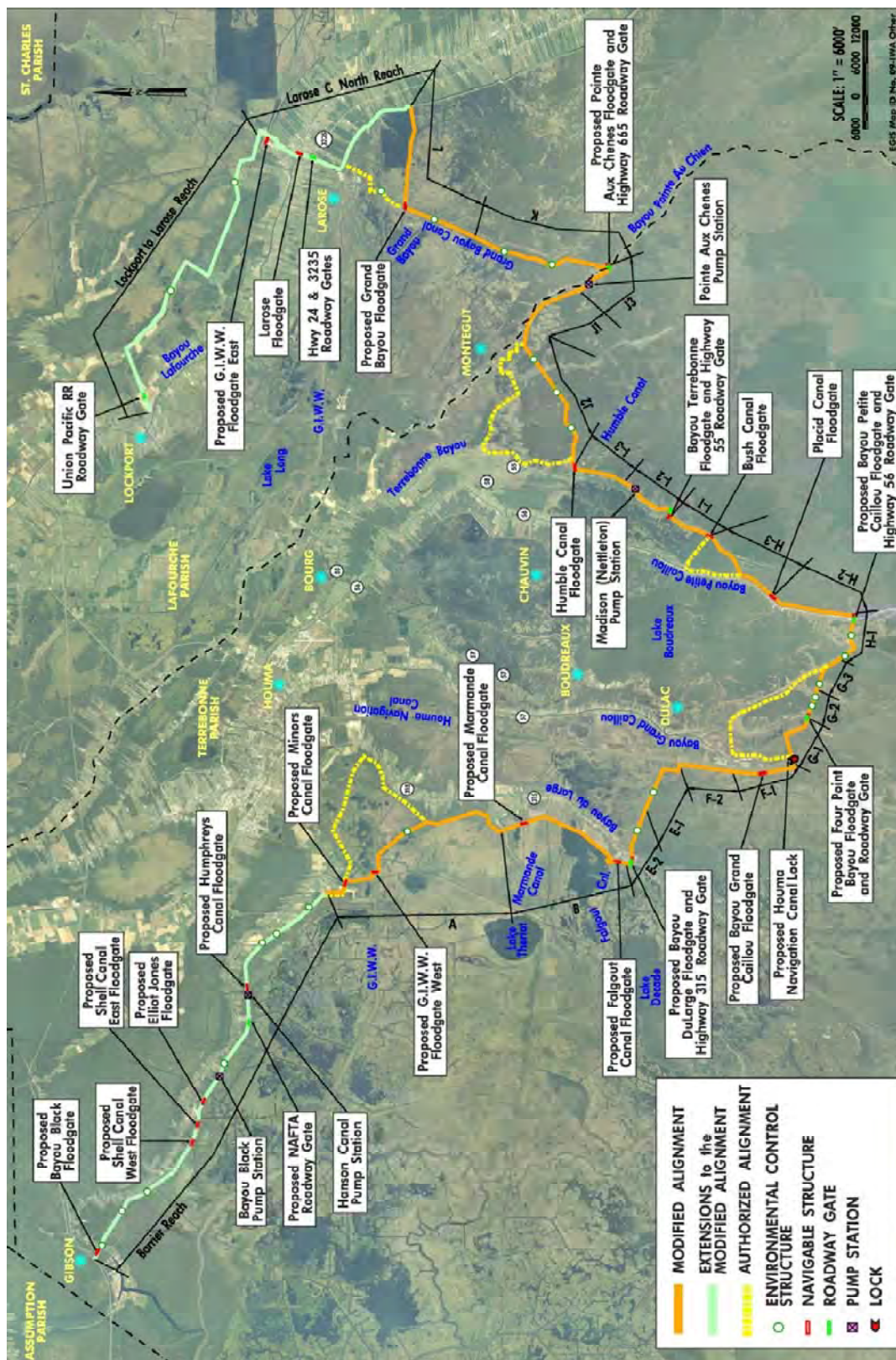


Figure S-2. Post-Authorization Morganza to the Gulf Project Map

Changes in Scope of Authorized Project

The post-authorization plan has the same target level of risk reduction as the authorized plan (1% AEP). More rigorous storm surge modeling and more robust post-Katrina HSDRRS standards expanded the scope of the authorized project as follows:

- **Total levee length** increased from 72 miles to 98 miles. Post-authorization refinements initially reduced the length of the 72-mile authorized alignment by approximately 11 miles, however, post-Katrina surge modeling, which considered higher rates of relative sea level rise and higher surge and waves in the future, demonstrated that the authorized project could potentially be flanked at either end. The proposed levees were also extended to address potential costs to complete the Morganza to the Gulf system in the event that other previously proposed hurricane and storm damage reduction projects in the area are never authorized and/or constructed. The alignment was extended 16 miles to the west and 21 miles to the east to complete the system.
- **Levee and structure elevations** increased by several feet in all reaches and more than doubled in some reaches. Authorized levee and structure elevations along the authorized alignment vary from a minimum elevation of 9 ft National Geodetic Vertical Datum (NGVD) to a maximum elevation of 15 ft NGVD. Post-authorization levee elevations (for future conditions at year 2085) range from 15 ft North American Vertical Datum (NAVD88 epoch 2004.65) at the lowest point to 26.5 ft NAVD88 at the highest point, and structure elevations range from 17 ft NAVD88 at the lowest structure to 33 ft NAVD88 at the highest structure. Note the different datum for the authorized (NGVD) and current (NAVD88) elevations. The change in elevation due to datum differences varies by location, and is around 0.5 to 1.5 ft. Most of the increase is attributable to higher predicted surge and waves and post-Katrina HSDRRS design criteria. For the structures, 2 ft of the increase is attributable to the HSDRRS structural superiority requirement.
- **Levee widths** increased by several hundred feet and are now four to eight times wider. Authorized levee widths range from 40- to 200-ft wide; post-authorization levee widths range from 282- to 725-ft wide. The increases in levee widths are attributable to the increases in levee heights and the HSDRRS increase in Geotechnical Stability Factor of Safety.
- **The HNC lock complex and GIWW floodgate features**, which are located on Federally-maintained navigation channels, are generally the same except for the following changes: The GIWW West floodgate near Houma was re-designed to eliminate one of the two sector gates. Both the GIWW West and GIWW East floodgate sizes were reduced from 175-ft to 125-ft sector gates consistent with the authorized channel width and as a cost-saving measure. The HNC floodgate width increased from 200 to 250 ft. The reason the HNC floodgate had to be widened is that the floodgate's pre-Katrina arrangement is no longer technically feasible given the increase in design height. HNC structure sill depths may increase by 5 ft as part of a requested sponsor funded additional work item.
- **The number of floodgates on other canals and bayous** increased from 9 to 19 for two reasons. One reason is that during PED, several bayous were identified as being used for

navigation, but were not noted as such in the original feasibility study. Another reason is that the western and eastern levee extensions contain several navigable bayous. The assumption for the PAC report was that all currently navigable bayous must remain navigable in the future; the number/sizes of gates may be reduced during PED with additional data on navigation.

- **The number of environmental flow control structures** increased from 12 to 23 sets of concrete box culverts with sluice gates. In the 2002 feasibility report, a single design criterion stated that the environmental control structures should be sized to “return the specified wetland storage area elevations to pre-storm elevations within 14 days.” The PAC report includes a more refined set of criteria, including precipitation event conditions, water level, velocity, and box culvert design criteria.
- **The number of road gates and modifications to existing pump stations** also increased because of the western and eastern levee extensions.
- **Environmental mitigation features** for the project authorized in WRDA 2007 included creation of 1,352 acres of marsh habitat. At this time, mitigation features for the post-authorization project have only been identified for the constructible features (i.e. levee reaches F-1, F-2, and G-1; the HNC lock complex; and the Bayou Grand Caillou floodgate). Mitigation for direct and indirect impacts of the constructible features includes approximately 394 acres intermediate marsh restoration, 358 acres brackish marsh restoration, and 883 acres saline marsh restoration. For the remaining programmatic features, mitigation costs and land requirements were estimated, but the exact number of acres will be determined in the future as more specific designs are completed and impacts are assessed in future supplemental NEPA documents.
- **A preliminary nonstructural buyout plan** has been developed for high risk areas outside the proposed levee system. Hydrologic modeling indicates that the levee could potentially increase storm surge flooding in these areas; however, additional modeling and analysis would need to be conducted during PED. For purposes of this report, the worst case scenario (most expensive option) has been assumed, which would be a 100 percent buyout of all structures in the impacted areas (approximately 1,000 structures). Should this scenario prove to be the appropriate mitigation method, approximately 2,500 people would need to be relocated to areas behind the Federal levee system.

Changes in Project Costs and Benefits

Both project costs and benefits have increased significantly since authorization. As shown in table S-1, project first costs have increased by an order of magnitude. As described in the previous section, the primary reasons for the cost increases are changes in predicted surge elevations and more robust post-Katrina HSDRRS guidelines. As a result, levee lengths, levee and structure heights, and levee widths have increased significantly.

As shown in table S-2, benefits have increased proportionately to costs, because the same, updated storm surge modeling indicates that more structures have a higher probability of getting flooded. The 1% AEP surge elevations have increased from 4 to 6 ft, to 12 to 14 ft, so the 1% AEP floodplain is now larger and incorporates more structures. The 2009/2010 PAC inventory

included approximately 53,000 structures, which is over twice the number of structures in the original 1997/1998 feasibility study inventory, which included approximately 26,000 structures.

Table S-1. Changes in Project First Costs (\$ Millions) by Project Feature

Work Breakdown Structure No. & Civil Works Feature Description	Project as Authorized by Congress (WRDA 2007)	Authorized Project (Updated)	3% AEP PAC Alternative	1% AEP PAC Alternative
Effective Price Level	Oct 2006	Oct 2012	Oct 2012	Oct 2012
02 Relocations	43	51	274	291
05 Locks	169	228	530	622
06 Fish & Wildlife Facilities	55	66	619	941
11 Levees & Floodwalls	253	314	2,467	5,351
15 Floodway Control & Diversion Structures	219	262	763	1,068
Construction Totals:	\$739	\$921	\$4,652	\$8,273
01 Lands and Damages	10	11	339	355
30 Planning, Engineering & Design	87	115	574	1,006
31 Construction Management	50	67	385	631
Project Cost Totals:	\$887	\$1,113	\$5,950	\$10,265

Note: Authorized project costs in 2006 and 2012 price levels developed using Form 17 (project cost estimates used to support budget submissions).

Table S-2. Changes in Annual Costs and Benefits (\$ Millions)

(All costs and benefits in \$millions)	Project as Authorized by Congress in WRDA 2007	Authorized Project (Updated)	3% AEP PAC Alternative	1% AEP PAC Alternative
Effective Price Level, Interest Rate:	Oct 2006, 5.125%	Oct 2012, 3.75%	Oct 2012, 3.75%	Oct 2012, 3.75%
Structures, Contents and Vehicles	91	98	609	959
Emergency Costs	9.6	10	37	54
Boats	1.6	2	<1	<1
Agricultural	2	2	N/A	N/A
Water Supply	0.3	0.3	<1	<1
Avoided Structure Raising Costs	N/A	N/A	10	10
Total Equivalent Annual Benefits	104	113	657	1,023
Annual Costs	49	36	442	716
Benefit-Cost Ratio	2.12	3.16	1.48	1.43
Net Benefits	55	77	214	307

Note: Benefits for boats in 2006 price levels updated to 2012 price levels using the Energy Information Administration Diesel Fuel Price on Gulf Coast; Agricultural benefits updated using the National Agricultural Statistical Service ratio of prices received and paid; all other benefit categories updated using the Composite Index Civil Works Construction Cost Index System. Agricultural benefits were calculated for the 2002 authorized plan, but not for the PAC because a certified model was not available to incorporate risk analysis, and the agricultural benefits were a small percentage of the total PAC benefits.

Emergency cost reductions for the authorized project were based on pre-Hurricane Katrina/Rita information, and the emergency cost reductions for the post-authorization project were based on post-Hurricane Katrina/Rita information. Also, the emergency cost reductions for the post-authorization project include damages to transportation infrastructure, while these damages were not included in the emergency cost reductions for the authorized project.

The project benefit-to-cost ratio in the 2002 feasibility report was 1.43 based on 2000 price levels and an interest rate of 6.625 percent. The benefit-to-cost ratio of the 1% AEP post-authorization project is 1.43 based on 2012 price levels and a 3.75 percent interest rate. The benefit-to-cost ratio based on 2012 price levels and a 7.0 percent interest rate is 0.69 (required by ER 1105-2-100, Appendix H, Exhibit H-11).

Changes in Cost Allocation and Apportionment

No changes in cost allocation have occurred since authorization; all costs are for hurricane and storm damage reduction. The post-authorization project does not include any changes in the local cooperation requirements or changes in Federal/non-Federal cost share percentages. The cost apportionment would be 65 percent Federal and 35 percent non-Federal for construction.

The non-Federal sponsor requests that the entire non-Federal share be provided as work-in-kind rather than cash. The non-Federal sponsor would focus their effort on earthen levee construction (multiple lifts) concentrated between Reach E-2 and Reach L. The non-Federal sponsor would also construct floodgates on some bayous within the same geographical area, such as Bush Canal, Placid Canal, Bayou Pointe aux Chenes, Bayou Terrebonne, Humble Canal and Bayou Petit Caillou. Details regarding specific features and schedules for work-in-kind would continue to be coordinated between the USACE and the non-Federal sponsor throughout the design and construction phase of the project. Table S-3 compares the Federal and non-Federal cost-share of the authorized project and post-authorization project.

Table S-3. Changes in Cost Apportionment (Costs in \$1000s)

(All costs in \$1000s)	Authorized Project		Post Authorization 1% AEP Plan
	Authorized in WRDA 2007	Updated Price Levels	
	Effective Price Level:	Oct 2006	Oct 2012
Total Project Cost	\$886,700	\$1,113,000	\$10,265,100
Federal Share (65%)	576,355	723,450	6,672,315
Non-Federal Share (35%)	310,345	389,550	3,592,785
Value of Proposed Work-in-Kind	139,655	177,934	2,947,262
LERRDs	51,970	60,357	645,523
Additional Cash Required	118,720	151,259	0

Note: Authorized project costs (including LERRDs) in 2006 and 2012 price levels developed using Form 17 (project cost estimates used to support budget submissions). Authorized project work-in-kind and cash breakdown in 2006 and 2012 price levels estimated based on percentage from 2002 feasibility report (work-in-kind was 45% of non-Federal share).

Public Involvement and Environmental Considerations

A Revised Programmatic Environmental Impact Statement (RPEIS) was prepared to update environmental and socioeconomic impacts of the project. Given the size and complexity of the Morganza to the Gulf project and the uncertainties associated with unidentified borrow sources and future indirect impacts, most of the RPEIS is at a broad, programmatic level. The RPEIS

includes a more in-depth analysis of features for which borrow sources have been identified and that could be constructed in the near future, including the HNC lock complex, the Bayou Grand Caillou floodgate, and levee reaches F and G-1. For these features, the RPEIS provides sufficient detail so that no further environmental clearances would be needed upon signing of a Record of Decision. The remaining programmatic features would require supplemental National Environmental Policy Act (NEPA) documents (i.e. EISs or Environmental Assessments) before they could be constructed.

The Draft PAC/RPEIS documents were open to public comment from January 4, 2013 to February 19, 2013. A public meeting was held in Houma, LA on January 31, 2013. The most common concern in the top 10 comment themes (representing over 50 percent of the comments) are the potential environmental impacts of the project and associated mitigation requirements. Federal and State agencies noted that in the future there is a potential for adverse indirect and cumulative impacts to wetlands, fisheries, water quality, and navigation assuming there would be increased frequency and duration of water control structure closures as sea level rise accelerates. In response to these concerns, the Final PAC/RPEIS includes a quantitative analysis of the range of potential indirect impacts, including a mitigation plan, for the constructible features, and a qualitative analysis of the potential impacts for the entire project.

The remaining 9 of the top 10 comment themes (from most common to least common with each theme representing less than 10 percent of the total comments) were related to communication, coordination, and consideration of socioeconomic/cultural impacts; plan realignment or reformulation; design standards, RSLR, & constructability; project economics; nonstructural measures; the relationship of Morganza to other plans or projects, such as the State Master Plan and Louisiana Coastal Area (LCA) projects; GIWW floodgate size change, modeling, and impacts; non-Federal contributions; and general support for the project.

Project Benefits, Costs, and BCR Risk and Uncertainty

Although the costs, benefits, and project benefit-to-cost ratio are presented as “most likely” values in this report, there are large uncertainties surrounding single values. Uncertainty and variability are intrinsic in water resources planning, modeling, and design. Risk and uncertainty arise from measurement errors and from the underlying variability of complex natural, social, and economic situations. Major sources of uncertainty associated with the Morganza to the Gulf project that could impact the benefit-cost ratio include the following:

- **Uncertainty surrounding engineering models and inputs.** The uncertainty surrounding three key engineering parameters (ground elevations, stage-probability curves, and performance of existing and proposed levees) was quantified in the HEC-FDA model. Uncertainty in these engineering inputs arises from imperfect data and coastal storm damage models that represent complex meteorological and hydrologic conditions across a highly variable and changing coastal landscape. In general, the standard deviation associated with estimated still water elevations is greater than a foot. In reviewing the HEC-FDA risk analysis, the USACE Risk Management Center concluded that the lack of data on existing levees resulted in underestimating the without-project damages. The analysis performed on the with-project conditions understated the performance of the Federal levees as well as overstated the residual damages due to the interior/exterior relationships used in the economic model. The net effect of understating

the without-project damages and overstating the with-project residual damages is that the benefit-cost ratio is understated.

- **Uncertainty surrounding economic inputs.** The uncertainty surrounding four key economic variables (structure values, contents-to-structure value ratios, first floor elevations, and depth-damage relationships) was quantified in the HEC-FDA model. Uncertainties arise from measurement errors associated with collection of this economic input data and extrapolation of a small set of samples to a large, highly variable study area. The samples used to develop the contents-to-structure value ratios (CSVs) for the various residential and non-residential damage categories could not be randomly selected due to the difficulty in obtaining volunteers to participate in the surveys. Consequently, there is the risk that the CSVs used in the economic analysis may not accurately reflect the true mean CSVs of the population of residential and non-residential properties in the evaluation area. The uncertainty surrounding the first floor elevations assigned to structures is less than a third of a foot; however, adjustments were made to the structure inventory assuming that structures that are repetitively damaged (i.e. in the 10-yr damage floodplain) will be rebuilt over time to higher elevations such that they are outside of the 100-yr floodplain. If more structures than expected are removed from the floodplain, the benefits would be lower than estimated. If fewer structures than expected are removed from the floodplain, the benefits would be higher than estimated.
- **Changes in the discount rate.** The 2013 discount rate of 3.75 percent is at a record low. All other variables being equal, the breakpoint for project justification is around a discount rate of 5.25 percent, meaning that if the discount rate rises above 5.25 percent and all other variables remain unchanged, the project would no longer have a benefit-cost ratio greater than unity.
- **RSLR uncertainty.** The National Research Council predicts that eustatic sea level (not accounting for subsidence) could increase 1 to 4 feet by 2085. Assuming that historic, local subsidence rates continue into the future, the amount of RSLR (sea level rise plus subsidence) for the Morganza to the Gulf area could range from 1.7 to 4.8 ft. The RSLR scenario selected for calculating the benefit-cost ratio assumes an intermediate level of approximately 2.4 ft RSLR by 2085. If the combined effect of RSLR is lower than expected, project benefits and costs would both be lower than estimated. If actual RSLR is higher than 2.4 ft, project benefits and costs would be higher than estimated. Based on a sensitivity analysis, the net effect on the benefit-cost ratio is minimal (a few tenths of a point) and the project would still be justified under any RSLR scenario (holding all other variables the same).
- **Total project cost uncertainties.** For the Morganza to the Gulf project, the high risk cost items are the structural and geotechnical uncertainty, steel cost, fuel cost, unidentified borrow pit for hauled in material, and construction modifications. A detailed cost risk analysis has been conducted and resulting project feature contingencies range from 26 to 35 percent, which results in a total project contingency of around \$2.3 billion. Although there is a risk that costs could be underestimated, there is also the risk that costs could be overestimated.

- **Mitigation cost uncertainties for indirect impacts.** Compensatory mitigation costs for the 1% AEP plan are based on direct construction impacts assuming that tidal ebb and flow would be maintained by the environmental control structures designed throughout the levee alignment such that there would be minimal indirect impacts. However, if future sea level rise predictions come to fruition, these environmental control structures would have to be closed more frequently resulting in indirect impacts. Based on this assumption, the Habitat Evaluation Team estimates the constructible features could impact an additional 721 to 1,442 acres (216 to 418 AAHUs), which would require additional compensatory mitigation at a cost of \$60 million to \$120 million. Mitigation costs resulting from additional indirect impacts from the programmatic features would be covered in future supplemental NEPA documents.
- **Site-adapting the HSDRRS standards.** Estimated project costs in the PAC report are the best available and compliant with current HSDRRS standards. Based on a risk assessment of the Morganza to the Gulf project conducted after the PAC analysis was complete, risk-based modifications to current design criteria have the potential to reduce the total project cost estimates reflected in the PAC report. The USACE is also conducting a risk assessment to ensure risk is addressed consistently across the country. Once this assessment is complete, the results may be applied to the Morganza to Gulf project area. Such modifications would be made to designs and costs during the next phase of implementation, Pre-construction Engineering and Design (PED). Any decrease in costs would increase the benefit-cost ratio assuming the benefit remain unchanged.

Findings

The District Commander has updated the Morganza to the Gulf of Mexico, Louisiana authorized project and finds that the updated 1% AEP plan is economically justified, environmentally acceptable and engineeringly sound. Post-Katrina engineering design criteria and standards for gulf coast communities were applied to reduce the potential of loss of life and property from coastal storms. These engineering practices were developed using the findings of the *Interagency Performance Evaluation Task Force* including key lessons learned from Hurricane Katrina and their implications for future hurricane preparedness and planning for south Louisiana. Project modifications were also found necessary to address developments after the project was authorized, including community resettlement patterns after Katrina, to incorporate improved water control elements and floodgates, and to update other outmoded aspects of the authorized project to more effectively provide the utility of function originally intended by Congress.

The District Commander has considered all the significant aspects of this study including the environmental, social, and economic effects, the engineering feasibility, and the comments received from other resource agencies, the non-Federal sponsors, and the public and has determined that the updated authorized project presented in this report remains in the overall public interest and a justified expenditure of Federal funds. In coordination with other Federal, State of Louisiana, and parish agencies, USACE planned and would design a project that serves the needs of the nation.

The updated total cost for the project is \$10,265,100,000 (October 2012 dollars) inclusive of associated investigation, environmental, engineering and design, construction, supervision and administration, and contingency costs (and exclusive of OMRR&R costs). The fully funded total project cost (includes inflation) is approximately \$12,872,846,000. The project would be funded 65 percent by the Federal Government and 35 percent by the non-Federal sponsors, and subject to the implementation requirements specified in section 8 of this report.

The OMRR&R costs of this project are estimated to be approximately \$7,400,000 annually. Approximately \$1,700,000 annually would be a Federal responsibility, including OMRR&R for the GIWW floodgates and the HNC lock complex and a portion of cost-shared mitigation OMRR&R. The remaining annual OMRR&R costs of approximately \$5,700,000 would be the responsibility of the non-Federal sponsor, including OMRR&R for all project features (except the GIWW floodgates and HNC lock complex), the sponsor funded additional work item, a portion of cost-shared mitigation OMRR&R, and the remainder of mitigation OMRR&R once USACE determines that the mitigation has achieved initial success criteria.

The benefit-to-cost ratio for the post-authorization project is 1.43 based on October 2012 price levels and a 3.75 percent interest rate.

The recommendations contained herein reflect the information available at the time and current Department of the Army policies governing the formulation of individual projects. They do not reflect programming and budgeting priorities inherent in the formulation of National Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to the transmission to Congress, the state, federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment.

**FINAL POST AUTHORIZATION CHANGE REPORT
MORGANZA TO THE GULF OF MEXICO, LOUISIANA**

May 2013

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Attachments

- 1 – Project Map
- 2 – Economic Reach Maps
- 3 – Inundation Depth Maps

Appendices

- Engineering Appendix
- Economic Appendix
 - Regional Economic Appendix
 - Other Social Effects Appendix
- Real Estate Plan

1 Introduction and Background

The following sections describe the project construction authorization, purpose and scope of the Post Authorization Change (PAC) report, project history, design changes, cost sharing and funding, and related projects.

1.1 Project Authorization

The Water Resources Development Act of 2007 (WRDA 2007), Public Law 110-114, authorized construction of the Morganza to the Gulf of Mexico, Louisiana hurricane and storm damage reduction project (“Morganza to the Gulf”) at a total cost of \$886.7 million. Section 1001 of WRDA 2007 states:

“(24) MORGANZA TO THE GULF OF MEXICO, LOUISIANA.—
(A) IN GENERAL.—The project for hurricane and storm damage reduction, Morganza to the Gulf of Mexico, Louisiana: Reports of the Chief of Engineers dated August 23, 2002, and July 22, 2003, at a total cost of \$886,700,000, with an estimated Federal cost of \$576,355,000 and an estimated non-Federal cost of \$310,345,000.
(B) OPERATION AND MAINTENANCE.—The operation, maintenance, repair, rehabilitation, and replacement of the Houma Navigation Canal lock complex and the Gulf Intracoastal Waterway floodgate features of the project described in subparagraph (A) that provide for inland waterway transportation shall be a Federal responsibility in accordance with section 102 of the Water Resources Development Act of 1986 (33 U.S.C. 2212).”

In accordance with the 2002 and 2003 reports of the Chief of Engineers, the Morganza project is authorized as a feature of the Mississippi River and Tributaries (MR&T). To date, Congress has not appropriated any construction funds. Therefore, the project remains in Preconstruction Engineering and Design (PED) phase.

1.2 Purpose and Scope of the PAC Report

Plans in the 2002 Morganza to the Gulf Feasibility Study were developed well before Hurricane Katrina’s devastating impact on the New Orleans hurricane levees in August 2005. Changes in hurricane levee design standards and other changes since project authorization caused the Morganza to the Gulf project to exceed the 20 percent cost increase limit specified in WRDA 1986, Section 902.

There are two types of post-authorization reevaluation studies. “General” reevaluation studies are to affirm, reformulate or modify a plan, or portions of a plan, under current planning criteria. “Limited” reevaluation studies should only require modest resources and documentation. If any part of the reevaluation will be complex, or will require substantial resources, or if the authorized plan will change in any way, a general reevaluation is required. General reevaluation studies frequently are similar to feasibility studies in scope and detail. Given the scale of the Morganza to the Gulf project and the significant design changes since authorization, the PAC report resembles a general reevaluation study, but does not include a complete reformulation of the project.

The PAC primarily focuses on analysis of two levels of risk reduction (pre- and post-Hurricane Katrina “100-year” designs) along the authorized alignment. The PAC report includes discussions on post-Katrina design criteria, project designs and costs, and economic analysis

necessary for plan selection. For a summary of major changes since project authorization, see section 1.5. For example, the term 100-year has been replaced with 1 Percent Annual Exceedance Probability (1% AEP).

The Morganza to the Gulf project authorized for construction in the 2007 WRDA is based on the 2002 Feasibility Report and subsequent 2002 and 2003 Chief of Engineers Reports. The PED phase started two months after publication of the March 2002 Feasibility Report and has continued through the PAC analysis. The PAC report describes all changes to the Morganza project since the 2002 Feasibility Report. These changes have occurred at different points in time over the last 10 years and are based on evolving data sets and methodologies. The following summary highlights sections throughout the PAC report describing project changes and analyses occurring at different periods of time:

- Section 1.3, **Authorized Project Description**, describes the 72-mile authorized levee project as recommended in the 2002 Feasibility Report and the 2002 and 2003 Chief's Reports as authorized by WRDA 2007.
- Section 4, **Initial Reevaluation of the Authorized Plan**, includes a preliminary evaluation of three alternative levee alignment strategies in 2008 (section 4.3), which was a reconnaissance-level analysis for the purpose of determining whether or not there would still be a Federal interest in the project with post-Katrina criteria incorporated and whether a feasibility-level PAC report should be initiated.
- Section 5, **Post Authorization Changes to the Levee Alignment**, describes modifications and extensions to the authorized levee alignment during PED and the PAC analysis. The resulting 98-mile post-authorization levee alignment (see the project map in Attachment 1) is the basis for comparison of two levels of risk reduction in Section 6.
- Section 6, **Evaluation and Comparison of Alternatives**, describes two alternatives that are the primary focus of the feasibility-level PAC analysis. The alternatives follow the same 98-mile levee alignment but at different levels of risk reduction (1% and 3% AEP).
- Section 7, **Description of the 1% AEP Post-Authorization Plan**, describes in more detail the alternative that has the highest net benefits of the two alternatives.

As the result of post-authorization changes, all project-related benefits and environmental impacts must be updated. A Draft Revised Programmatic Environmental Impact Statement (RPEIS) was prepared concurrently with the PAC report to document the environmental and socioeconomic impacts. Given the size and complexity of the Morganza to the Gulf project, most of the Draft RPEIS is at a broad, programmatic level; however, the Draft RPEIS includes a more in-depth analysis for a few features that have borrow sources identified and are closest to being ready for construction. For those features, the Draft RPEIS provides sufficient detail so that no further environmental clearances would be needed upon signing of the Record of Decision. All other features would require supplemental National Environmental Policy Act (NEPA) documents (i.e. environmental impact statements or environmental assessments) before they can be constructed.

The report will ultimately be reviewed by the Assistant Secretary of the Army (Civil Works) and coordinated with the Office of Management and Budget as appropriate for submission to the Congress.

1.3 Authorized Project Description

The primary purpose of the authorized Morganza to the Gulf of Mexico MR&T project, as described in the WRDA 2007 authorization, is *hurricane and storm damage reduction*.

1.3.1 Location

The project/study area is about 60 miles southwest of New Orleans, LA (figure 1-1) and includes most of Terrebonne Parish and a portion of Lafourche Parish. The study area extends south to the saline marshes bordering the Gulf of Mexico and encompasses approximately 1,900 square miles.

The Gulf Intracoastal Waterway (GIWW) and the Houma Navigation Channel (HNC) are major waterways in the area. The GIWW passes through Houma in an east-west direction. The HNC extends due south from Houma to the Gulf of Mexico. Bayou Lafourche runs along the northeastern boundary of the project/study area.



Figure 1-1. General Project Location

The authorized Morganza to the Gulf of Mexico levee alignment primarily follows existing hydrologic barriers, such as natural ridges, roadbeds, and existing local levees. Figure 1-2 shows the authorized Morganza to the Gulf levee alignment. The eastern extent of the authorized levee alignment ties into Larose to Golden Meadow levee south of the GIWW. The western extent of the authorized alignment ties into the Bayou Black ridge north of the GIWW.

1.3.2 Features

The August 2002 Chief's Report recommended a plan to reduce hurricane and storm damages by providing a 1% AEP (referred to as 100-year in the Chief's Report) level of risk reduction including the following features:

"...raising or constructing 72 miles of levees to elevations varying from +15.0 feet National Geodetic Vertical Datum (NGVD) to +9.0 feet NGVD. The plan includes constructing nine 56-foot-wide sector gate structures in various waterways, one 125-foot floodgate in the Gulf Intracoastal Waterway (GIWW) near Bayou Lafourche, two 125-foot floodgates in the GIWW near Houma, a 200-foot-wide and 1,200-foot-long lock structure in the Houma Navigation Canal (HNC), and new discharge pipes for six existing pump stations. The plan also includes twelve sets of 6-foot by 6-foot concrete box culverts through the levee to allow tidal ebb and flow. Mitigation features in the plan include the creation of 1,352 acres of marsh habitat and widening 10,600 feet of Minors Canal by 40 feet. Consistent with reducing hurricane and storm damages in an environmentally sustainable manner, the project will be designed and operated to achieve coastal wetland conservation through the improved distribution of freshwater inflows to wetlands wherever feasible. The specific designs and operating plans will be formulated in consultation with the interagency habitat evaluate team."

The purpose of the earthen levee system is to stop or slow down surge inundation. Floodgates provide storm damage reduction during tropical storms and allow currently navigable waterways

to remain open to navigation during non-storm conditions. The purpose of the HNC lock is to control saltwater intrusion at the Houma water treatment plant while allowing for navigation. Environmental control structures (box culverts) through the levee allow tidal ebb and flow.

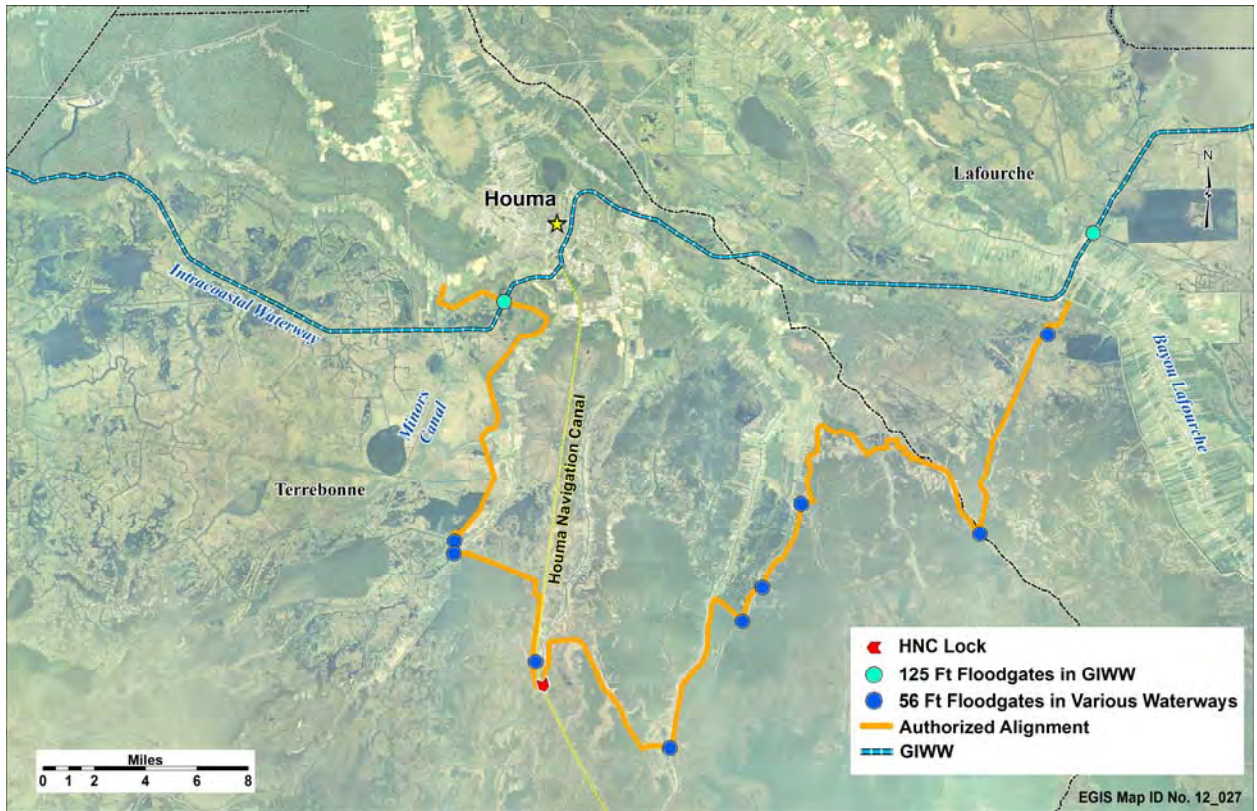


Figure 1-2. Authorized Project Map

1.4 Project History

Table 1-1 provides a timeline of authorizations, studies, and tropical storm events related to the Morganza to the Gulf and HNC lock projects.

Table 1-1. Timeline of Morganza Authorizations and Studies

1985	Hurricane Juan caused extensive flooding in Terrebonne and Lafourche parishes.
1992	Reconnaissance study authorized by resolution adopted April 1992 by the Committee of Public Works and Transportation of the U.S. House of Representatives. In August, Hurricane Andrew caused extensive flooding in Terrebonne and Lafourche parishes.
1994	USACE completed the Morganza to the Gulf reconnaissance report (USACE, 1994).
1995	In the Energy and Water Development Appropriation Act of 1995 (PL 103-316), Congress directed the USACE to consider the interrelationship of studies and projects that impact the coastal area of Louisiana, including the Morganza feasibility study, the Lower Atchafalaya Basin reevaluation study, and several projects being pursued under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) program, and directed the USACE to consider improvements at and/or within the HNC. The Feasibility Cost Share Agreement was executed in June 1995.
1996	Section 425 of WRDA 96 (PL 104-303) required the USACE to develop a study of the HNC lock as an independent feature of the Morganza to the Gulf project.
1997	USACE completed the HNC lock study, which recommended a 200-ft wide lock in the HNC south of Bayou Grand Caillou and concluded that a lock structure would provide direct and indirect benefits to the environmental (marsh) habitat in the study area (USACE, 1997). The report recommended that the HNC lock continue to be investigated as part of comprehensive Morganza to the Gulf hurricane and storm damage reduction plans and that the detailed design phase of the lock be expedited and proceed concurrently with the feasibility study.
1998	Congress authorized the USACE to initiate detailed design of the multipurpose HNC lock.
2000	The Morganza to the Gulf of Mexico project was conditionally authorized in WRDA 2000 at a cost of \$550 million subject to having a favorable Chief of Engineer's report completed by December 2000; the terms of this conditional authorization were not met. The PED phase on the HNC lock complex was initiated in advance of the PED phase for the Morganza to the Gulf of Mexico hurricane and storm damage reduction project. The PED Agreement for the HNC lock was signed in January 2000.
2002	The Morganza to the Gulf feasibility study and PEIS were completed in March 2002 (USACE, 3/2002). The PED Agreement for the overall project was signed in May 2002. In August 2002, the USACE issued a Chief of Engineers report (USACE, 9/2002). In September and October, Tropical Storm Isidore and Hurricane Lili impacted the study area.
2003	In July 2003, the USACE issued a supplemental Chief of Engineers report (USACE, 2003), which made changes to the non-Federal sponsor's in-kind services.
2004	Section 158 of the Energy and Water Development Appropriations Act, 2004 (Public Law 108-137) authorized construction on Reach J-1, which had been previously identified as work-in-kind.
2005	The PED Amendment 1 executed in March 2005 combined the two PED efforts into one and allowed the non-Federal sponsor to advance funds on the combined PED effort. In August and September, Hurricanes Katrina and Rita impacted the study area.
2007	WRDA 2007 authorized the Morganza to the Gulf of Mexico, Louisiana project for hurricane and storm damage reduction at a total cost of \$886.7 million.
2008	A recon-level analysis and programmatic cost estimate (ARCADIS, 2008) was completed to determine whether or not there would still be a Federal interest in the project with post-Katrina interim criteria (USACE, 2007) incorporated and whether a feasibility-level PAC report should be initiated. Based on an analysis of four alternatives, the general alignment strategy for the PAC report was determined, but not the final level of risk reduction. Phase I Design for the HNC lock and floodgate was finalized in a 50 percent Design Documentation Report (URS, 2008). In September, Hurricanes Gustav and Ike impacted the study area.
2011	The PED Amendment 2 executed in January 2011 increased the funding ceiling and changed the name of the non-Federal sponsor from Louisiana Department of Transportation and Development (DOTD) to the Louisiana Coastal Protection and Restoration Authority.
2012	Legislation changed the former Office of Coastal Protection and Restoration (OCPR) to the Coastal Protection and Restoration Authority (CPRA) and changed the former Coastal Protection and Restoration Authority (CPRA) to the Coastal Protection and Restoration Authority Board (CPRAB).

1.5 Policy, Procedural, and Design Criteria Changes since Authorization

Several policy, procedural, and design criteria changes have been made since the 2002 Morganza to the Gulf Feasibility Report was completed. Lessons learned from Hurricane Katrina and other recent storms have been incorporated into new design guidelines referred to as the Hurricane and Storm Damage Risk Reduction System (HSDRRS) Design Guidelines (USACE, 2/2011). These guidelines were developed by members of the U.S. Army Corps of Engineers (USACE), academia, and industry and have been peer reviewed. In accordance with Assistant Secretary of the Army (Civil Works) direction, USACE is applying the HSDRRS guidelines to all hurricane levee system work in the New Orleans District, including the Morganza to the Gulf PAC project. The HSDRRS guidelines provide a comprehensive collection of best practices and were developed to provide redundancy, resiliency, and robustness of the interfaces between structures, materials, and members of the hurricane risk reduction system for the desired level of risk reduction. The HSDRRS guidelines are available at www.mvn.usace.army.mil/ENG/PageA.asp.

The HSDRRS guidelines include some criteria that are more stringent than required for other USACE structures. Changes leading to larger levees and structures, and higher costs, include the following:

- **Increase in Hydraulic Design Elevations** – Storm surge modeling in the 2002 report was based on only 17 tropical storms and did not consider relative sea level rise in the model. New storm surge modeling predicts water levels based on 115 theoretical storms and incorporates the effects of relative sea level rise within the model. In addition, the 1 percent annual chance exceedance water levels in the 2002 report were based on the 50 percent confidence values, which have a 50 percent chance of being under-predicted. The new design guidelines require levees to be designed based on the 90 percent confidence values, which have only a 10 percent chance of being under-predicted. All of these factors result in prediction of higher surge and waves, and wave run up used to set levee elevations.
- **Change from I-Walls to T-Walls** – In the 2002 report, floodwalls could be based on I-wall designs. Under the new guidelines, I-walls are not permitted in most cases and have been replaced with more robust and more expensive T-walls.
- **Increase in Geotechnical Stability Factor of Safety** – The analysis method for global stability changed, leading to a higher factor of safety, resulting in taller and wider levees and cost increases.
- **Addition of Structural Superiority** – All new structures that are difficult to construct because of disruptions to navigation or traffic, large utility crossings, or requiring cofferdams must be designed with a minimum of 2 ft of additional wall height resulting in cost increases.

In addition, new regulations on risk and sea level change have been issued since 2002 as discussed in the following sections.

1.5.1 Changes in Risk Reduction Levels for Authorized Design Elevations

The pre-Katrina levee elevations for the 2002 Morganza to the Gulf project are based on outdated storm and levee design information, resulting in a project that is unable to provide the 1% AEP level of risk reduction. The first step in assessing the authorized project's current level of risk reduction was to convert the 2002 feasibility report stillwater elevations from the National Geodetic Vertical Datum (NGVD) to the current North American Vertical Datum (NAVD88

epoch 2004.65). The next step was to perform a statistical analysis on each levee reach, which determined that a 3% AEP level of risk reduction best describes the 2002 Chief’s Report Plan. For the PAC report, the 2002 Chief’s Report Plan was subsequently redesigned based on the current projected 3 percent annual chance exceedance surge elevations. The PAC addresses the civil and structural improvements required to achieve the pre-and post-Katrina designs (3% and 1% AEP) as per the HSDRRS guidelines (USACE, 2/2011).

1.5.2 Risk and Uncertainty Guidance

Risk and uncertainty are intrinsic in water resources planning and design. Engineering Regulation (ER) 1105-2-101 provides guidance on the risk evaluation framework to be used in USACE flood damage reduction studies. In a coastal environment, flood risk can be caused by a combination of hurricane surge, waves, wave overtopping of structures, riverine flooding due to rainfall and/or snowmelt, or other sources. Unlike areas located along major rivers such as the Mississippi River or Atchafalaya River, in the Morganza to the Gulf project area, the dominant source of flood risk is from hurricane storm surge and waves. Both storm surge and waves are taken into account in proposed levee designs, however, the risk analysis has been simplified as “the probability an area will be flooded by storm surge, resulting in undesirable consequences.”

Risk is composed of two components:
 (1) the likelihood of being flooded and
 (2) the consequences.

ER 1105-2-101 requires project performance to be described in terms of annual chance or exceedance probability and long-term risk, rather than level-of-protection. A ‘100-year level-of-protection levee’ is often misunderstood to mean a levee that defends against a storm surge that is only expected once every 100 years. In terms of annual chance or exceedance probability, a 100-year levee is designed to withstand a storm surge that has a 1 in 100, or 1 percent, chance of occurring in any given year, not a storm surge that occurs only once every 100 years. For this reason, the terminology ‘100-year’ has been changed to the ‘1% AEP.’

For investment decisions, risk is typically evaluated in annual probabilities, but when considering the value of levee investments and the assets behind them, one year is short term. Although the 1% AEP levee design has a low probability of being exceeded in any given year, the probability increases the longer the timeframe considered. For the average person’s mortgage (30 years), the probability of the 1% AEP flood occurring is 26 percent. For the average person’s life, the probability is greater than 50 percent.

Table 1-2. Comparison of AEP and Long-Term Risk

Example Alternative Design Level	Annual Chance of Exceedance	Annual Probability of Exceedance	Long-Term Risk (Probability of Exceedance Over Indicated Time Period)				
			10 Years	30 Years	50 Years	70 Years	100 Years
No Action	1 in 10	0.10 or 10%	65%	96%	99%	100%	100%
3% AEP Design	1 in 35	0.03 or 3%	25%	58%	77%	87%	94%
1% AEP Design	1 in 100	0.01 or 1%	10%	26%	39%	51%	63%
0.2% AEP Design	1 in 500	0.002 or 0.2%	2%	6%	10%	13%	18%

Table 1-2 provides an example of long-term risk for several design levels. The 10% AEP is an example of the no action condition in some locations; the actual AEP varies by location within the study area. Similarly, the 3% AEP and 1% AEP system designs do not result in a consistent AEP in every location. Actual AEP depends on factors unique to every location including elevation, hydrology, presence of local levees, etc.

1.5.3 Sea Level Change Guidance

Recent climate research by the Intergovernmental Panel on Climate Change predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea level. Sea level change can cause a number of impacts in coastal and estuarine zones, including changes in shoreline erosion, inundation or exposure of low-lying coastal areas, changes in storm and flood damages, shifts in extent and distribution of wetlands and other coastal habitats, changes to groundwater levels, and alterations to salinity intrusion into estuaries and groundwater systems. Impacts to coastal and estuarine zones caused by sea level change must be considered in all phases of Civil Works programs. Engineering Circular (EC) 1165-2-212, *Sea-Level Change Considerations for Civil Works Programs*, which replaced EC 1165-2-211, provides guidance for incorporating the direct and indirect physical effects of projected future sea level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Feasibility level designs, cost estimates, and benefit-cost ratios for the PAC report alternatives are based on an Intermediate Relative Sea Level Rise (RSLR) scenario of 2.4 ft. The effects of the Low (Historic) or High RSLR scenario were also evaluated, consistent with EC 1165-2-212.

1.6 Non-Federal Sponsor

The Louisiana Coastal Protection and Restoration Authority Board (CPRAB) and the Terrebonne Levee and Conservation District (TLCD) intend to be non-Federal co-sponsors for the Morganza to the Gulf project (hereafter referred to as the non-Federal sponsor). In a letter dated 21 December 2012, the non-Federal sponsor expressed commitment and understanding of non-Federal cost share responsibilities for construction and operation and maintenance, repair, replacement and rehabilitation (OMRR&R). Section 1001(24) of WRDA 2007 specifies Federal responsibility for OMRR&R of the HNC lock complex and the GIWW floodgate features that provide for inland waterway transportation in accordance with Section 102 of WRDA 1986, as amended. The non-Federal sponsor is responsible for OMRR&R of all other project features. Additional responsibilities of the non-Federal sponsor are listed in section 8.3 of this report.

1.7 Funding and Cost Share

Federal and non-Federal cost share proportions change as a USACE Civil Works project progresses from the feasibility phase to PED to construction. Expenditures for the completed Morganza to the Gulf feasibility study were \$9,320,000, which was cost shared 50 percent Federal and 50 percent non-Federal.

The Energy and Water Appropriations Act of 1998 (PL105-62) included funds to initiate design on the HNC lock feature of the Morganza to the Gulf project, which initiated the Preconstruction Engineering and Design (PED) phase for the HNC lock feature in advance of completing the Feasibility Report (2002) and signing of Chief's report (also 2002). The USACE and non-Federal sponsor signed a Design Agreement for the HNC lock in January 2000, and the non-

Federal sponsor first contributed matching funds for PED in 2000. The first non-Federal contributions to the overall Morganza to the Gulf project were in September 2002.

Approximately \$61,650,000 has been allocated for the Morganza to the Gulf PED phase, which includes the PAC report. Most of the PED funds have been spent on engineering design and geotechnical investigations, rather than on the PAC feasibility-level analysis. Per USACE guidance, study costs for the PAC report are being cost shared 75 percent Federal and 25 percent non-Federal. The PAC study is cost shared under a Design Agreement originally executed on 22 May 2002 and amended on 24 March 2005 and 11 January 2011. While the Design Agreement provides for 75/25 cost share during design, WRDA 1986 (PL99-662), Section 105(c), stipulates that the non-Federal share of the cost of design is the same percentage as the non-Federal share for construction, which in this case is 35 percent. The design cost is shared per the percentage of construction cost with 25 percent being collected from the non-Federal sponsor during the Design Agreement and the remaining 10 percent collected in the first year after the Project Partnership Agreement (PPA) is executed.

Pending re-authorization, the construction cost share would be 65 percent Federal and 35 percent non-Federal. No Federal funds have been appropriated for construction of the Morganza to the Gulf project.

1.8 Non-Federal Sponsor Work Independent of the Federal Authority

The 2003 Chief's Report and 2004 Energy and Water Development Appropriations Act specified two floodgates and 21.5 of the original 72 miles of levee in the authorized project for in-kind credit. The July 2003 supplemental Chief's Report listed features that *may be designed, constructed, or managed during construction by the sponsor with in-kind services* as follows:

- *A 56-foot-wide floodgate on Bayou Pointe au Chien¹;*
- *A 56-foot-wide floodgate on Bush Canal;*
- *A 14-foot-high and 12-mile-long levee from the Bayou Pointe au Chien floodgate to the Humble Canal floodgate, and the structures therein;*
- *A 14-foot-high and 6.5-mile-long levee from the Bayou Petite Caillou floodgate to the Bush Canal floodgate, and the structures therein; and,*
- *A 14-foot-high and 3-mile-long levee from the Bush Canal floodgate to the Bayou Terrebonne floodgate and the structures therein.*

Reach J-1 was separately authorized for construction in advance of the Morganza to the Gulf project. Section 158 of the 2004 Energy and Water Development Appropriations Act (Public Law 108-137) authorized construction of Reach J, Segment 1 (J-1) at a total cost of \$4,000,000.

“The Secretary may carry out the Reach J, Segment 1, element of the project for hurricane and storm damage reduction, Morganza to the Gulf of Mexico, Louisiana, in accordance with the report of the Chief of Engineers, dated August 23, 2002, and supplemental report dated July 22, 2003 at a total cost of \$4,000,000.”

In order to receive credit for in-kind work, the non-Federal sponsor must sign a PPA with the Department of the Army prior to the work being undertaken by the project sponsor. A PPA has

¹ Pointe au Chien and Pointe aux Chenes are used interchangeably throughout the report. The community of Pointe aux Chenes was Pointe au Chien until community members had the legislature make a name change in the late nineties. Various features mentioned throughout this report such as the bayou, the proposed floodgate, the Wildlife Management Area (WMA) may be spelled differently but all refer to the same area.

not been signed by the sponsor and the Army. The non-Federal sponsor has started work on reaches that were initially proposed to be a part of the Morganza to the Gulf project, at their own expense, acknowledging that there is no signed PPA in place. The sponsor has substantially completed approximately 9 miles of what would amount to first lift levees and a few floodgates located along the proposed Morganza to the Gulf project alignment. Discussion of those features is included in section 2 of this report.

In the absence of an executed PPA, the locally constructed levees do not form an integral part of the Morganza to the Gulf project, and the work performed by the non-Federal sponsor is not eligible for consideration and approval of work-in-kind credit. If the Morganza to the Gulf project is reauthorized, the non-Federal Sponsor will be entitled to LERRRDs credit for the real estate acquired for those local levees only to the extent that the non-Federal sponsor is required to provide authorization for entry to LERRDs necessary for any future Morganza to the Gulf project work that is conducted on the locally constructed levees.

1.9 Related Projects

Some of the most heavily used navigation waterways in Louisiana are located within the project area, including the Federally-maintained HNC and GIWW. Other major water resource projects in the vicinity include the Larose to Golden Meadow hurricane and storm damage reduction project and several ecosystem restoration projects. Table 1-3 summarizes projects most relevant to the Morganza to the Gulf project. Additional details are provided in the RPEIS.

Table 1-3. Projects, Programs and Reports Related to Morganza to the Gulf

	Name	Relationship to Morganza
Navigation Projects	Gulf Intracoastal Waterway (GIWW)	The GIWW runs contiguously through the Morganza to the Gulf project area from Bayou Lafourche at Larose through Houma and on to the Atchafalaya River. The Morganza to the Gulf hurricane levee system crosses the GIWW in two locations requiring floodgates. The GIWW has an authorized depth of 12 ft.
	Houma Navigation Canal (HNC) Deepening Study	The 40-mile HNC connects Houma and the GIWW directly to the Gulf of Mexico. Oil and gas industries in Houma rely heavily upon the channel. In accordance with USACE planning regulations, Morganza to the Gulf plans must assume that the current authorized depth of the canal, -15 ft, will remain as currently authorized in the future; however, there is the possibility that the HNC will be deepened in the future given the preliminary results of an ongoing HNC Deepening Study.
Storm or Flood Damage Reduction Projects	Larose to Golden Meadow Hurricane and Storm Damage Reduction Project	The eastern endpoint of the Morganza to the Gulf authorized levee ties into the existing 48-mile Larose to Golden Meadow ring levee system. The Larose project was originally authorized to provide risk reduction from a Standard Project Hurricane, but is currently undergoing a PAC analysis to ensure that completion of project features are in compliance with post-Katrina guidelines.
	Non-Federal Levees in Terrebonne Parish	In Terrebonne Parish, there are approximately 92 miles of non-Federal levees, along with several pump stations and floodgates, which are operated and maintained by either the Terrebonne Parish Consolidated Government or the Terrebonne Levee and Conservation District (TLCD). The TLCD has recently started building components of the authorized Morganza to the Gulf project, including 9 miles of first-lift levees and interim barge gate structures on several critical bayous.

	Name	Relationship to Morganza
Ecosystem Restoration Programs	Louisiana Coastal Area (LCA) Program	Several LCA projects authorized by WRDA 2007 are located within the Morganza study area, including but not limited to: (1) Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock (2) Modification of Davis Pond Diversion and (3) Land Bridge between Caillou Lake and Gulf of Mexico. By letters dated 20 August 2012 and 16 October 2012, CPRAB has notified USACE that it desires to suspend study and design on these projects. The decision of CPRAB to suspend these projects results in some degree of uncertainty regarding implementation of these projects as part of the authorized Federal LCA. For more details, see section 10.1.7, LCA Program Uncertainties.
	Coastal Impact Assistance Program (CIAP)	The CIAP Falgout Canal Freshwater Enhancement Project is located along the proposed footprint of Morganza Levee Reach E. The goal of the project is to improve efficiency of freshwater flow and to restore salinity to levels that are favorable for fresh and intermediate marsh within the basin. Morganza Reach E includes culverts that would provide similar benefits.
	National Estuary Program	The Barataria-Terrebonne Basin was selected for the National Estuary Program in 1990. The program is cost-shared by the U.S. Environmental Protection Agency (USEPA) and Louisiana's Wetlands Conservation and Restoration Trust Fund.
Multi-Purpose Coastal Plans	Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report	The LACPR technical report includes a coast-wide analysis of a multiple lines of defense approach to "Category 5" risk reduction. The report includes structural measures, such as floodgates, floodwalls, and levees, nonstructural measures, such as elevating homes, and coastal restoration measures, such as diversions and marsh restoration. LACPR technical data was used in the preliminary post-authorization analysis of Morganza alternative alignments.
	Louisiana's 2012 Coastal Master Plan	In the first implementation period (2012-2031) of its 50-year coastal master plan (2012-2061), the State of Louisiana recommends constructing the Morganza to the Gulf hurricane storm surge risk reduction project at the 1% AEP design elevations.

2 Risk-Based Inundation Reduction Benefits Analysis

Most benefits from a hurricane and storm damage reduction project result from the reduction of actual or potential damages due to inundation. Physical inundation reduction damages include damages to residential and commercial structures, losses to the contents in those structures, and damages to privately owned automobiles. Inundation reduction benefits on both existing and future development were considered for project justification.

2.1 Analysis Years

The period of analysis begins with day 1 of the base year and extends generally 50 years for USACE projects. The National Economic Development Procedures Manual, Institute of Water Resources Report 93-R-12 excludes the construction or implementation period from the period of analysis. Early in the PAC study, the 50-year period of analysis was defined as 2035 to 2085. The base year was set based on the assumption that 2035 would be the soonest that the Morganza to the Gulf project constructed to post-Katrina design standards could achieve the 1% AEP level of risk reduction.

Project construction is expected to take place over many years and would result in a closed system providing partial risk reduction prior to achieving the full base year level of risk reduction. It was determined that both alternatives could achieve a closed system by 2024, which provides benefits during construction. Therefore, Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) models were developed to represent existing conditions (2010), pre-base year conditions (2024), base year conditions (2035), and future year conditions (2085). Outputs from each model are then interpolated to develop annual damage and benefit results.

2.2 Reaches

The PAC report refers to two types of “reaches” as follows:

- **Levee reaches** are segments of the proposed Federal hurricane levee. For the risk analysis, the Morganza levee was divided into major reaches designated by a letter (e.g. J). For detailed design, some of the levee reaches are further sub-divided (e.g. J-1, J-2, J-3).
- **Economic reaches** are sub-areas within the overall study area. Each economic reach has an assigned stage-probability relationship, which is used to calculate damages and benefits. For purposes of planning and analysis, the Morganza study area was originally divided into 276 economic sub-areas or reaches (see Economic Reaches map in Attachment 2). Of the 276 reaches, 264 were determined to be at risk from storm surge. Of the 264 reaches at risk, 234 reaches contain residential and/or non-residential structures; the remainders are open water or wetland areas.

2.3 Datum

The only datum used in the PAC analysis is NAVD88 2004.65. If figures or tables reference older data that was based on a different datum, it is clearly stated.

2.4 Risk and Uncertainty Variables

The HEC-FDA software program was used to perform the risk-based benefits analysis. The HEC-FDA program incorporates risk using statistical Monte Carlo simulations. As required by

ER 1105-2-101, risk and uncertainty is explicitly incorporated in the calculation of net benefits for the following variables:

- **Stage Discharge Function Exceedance Probability with Uncertainty.** The probability functions are assigned an equivalent record length in HEC-FDA. The model uses this parameter to derive confidence limit curves/bands.
- **Geotechnical Failure Analysis.** This feature allows the user to assign uncertainty to the structural integrity of the levee based on geotechnical evaluations of existing and proposed levees. Levees can experience different modes of failure. Slope failure is normally the first in a series of events that happen to cause a breach. Based on geotechnical analyses, the probability of failure due to stability was insignificant compared to the probability of failure due to overtopping and erodability. Therefore overtopping rates and erodability were the predominate factors used to define levee performance. Levee performance is captured in the HEC-FDA model by designating the “top of levee” only or with a supporting fragility curve. The “top of levee” is the 100 percent levee exceedance or failure point.
- **Wave Overtopping Analysis.** This feature allows the user to include uncertainty to account for the impacts of wave overtopping when analyzing levees. An analysis was completed outside of the software and incorporated by entering the computed failure height as the top of levee elevation for each levee in HEC-FDA.
- **Economic Variables.** Quantified uncertainty surrounding the following four key economic variables: structure values, contents-to-structure value ratios, first floor elevations, and depth-damage relationships. The HEC-FDA model uses the uncertainty surrounding these variables to estimate the uncertainty surrounding the stage-damage relationships developed for each study area reach.

The geotechnical failure and wave overtopping analyses were based on assessments of prior levee loadings due to hurricane surge in similar coastal areas, and discussions with national geotechnical engineering experts at the USACE Risk Management Center, as well as other geotechnical engineers in the New Orleans District who have had field experience in developing fragility curves during the rebuilding of levees following Hurricane Katrina. The erosion analysis was based on the extensive levee overtopping laboratory tests performed for the New Orleans District following Hurricane Katrina. Therefore, the overtopping rate that caused erosion on levees with similar composition was well established.

2.5 Simplifying Assumptions

Net benefits are calculated as “without-project damages” minus “with-project damages.” Figure 2-1 depicts the actual without-project conditions (existing local levees and no Federal action) and with-project conditions (existing local levees and proposed Federal levees). Additional details on the without-project condition are provided in section 3. Figure 2-2 depicts the simplified approach used to calculate damages in the certified HEC-FDA model.

Use of the certified HEC-FDA model requires a simplified approach for two primary reasons: (1) Model functionality does not allow more than one levee to be assigned to a single economic damage reach, so both sets of levees could not be directly modeled in HEC-FDA. (2) The overtopping equation in the model applies to river levees and is different than the equation used to calculate overtopping for hurricane and storm damage reduction levees. Instead, overtopping can be calculated outside of the program.

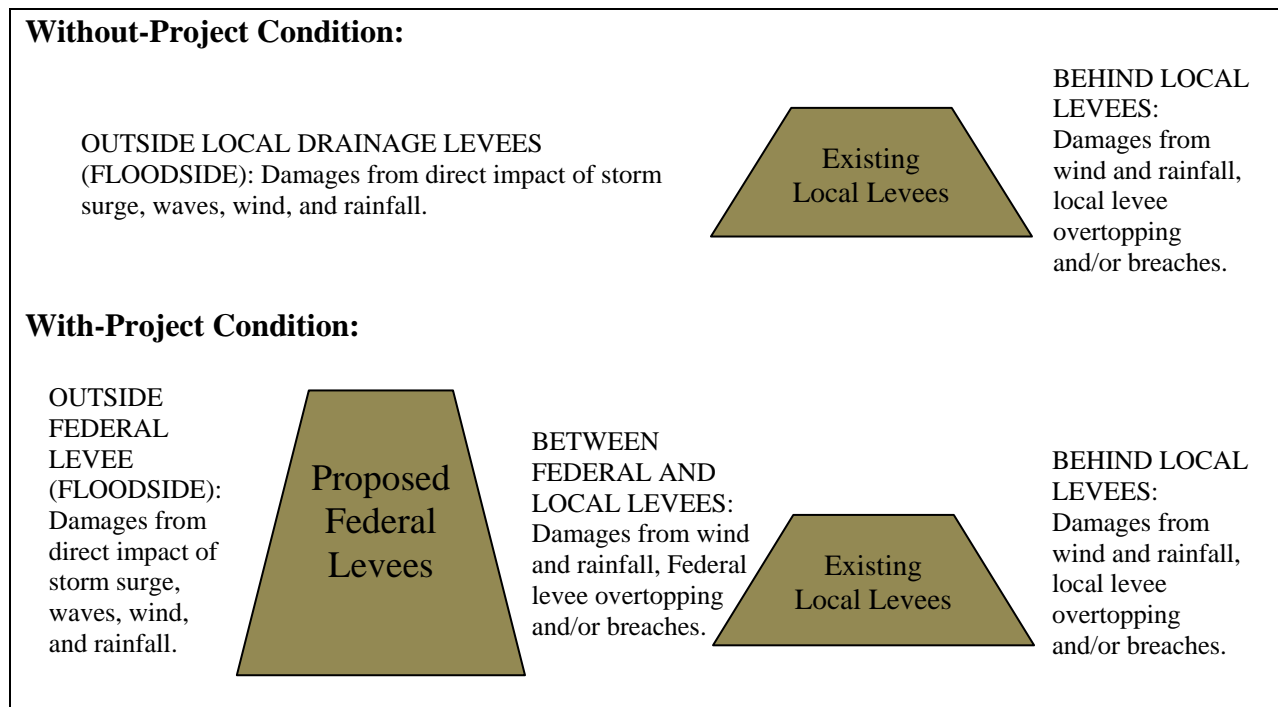


Figure 2-1. Conceptual Depiction of Without- and With-Project Conditions

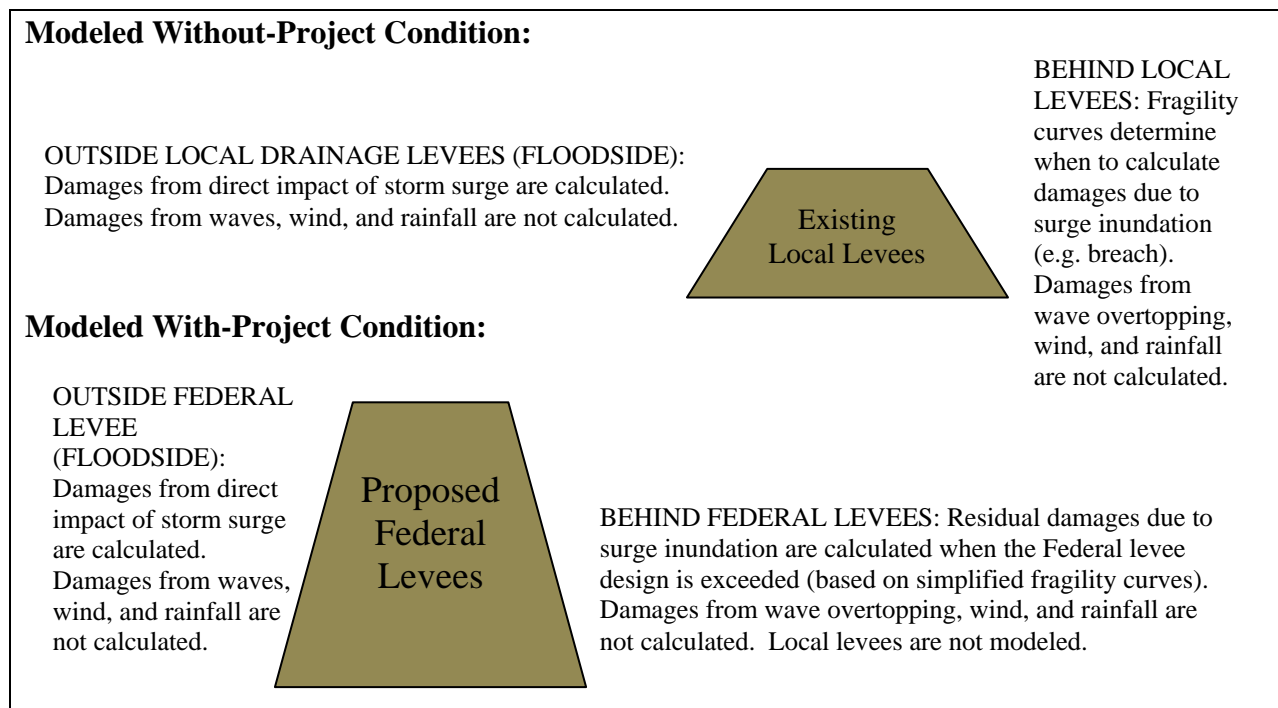


Figure 2-2. Conceptual Depiction of Simplified Conditions in the Certified HEC-FDA Model

Given the simplifying assumptions needed to calculate damages in HEC-FDA, the modeled benefits are expected to be less than the actual economic benefits of the Federal levee for the following reasons:

- Not including the local levees in the with-project condition could overstate residual damages for some types of storm events. In the event of a hurricane event large enough to exceed the Federal design, the performance of the local levees would depend on the location of the breach and how much storage was between the Federal levee and the local levee. As modeled, the volume of water overtopping the Federal levees before failure would not be large enough to raise the interior stages high enough to cause damages. In most cases, the overtopping water would not even reach the local levees. If a hurricane event is large enough to cause a breach in the project levees, then it is assumed the local levees would breach as well; therefore, the impact of not including the local levees in the analysis is minor.
- Ignoring wave damages in both the without- and with-project conditions underestimates damages mostly for the without-project condition, which underestimates benefits of the Federal levee. Surge and/or wave overtopping damages in the with-project condition (where the levee design is not exceeded) are expected to be minimal because of the large storage areas behind most of the Federal levees.
- Erosion of the Federal levee is assumed to occur before the surge still water elevation reaches the top of the levee because of waves on top of the still water elevation. Once the HEC-FDA model determines that an exterior stage (floodside) would cause the Federal design to be exceeded, an exterior/interior relationship defines the interior (protected side) stage. If this relationship is not specified, the HEC-FDA model will use the same stages on the interior as on the exterior. Since the exterior stage would be lower once the levee breaches, a simplifying assumption was that the interior stage will equal the without-project stage once the levee breach occurs. In reality, due to insufficient volume of water and duration associated with a typical hurricane storm surge (short duration), filling the protected area to the without-project elevation is extremely unlikely. The consequences of a hurricane event would be based on a flood elevation that is much lower than the estimated surge elevation. This effect has been validated by observations during Hurricane Katrina in the New Orleans Metro area, New Orleans East, and St. Bernard Parish where the flood elevations in the protected areas were notably lower than the storm surge elevations.

Rainfall is not part of the HEC-FDA model because the proposed Federal levee is not expected to impact rainfall damages in the populated areas during or after construction (i.e. rainfall would be the same both with and without the proposed Federal levee). The populated areas are located within forced drainage levee systems, i.e. a system of levees and pumps that provide controlled drainage for an area, allowing the area to remain dry under normal tidal conditions, even if the area is below sea level. Rainfall would continue to be pumped outside of the local forced drainage levee systems and into an area that would be surrounded by the proposed hurricane levee, leaving storage between the Federal and local levee systems.

Impacts of the proposed Federal levee on the interior area were initially modeled using UNET (Unsteady flow through a NETwork of open channels). The purpose of the UNET model was to determine the relative change in water surface elevation between without and with project

conditions. The only appreciable difference in water surface occurs when the levees are overtopped at the less frequent return intervals.

In the areas where natural drainage has been cut off by the proposed levees, environmental structures have been evaluated and sized using an ADH model for general flow patterns; designs were then refined using a HEC-RAS model. These models were used to assess rainfall and interior drainage on the protected side of the proposed hurricane levee system and the structures were sized to prevent induced ponding of any additional water during normal open operating conditions. The environmental structures are to be closed only during a tropical event that affects the local area. The proposed levee system will cause the water to remain in the system for a longer duration than without the proposed levee. The storage time of 7 days has been coordinated with the Habitat Environmental Team and the water in the system is fresh rather than saline. The environmental control structures cannot and are not intended to be operated to reduce rainfall-related damages.

In the areas not cut off by the proposed Federal levee, natural drainage is not affected and so no further studies or drainage improvements were considered. Given the large storage areas behind the Federal levee (e.g. Lake Boudreaux), and environmental control structures throughout the levee alignment, additional pumping capacity for rainfall is not needed.

2.6 Stage-Probability Inputs

For each of the four HEC-FDA models (2010, 2024, 2035, and 2085), stage-probability inputs were based on the following eight points: 0.999, 0.2, 0.1, 0.05, 0.02, 0.01, 0.005, and 0.002. Except for the 2010 existing conditions model, which does not have a with-project condition, each HEC-FDA model contains two sets of stage-probability data in each of the 264 economic reaches—one for the with-project condition and one for the without-project condition.

Stage-probability values were developed using gage data for the more probable events (lower stages) and surge model results for the less probable events (higher stages). Since RSLR was one of the surge model inputs, the surge model results already reflected RSLR effect on future stages; however, RSLR had to be added to the gage data for future years. The 0.999 (1-year), 0.2 (5-year), and 0.1 (10-year) stages were determined from gage data. The 0.02 (50-year), 0.01 (100-year), 0.005 (200-year), and 0.002 (500-year) stages are based on interpretation of surge model results. The 0.05 (25-year) stages were interpolated between the 0.1 (10-year) and 0.02 (50-year) points. If the surge model did not show surge propagated far enough in the basin to produce a surge elevation in an economic reach, an elevation lower than the invert elevation was reported. The minimum elevation is referenced to Morganza to the Gulf project LiDAR (NAVD88).

2.7 Existing Non-Federal Levees in the Without-Project Condition

Fragility curves describe the performance of existing non-Federal levees in the HEC-FDA model. The fragility curve gives the probability of the levee segment reaching its respective failure limit, conditioned on surge water levels. There are two types of non-Federal levees within the Morganza to the Gulf project area. The first type refers to hundreds of miles of forced drainage levees and/or levee-like features, including local levees, roads, natural ridges, drainage ditch spoil banks, and other non-engineered levees that lie interior to the authorized alignment. The second type refers to 9 miles of non-Federal levees that were designed for hurricane surge risk reduction and were constructed along the Morganza to the Gulf project alignment.

2.7.1 Forced Drainage Levees and Other Levee-Like Features

Existing forced drainage levees and other levee-like features protect against normal tidal fluctuations, but not storm surge flooding from hurricanes. Either the Terrebonne Parish Consolidated Government or the TLCD currently maintains and operates a total of 92 miles of forced drainage levees along with several pump stations and flood control structures. Private landowners have also constructed levee systems to protect their land from frequent flooding; however, private levees are not necessarily subject to regular maintenance. This set of levee features is reflected in the existing condition, and fragility curves were developed for each of the levees and levee-like features that enclose 78 of the 276 storage areas in the Morganza to the Gulf study area.

2.7.2 Non-Federal Levees Constructed as a Base for the Morganza to the Gulf Project

Approximately 9 miles of non-Federal levees are located along the authorized Morganza to the Gulf alignment in reaches J-1, H-2, and H-3 (refer to the project map in Attachment 1 for the location of these reaches). These levees were constructed by the non-Federal sponsor to meet HSDRRS criteria (USACE, 2/2011) in anticipation of Federal project re-authorization but are not part of the Federal project. Of these 9 miles of levee, only Reach J-1 (elevation +8.5 ft NAVD88), authorized separately for construction under Energy and Water Development Appropriations Act of 2004, was in place in 2008 when the project storm surge modeling was initiated and is included as part of the existing condition. There is a local levee fragility curve associated with levee Reach J-1. Construction of the remaining 6 miles, Reaches H-2 and H-3 (elevation +10 ft NAVD88), did not begin until 2009 and therefore could not be reflected in the without-project condition. Since H-2 and H-3 do not create a closed system (remains open to south, west, and north), their construction would not significantly affect the without-project condition, and there is no fragility curve associated with these two levee reaches.

Levees constructed by the non-Federal sponsor along the Morganza to the Gulf alignment are generally at an elevation less than +12 ft NAVD88 in areas where the Federal levee could eventually be over +26 ft NAVD88. The local levees appear to be constructed to HSDRRS standards (USACE, 2/2011) and would likely promote soil consolidation as a foundation to the Federal project. Floodgates put in place by the non-Federal sponsor (steel barge gates) do not meet HSDRRS standards and would eventually be removed and replaced with sector gates that are part of the Federal project.

2.7.3 Development of Fragility Curves for Existing non-Federal Levees

Development of fragility curves for the local levees considered two conditions: (1) global stability without overtopping and (2) overtopping with subsequent erosion. The local levees vary in elevations, compositions, top width, and side slopes and are scattered throughout the study area. Local levee elevations range from approximately +3 to +10 ft and have an average elevation of around +6 ft NAVD88. Levee slopes range from 1:10 to 1:3. There is little or no levee design documentation available, so geometric and engineering material properties of the local levees were determined from aerial photographs, Geographic Information System (GIS) overlays, available geotechnical data, extensive interviews with levee district personnel, and best engineering judgment. Stability analysis was performed on the local levees based on this limited information. The results of the stability analysis indicate that the local levee system's probability of failure due to stability or under seepage was relatively low for still water elevations reaching to the top of the levee. Therefore, the fragility curves were primarily based on erosion from wave overtopping, which is expected to be the dominant failure mode.

To construct the fragility curve for each local levee system, calculations were made to correlate surge elevations with overtopping rates, and failure probabilities were then assigned to those surge elevations. Based on the past loading and performance of these local levees for Hurricanes Gustav (August 2008) and Ike (September 2008), the probabilities of levee failure assigned to 0.1 and 1.0 cfs/ft were established based on the best available engineering judgment. Since the levee would begin to erode at an overtopping rate of 0.1 cfs/ft, the surge still water elevation corresponding to this overtopping rate was assigned a failure probability of 45 percent. At an overtopping rate of 1 cfs/ft, the levee could experience catastrophic failure and was therefore assigned a failure probability of 95 percent. The probabilities of failure assigned to the various overtopping rates are very subjective. Most levee performance criteria contain information on flow rate, embankment geometry, material, and vegetation cover and the engineer tries to relate it to probability. Each project is completely different and dependent on the external conditions and forces acting on the levee as well as the levee integrity.

As an example of how the local levee fragility curves relate to actual performance, one reach of local levee has an average levee height of approximately 7 ft. An overtopping computation resulted in a 1.0 to 1.2 cfs/ft overtopping rate at elevation 6.5 ft. The probability of failure in the fragility curve at that elevation is 95 percent, stating that failure is likely or very likely. This levee actually failed during Hurricane Ike with a storm surge height of 6.2 ft. In contrast, this levee reach experienced a storm surge height of 4.9 ft during Hurricane Gustav and did not fail. Based on the local levee fragility curve developed for this reach, at elevation 5.3 ft, the levee has a less than 10 percent chance of failure.

Figures 2-3 and 2-4 are examples of breaches at two locations. There were no levee breaches during Hurricane Gustav. Hurricane Ike produced some severe scour areas, two levee breaches, and a fronting protection failure. Of those damages, only the control structure breaches along the Louisiana Department of Wildlife and Fisheries marsh management levee (Morganza Reach J-2) and a heavy scour area on the west side of Bayou Dularge (Morganza Reach B) fall along the Morganza authorized alignment. All other breaches and scour areas were along local levees that are not planned for incorporation into the Morganza alignment. Morganza Reach J-1, constructed by the non-Federal sponsor, was overtopped but remained fully intact throughout this storm event. There were no initial damages to report on Reach J-1.

2.8 Proposed Federal Levees in the With-Project Condition

For each major Federal levee reach, a design exceedance elevation is entered in HEC-FDA along with an exterior/interior stage relationship. The design exceedance point is below the actual top of levee based on wave heights, overtopping, and erodability calculations. The design exceedance elevation is set at the still water elevation that equates to 2 cfs/ft wave overtopping. The 2 cfs/ft point was selected based on data from Colorado State University lab testing on grass-covered levees that showed erosion starting at 2 cfs/ft. This approach is conservative in that benefits and project performance are underestimated; the proposed Federal levee is designed to withstand higher surge elevations and some erosion before breaching would occur. Using the actual top of levee, however, would have overestimated benefits and project performance to some extent because there would be more overtopping using the actual top of levee elevations.



Figure 2-3. Breach at West Corner of “Stair-Step” Portion of Montegut Non-Federal Levee



Figure 2-4. Breach at Lashbrook Pump Station on Ward 7 Levee along Boudreaux Canal
Scour has undermined timber fronting protection, allowing water to seep under pump station.

3 Without-Project Conditions (No Action)

Existing conditions and modeling methods have changed in the approximately 15 years since the original feasibility analysis was initiated. Some of the major changes include storm surge and wave height predictions, sea level predictions, and updates to the residential and nonresidential structure inventory. Further details on without-project conditions can be found in the RPEIS and Economic and Engineering Appendices.

3.1 Topography and Land Use

The study area lies at the southern end of the Terrebonne Basin and contains a complex of habitat types, including natural levees, lakes, swamps, marshes, and bayous formed from sediments of abandoned Mississippi River deltas. The majority of the study area is undeveloped wetlands and open water. Elevations in the study area range from less than 1 ft near the Gulf of Mexico to approximately 10 ft near Houma, the largest city in the area. The elevation along the bayou ridges is 4 to 5 ft.

The study area is situated within the Barataria-Terrebonne estuary. The marsh habitat in the estuary transitions from fresh marsh in the more northerly portions to intermediate and brackish marshes, and to saline marsh near the coast. The remaining wetlands consist mainly of woody wetlands (primarily bald cypress/tupelo swamps and bottomland hardwood forest). Wetland areas within the hurricane and storm damage reduction system are deteriorating due to subsidence, saltwater intrusion, and storm surge flooding.

Only about one tenth of the study area has been developed. Communities located within the study area include the city of Houma, the towns of Chauvin, Dulac, and Montegut in southern Terrebonne Parish, the towns of Donner and Gibson in western Terrebonne Parish, and the towns of Gray and Schriever in northern Terrebonne Parish. Also included are the towns of Raceland, Lockport, and Pointe aux Chenes in Lafourche Parish and the portion of the city of Thibodaux south of Bayou Lafourche. Agricultural land is primarily used for pasture/hay and sugar cane.

Nearly all residential development occurs along one of the major bayou ridges, which generally do not flood except during extended and/or strong tropical storm events. Future development is expected to remain within forced drainage systems and along the ridges due to the increased costs associated with constructing homes outside of those areas. Very few residential structures are located in marsh; rather, hunting and fishing camps built on pilings are typically found in those areas.

3.2 Coastal Vegetation and Wetland Loss

Wetland loss in coastal Louisiana continues to be a major problem affecting both the ecosystem and storm surge risk reduction. The study area encompasses over half a million acres of vegetated coastal wetlands. The Louisiana Natural Heritage Program, which describes rare, unique, and imperiled plant species and vegetative communities occurring in Louisiana, lists 45 plant species or natural communities as occurring in Terrebonne and Lafourche Parishes. Storm surge exerts widespread stress upon vegetation through the introduction of higher salinity concentrations than are normally present within the study area and by direct erosion of marsh plants and soils. As area marshes convert to open water, vital fish and wildlife habitat, economic benefits, and hurricane and storm damage reduction benefits are lost. While wetlands cannot prevent the devastating effects of major hurricanes such as the recent Hurricanes Katrina, Rita,

and Gustav, wetlands can potentially reduce the storm surges associated with smaller tropical storm events.

As shown in figure 3-1, the land trend between 1985 and 2008 was a loss of approximately 2,600 acres per year, which equates to almost 60,000 acres lost over that period. Projecting that loss rate over the next 75 years would be almost 200,000 additional acres lost, which could be even greater with higher rates of sea level rise and/or subsidence.

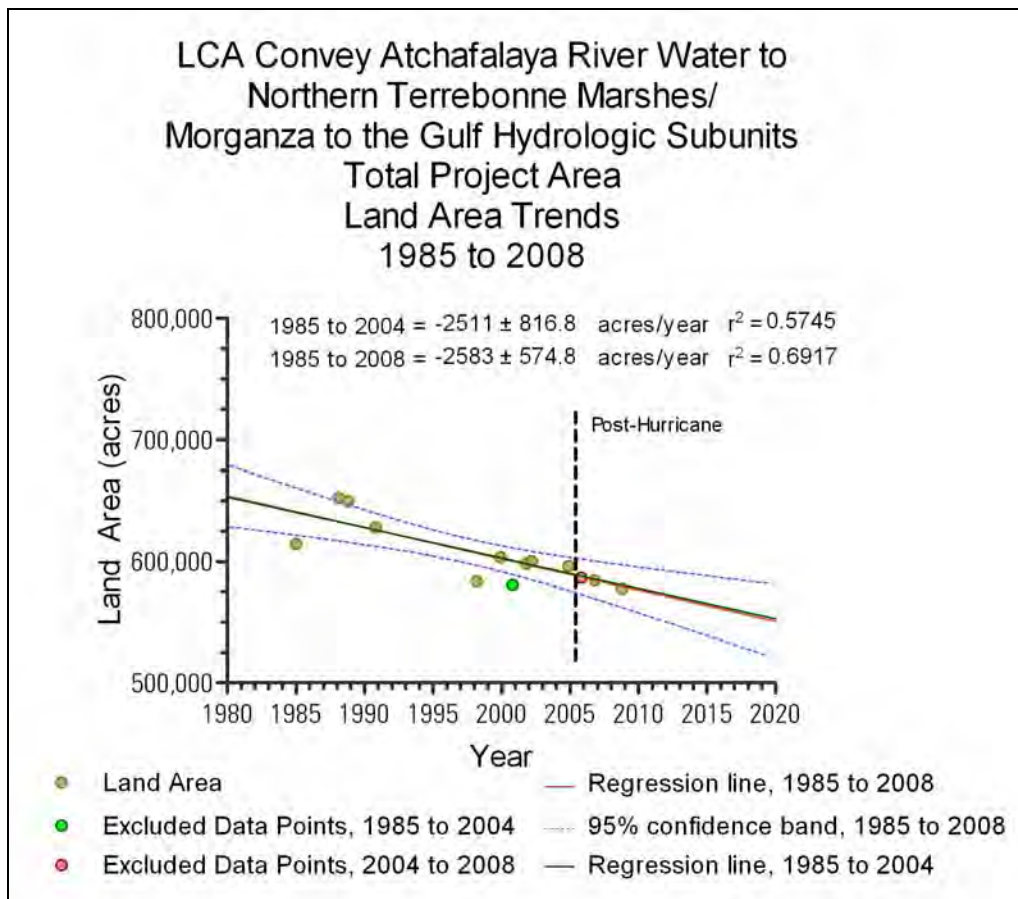


Figure 3-1. Land Area Trends from 1985 to 2008 Projected through 2020

Significant resources may be affected by coastal vegetation and wetland loss including, but not limited to, prime and unique farmland; aquatic resources; fisheries; essential fish habitat; wildlife; threatened and endangered species; water quality; recreation; aesthetics; and cultural resources. For a complete discussion on significant resources, refer to the RPEIS.

3.3 Hurricane Surge and Waves

Since the 2002 feasibility report was completed, Hurricanes Katrina and Rita (2005) and Hurricanes Gustav and Ike (2008) have impacted the study area. Flooding as a result of Hurricane Ike significantly impacted the town of Chauvin, which is located southeast of Houma. The town remained under water for nearly a week after the hurricane, as shown in figure 3-2.



Figure 3-2. Flooding Impacts of Hurricane Ike in Chauvin, Terrebonne Parish

Source: Louisiana Recovery Authority (<http://www.lra.louisiana.gov>)

Without-project surge and wave modeling was completed in 2008 using 2007 conditions to represent existing/no action conditions. A suite of theoretical hurricanes were modeled within an integrated modeling system to generate storm surge and wave simulations. The ADCIRC Coastal Circulation and Storm Surge Model is coupled with offshore and nearshore wave models (WAM and STWAVE). The ADCIRC surge model used for the Morganza PAC analysis is based on the model that was validated for Interagency Performance Evaluation Task Force (IPET) with Hurricane Katrina data and subsequently validated with data from Hurricane Rita for this and other USACE coastal surge studies. Prior to use of the surge model, modifications to the bathymetry, topography, and levee heights specific to the Morganza study area were made.

The without-project condition was modeled with all existing non-Federal levees and other “levee-like” features in place except for the 6 miles of first lift levees along reaches H-2 and H-3, which were not constructed until after modeling was complete. The without-project conditions do not need to be re-modeled with H-2 and H-3 in place because they do not result in a closed system and would not significantly reduce damages. Storm surge could flank the levee system and/or proceed up uncontrolled bayous and canals, thereby flooding the project area. The constructed first-lift levee reaches are expected to settle within the first couple of years, reducing their ability to protect against a tropical storm surge. If overtopping occurs during a storm event, scour would most likely erode the unprotected side, causing the levees to fail.

Future relative sea level rise was incorporated into surge and wave modeling. Surge propagation over wide, shallow wetland areas is highly sensitive to sea level rise. Increased water depths resulting from sea level rise and wetland degradation can increase surge propagation speed and allow greater inundation. If the mean water level increases in the future, low-lying areas could experience higher surges on average. Waves also generally increased significantly for all sea level rise cases. Wave height increases are significant, but less dramatic than the surge increases.

Three Relative Sea Level Rise (RSLR) scenarios, based on Low (historic), Intermediate, and High sea level rise rates, are part of the risk assessment for the Morganza to the Gulf project. The local historic RSLR trend was determined based on the Leeville, Louisiana gage. Subsidence is included in the gage readings. Applying a linear trend to the 43 years of available data gives a yearly relative sea level increase of approximately 0.3 in/yr. EC 1165-2-212, *Sea-level Change Considerations for Civil Works Programs*, provides the equations for calculation of the RSLR values for the three scenarios. Table 3-1 shows the calculated values for 2010 to 2035 (existing conditions to base year), and for 2010 to 2085 (existing conditions to future year).

Table 3-1. Total Relative Sea Level Rise by 2035 and 2085 by Scenario

Scenario	Total RSLR (ft)	
	Over 25 years: 2010 to 2035	Over 75 years: 2010 to 2085
Low (Historic Rate)	0.6	1.7
Intermediate (Rate 1)	0.7	2.4
High (Rate 2)	1.2	4.8

Since much of the surge and wave modeling for the Morganza to the Gulf PAC was completed prior to issuance of EC 1165-2-212, the modeled RSLR values vary slightly from the EC-calculated values. Simulations were run for approximately 1, 3, and 5 ft of RSLR, and the results were then interpolated for the three RSLR scenarios. Modeling results demonstrated that surge does not increase linearly with sea level rise. Present day surges of 7 to 10 ft could increase by as much as 3 to 7 ft more than the sea level rise increase in the future.

After running storm surge models, results were statistically analyzed to estimate stage-probabilities for the intermediate RSLR scenario (table 3-2).

Table 3-2. Representative Without-Project Surge Still Water Elevations (No Waves)

Frequency	Existing Condition (2010)	Base Condition (2035) Intermediate RSLR	Future Condition (2085) Intermediate RSLR
0.04 (25-yr)	6 to 8 ft	7 to 9 ft	9 to 10 ft
0.02 (50-yr)	9 to 10 ft	10 to 11 ft	11 to 13 ft
0.01 (100-yr)	11 to 12 ft	12 to 13 ft	13 to 15 ft
0.005 (200-yr)	13 to 14 ft	14 to 15 ft	15 to 17 ft
0.002 (500-yr)	15 to 16 ft	16 to 17 ft	16 to 19 ft

Note: Values are rounded to the nearest foot. More detailed information can be found in the Engineering Appendix. Values are for the Intermediate RSLR scenario. See section 6.9 for a discussion on the Low and High RSLR scenarios.

See Attachment 3 for a set of maps corresponding to the 50-, 100-, and 500-yr surge inundation depths for 2010, 2035, and 2085 without-project conditions.

3.4 Local Hydrodynamics and Salinity

The major rivers and their tributaries affecting the study area are the Mississippi River to the east and the Atchafalaya River to the west. Rainfall typically flows away from the major streams and collects between the ridges to form bayous, such as Bayou Lafourche, that flow south toward the Gulf of Mexico. Anthropogenic changes within the study area, such as construction of canals, pipelines, roads, railroads, navigation channels, and levees, have altered the natural flow patterns. Major waterways crossing the study area include the east-west GIWW and the north-south HNC. The HNC has been implicated in higher salinity in the Houma area. The study area also has numerous forced drainage systems that remove excess stormwater by a combination of earthen levees, drainage canals, and pumps.

To determine hydrodynamic and salinity effects, a TABS-MDS numerical model has been created for the Morganza area. The primary freshwater inflows to the system are the Atchafalaya River and the Wax Lake Outlet. Additional smaller inflows (Bayou Boeuf, GIWW at Larose, Bayou Lafourche, and three drainage channels) were also included in the model geometry. Without the project in place, storm surges push seawater from the Gulf of Mexico and increases salinity in the study area. The salinity gradient in the basin varies from 0 ppt in the upper basin to 27 ppt at certain times of the year in the Gulf of Mexico as shown in figure 3-3. Factors affecting salinity in the project area include the Atchafalaya River discharge via the GIWW, Gulf of Mexico salinity and circulation, wind, rainfall/evaporation, tidal exchange, vertical mixing in deeper channels, and bathymetry.

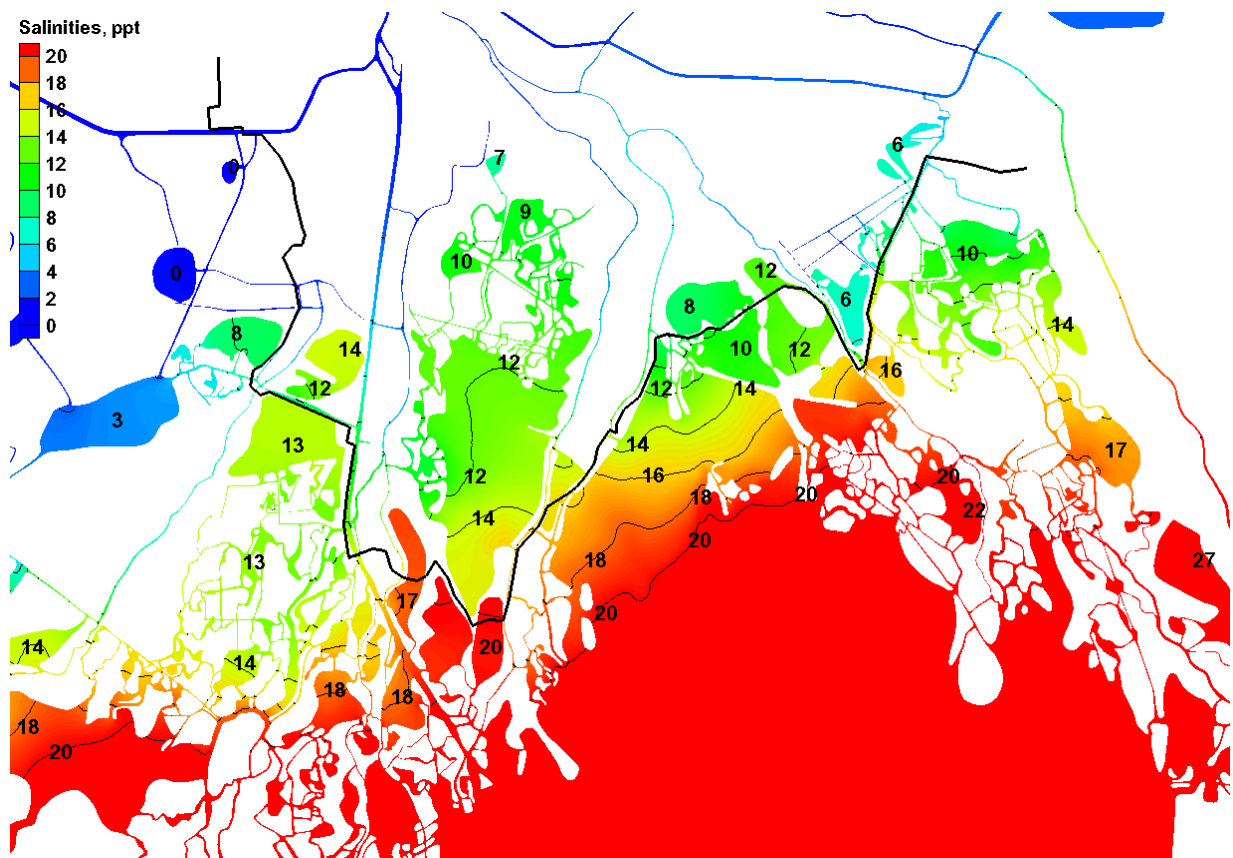


Figure 3-3. Base Average Salinity for October to December 2004 Without-Project Conditions

3.5 Population and Storm Surge Damages

The structure inventory for the original Morganza feasibility study (2002) was collected in 1997-98. To update the inventory for the PAC report, field surveys were collected in 2009. The location of inventoried residential and non-residential structures is shown in figure 3-4. As shown in table 3-3, the number of structures in the study area has more than doubled since the original inventory was collected in 1997/1998 because of population growth and an expansion of the flood risk area.

Since Morganza PAC surge modeling results were not yet available when the inventory was collected, potential damage areas were identified using the largest surge extent developed as part of the post-Katrina LACPR evaluation. In addition to areas outside of the storm surge extent, the area north of Bayou Lafourche between Lockport and Larose was not inventoried because it was originally part of the Donaldsonville to the Gulf study area and was not incorporated into the Morganza to the Gulf study area until after the inventory was collected.

Based on the information collected during the field surveys, a depreciated replacement cost for residential and non-residential structures was calculated. The value of the land was not included in the analysis. A small number of industrial structures were also inventoried using interview forms approved by the Office of Management and Budget.

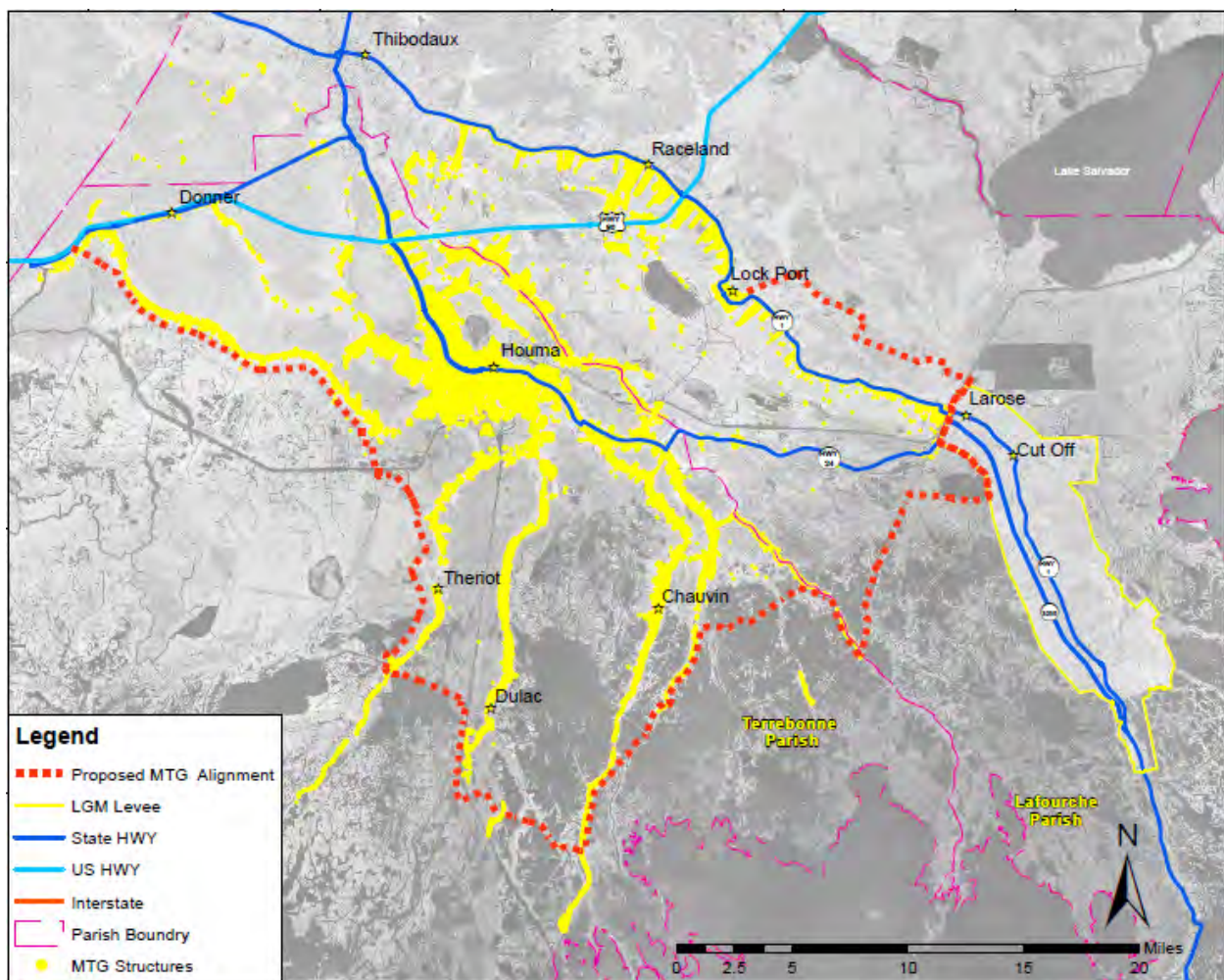


Figure 3-4. Location of Structures in the Morganza to the Gulf Study Area

Table 3-3. Number of Structures Inventoried in 1998 and 2009.

Structure Type	Number Inventoried	
	Updated PAC Survey (2009)	Original Survey (1997/98)
One-Story Slab	21,694	10,146
One-Story Pier	12,723	9,891
Two-Story Slab	1,656	2,399
Two-Story Pier	615	401
Mobile Home	9,859	1,753
Multi-occupancy	See note*	178
Residential Subtotal	46,547	24,768
Nonresidential Subtotal**	6,263	880
Total Structures	52,810	25,648

*In the 2002 feasibility report, multiple-occupancy/multi-family structures were grouped under residential. Multiple-occupancy/multi-family structures are currently grouped under non-residential and there were 309 inventoried in 2009.

**In the 2002 feasibility report, the four nonresidential categories were (1) Agriculture, Mining, Construction, Manufacturing, and Transportation/Communications/Utility sectors (2) Wholesale and Retail sectors (3) Finance/Insurance/Real Estate and Services sectors and (4) Public sector. In 2009, nonresidential structures were subdivided into the following eight categories: Eatery, Professional, Public, Repair, Retail, Warehouse, Grocery, or Multi-Occupancy.

The increase in the number of households that occurred in the two parishes between 1997 and 2009 was commensurate with the population growth experienced by the entire Gulf Coast region during the same period. In 2010, there were approximately 28,800 people residing in the inventoried structures in Lafourche Parish and approximately 104,900 people in Terrebonne Parish for a total of 133,700 residents at risk of storm surge inundation. The population of Lafourche Parish is projected to total approximately 29,300 in 2035 and about 31,200 in 2085. In Terrebonne Parish, the population in this area is expected to total 113,200 in 2035 and 133,800 in 2085.

Historically, hurricanes have not resulted in outmigration from the area (figure 3-5). Despite having experienced numerous flood events, residents have shown an unwillingness to leave the study area, in large part due to economic and cultural ties to the land. The population decline in the mid- to late-1980s was employment-driven (i.e. lack of employment due an oil bust), rather than as the result of Hurricane Juan.

Data from the 2000 Census show that approximately 65 percent of residents in the Lafourche and Terrebonne Parishes lived in the same housing unit as they had in 1995. This percentage ranged from a high of 81 percent in Dulac (southern portion of the study area) to a low of 54 percent in Thibodaux (northern portion of the study area). In comparison, the national percentage of the population residing in the same house in 2000 as in 1995 was 54 percent.

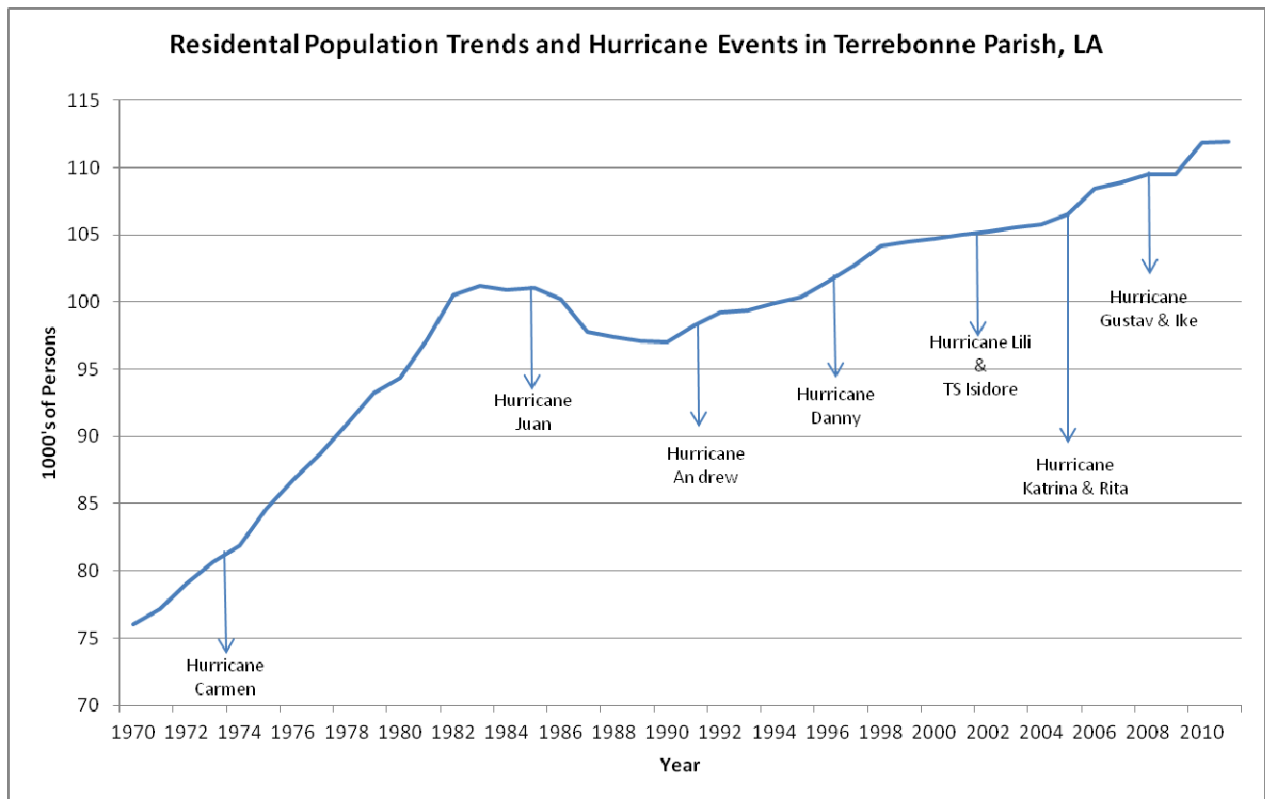


Figure 3-5. Terrebonne Parish Population Trends with Hurricane Events (Source: US Census Data)

According to local officials, residents in low-lying communities began relocating to areas in the northern parts of the study area after Hurricanes Katrina and Rita in 2005. Reasons for this intra-parish shift was a combination of weariness on the part of residents of having to deal with repeat flooding and the more stringent requirements to obtain permits for rebuilding after homes were damaged. In order to rebuild, residents had to incur the cost of building to higher elevations. The ability to secure insurance at a reasonable price was also cited as a reason for the exodus.

The rate of retreat from the southern communities slowed around 2008 after Hurricane Ike impacted the area due to federal assistance, as well as the construction of local levees, which reduced damages to the area. In addition, the two parishes have also implemented elevation programs designed to raise the structures in flood-prone areas. Local officials also stated that residents prefer to remain due to the culture of the residents and the economy of the area. The economy of Terrebonne Parish is closely tied to its abundant natural resources, and many of the residents in the small communities outside of Houma are shrimpers, oystermen, crabbers, fishermen, and trappers. In Lafourche Parish, the economy is strongly tied to the production and distribution of natural gas and oil, commercial fishing, and sugar cane.

The HEC-FDA model used to calculate damages implicitly assumes that all damaged assets are restored to their prior market value completely and within a year after a flood event. Historical data show that major flooding events have not resulted in significant outmigration from the study area, and the post-flood response of property owners is consistent with the HEC-FDA assumption of complete and immediate repair of damaged property. However, the manner in which property owners have responded in the past may or may not be representative of how they will respond in the future to more repetitive and damaging flood events. Even if property owners

have been willing to repair flood-damaged property at existing elevations in the past, under future without-project conditions, increased flood risks due to expected relative sea level rise and an increase in the frequency of flooding may result in different post-flood responses over the period of analysis. Property owners could opt to have their structures raised in place, floodproof and/or retrofit their structures, relocate within the floodplain, or permanently evacuate from the study area. The course of action selected by an individual property owner following repetitive flood losses depends upon many factors, including the degree of aversion to future anticipated flood risk by that property owner and Federal, State, and local floodplain regulations.

The initial without-project expected annual damages computed by the HEC-FDA model did not consider the behavior of property owners whose structures incur repetitive flood losses. A breakdown of expected annual damages revealed that there were a significant number of structures with damage exposure from relatively frequent events. Approximately 7,500 residential and non-residential structures would incur flood damages from a 0.1 ACE (10-year) storm event in the year 2035, and approximately 2,000 residential structures would incur damages greater than or equal to 50 percent of the structural value. Given the number of structures at risk from frequent flooding, the magnitude of these damages, and the increased frequency which residential and non-residential structures would be exposed to flooding, adjustments to the implicit assumptions of the HEC-FDA model were deemed necessary. Thus, adjustments were made to the 2024, 2035, and 2085 structure inventories as described in the Economic Appendix.

The preliminary unadjusted expected annual without-project damages ranged from \$515 million in 2010 to \$1.46 billion in 2085 primarily as the result of increasing stage-probabilities due to relative sea level rise. The final expected annual without-project damages for the adjusted inventories range from \$486 million to \$1.16 billion in 2085.

4 Initial Reevaluation of the Authorized Plan

In the evolution of the Morganza to the Gulf project, various alternative plans have been developed and evaluated with the goal of maximizing hurricane and storm damage reduction benefits while minimizing costs and adverse impacts to the environment, local interests, navigation, and industry. Engineering, environmental, economic, sociological, and institutional factors have been key considerations in the formulation and evaluation of alternatives. Measures and alternatives that were either not feasible, unacceptable, or did not meet the planning objectives were eliminated from consideration as final alternatives.

This section describes the limited re-evaluation of post-authorization alternatives. Prior to initiation of the PAC analysis in 2008, a recon-level analysis of four alternatives was conducted to determine whether the Morganza to the Gulf project could still provide positive net benefits. The 2008 analysis evaluated the authorized alignment at two levels of risk reduction, and two other levee alignments to see if they would produce higher net benefits than the authorized alignment. The authorized alignment was determined to have the potential to produce the highest net benefits.

4.1 Problems, Opportunities, Goals, Objectives, and Constraints

No changes in problems, opportunities, goals, objectives, and constraints have occurred since the 2002 feasibility report analysis. The primary problem continues to be the flood risk associated with storm surge and waves, which is increasing due to wetland loss, sea level rise, and subsidence. Tropical storms cause widespread flooding of residential and commercial properties resulting in extensive damage and economic losses. Despite local efforts to maintain a system of forced drainage levees, pump stations, and flood control structures, an adequate storm surge risk reduction system is not currently in place. Although the USACE cannot affect the root causes of storm surge and wetland loss, such as hurricanes, sea level rise, and subsidence, it has the opportunity to address some of the problems related to storm surge flooding. The overarching goal is to reduce the risk to people and property in the vicinity of Houma, Louisiana. All project benefits are related to hurricane and storm damage risk reduction. No flood damage reduction, navigation, or ecosystem restoration benefits are quantified for this project.

4.2 Nonstructural Alternatives

Nonstructural measures complement structural measures and are an essential part of a comprehensive hurricane and storm damage reduction program (NAS 2009). Nonstructural measures reduce risk without significantly altering the nature or extent of flooding. Examples include flood proofing, relocation of structures, elevation of structures, flood warning and preparedness systems, evacuation plans, public education, zoning, and flood insurance. The WRDA of 1974 (PL 93-251) requires that Federal agencies consider nonstructural measures to reduce or prevent flood damage. Nonstructural measures are the responsibility of not just the Federal government, but also state and local governments and private citizens.

Nonstructural alternatives for direct comparison to the authorized Morganza to the Gulf levee project were not formulated as part of this PAC report. The 2002 Morganza to the Gulf feasibility study showed that hurricane and storm damage problems cannot be solved entirely through nonstructural means for the study area. Large-scale relocation is problematic both socially and economically because homes and businesses would have to be moved considerable distances north to the Houma or Thibodaux areas to remove them from the threat of coastal flooding from the 1% AEP (100-year) storm surge event. The 2002 feasibility report did explore

the possibility that some structures along the bayous might lend themselves to nonstructural solutions. For 6,000 residential structures along the bayou ridges south of Houma (including approximately 5,000 structures that are located within the authorized alignment), alternatives included either raising them above or relocating them out of the 1% AEP floodplain. Neither nonstructural option for these areas was economically justified so they were eliminated from further consideration.

Five communities (approximately 1,000 structures) residing outside the authorized Morganza to the Gulf alignment are described below (see figure 4-1):

1. Isle de Jean Charles – An isolated community of State-recognized Biloxi-Chitimacha tribe members that has lost a significant percentage of its population in the past 10 years. There are currently about 25 families using the “Island” as their primary residence. The majority of the remaining structures are weekend camps. Most of the residential structures are already elevated. The 2002 feasibility report determined that a relocation plan was economically justified; however, it was not recommended because the proposed plan was not supported by the Isle de Jean Charles community. Instead, the TLCD constructed an earthen levee to approximately elevation 6 ft. In addition, the only road to the island was raised to provide a better evacuation route.
2. Lower Chauvin/Cocodrie – The most southern part of LA Hwy 56 (4.5 miles) is outside the Morganza to the Gulf alignment. This area include a University Marine Research Facility (LUNCOM), several fishing marinas, commercial fishing docks and facilities, oil and gas facilities (docks) and many fishing camps. There are very few local residents who still consider this area their primary residence.
3. The “Four Point” area in lower Bayou Grand Caillou/Dulac – The only part of Grand Caillou that is located outside of the Morganza to the Gulf alignment consists of fishing camps and a small marina at the end of Four Point Road.
4. Lower Bayou Dularge – This portion of Bayou Dularge is the most populated area not included in the Morganza to the Gulf alignment. This area has many local commercial fishermen along with docks and one marina. The TLCD intends to protect the entire Dularge community as much as possible and currently maintains about 15 miles of local levees in lower Dularge with a 56-ft wide barge floodgate at the end of Bayou Dularge.
5. Gibson - Gibson is an unincorporated community in Terrebonne Parish at the termination of the western extent of the Morganza PAC alignment. Gibson was not identified as a community at risk in the original feasibility study because modeling at that time did not show storm surge reaching that area.

For the PAC report, a preliminary nonstructural buyout plan has been developed for high risk areas outside the proposed levee system as shown in figure 4-1 and described in section 6.5.1 of this document. Socioeconomic considerations associated with the potential buyouts are described in RPEIS section 5.2.13, and Environmental Justice is discussed in RPEIS section 6.14.8 and RPEIS Appendix J.

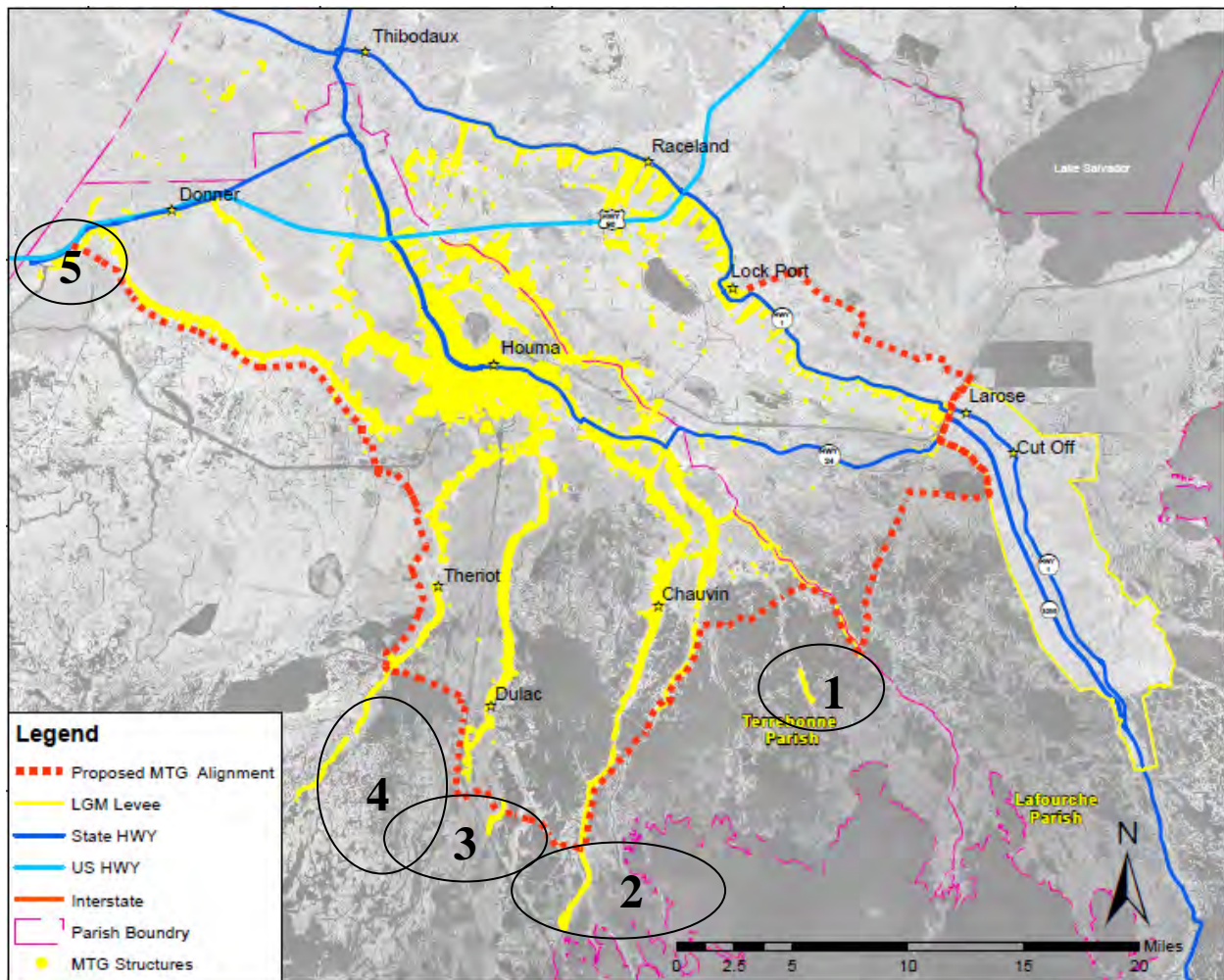


Figure 4-1. Location of Structures Outside the Morganza to the Gulf Levee System

4.3 Preliminary Evaluation of Alternative Levee Alignments

Following the 2007 WRDA authorization, a set of four Morganza to the Gulf alternatives were evaluated based on post-Katrina/Rita interim design guidelines using LACPR data and methods. The purpose of the 2008 analysis was to determine whether or not there was still a Federal interest in the project and whether a feasibility-level PAC study should be initiated. The four alternatives were developed in 2008 in coordination with the CPRA, TLCD, and a group of non-governmental organizations. The alternative alignments are shown in figures 4-2 through 4-4 and are as follows:

1. Authorized Alignment at Post-Katrina 1% AEP Elevations – Alternative 1 (2008) generally follows the authorized plan alignment; however, it includes a few minor modifications to Reach G that were made between 2003 and 2008. The Reach G modifications are described in section 4.4.
2. Reconnaissance Alignment at Post-Katrina 1% AEP Elevations – Alternative 2 (2008) is based on the “Reconnaissance” alignment from the 2002 Feasibility Report.
3. Multiple Lines of Defense Strategy Alignment at Post-Katrina 1% AEP Elevations – Alternative 3 (2008) is based on a “Multiple Lines of Defense Strategy (MLODS),” presented by a group of non-governmental organizations, which considers the storm

buffering potential of natural landscape features such as wetlands as the first line of defense against storm surge and waves. This alignment was not previously considered in the 2002 Feasibility Report. The Alternative 3 alignment includes Theriot and Dulac ring levees. As compared to the other alternatives, the MLODS alignment is located closer to development and has more marsh located outside the levee system.

4. Authorized Alignment at Pre-Katrina Elevations – Alternative 4 (2008) follows the same alignment as Alternative 1 (2008). The authorized project levees, lock, floodgates, environmental facilities, and floodwalls were reengineered to meet post-Katrina design criteria, but not the post-Katrina 1% AEP design elevations. This alternative was evaluated in order to compare the Pre- and Post-Katrina versions of the 2002 Feasibility Study Recommended Plan.

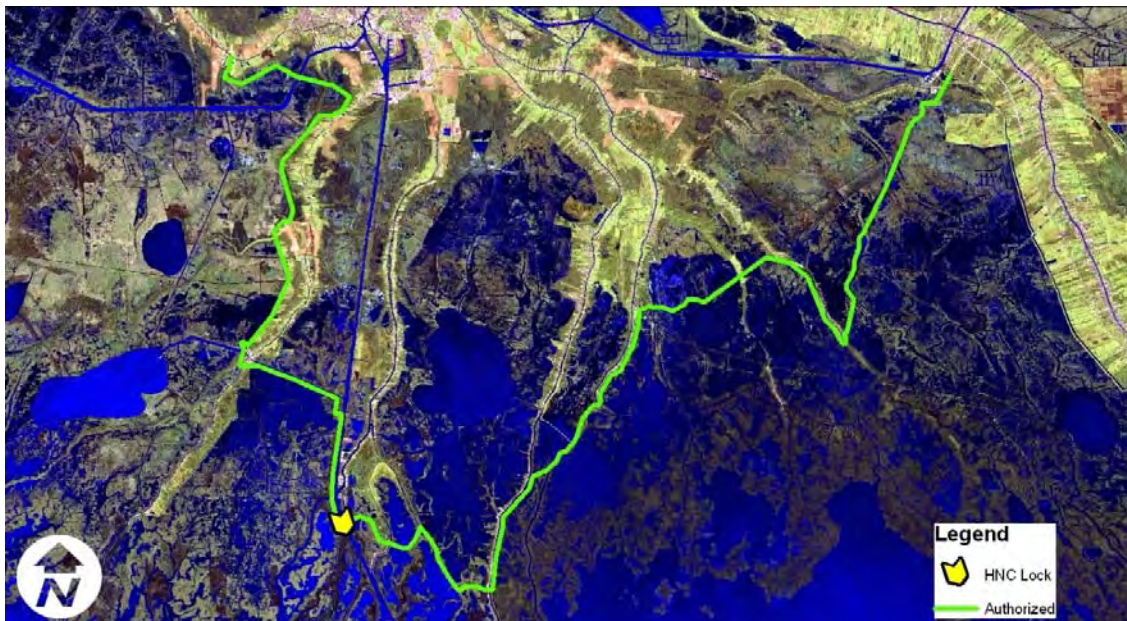


Figure 4-2. Alignment for 2008 Alternative 1 and 2008 Alternative 4



Figure 4-3. Alignment for 2008 Alternative 2



Figure 4-4. Alignment for 2008 Alternative 3

Note: Figure 4-4 (2008 Alternative 3) represents the MLODS alignment as originally proposed; however, the HNC lock would actually be located where the levee alignment intersects the HNC. In addition, a salinity control structure that could be overtopped during hurricane events would be located where the HNC lock is shown on the map.

Table 4-1 presents the results of the 2008 analysis of alignment alternatives. The 2008 analysis was based on the best available information at the time. Interim HSDRRS design criteria (USACE, 2007) available at the time were used. Some major differences between the 2008 analysis and the full feasibility analysis for the PAC report are described following the table.

Table 4-1. Alignment Alternative Comparison of Elements

Feature	2008 Alternative 1	2008 Alternative 2	2008 Alternative 3	2008 Alternative 4
Hurricane and Storm Damage Reduction Design standards (year)	Post-Katrina (2008)	Post-Katrina (2008)	Post-Katrina (2008)	Pre-Katrina (2000)
B/C Ratio (Low to High Scenario)	0.67 to 1.07	0.60 to 0.98	0.49 to 0.79	0.59 to 1.40
Equivalent Annual Net Benefits in \$Millions (Low to High Scenario)	(\$197) to \$44	(\$223) to (\$12)	(\$335) to (\$136)	(\$98) to \$99
Estimated Cost (High Scenario)	\$ 8.6 B	\$ 7.5 B	\$ 8.3 B	\$ 2.5 B
Levee Length	64.6 miles	55.2 miles	63 miles	64.6 miles
Total Cost per Mile	\$133,000,000	\$135,700,000	\$131,300,000	\$38,480,000
Levee Cost per Mile	\$81,970,000	\$81,270,000	\$72,860,000	\$17,430,000
Levee Height	Varies 18.5 to 28.5 ft	Varies 18.5 to 28.5 ft	Varies 18.5 to 23 ft	Varies 11 to 15 ft
Low: 14 to 18 ft	0 Miles	0 Miles	0 Miles	64.6 miles
Medium: 18.5 to 24.9 ft	33.3 Miles	29.9 Miles	63 Miles	0 Miles
Tall: 25 ft and over	31.3 Miles	25.3 Miles	0 Miles	0 Miles
Levee Base Width				
Lower Range	524	524	442	164
Upper Range	725	725	680	243
Embankment in Place (CY)	153,089,711	130,674,856	133,708,696	23,936,090
No. Lifts to Construct	Maximum of 5	Maximum of 5	Maximum of 5	Maximum of 3
Marsh Impacted(direct)	5,558 acres	4,953 acres	3,901 acres	1,562 acres
Bottomland Hardwoods Impacted (direct)	1,024 acres	1,358 acres	3,776 acres	331 acres
Right of Way Areas	14,527 acres	11,781 acres	13,381 acres	1,614 acres
Stability Berms	Both sides of levee	Both sides of levee	Both sides of levee	Unprotected side only
Nos. of Structures	40	36	40	39
HNC Lock Complex	1	1	1	1
250 ft Sector Gate	0	0	1	0
125 ft Sector Gate	3	3	3	3
56 ft. Sector Gate	10	8	9	10
46 ft. Tainter Gate	5	4	5	5
Sluice Gates	13	14	8	13
Fronting Protection	3	3	3	3
Highway Gates	5	3	10	5

*Benefits and costs are presented for a high damage scenario (high employment, highly dispersed land use, and high relative sea level rise). The without-project equivalent annual damages were estimated at \$1.1 billion. Marsh and bottomland hardwood impacts are for direct construction of the levee only. Indirect impacts were not quantified for the 2008 preliminary analysis, but were considered by the interagency team.

The 2008 designs and costs are based on a typical levee cross-section to elevation +28 ft NAVD88 and representative structure designs. Engineering judgment was applied to scale each typical section higher or lower to match the design elevation provided for each specific hydraulic reach to estimate the required levee footprint, overbuild heights, and estimated lift schedule. The cost estimates (ARCADIS, 2008) include levees, floodgates, the HNC lock complex, tidal exchange/environmental control structures, pumping station fronting protection, road gates, utility relocations, real estate, Engineering and Design, Construction Management, and mitigation for direct impacts to marsh and bottomland hardwoods (wet and dry). A Cost and Schedule Risk Analysis Process was also performed according to guidelines set out by the USACE Walla Walla

District in a March 2008 document. Overall, the contingency for the 2008 estimate was calculated to be 23.5 percent at 80 percent confidence level. Since the 2008 analysis, additional borings have been taken to refine structure designs and cost estimates in the final alternatives analysis.

The 2008 economic benefits analysis was based on LACPR data and methods (LACPR, 2009) to calculate damages for the residential and non-residential categories, agricultural resources, transportation infrastructure and emergency cost savings and benefits during construction. The damages to boat fleets and business from saltwater intrusion were based on the 2002 feasibility report. The LACPR census block data was used instead of updated, detailed structure inventory data, which was not available at the time. Economic benefits were calculated using the LACPR GIS database instead of the USACE certified model for performing flood damage analysis, i.e. HEC-FDA.

Annualized benefits and costs were compared over a period of analysis from 2010 to 2081. The assumed base year, when the project would begin to provide the specified level of risk reduction, was assumed to be 2032 for Alternatives 1, 2, and 3 and 2020 for Alternative 4. In order to make the alternatives comparable, the Alternative 4 benefits stream was compounded 12 years from 2020 to 2032 to reflect a common base year (2032) for all four alternatives. Benefits during construction were calculated for all four alternatives. The benefit and cost values were converted to an equivalent time frame using October 2008 price levels and a Federal discount rate of 4-7/8 percent for the amortization period of 50 years.

Reflective of economic evaluations conducted under LACPR, the four alternatives were evaluated under two damage scenarios. The “high” damage scenario incorporates high employment, highly dispersed land use, and high relative sea level rise. The “low” damage scenario incorporates business-as-usual future development, compact land use, and low relative sea level rise.

Preliminary estimates of direct environmental impacts for each of the four alternatives and adjacent borrow sites were developed for the 2008 verification of the authorized alignment. The footprints of project features (levees, adjacent borrow pits, and the mitigation areas) were categorized by land form (wetlands, open water, or non-wet) and a spreadsheet was used to calculate impacts by wetland type (marsh, bottomland hardwood-dry, and bottomland hardwood-wet or “swamp”). All mitigation cost estimates in the PAC report are based on the following:

- Marsh mitigation at \$80,000 per acre and a ratio of 1-to-1.
- Bottomland hardwood mitigation at \$37,000 per acre and a ratio of 3-to-1, or \$111,000 per acre, for bottomland hardwood-wet (swamp) and a ratio of 6-to-1, or \$222,000 per acre, for bottomland hardwood-dry.

Wetland replacement ratios are for mitigation cost estimating purposes only; actual mitigation costs would be determined based on replacement of wetland habitat values and ratios could be higher or lower depending on specific habitat type (brackish, fresh, saline, etc).

As shown in table 4-1, Alternatives 1 and 4 (2008), which are both based on the authorized alignment, had the highest net benefits among the alternatives and indicated a potential for positive economic justification based upon the results for the high damage scenario. Alternatives 2 and 3 (2008) produced negative annual net benefits under both the high and low damage scenarios. This analysis demonstrates that both alternatives along the authorized alignment potentially remain economically justified, while the alternative alignments examined in Alternatives 2 and 3 (2008) are not likely to be economically justified. Alternatives 2 and 3 were also screened for the following reasons:

- Based on surge modeling, areas outside the levee system may experience higher statistical water levels than without the project. Alternatives 1 and 4 leave fewer assets outside of the levee alignment, most of which are camps or secondary residences. Alternatives 2 and 3 leave many more assets outside the levee system, which has greater implications for induced flooding impacts.
- Alternatives 1 and 4 provide much more internal storage in the case of levee overtopping or significant rainfall during a storm event. Alternatives 2 and 3 would likely require additional pumping capacity and would have higher residual risk in the case of levee overtopping.
- Although Alternatives 1 and 4 enclose more wetlands than Alternatives 2 and 3, the authorized alignment would be mostly constructed along existing raised features (e.g. ridges, local levees, etc.) and the addition of water control features would actually improve the hydrologic exchange in some areas. Although the shorter Alternative 2 and 3 alignments enclose fewer wetlands and have less direct marsh impacts, those alignments actually impact more bottomland hardwoods than the authorized alignment.

For the reasons stated above, the authorized alignment was reconfirmed as the alignment that best meets Federal objectives, i.e. most effective, efficient (cost-effective), complete, and acceptable, and was therefore carried forward for more detailed analysis.

5 Post-Authorization Changes to the Levee Alignment

As a result of new information obtained during the PED phase, several of the authorized levee reaches have been refined to reduce costs, reduce environmental and cultural resources impacts, and improve risk and reliability. For example, Hurricane Katrina and advances in storm surge modeling revealed that narrow, sharp indentations in the alignment can lead to stacking of surge, which increases risk and makes the levee less reliable. These refinements reduced the length of the 72-mile authorized alignment by approximately 11 miles, however, post-Katrina surge modeling demonstrated that the authorized project could potentially be flanked at either end. The alignment had to be extended 16 miles to the west and 21 miles to the east to complete the system. The result of these alignment modifications and extensions resulted in a 98-mile levee project as shown in Attachment 1.

5.1 Modifications to the Authorized Alignment

The following sections describe each of the post-authorization levee reach modifications starting with modifications to the reaches that were part of the authorized project (A, G, H, J, and L). No changes were made to Reaches B, E, F, I, or K.

5.1.1 Reach A

In October 2009, the USACE evaluated four alignment options for Reach A as follows:

- The 12-mile **A1** alignment is Reach A from the authorized project alignment. The authorized alignment follows the development line along Bayou Dularge.
- The 14-mile **A1A** alignment is a slight variation on the authorized (A1) alignment. A1A generally follows the A1 Alignment with an additional 2 miles of levee around an agricultural area, which is located along a natural ridge and has the potential for future development.
- The 10-mile **A2** alignment is located west of the authorized (A1) alignment and was considered because some landowners wanted more of their farmland inside the levee. The A2 alignment shortened the authorized (A1) alignment by 2 miles and reduced marsh and bottomland hardwood impacts.
- The 9-mile **A3** alignment is a compromise between A1 and A2. A3 is the shortest alignment, has the least marsh impacts, and bottomland hardwood impacts similar to A2.

Each alternative includes two 125-foot floodgates on the GIWW (reduced to one 125-ft sector gate in the final PAC alternatives), one 56-foot sector gate at Minors Canal, and 6-ft by 6-ft box culverts at four locations, except for the A2 Alignment which has only two box culvert locations also has three tainter gates associated with the sector gate. Subsequent to the analysis of the four options, an even more cost effective alignment was identified which is labeled “Current Alignment” in figure 5-1.

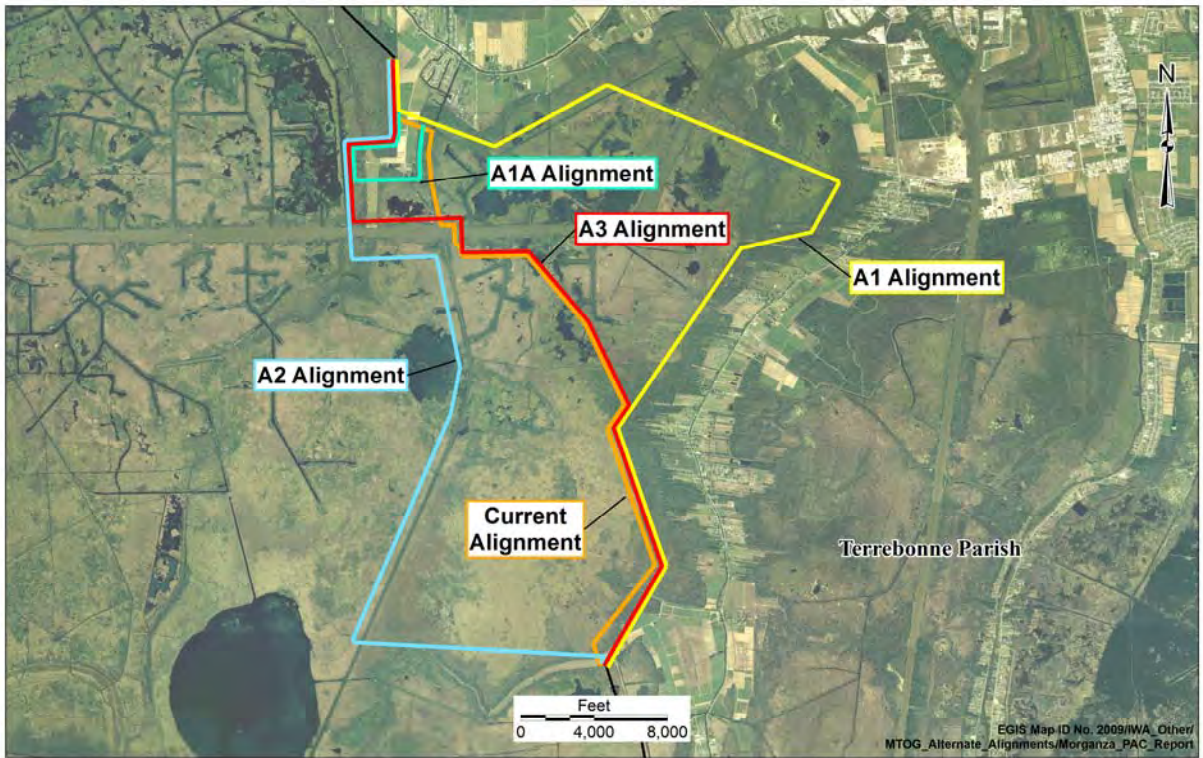


Figure 5-1. Levee Reach A Alignment Options

Environmental impacts were evaluated based on the amount of direct impacts to both marsh and bottomland hardwoods (wet and dry) and the approximate cost of mitigation as shown in table 5-1. Both Options A2 and A3 have the potential to impound more wetlands than Option A1, but box culverts are designed to reduce any potential indirect impacts. As compared to the authorized alignment (A1), the A3 alignment has more acres of bottomland hardwood (dry) impacts, but less bottomland hardwood (wet) impacts and marsh impacts.

Table 5-1. Direct Environmental Impacts for Reach A Options

Levee Impacts (acres)				Approximate Mitigation Costs (\$ Millions)			
Reach	Marsh	BLH Dry	BLH Wet	Marsh	BLH Dry	BLH Wet	Total
A1	312	33	168	\$25	\$7	\$19	\$51
A1A	312	68	222	\$25	\$15	\$25	\$65
A2	306	56	62	\$25	\$12	\$7	\$44
A3	256	60	67	\$21	\$13	\$7	\$41

BLH = bottomland hardwood

The estimated project cost was compared for each alternative alignment as shown in table 5-2. Cost estimate includes the cost of construction, real estate, and mitigation. Cost estimates assume levees are constructed from hauled-in material from off-site borrow.

Table 5-2. Cost Estimates for Reach A Options

Reach A Options	Estimated Total Cost (\$ Millions)
A1	\$767
A1 including A1A	\$870
A2	\$680
A3	\$626

Originally, Option A3 was selected because it was the most cost effective of the four alignment options. The alignment was later modified to exclude the agricultural area with the potential for future development (see area protected by Option A1A in figure 5-1). The alignment designated as “Current Alignment” in figure 5-1 is the Reach A alignment carried forward into the Morganza to the Gulf PAC levee alignment.

5.1.2 Reach G

Five alignment options for Reach G were evaluated as shown in figure 5-2 (ARCADIS, 2011). The options included the authorized alignment from the 2002 feasibility report, an alignment developed during the PED phase, and three other alignments developed for the PAC report as follows:

- **Feasibility** alignment (7.5 miles) – Includes one road crossing and two drainage structures.
- **PED** alignment (5.3 miles) – Includes one road crossing, a 30-ft stop log, and two drainage structures.
- **PAC 1** alignment (4.6 miles) – Includes one road crossing, a 30-ft stop log, and two drainage structures.
- **PAC 2** alignment (4.3 miles) – Includes one road crossing, a 30-ft stop log, and three drainage structures.
- **PAC 3** alignment (4.9 miles) – Includes one road crossing and two drainage structures.

The PED alignment reduced the authorized (feasibility) alignment costs by shortening the alignment and reducing wetland impacts by crossing open water. The remaining PAC alternatives were attempts to optimize the alignment to achieve the most cost-effective number of structures balanced with the shortest alignment and least environmental impacts.

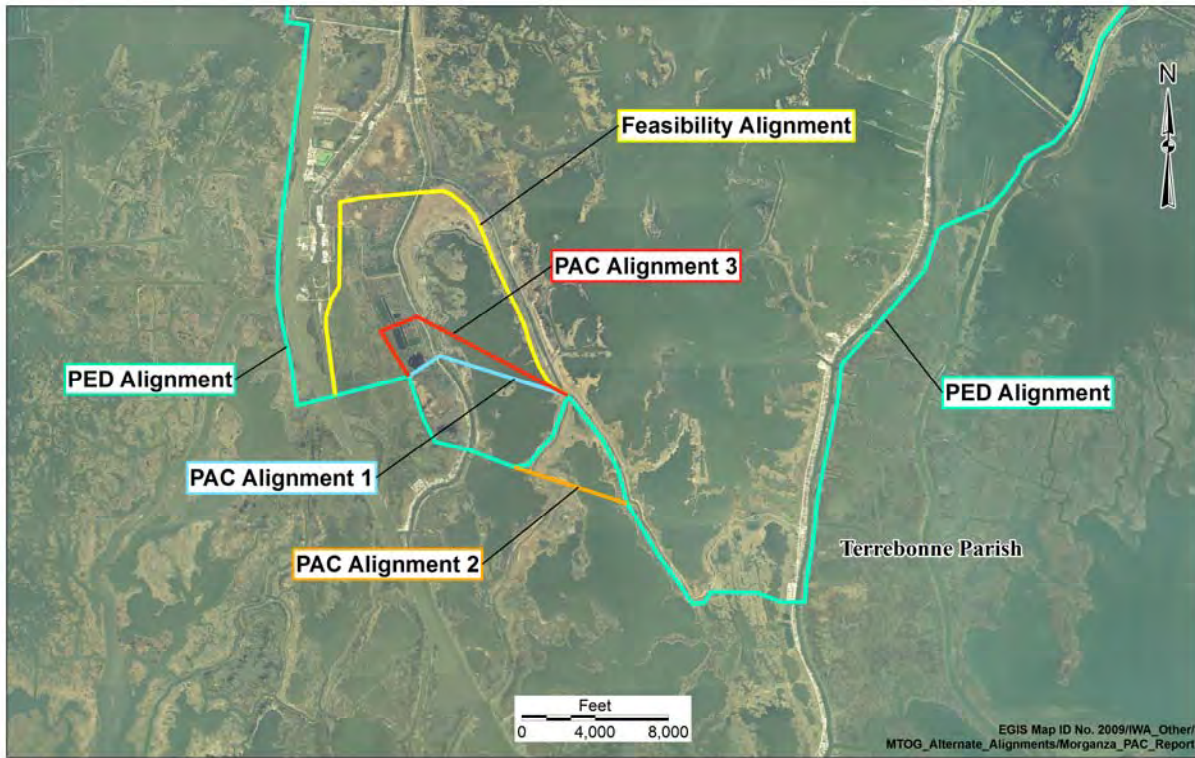


Figure 5-2. Levee Reach G Alignment Options

Environmental impacts were evaluated based on the amount of direct impacts to both marsh and bottomland hardwoods (wet and dry) due to the levee placement and the borrow pits as shown in table 5-3. Cost for the mitigation was based on a ratio, not on habitat value.

Table 5-3. Direct Environmental Impacts for Reach G Options

Reach G Options	Levee Impact (Acres)			Borrow Impact (Acres)			Total Impact (Acres)			Total Mitigation Cost (\$ Millions)
	Marsh	BLH Dry	BLH Wet	Marsh	BLH Dry	BLH Wet	Marsh	BLH Dry	BLH Wet	
Feasibility	336	0	31	143	0	2	479	0	32	\$42
PED	238	0	5	30	0	0	268	0	5	\$22
PAC1	171	0	4	73	0	0	244	0	4	\$20
PAC2	178	0	0	33	0	0	211	0	0	\$17
PAC3	177	0	<1	56	0	0	233	0	<1	\$19

BLH = bottomland hardwood

The estimated project cost was compared for each alternative alignment as shown in table 5-4. Cost estimates include the cost of construction, real estate, and mitigation.

Table 5-4. Cost comparison for Reach G Alignment Options

Reach G Options	Estimated Total Cost
Feasibility	\$581
PED	\$445
PAC 1	\$407
PAC 2	\$400
PAC 3	\$410

The feasibility alignment was screened out because it has the highest cost, highest direct impacts, and two known cultural sites within the alignment. The PAC2 option was selected as the preferred alternative because it is the most cost effective alternative. The PAC2 option presents a tradeoff between direct and potential indirect impacts. Of all the options, the PAC2 option would have the least direct wetland impacts, but would enclose the largest amount of marsh and open water. The National Marine Fisheries Service (NMFS) and the rest of the Habitat Evaluation Team were initially concerned about the potential for indirect impacts to marsh and fishery access to wetlands and Essential Fish Habitat on the protected side; however, those concerns have been reduced by demonstrating minimal indirect impacts through systemwide modeling of environmental control structures.

5.1.3 Reach H, Segments 2 and 3 (H-2/H-3)

In 2005, the TLCD performed an alternative alignments analysis on Reach H, Segments 2 and 3 (Shaw, 2005). Agency representatives from USACE, U.S. Fish and Wildlife Service (USFWS), and NMFS had input on the alternative analysis, which considered engineering feasibility, environmental impacts, and construction costs. The following four alignments were evaluated (see figure 5-3):

- The Existing Alignment from the 2002 feasibility report, which follows the natural ridge.
- A Set Back Alignment, which moves the levee alignment out away from the ridge.
- An Existing Alignment Cross Over, which follows the Existing Alignment (see first bullet) from the south, but then crosses over to the northeast to join Reach I, eliminating the need to improve the Bush Canal levee and associated pump station in Reach I.
- A Set Back Alignment Cross Over, which follows the Set Back Alignment (see second bullet) from the south, but then crosses over to the northeast to join Reach I, eliminating the need to improve the Bush Canal levee and associated pump station in Reach I.

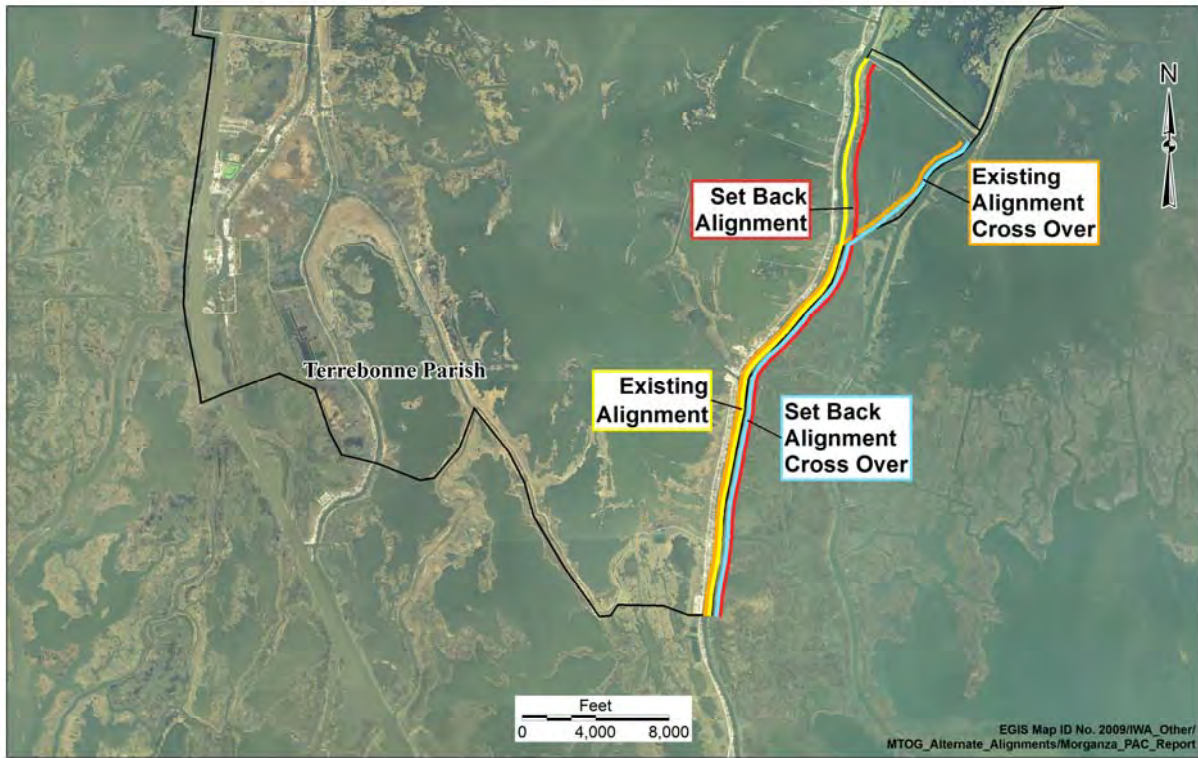


Figure 5-3. Levee Reach H Alignment Options

Additional alternatives were evaluated by combining the four alignments with different borrow assumptions (i.e., adjacent borrow, haul-in borrow, etc.). Adjacent borrow was found to be the most cost effective method. Table 5-5 shows a comparison of the four alignment alternatives assuming adjacent borrow.

Table 5-5. Estimated Costs and Direct Impacts for Reach H Options

Reach H Options	Total Impacts (acres)*	Estimated Costs (\$ Millions)				
		Construction Cost	Mitigation Cost	Total Cost	Bush Canal Savings	Total with Bush Canal Savings
Existing Alignment	368	\$13	\$7	\$20	\$0	\$20
Set Back Alignment	453	\$16	\$9	\$25	\$0	\$25
Existing Alignment Cross Over	291	\$14	\$5	\$19	\$2	\$17
Set Back Alignment Cross Over	447	\$15	\$9	\$24	\$2	\$22

*Includes ridge, marsh, spoil bank, and marsh impoundment.

Total costs of alternatives, taking Bush Canal savings into consideration, ranged from approximately \$17 million to \$72 million (an alternative with offsite borrow not shown in table 5-5). The Existing Alignment Cross Over alternative was selected as the new alignment since it had the lowest total cost of all the alternatives, either with or without the Bush Canal savings, of approximately \$17 million or \$19 million, respectively.

Both economically and environmentally it made sense to move the alignment to its current location. This decision was confirmed during the USACE Section 10/404 permit and State of Louisiana Coastal Use Permit evaluations. The TLCD was ultimately granted a Department of the Army permit for reaches H-2 and H-3 in November 2008.

5.1.4 **Reach J, Segment 2 (J-2)**

In 2004, the TLCD, in cooperation with the USACE, evaluated two alternatives for Reach J, Segment 2 as shown in figure 5-4 (GSE, 2005). In the cost projections prepared for the 2002 feasibility report, the proposed hurricane levee (J-2 Northern) was assumed to be located on natural levee soil landforms consisting of moderately strong to strong clays. An analysis of geotechnical and historic data along the existing Montegut Forced Drainage Levee system, however, indicated that as much as 70 percent of the J-2 Northern alignment, which lies outside (flood side) of the existing forced drainage levee alignment, would be placed on landforms consisting of relatively deep peat layers, overlying weak clay deposits. The unanticipated soil conditions led to an increase in projected costs associated with the planned alignment (J-2 Northern).



Figure 5-4. Levee Reach J-2 Alignment Options

As an alternative to the J-2 Northern alignment, the team evaluated an alignment following the existing Department of Natural Resources (DNR) marsh restoration levee. Table 5-6 provides a comparison of the J-2 Northern alignment and the alternative J-2 DNR alignment. The J-2 DNR alignment shortens the total levee length from the Humble Canal to the western terminus of Segment J-1 from approximately 9.5 to 5.3 miles. The J-2 DNR levee would reduce direct wetland impacts from 345 acres to 83 acres. The J-2 DNR levee alignment would also reduce all

bottomland hardwood impacts to zero. Indirect impacts would be minimal because of the existing levees and structures associated with the J-2 DNR marsh management system.

Table 5-6. Comparison of Reach J-2 Alignment Options

Item	J-2 Northern Alignment	J-2 DNR Alignment
Levee Length	9.5 miles	5.3 miles
Environmental Control Structures	1	3
Pipeline crossings	4	3
Footprint Area	556 acres	323 acres*
Wetlands Impacted	345 acres	83 acres
Additional Wetlands Restoration Area	0 acres	1,035 acres
Total Cost	\$32 Million	\$18 Million

*Within the 323-acre footprint, 138 acres are existing levee and borrow canal, so the DNR Alternate Alignment only adds 185 acres to the new footprint.

The J-2 DNR alternative was selected because it has less environmental impact and is less expensive than the original J-2 Northern alignment. The cost savings associated with the construction of the J-2 DNR alignment versus the construction of the original J-2 Northern alignment was estimated at over \$14 million. The reduced cost for the construction of the more southern J-2 DNR alignment is primarily due to the fact that most of this levee would be constructed on existing levees. Approximately 20 percent of the alignment would be on stable levees and would not require reinforced geotechnical fabric or a sand base. Those portions of the new levee constructed on the J-2 DNR levee sections would require less embankment fill, as well as less sand fill than required in the authorized alignment.

5.1.5 Reach L

In October 2009, the USACE evaluated three alignment options for Reach L (see figure 5-5):

- **L1** is the authorized alignment, which consists of 5.4 miles of levee and two box culvert locations.
- The **L2 alignment** was developed during PED discussions as having potential to reduce Larose to Golden Meadow upgrade costs. L2 consists of 6.1 miles of levee and two box culvert locations.
- **The L3** alignment was requested by stakeholders, because it is similar to L2 in length and impacts and has the added economic benefit of including Apache Mineral property inside the alignment and further reducing Larose to Golden Meadow improvement costs. L3 consists of 6.1 miles of levee and one box culvert location.

Each alternative has one 56-ft sector gate with three 46-ft tainter gates and 6-ft by 6-ft box culverts at various locations.

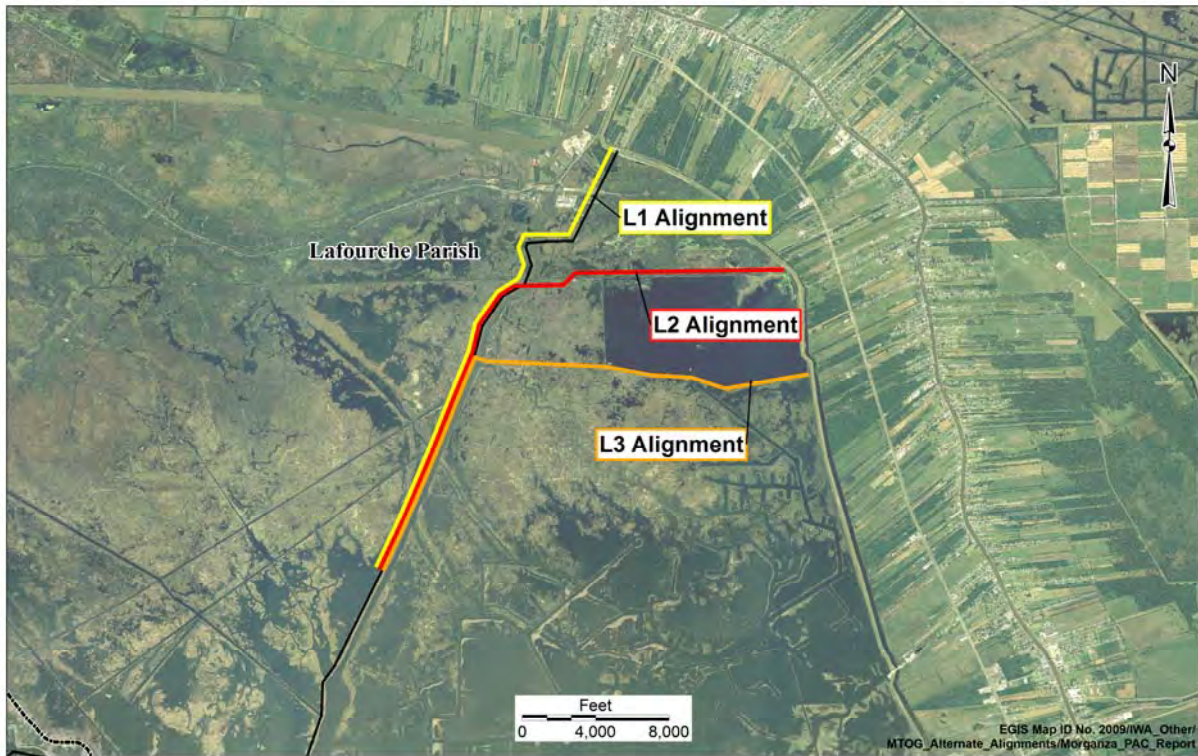


Figure 5-5. Levee Reach L Alignment Options

Environmental impacts were evaluated based on the amount of direct and indirect impacts to both marsh and bottomland hardwoods (wet and dry) and the approximate cost of mitigation as shown in table 5-7.

Table 5-7. Direct Environmental Impacts for Reach L Options

Levee Impacts					Approximate Mitigation Costs (\$ Millions)			
Reach L Options	Levee length (mile)	Marsh* (acres)	BLH dry (acres)	BLH wet (acres)	Marsh [#]	BLH Dry	BLH Wet	Total
L1	5.4	209	19	0	\$17	\$4	\$0	\$21
L2	6.1	240	0	29	\$19	\$0	\$3	\$22
L3	6.1	163	0	0	\$13	\$0	\$0	\$13

BLH = bottomland hardwood.

Option L3 assumes placement of the alignment inside existing levee, not south of it. With Option L2 there is a potential to enclose approximately 1,320 acres of wetlands more than L1. With Option L3 there is a potential to enclose approximately 1,970 acres of wetlands more than the L1 alignment. The estimated project cost was compared for each alternative alignment as shown in table 5-8.

Cost estimates include the cost of construction, real estate, and mitigation. All earthen levees would be constructed of hauled-in material from off-site borrow. Although Reach L3 is longer

than the authorized alignment (L1), it would reduce the length of the existing Larose to Golden Meadow levee that would need to be raised, resulting in an overall lower net cost.

Table 5-8. Cost Estimates for Reach L Options

Reach L Options	Estimated Costs (\$ Millions)		
	Total Cost	Larose Savings*	Net Costs
L1	\$561	\$0	\$561
L2	\$633	\$207	\$427
L3	\$615	\$297	\$319

*Savings for portions of Larose to Golden Meadow levees that would not need to be raised. These savings may or may not be realized pending the outcome of the Larose PAC, which is not yet complete. Additional discussions on the Larose to Golden Meadow project are included in sections 5.2.2 and 6.5.2.

Option L3 was selected because it is the most cost effective alternative. As compared to the authorized alignment, the new alignment has less bottomland hardwood (dry) impacts and less marsh impacts. Option L3 encloses approximately 2,000 additional acres compared to the authorized alignment (L1), but box culverts are designed to reduce any potential indirect impacts.

5.2 Extensions to the Authorized Alignment

Based on relative sea level rise projections and higher post-Katrina surge levels, the authorized alignment had to be extended to the west and to the east in order to complete the Morganza to the Gulf project. Both PAC alternatives follow the same 98-mile levee alignment but at different levels of risk reduction (1% and 3% AEP).

5.2.1 Western Levee Extension (Barrier Reach)

Two alternative alignments were evaluated as part of a screening-level analysis—a “Barrier Alignment” and a “Northern Alignment.” Both alignments originate at Minors Canal. The alternatives are as follows:

- The Barrier Alignment is 15.4 miles and generally follows the edge of development along the south side of the Black Bayou ridge (LA 182/Old US 90).
- The Northern Alignment is 15.6 miles and runs west along Bayou Black Ridge for approximately 2 miles, then turns north and follows Savane Road (Parish Road 23) up to the Little Bayou Black Ridge. The alignment then follows the southern development boundary along Bull Run Road (Chacahoula ridge) northwest until it ties in to Highway 90.

As shown in figure 5-6, the Barrier Alignment incorporates additional assets and people along the Bayou Black ridge that are not included within the Northern alignment. Table 5-9 includes the number of people and the value of equivalent annual benefits based on the 2009 inventory of structures located between the Barrier and Northern alignments. Table 5-9 also provides the estimated cost for each alignment as well as the cost difference between the two alignments. The Northern Alignment has not been designed to full feasibility level, but would have the same levee width as the Barrier, but at a slightly lower elevation. The Northern Alignment would also require fewer structures than the Barrier alignment.

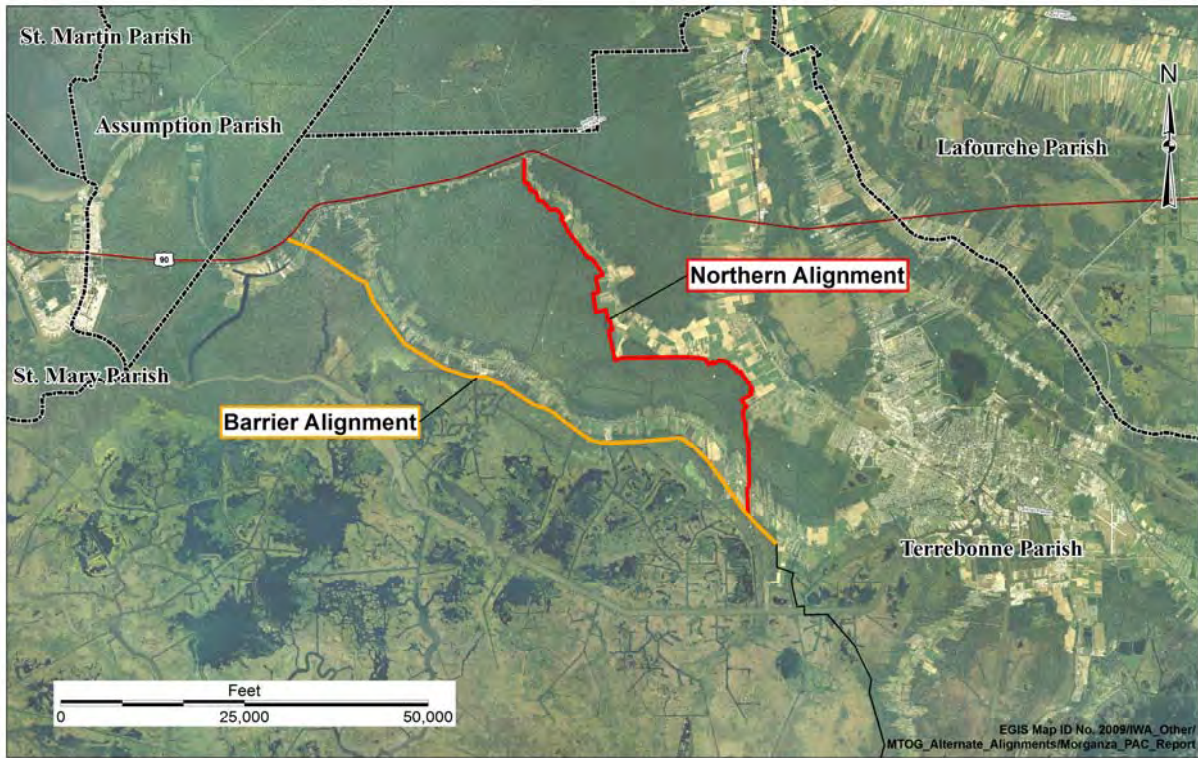


Figure 5-6. Barrier and Northern Levee Alignment Options

Table 5-9. Incremental Costs and Benefits between Northern and Barrier Levee Alignments

Options	Estimated Cost (\$millions)	Incremental Total Benefits (\$millions)	Incremental Equivalent Annual Benefits (\$millions)	Incremental Number of People
Northern Alignment	\$710	N/A	N/A	N/A
Barrier Alignment	\$965.2	\$603.3	\$28.1	3,400
Increment Between Barrier and Northern	\$255.2	\$603.3	\$28.1	3,400

Note: Economic benefits calculated based on 2035 to 2085 period of analysis. Number of people estimated based on 2009 structure inventory. Construction cost does not include mitigation costs; see table below.

Table 5-10. Direct Wetland Impacts for Northern and Barrier Levee Alignment Options

Option	Total Footprint Acres	Marsh Acres	Swamp Acres	Other Acres (uplands, open water, etc.)	Estimated Mitigation Cost (\$millions)
Barrier	691	86	518	87	\$64.4
Northern	634	0	464	170	\$51.5

Although the Barrier Alignment has a slightly larger footprint and impacts more wetlands as shown in table 5-10 and has a higher cost than the Northern Alignment, the Barrier was selected to complete the Morganza to the Gulf levee alignment because it reduces risk to 3,400 more people than the Northern Alignment. As well as leaving a large number of people unprotected, the Northern alignment could induce damages on Bayou Black areas to the south and west of the alignment.

5.2.2 Eastern Levee Extensions (Larose C-North and Lockport to Larose Reaches)

The eastern extent of the authorized Morganza to the Gulf project (Reach L) ties into the northwestern portion of the existing Larose to Golden Meadow project. The Larose to Golden Meadow ring levee system extends from the town of Larose, LA to a point 2 miles south of Golden Meadow, LA and provides hurricane and storm damage reduction to roughly 25,000 people living on both sides of Bayou Lafourche. Surge modeling for the 2002 feasibility report did not show flanking of the Morganza project from the east across Bayou Lafourche, but new modeling shows that the Morganza project could be flanked if the existing Larose to Golden Meadow levee elevations are not brought up to Morganza-compatible design standards.

The Larose to Golden Meadow project is currently undergoing a PAC analysis similar to the Morganza to the Gulf PAC analysis and future levee elevations for the Larose ring levee system have not yet been determined, however, none of the Larose PAC alternatives include raising the Larose levees to the 1% AEP risk reduction level. The highest level of risk reduction being considered is a 2% AEP plan. In the event that Congress does not re-authorize and fund improvements to the Larose to Golden Meadow ring levee to bring it up to a level of risk reduction comparable to the Morganza project, a 7-mile levee following a portion of the Larose to Golden Meadow levee alignment has been added to the Morganza PAC project (labeled as C-North and GIWW reaches on figure 5-7 but collectively referred to as “Larose C-North Reach” throughout the rest of this report).

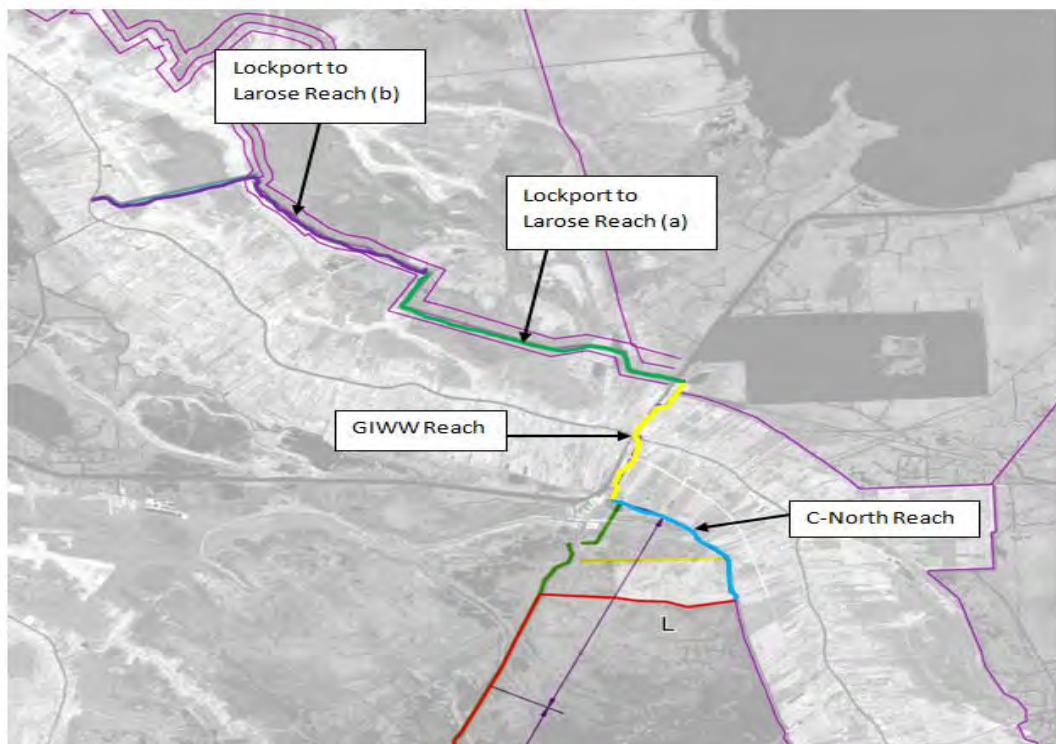


Figure 5-7. Barrier and Northern Levee Hydraulic Reaches

To complete the Morganza to the Gulf system, the alignment had to be further extended from the Larose C-North Reach up to Lockport, LA (see figure 5-7). The Lockport to Larose Reach follows an alignment formerly proposed under the Donaldsonville to the Gulf feasibility study. This levee reach was included because the Bayou Lafourche ridge, which is approximately 6 ft in elevation, provides some protection from surges coming up from the Barataria Basin, but could be overtopped in the future with relative sea level rise.

6 Evaluation and Comparison of Alternatives

In accordance with the WRDA 2007 implementation guidance, the PAC report compares the following two alternatives in detail:

- **3% AEP Alternative (pre-Katrina 100-yr alternative)** - The 3% AEP alternative is a hurricane levee system that provides risk reduction for water levels that have a three percent probability of occurring each year. This alternative is generally based on the pre-Katrina authorized project, but is modified to be consistent with post-Katrina design standards. Levee elevations for future conditions (year 2085) range from +13 to +20 ft NAVD88. Structure elevations range from +15 to +25 ft NAVD88.
- **1% AEP Alternative (post-Katrina 100-yr alternative)** - The 1% AEP alternative is a hurricane levee system that provides risk reduction for water levels that have a 1 percent probability of occurring each year. This alternative has the same intended level of risk reduction as the pre-Katrina authorized project, but is modified to be consistent with post-Katrina design standards. Levee elevations for future conditions (year 2085) range from +19.5 to +26.5 ft NAVD88. Structure elevations range from +17.5 to +33 ft NAVD88.

The 3% and 1% AEP alternatives both follow the same 98-mile levee alignment previously described in section 5, Post-Authorization Changes to the Levee Alignment.

6.1 Comparison of 3% and 1% AEP Levee and Floodgate Designs

The same storms used to model the without-project condition were simulated to estimate water levels and waves along the proposed levee project alignment. Outputs included surge and wave information at 320 locations along the proposed levee alignment. Table 6-1 summarizes the approximate surge and wave elevations used to design levee elevations by reach.

Table 6-1. Predicted With-Project Surge and Waves from 2035 (Base) to 2085 (Future)

Levee Reach(es)	Surge Still Water Elevations (ft NAVD88)		Wave Heights (ft NAVD88)	
	3% AEP	1% AEP	3% AEP	1% AEP
Barrier Reach and Reach A North of the GIWW	7 to 10	10 to 14	2 to 3	3 to 5
Reach A South of the GIWW and Reach B	9 to 11	12 to 14	2 to 3	4 to 5
Reaches E and F	11 to 12	15 to 17	2	4 to 5
Reach G	11 to 12	15 to 16	5	7
Reaches H, I, and J	12 to 14	16 to 18	5 to 6	7 to 8
Reaches K and L	12 to 13	16 to 18	3 to 4	5 to 6
C-North (section of Larose)	10 to 12	14 to 16	2 to 3	3
GIWW (section of Larose)	7 to 9	9 to 11	2	2 to 3
Lockport to Larose (a)	7 to 9	9 to 10	3 to 4	4 to 5
Lockport to Larose (b)	6 to 8	8 to 9	2 to 3	3 to 4

Note: Values are rounded to the nearest foot and are summarized from more detailed information in Engineering Appendix tables 40, 42, 51, 52, 53, 94, 95, 97, and 98. Values are for the Intermediate RSLR scenario. See section 6.9 for a discussion on the Low and High RSLR scenarios.

Levee dimensions are shown in table 6-2. Levee crown elevations were determined by ensuring that the elevation equaled or exceeded the required hydraulic design elevation given the Intermediate RSLR scenario at any given point in time between the base (2035) and future (2085) years. The design elevations vary by levee reach because of surge and wave differences due to storm path, wind speeds and direction, etc. The variation in design elevations is required to provide the same level of risk reduction along the entire length of the project. The 1% AEP alternative design elevations are generally 5.5 to 8 ft higher than the corresponding 3% AEP design elevations.

Table 6-2. Comparison of Levee Reach Dimensions for the 3% and 1% AEP Alternatives

Levee Reach	Approx. Length (miles)	Authorized Elevation (NGVD)	Range of Levee Design Elevations Between 2035 and 2085 (ft NAVD88)		Maximum Levee Toe to Toe Width (ft)	
			3% AEP Alternative	1% AEP Alternative	3% AEP	1% AEP
Barrier	16	N/A	10 to 13	15.5 to 20	174	329
A	8	10.5	10 to 13	15.5 to 20.5	174	329
B	5	12	11.5 to 13.5	17.5 to 20.5	355	610
E	5	14	14.5 to 15.5	21.5 to 23.5	440	725
F	4	14	14.5 to 15.5	22 to 23.5	270	490
G	6	15	16.5 to 17.5	22.5 to 24	270	550
H	8	15 to 16	18.5 to 20	24 to 26.5	330	500
I	6	14 to 15	18.5 to 20	24 to 26.5	319	570
J	9	14	18.5 to 20	24 to 26.5	337	660
K	5	12 to 14	16.5 to 17.5	22.5 to 25.5	400	635
L	6	10 to 11	16.5 to 17.5	22.5 to 25.5	400	635
Larose C-North	7	N/A	13.5 to 15.5	18 to 20.5	252	467
Lockport to Larose	13	N/A	8.5 to 12	10.5 to 15	282	282

Note the different datum for the authorized (NGVD) and current (NAVD88) elevations. The change in elevation due to datum differences varies by location, and is around 0.5 to 1.5 ft.

Table 6-3 lists floodgates along the levee alignment from west to east; the floodgate dimensions refer to the primary gate width. Structure elevations are higher than levees within the same reach because structure designs include 2 ft of additional height (structural superiority) to accommodate potentially higher RSLR and other uncertainties.

Hundreds of detailed engineering drawings showing phased construction site plans, cross sections, and foundation plans were developed for the PAC report. For most structural features, designs were prepared for a limited number of structures and the remainders were pro-rated.

Table 6-3. Floodgate Elevations for the 3% and 1% AEP Alternatives

Reach	Waterway	Structure Design Size/Type (subject to change during detailed design)	3% AEP Design Elevation (ft)	1% AEP Design Elevation (ft)
Barrier	Bayou Black	56-ft sector gate	15.0	22.0
	Shell Canal West	30-ft stop log gate	16.0	23.5
	Shell Canal East	56-ft sector gate	16.0	23.5
	Elliot Jones Canal	20-ft stop-log gate	16.0	23.5
	Humphreys Canal	20-ft stop-log gate	16.0	23.5
A (north of GIWW)	Minors Canal	56-ft sector gate	16.0	23.0
A	GIWW West (at Houma)	125-ft sector gate and nine 16-ft sluice gates	16.0	23.0
B	Marmande Canal	30-ft stop-log gate	16.5	23.0
	Falgout Canal	56-ft sector gate and nine 16-ft sluice gates	16.5	23.0
E-2	Bayou Dularge	56-ft sector gate	18.0	25.5
F-1	Bayou Grand Caillou	56-ft sector gate and nine 16-ft sluice gates	18.0	25.5
G-1	HNC	110-ft wide by 800-ft long lock with an adjacent 250-ft wide sector gate and ten 10-ft sluice gates	22.5	30.5
G-2	Four Point Bayou	30-ft stop-log gate	22.5	30.0
H-1	Bayou Petit Caillou	56-ft sector gate and six 16-ft sluice gates	22.5	30.5
H-2	Placid Canal	56-ft sector gate and six 16-ft sluice gates	24.0	31.5
H-3	Bush Canal	56-ft sector gate and nine 16-ft sluice gates	25.0	33.0
I-1	Bayou Terrebonne	56-ft sector gate	25.0	33.0
I-3	Humble Canal	56-ft sector gate	25.0	33.0
J-3	Bayou Pointe aux Chenes	56-ft sector gate	25.0	33.0
L	Grand Bayou	56-ft sector gate and nine 16-ft sluice gates	21.0	29.5
Larose C-North	Bayou Lafourche	56-ft sector gate	14.0	17.0
	GIWW East (at Larose)	125-ft sector gate and six 16-ft sluice gates	17.0	21.5

6.2 Multi-Lift Levee Construction

Levees were placed as close as practical to the natural ridges along existing or former bayous to take advantage of the stronger foundation conditions and reduce the probability of failure during and after construction. Sediments that comprise the natural ridges are stronger than the sediments in the lower surrounding areas, especially sediments that are in open water environments. Levee construction on top of the marsh sediments will be challenging from a stability and settlement viewpoint, especially for levee heights exceeding 15 ft. Multi-lift construction will help achieve the desired crown elevations. Geotextile reinforcement, berms, and flat berm slopes were used to achieve stable levees. Settlement analyses are an important part of the study due to the added construction cost associated with settlement during and after construction.

Generally, the approach for multi-lift levee construction consists of an initial preload lift to an elevation between +12 to +14 ft NAVD88 to provide a good base and working surface. Prior to construction on the second lift (first enlargement), the initial preload lift is expected to settle to approximately +10 ft NAVD88. As part of second lift construction, the existing preload levee would be degraded to approximately +4 ft NAVD88 and reinforcing geotextile installed. To achieve levee design elevations at target years 2035 and 2085, each reach requires two or three additional lifts between approximately 2020 and 2070. Levee lift elevations at the time of construction would generally be a few feet higher than the targeted design elevations to allow for levee settlement. After construction of each levee lift is completed, the levee would be covered in grass to increase its resilience in the case of wave overtopping.

As shown in table 6-4, the 1% AEP plan requires more than twice the material for levee construction as the 3% AEP alternative plan.

Table 6-4. Material Quantities by Levee Lift and Alternative

Levee Lift	Estimated Quantities (CY)	
	3% AEP Alternative	1% AEP Alternative
1st Lift/Preload	40,596,000	43,396,000
2nd Lift/1st Enlargement	14,458,000	65,929,000
3rd Lift/2nd Enlargement	4,581,000	10,725,544
4th Lift/3rd Enlargement*	1,224,000	6,182,000
Total	60,859,000	126,233,000

*Since C-North is the only reach with a 5th Lift/4th Enlargement, those quantities have been grouped with the 4th Lift/3rd Enlargement quantities for the rest of the levee reaches. All quantities rounded to the nearest 1,000.

Figures 6-1 and 6-2 are examples of lift schedules for different levee reaches and different levels of risk reduction. Figure 6-1 shows the lift schedule for Reach A/Barrier in the 3% AEP alternative, which has the lowest elevation and requires only three lifts to achieve the final design elevation (13 ft) in 2085. Reach A/Barrier would meet the 2035 design elevation (10 ft) after the first lift. Figure 6-2 shows the lift schedule for Reach J in the 1% AEP alternative, which has the highest elevation and requires four total lifts to achieve the final design elevation (26.5 ft) in 2085. Reach J would meet the 2035 design elevation (24 ft) after two lifts.

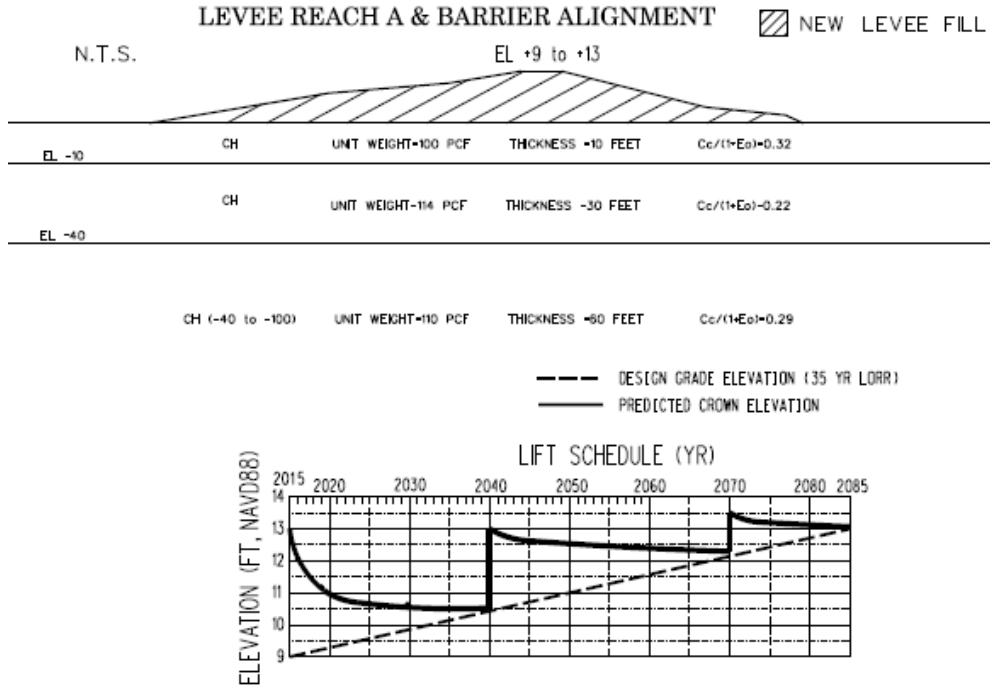


Figure 6-1. Example Lift Schedule for 3% AEP Alternative Reach A/Barrier

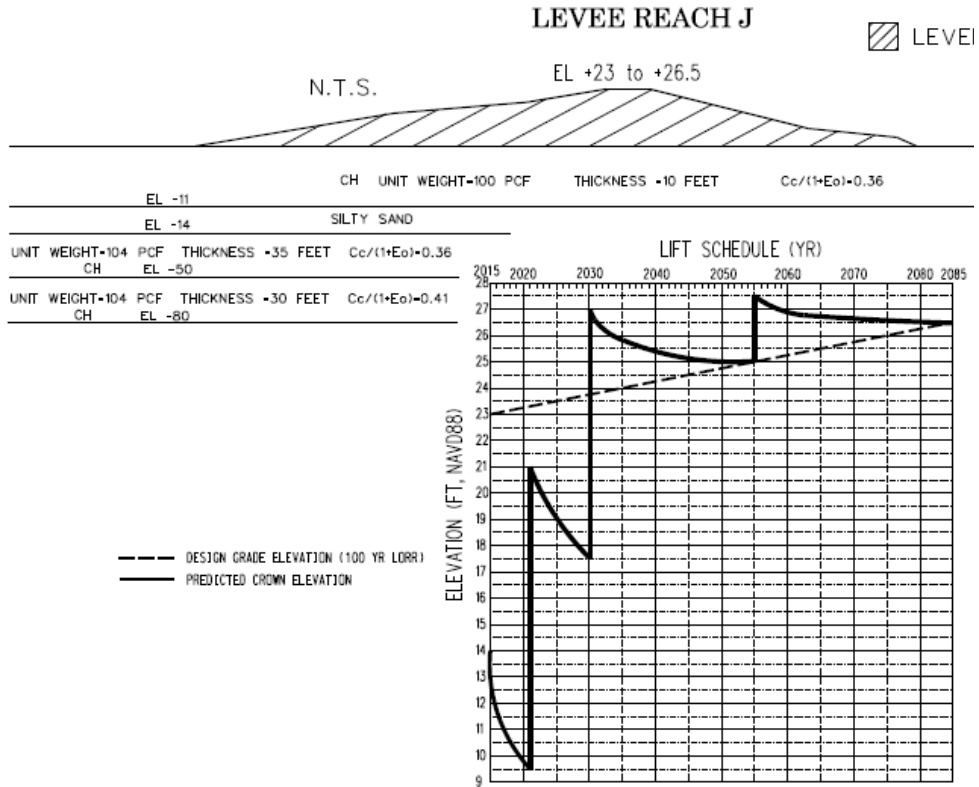


Figure 6-2. Example Lift Schedule for 1% AEP Alternative Reach E

6.3 Construction Schedule Assumptions

Preliminary construction schedules for alternatives are needed to calculate annual cost streams and benefit-cost ratios. Project benefits cannot start accruing until a “closed” risk reduction system is in place, which would require, at a minimum, all structures and first lift levees to be constructed. Assuming construction starting in 2015 and adequate funding (schedules were not constrained by potential funding levels), both alternatives would have a closed system by 2024. Based on reasonable construction durations that allow for levees to settle and compact between lifts, the alternatives could achieve their associated 3% or 1% AEP levels of risk reduction by 2035, however, as shown in table 6-5, the 3% AEP plan could achieve its base year design elevations almost 10 years sooner than the 1% AEP plan.

Table 6-5. Implementation Schedule Assumptions by Activity

Activities	Timeframe for 3% AEP	Timeframe for 1% AEP
Acquire Real Estate, Relocate Utilities, and Mitigate	2014 to 2023	2014 to 2025
Construct Lock, Floodgates, and Environmental Control Structures	2015 to 2024	2015 to 2024
Construct Levee Lifts to Achieve Base Year Elevations	2015 to 2026	2015 to 2035
Construct Levee Lifts to Achieve Future Year Elevations	2033 to 2072	2035 to 2075

The 1% AEP alternative takes longer to achieve its base year level of risk reduction, because more material is required to build the larger levee, and in some levee reaches, more than one lift is required to achieve the base year (2035) design elevations, as shown in table 6-6.

Table 6-6. Number of Levee Lifts Required to Achieve Base and Future Year Design Elevations

Reach	3% AEP Alternative		1% AEP Alternative	
	Base Year (2035)	Future Year (2085)	Base Year (2035)	Future Year (2085)
Barrier & A	1	3	2	4
B & E	2	3	3	4
F	2	4	3	4
G	2	3	3	3
H & I	2	3	3	4
J	2	4	3	4
K & L	2	3	3	4
Larose C-North	1	4	1	5
Lockport to Larose	1	2	2	3

After 2035, both alternatives would require additional levee lifts to achieve the future year (2085) design elevations because of continuing sea level rise and subsidence. The lift schedule is based on keeping the actual levee elevation at or above the design elevation between 2035 and 2085 allowing for several years of settlement after construction of each lift. The actual level of

risk reduction for each alternative would vary over time depending on the construction timing.

6.4 Environmental Impacts

The following sections briefly describe direct and indirect impacts of the alternatives. A more detailed wetland impact study of direct, indirect, and cumulative environmental impacts of the alternatives and associated mitigation requirements are included in the RPEIS.

6.4.1 Direct Impacts

The major direct impact of the project is the loss of wetlands within the project right-of-way. Construction of the 3% or 1% AEP alternatives would directly impact 3,213 or 4,113 wetland acres (combination of marsh, swamp, and bottomland hardwoods). The direct wetland losses are calculated based on the right-of-way limits (includes the levee footprint, the borrow canal and the widths of the offsets required for both levee stability and borrow pit stability) plus the extents of the proposed mitigation areas. The right-of-way limits are depicted in the RPEIS Mapbook Appendix.

Direct impacts can be determined with a reasonable level of certainty, although the exact number could vary depending on wetland loss prior to construction, which could be caused by sea level rise, subsidence, hurricanes, construction of non-Federal levees along the proposed alignment, or other factors. Since the PAC levee design is based on the Intermediate RSLR scenario, for the purpose of updating project costs and benefits, current estimates of direct wetland impacts for the levee footprints are also based on the Intermediate RSLR scenario. Impacts of the project would slightly decrease as sea level rises because there would be less wetland acres left to be impacted at the time of construction.

The direct impacts of the project on the aquatic habitat of Lake Boudreaux would be temporary. The project would directly impact a narrow band of riparian habitat along the banks of the Bayou Grand Caillou. Direct impacts can be reduced by placement of dredged material in open areas, where practicable.

6.4.2 Indirect Impacts

The authorized alignment builds on existing hydrologic barriers, such as natural ridges, roadbeds, or existing levees that have been built for other purposes such as forced drainage or marsh management. Of the estimated 72 miles of levee originally proposed in the authorized alignment, approximately 15 miles would cross part of the estuaries that are currently open to estuarine exchange. Of the estimated 98 miles of levee in the PAC alternatives, approximately 14 miles would cross open estuaries. The proposed project alternatives include numerous environmental water control structures to allow hydrologic exchange through the levees.

A Systemwide Model was used to determine the impacts of the proposed project on hydrology and salinity. Both the 3% and the 1% AEP alternatives would have similar indirect impacts. The validated model (McAlpin, 2009) for calendar year 2004 was modified to include three system or “plan” configurations and was used to compare the existing without-project conditions to with-project conditions. All three configurations represent operation during non-tropical storm conditions. During tropical storm conditions, all structures would be closed. A comprehensive analysis was performed on the water surface elevations, discharges, and salinity to obtain an approximate indication of the resulting behavior of the system if the proposed changes were to occur.

Structures were modeled as part of two groups: (1) floodgates on navigable waterways and (2) environmental water control structures. Structure groups were modeled in either the open or closed position. The three conditions or “plans” are described below.

Plan 1 - All structures in the open position. The purpose of modeling this condition is to determine the scale of hydrodynamic and salinity impacts of the Morganza project under everyday non-storm conditions. Plan 1 possesses minimal global salinity changes with the largest changes occurring in the marsh area south of Falgout Canal. This area is newly connected to Falgout Canal allowing for a new freshwater inflow to this area, which in turn reduces the salinity (about 3 ppt) with the largest benefit occurring during the winter months and minimal benefit occurring during the summer months. Globally, the salinity changes tend to be less than 1 ppt.

Plan 2 - All floodgates on navigable waterways in the open position and all environmental water control structures in the closed position. This condition would never occur under the current structure operation plan, but was modeled to isolate the effects of the environmental water control structures. The structure operation plan for storm surge is to leave all structures open during everyday non-storm conditions and to close them during high water levels due to storm conditions. Plan 2 has minimal global salinity changes (less than 2 ppt) with some increased salinity possible in local areas newly cutoff by the proposed levee system. Plan 2 has some areas that possess no connection to the remainder of the domain (due to closed environmental water control structures) and therefore would remain stagnant with constant water levels and salinity.

Plan 3 - All structures in the open position with the exception of the HNC structure and lock in the closed position. This condition represents operation of the HNC lock complex for salinity control and would occur whenever certain salinity criteria are met at designated monitoring stations. Plan 3 has noticeable salinity changes along the HNC. Salinity increases along the southern portion (~4 ppt) and lowered north of the HNC structure. The Falgout Canal and Lake Boudreaux areas would be freshened as the closed HNC structure forces the freshwater flow to divert along other avenues, thereby freshening the surrounding areas.

Sensitivity simulations demonstrated the importance of the two GIWW structures. Reducing the size of the western structure reduces the freshwater inflow able to enter the Morganza levee system and thereby increases the salinity in the study area. Conversely, reducing the size of the eastern GIWW at Larose structure reduces the amount of freshwater able to leave the system and therefore decreases the salinity in the study area. While navigational concerns require certain structure sizes for these two areas, those simulations exhibit the type of control the new levee system would provide operators.

Indirect impacts described in the Draft PAC/RPEIS were based on existing sea level conditions because the H&H modeling results were not available for higher sea level rise scenarios. Additionally, there is a high level of uncertainty associated with the rate of sea level rise and how the structures would be operated in the future to compensate for sea level rise. Federal and State agencies that reviewed the Draft PAC/RPEIS noted that in the future there is a potential for adverse indirect and cumulative impacts to wetlands, fisheries, water quality, and navigation due to increased frequency and duration of water control structure closures. In response to these concerns, the Final PAC/RPEIS includes a quantitative analysis of a range of potential indirect impacts to wetlands for the constructible features, and a qualitative analysis of the potential indirect and cumulative impacts for the entire project.

6.5 Potential Induced Flooding

Given the modeling resolution at the time, the potential for induced flooding outside the levee was not identified in the 2002 feasibility report, however, post-Katrina surge modeling results indicate that the project could increase water levels in areas immediately outside the risk reduction system during storm events. When comparing the results of the ADCIRC runs for the without-project to the with-project conditions for existing 1% AEP water levels, the with-project water levels under a storm event are approximately 2 to 3 ft higher as shown in figures 6-3 and 6-4.

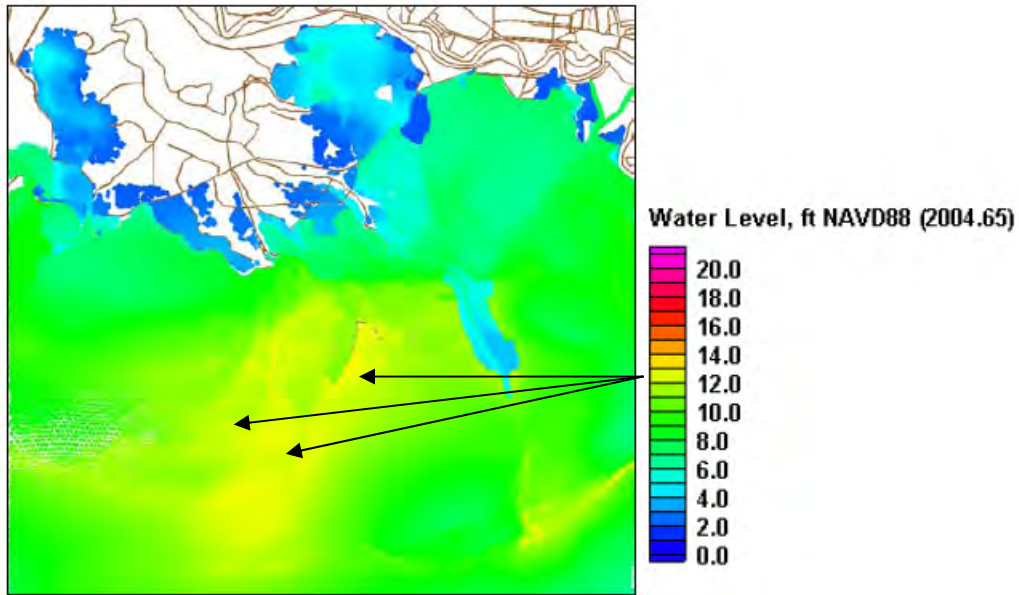


Figure 6-3. 1% AEP Existing Without-Project Water Levels

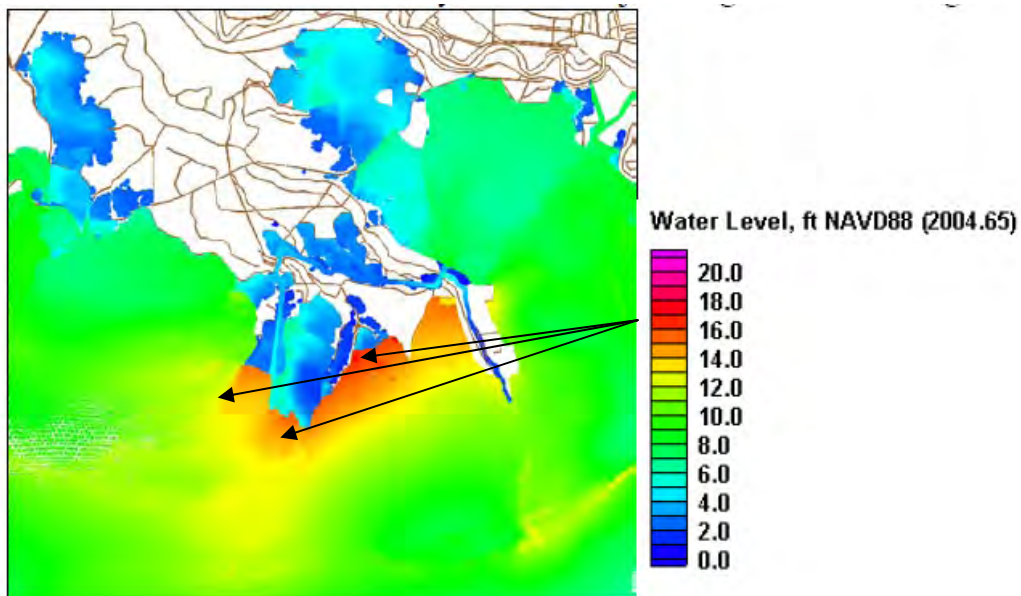


Figure 6-4. 1% AEP Existing With-Project Water Levels

6.5.1 Impacts on Structures Outside of the Risk Reduction System

An indirect impact of the construction of the project is the potential to raise water levels outside the levees by several feet during storm events causing induced flooding to several communities located outside of the proposed levee alignment. These areas include portions of the communities of Gibson, Bayou Dularge, Dulac, and all of Cocodrie and Isle de Jean Charles (see red areas in figure 6-5). Approximately 1,000 structures would remain outside of the Morganza to the Gulf risk reduction system. Although areas outside the levee system would already receive damages under the without-project conditions, the alternatives could increase damages during some events.

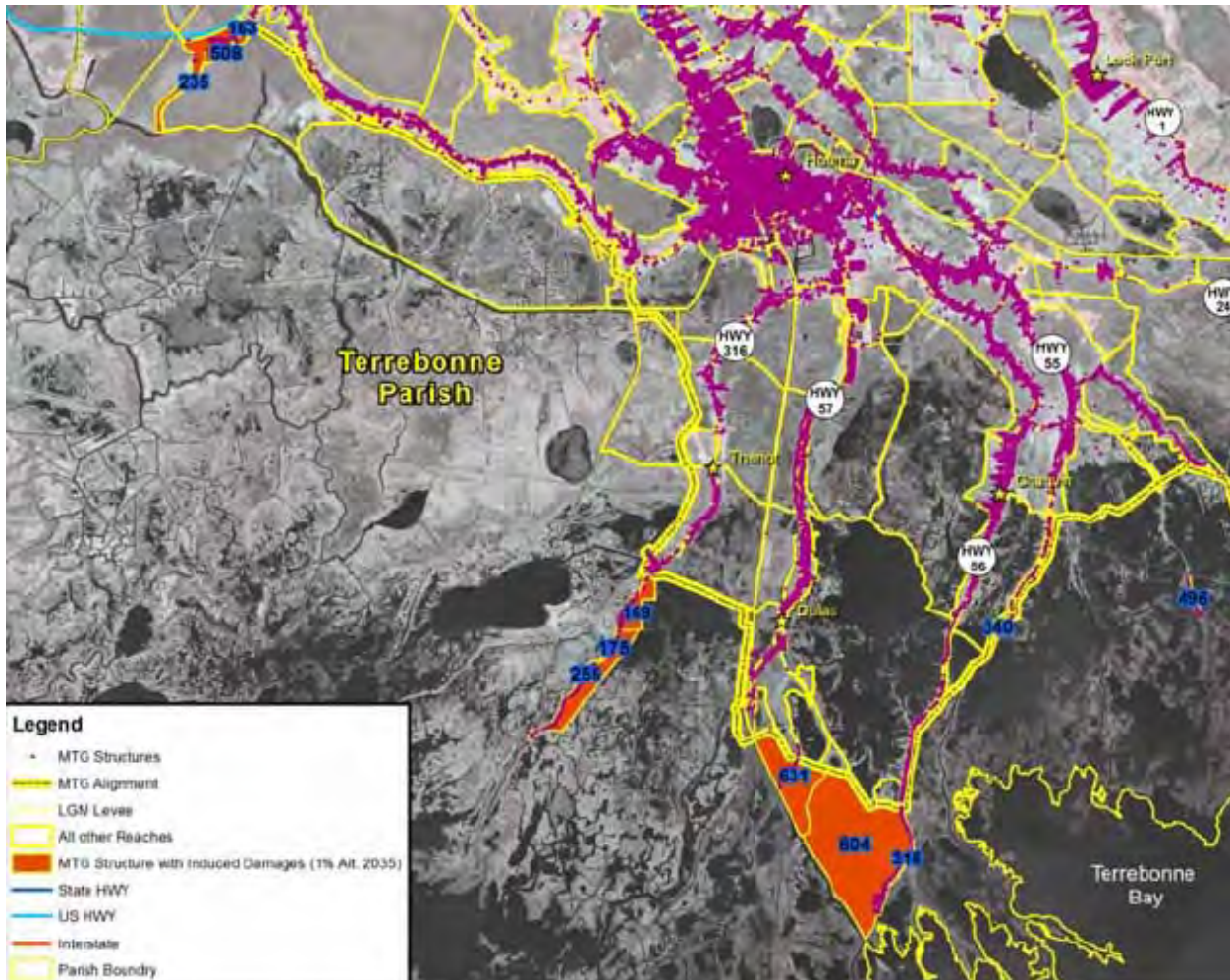


Figure 6-5. Economic Reaches With Possible Induced Damages

Induced damages were initially accounted for in the economic analysis as a negative value in the benefit calculation. For the base condition (2035), induced damages to areas outside the project levee reduced the expected annual benefits by between \$14.5 and \$22 million. Based on 2035 stage-probabilities, the probability that the target stage (equal to top of levee elevation or elevation where significant damages begin if no levee) would be exceeded within a given year with the Morganza project increases from 18 to 46 percent in Bayou Dularge and from 12 to 68 percent in Isle de Jean Charles. Over a 10-year period, the with- and without-project differences are less significant in these high risk areas. Local levee exceedance risk would increase from 87 percent to 100 percent in Bayou Dularge and from 71 percent to 100 percent in Isle de Jean Charles.

In order to prevent increased risk to people and structures, which are already located in high risk areas, a preliminary nonstructural plan has been developed. Presently, detailed information regarding the differences in frequency, depth, and duration of the flooding between the future without-project and future with-project conditions is not available. This detailed information typically would be assessed in light of the uses to which the particular land is zoned, and the appropriate mitigation methods, if any, would be implemented to address the effects of the Federal project. To ensure the public is informed of all potential impacts of the project, and to prevent schedule delays, for purposes of this report, the worst case scenario (most expensive option) has been assumed, which would be a 100 percent buy-out of all of the structures in the impacted areas. Should this scenario prove to be the appropriate mitigation method, approximately 2,500 people would need to be relocated to areas behind the Federal levee system.

The benefits and costs of the buy-out plan have been incorporated into the total project cost and benefits analysis. The buy-out plan increases equivalent annual benefits for the 3% and 1% AEP alternatives by approximately \$39 million and \$57 million, respectively. The total real estate cost associated with this acquisition is estimated to be approximately \$305 million as shown in table 6-7. The estimate of acquisition costs for residential structures includes the depreciated value of the improvement, the value of the land, moving costs, differential housing payment, payment of last resort, and administrative costs. The estimate of acquisition for the non-residential structures includes the depreciated value of the improvements, land value, moving costs, reestablishment costs, necessary and reasonable incidental costs, and administrative costs. Real Estate estimated an average Uniform Relocations Assistance cost for residential structures and one for non-residential structures, which was applied to all structures to be acquired.

Table 6-7. Preliminary Nonstructural Compensation Plan

	No. of Structures	Cost
Residential Acquisition	876	\$248,712,800
Non-Residential Acquisition	134	\$56,402,500
Total	1,010	\$305,115,300

The potential induced damages and mitigation for economic damages would be further addressed during detailed design and supplemental NEPA documents. Individual investigation and mitigation for each structure, if appropriate, will be done during PED. Additional factors (height of structures vs. induced stages, type of residential structure, social concerns, etc.) would have to be investigated under PED. Each structure would have to be evaluated under PED to determine if mitigation is appropriate. Further modeling will be performed during PED to determine whether there is a potential taking. A Takings Analysis will be prepared during PED to address this issue; at that time, it will be determined what real estate interest, if any, would be acquired.

Socioeconomic considerations associated with the potential buyouts are described in RPEIS section 5.2.13, and Environmental Justice is discussed in RPEIS section 6.14.8 and RPEIS Appendix J.

6.5.2 Morganza to the Gulf Impacts on the Larose to Golden Meadow Project

Impacts on the existing Larose to Golden Meadow levee that would result from construction of the Morganza to the Gulf levee were evaluated. As previously shown in figures 6-3 and 6-4, stages on the western side of the Larose ring levee will be higher with the Morganza project in place than without Morganza. Morganza does not affect levee sections on the east side of the Larose to Golden Meadow ring levee. Initial Morganza to the Gulf levee lifts may not impact the performance of Larose to Golden Meadow, but future lifts would need to be coordinated to ensure that the Morganza project does not induce damages on Larose and that costs are allocated appropriately between projects.

Costs for potential future levee extensions/lifts and to eliminate potential induced damages on Larose have been added to the Morganza project at this time, however, final determination on cost allocation between the projects has not been made. The 2% AEP Larose levee design elevations “with” and “without” Morganza in place were used to determine the increment of inducements attributable to the Morganza project (table 6-8). The Morganza inducements were quantified for the Larose PAC report using the ADCIRC model. Consistent with LACPR modeling assumptions, the Morganza project was modeled as a non-overtopping levee in the ADCIRC model; therefore, results do not differentiate between the 3% and 1% AEP Morganza alternatives.

Table 6-8. Comparison of Larose Levee Elevations With and Without Morganza

Larose Levee Section	Approx. Section Length (miles)	Larose Authorized Elevations (ft)	2085 2% AEP Larose To Golden Meadow Levee Elevations (with wave berm)		Levee Height Increment* (ft)
			Without Morganza (ft)	With Morganza (ft)	
C-South	3.6	11.4	20	23	3
B-North	6.3	11.4-13.4	20	21.5	1.5
B-South	1.6	13.4	19.5	20.5	1
A-West	4.1	13.4	20	21	1

*For the Larose sections with induced stages, the increment is the difference between 2% AEP elevations with and without Morganza in place. Section C-North is part of both the Larose to Golden Meadow and Morganza to the Gulf projects.

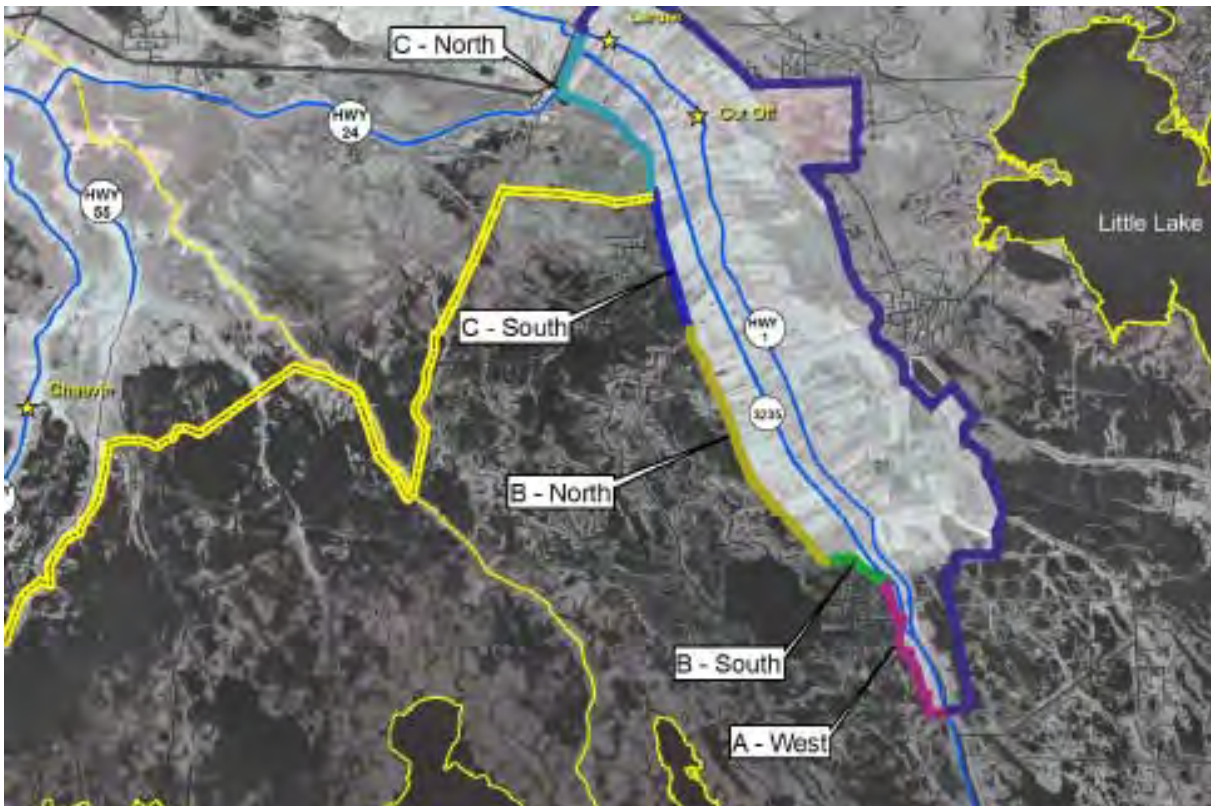


Figure 6-6. Morganza Reach L Tie-in to Western Side of Larose to Golden Meadow Ring Levee

Of the four levee reaches shown in table 6-8 (and in figure 6-6), the largest inducement is on Larose Section C-South. Table 6-9 compares the Larose still water elevations with and without Morganza for the same section. As shown in the table, the increment increases as the event becomes less probable (i.e. the larger the hurricane surge, the larger the inducement). Since the Larose to Golden Meadow project currently provides less than a 2% AEP level of risk reduction, the 3-ft stillwater and corresponding levee elevation increment was used rather than the 4.6 ft increment for Section C-South. The corresponding increments for the other reaches shown in table 6-7 were also used to develop costs.

Table 6-9. Comparison of Larose Still Water Elevations With and Without Morganza

Probability	Stillwater Elevation at Larose Section C-South		Increment (ft)
	Without Morganza (ft NAVD88)	With Morganza (ft NAVD88)	
2% AEP	11.2	14.3	3.1
1% AEP	14.6	18.2	3.6
0.2% AEP	18.3	22.9	4.6

Note that variations in side slopes (1 on 6 for Morganza; 1 on 3 for Larose) create variations in levee design elevations at same location.

If Congress does not re-authorize and fund improvements to the Larose to Golden Meadow ring levee to bring it up to a level of risk reduction comparable to the Morganza project, the costs to the Morganza project to mitigate the induced flooding could be around \$125 million.

6.6 Comparison of Alternative Project and OMRR&R Costs

Levees and floodwalls are the largest component of the project costs and the biggest difference in project costs between the alternatives as shown in table 6-10.

Table 6-10. Project First Costs by Civil Works Feature

Work Breakdown Structure No. & Civil Works Feature Description	Estimated Cost(\$Millions)	
	3% AEP Alternative	1% AEP Alternative
02 Relocations	274	291
05 Locks	530	622
06 Fish & Wildlife Facilities	619	941
11 Levees & Floodwalls	2,467	5,351
15 Floodway Control & Diversion Structures	763	1,068
Construction Estimate Totals:	\$4,652	\$8,273
01 Lands and Damages	339	355
30 Planning, Engineering & Design	574	1,006
31 Construction Management	385	631
Project Cost Totals:	\$5,950	\$10,265

Note: Costs are in October 2012 price levels rounded to the nearest \$million. Contingencies vary by category and range from 21 to 30 percent for the 3% AEP plan and from 26 to 35 percent for the 1% AEP plan.

The annual OMRR&R cost estimates used to compare the alternatives are shown in table 6-11. Annual OMRR&R costs are based on grass cutting for earthen levees and routine OMRR&R on all structures within the levee system, such as replacing flap gates, pumps, etc. The OMRR&R costs for the lock structure and all major floodgates (56-ft sector gates and larger) also include dewatering, which is estimated to be done once every 10 to 15 years.

Table 6-11. Comparison of Annual OMRR&R Costs for Alternatives

Alternative	Levee Grass Cutting		Structure OMRR&R (\$millions)	Total OMRR&R (\$millions)
	(acres)	(\$millions)		
3% AEP	3,500	\$2.2	\$3.2	\$5.4
1% AEP	6,500	\$4.0	\$3.2	\$7.2

Note: OMRR&R cost estimates are in 2012 dollars, include a 25 percent contingency, and are rounded up to the nearest \$100,000. Mitigation OMRR&R costs are not included in this table; those costs are added to the 1% AEP plan only (see table 7-4).

Annual levee OMRR&R costs are based on over 3,500 acres of grass cutting for the 3% AEP alternative and over 6,500 acres of grass cutting for the 1% AEP alternative. Grass cutting is estimated to be needed 16 times per year. In the months of March to October, grass would likely need to be cut every 3 weeks. In the months of November to February, grass would likely need to be cut every 4 to 5 weeks.

6.7 Net Benefits and Benefit-Cost Ratios

Net benefits are based on the following benefit categories: residential and commercial (structure/content/vehicles), industrial (structures/contents), highways, streets, debris removal and cleanup, water supply, boats, and avoided structure raising costs. Costs and benefits for each alternative are shown in table 6-12.

Table 6-12. Cost and Benefit Comparison of PAC Alternatives

(OCTOBER 2012 EFFECTIVE PRICE LEVEL, 3.75% INTEREST RATE)	3% AEP Alternative (\$Millions)	1% AEP Alternative (\$Millions)
First Costs	\$5,950	\$10,265
Equivalent Annual W/O Project Damages	906	906
Equivalent Annual With Project Damages (Residual Damages)	447	136
Equivalent Annual Benefits (Damages Reduced)	459	770
Equivalent Annual Benefits During Construction	198	253
Total Equivalent Annual Benefits	656	1,023
Total Annual Costs	442	716
Equivalent Annual Net Benefits	214	307
Benefit-to-Cost Ratio	1.48	1.43

6.8 Other Socioeconomic Benefits/Impacts

The following sections describe additional socioeconomic benefit and impact categories that are not factored into the benefit-cost ratio, including regional economic development, other social effects, and agricultural resources. For more information, refer to the Economic Appendix.

6.8.1 Regional Economic Development

The Regional Economic Development analysis measures the interdependence among industries and workers in an economy. This analysis uses a matrix representation of a region's economy to predict the effect of changes in one industry on others. The greater the interdependence among industry sectors, the larger the multiplier effect on the economy. Changes to government spending are projected to drive new levels of sales, employment, and income for each industry.

The construction of the Morganza to the Gulf levee system would yield significant increases in employment and gross regional product not only to the parishes of Terrebonne and Lafourche, but to Metro New Orleans and beyond. The 3% AEP alternative would generate an estimated \$5.8 billion in gross regional product and 85,000 worker-years of labor annually during the construction of the levee system. The 1% AEP alternative would generate an estimated \$10.2 billion in gross regional product and 155,000 worker-years of labor.

6.8.2 Other Social Effects

The Other Social Effects analysis considers the potential social ramifications of USACE actions so that decision makers and stakeholders are able to evaluate the social implications of each alternative and choose an alternative that will be judged as complete, effective, and fair.

The No Action Alternative would not reduce storm surge risk to residents of the Morganza evaluation area. Therefore, there is a high potential for extensive hurricane and tropical storm damage to continue occurring in the area. The relative sea level rise that has been taking place in the Morganza to the Gulf area, coupled with the anticipated population growth, is expected to magnify the flooding problems in the future. As a result, subsequent flooding events could cause even more damage to housing units, public facilities, and commercial structures than has previously been experienced. Under this alternative, the area would remain vulnerable to flooding, and long term resiliency would be hampered by the continued local efforts necessary to prepare for, and react to, flood events.

The 1% AEP alternative would result in the greatest potential for reduced flooding in the Morganza study area. This alternative would reduce the damages to housing units, public facilities, and commercial structures for 1 percent annual chance (and more probable) events. The area's social vulnerability would be reduced under this alternative, and thus, the potential for long-term growth and sustainability would be enhanced. Also, under this alternative, the area would be at a reduced probability of incurring the costs associated with clean-up, debris removal, and building and infrastructure repair as a result of flood events.

The 3% AEP alternative would also reduce the risk of flooding in the Morganza study area. However, this alternative would only provide risk reduction for 3 percent annual chance (and more probable) events. The area would still experience damage associated with less probable (more damaging) events.

Socioeconomic considerations associated with the potential buyouts are described in RPEIS section 5.2.13, and Environmental Justice is discussed in RPEIS section 6.14.8 and RPEIS Appendix J.

6.8.3 Agricultural Benefits

Agricultural benefits due to inundation reduction have been quantified as a number of acres rather than a dollar value. Between 2035 and 2085, the average annual agricultural benefits range from approximately 610 to 1,680 acres for the 3% AEP alternative and 770 to 1,860 acres for the 1% AEP alternative. Even if a high estimate of the net revenue generated by an average annual acre were used in the analysis, the total agricultural benefits would only equal approximately 1 percent of the total inundation reduction benefits to structures, contents, and vehicles for each of the project alternatives. Thus, estimates of agricultural benefits were not included in the net benefit computations.

6.9 Relative Sea Level Rise Scenario Sensitivity Analysis

Since this project will be constructed over 40 or more years, there will be opportunities to re-evaluate relative sea level rise. If over time it appears that the actual RSLR rate is higher than expected, additional lifts can be added to levees, and the levee alignment may need to be further extended to the west and to the east. If RSLR rates are lower than expected, then final levee lifts will not need to be constructed, although structures may remain overbuilt. For example, to achieve the 1% AEP levee elevations at 2085 for the Low RSLR scenario, levee reach elevations

could be reduced by 1 to 1.5 ft compared to the Intermediate RSLR elevations. For the High RSLR scenario, levee reach elevations would have to be increased by 3 to 6.5 ft.

Engineering data required for a complete economic analysis of the High and Low RSLR scenarios have not been generated; however, parametric designs and costs were used to compare the volumes and costs for the RSLR scenarios (not including levee extensions that may be needed for the High RSLR scenario). Table 6-13 summarizes the volume and cost increases or decreases. Cross-sectional areas were calculated for each of the levee reaches. The length of each reach was used to calculate the volumes of the levee reaches for each RSLR value. For each alternative, the Low RSLR volume was subtracted from the Intermediate RSLR volume to get the volume reduction, and the Intermediate RSLR volume was subtracted from the High RSLR volume to get the volume increase.

Table 6-13. Potential Change in Volume and Costs for Relative Sea Level Rise Scenarios

Alternative	RSLR Scenario	Average Cross-Sectional Area (sq.ft.)	Volume Difference Compared to Intermediate RSLR (cu.yd.)	Cost Difference Compared to Intermediate RSLR
1% AEP	Low (1.7 ft)	6,200	-3,600,000	-\$98,500,000
	Intermediate (2.4 ft)	6,400	N/A	N/A
	High (4.8 ft)	9,000	49,100,000	\$1,300,000,000
3% AEP	Low (1.7 ft)	2,300	-2,200,000	-\$58,200,000
	Intermediate (2.4 ft)	2,400	N/A	N/A
	High (4.8 ft)	3,200	13,900,000	\$376,500,000

If the High RSLR future scenario becomes as reality, the potential first cost increases to the project are estimated at \$1.3 billion for the 1% AEP alternative and \$377 million for the 3% AEP alternative. These first cost increases translate to 13 and 6 percent average annual cost increases. If the Low RSLR future scenario occurs, the potential savings to project first costs are \$99 million for the 1% AEP alternative and \$58 million for the 3% AEP alternative. These first cost decreases translate to approximately 1 percent decreases in average annual costs.

Stage probability functions for the alternative sea level rise scenarios have not been developed, making it impossible to precisely compute damages and benefits. In order to approximate damages and benefits for the Low RSLR scenario, the HEC-FDA modeled Intermediate RSLR damages for 2035 were held constant through the end of the period of analysis (as a “surrogate” for the Low RSLR scenario). The effect of this assumption is to allow no additional sea level rise beyond 2035. While the Intermediate RSLR increase up to 2035 would be greater than that associated with the Low RSLR scenario (stages for the 1% AEP would be approximately 0.2 ft higher on average), the amount of Intermediate RSLR by 2035 would be less than that associated with the 2085 Low RSLR scenario (stages for the 1% AEP would be approximately 1 ft lower on average). In general, over the period of analysis it would be appropriate to characterize the “surrogate” Low RSLR scenario as representing less increase than the Intermediate sea level rise scenario. It is believed that lower increases would be associated with lower without-project damages and lower benefits, therefore the without-project damages and benefits for the

“surrogate” Low RSLR scenario would be lower than the Intermediate sea level rise scenario. Using this conservative estimate of benefits for Low RSLR (a reduction of 16 percent for both the 1% and 3% AEP project alternatives compared to the Intermediate RSLR scenario), and adjusted annual costs as previously described, would result in benefit-cost ratios of approximately 1.2 to 1 and 1.3 to 1, respectively, for the 1% and 3% AEP project alternatives.

Approximation of the damages and benefits for the High RLSR scenario is more problematic given available data. It is expected that both damages and benefits would be higher with the High RSLR scenario. Consequently, Intermediate RSLR benefits are assumed as a conservative estimate of the High RSLR scenario. Using this conservative estimate of benefits for high sea level rise, and adjusted annual costs as previously described, would result in benefit-cost ratios of approximately 1.3 to 1 and 1.4 to 1, respectively, for the 1% and 3% AEP project alternatives.

6.10 Summary of Alternatives Comparison

As compared to the 3% AEP alternative, the 1% AEP alternative has:

- **Higher net benefits.** Both plans have positive benefit-cost ratios, but net benefits (excess benefits over costs) for the 1% AEP alternative plan are higher than the net benefits of the 3% AEP alternative plan.
- **Lower residual risk.** The 3% AEP alternative has a higher probability of overtopping and/or levee breaches than the 1% AEP alternative and therefore has higher residual damages than the 1% AEP alternative.
- **Greater flexibility.** The 1% AEP structures would be constructed at higher elevations than the 3% AEP structures to accommodate higher RSLR levels in the future. Although the total cost of the 1% AEP alternative is significantly higher than the 3% AEP alternative, not all funding and expenditures are required up front since earthen levees would be constructed in multiple lifts.

7 Description of the 1% AEP Post-Authorization Plan

The 1% AEP alternative has been identified the plan with the greatest net benefits of the two alternatives. Section 7 describes the 1% AEP alternative in more detail, however, much of this section would also apply to the 3% AEP alternative. The 3% AEP alternative has the same features as the 1% AEP alternative (i.e. same levee alignment, same number and types of structures). The primary differences in these two alternatives are the levee and structure dimensions resulting in different levels of risk reduction, direct impacts, net benefits, and costs.

7.1 Plan Description

As a comprehensive approach to reduce hurricane and storm risk in portions of Terrebonne and Lafourche Parishes, the 1% AEP post-authorization plan is a hurricane and storm damage reduction levee system designed to provide 1% AEP surge risk reduction based on post-Hurricane Katrina criteria. The levee system consists of 98 miles of grass-covered earthen levees tying into US 90 near the town of Gibson in Terrebonne Parish and Hwy 1 near Lockport, LA in Lafourche Parish (see the project map in Attachment 1). Levee elevations for base conditions (2035) range from 10.5 to 24 ft NAVD88, and final levee elevations (2085) range from 15 to 26.5 ft NAVD88 with final levee widths from 282 to 725 ft.

Structures include 1 lock, 22 floodgates on navigable waterways (3 on Federally-maintained navigation channels and 19 on other canals and bayous), 23 environmental water control structures, 9 road gates, and fronting protection for 4 existing pumping stations. Structures on Federally maintained navigation channels include the HNC lock and floodgate (250-ft sector gate) and two floodgates on the GIWW (125-ft sector gate east of Bayou Lafourche and 125-ft sector gate west of Houma). Fourteen 56-ft sector gates and five 20- to 30-ft stop log gates are located on various waterways that cross the levee system. Structure elevations range from 17 to 33 ft NAVD88.

As a sponsor funded additional work item, the HNC lock complex sill depth may be deepened from -18 to -23 ft NAVD88 in anticipation of future deepening of the HNC.

Levees would be covered in grass to increase resilience in the case of wave overtopping. All of the transitions between levees and floodwalls would be armored with reinforced concrete scour protection.

The post-authorization project would directly impact 4,113 acres of wetlands. Mitigation plan requirements are discussed in section 7.7 of the PAC report and in the RPEIS.

7.2 HNC Lock Complex

The largest structure in the Morganza to the Gulf project is the HNC lock complex, which consists of a 110-ft wide by 800-ft long lock with an adjacent 250-ft wide floodgate. The lock complex would have a 30.5 ft NAVD88 top elevation and either a -18.0 ft NAVD88 sill elevation consistent with current authorized channel depth, or a -23 ft NAVD88 sill elevation to account for a potential future channel depth (if funded as an additional work item by the non-Federal sponsor). When a storm approaches from the Gulf of Mexico, the lock and floodgate are closed, shutting the canal off to storm surge. During low water periods, the floodgate is closed, and marine traffic is locked through, reducing the quantity of salt water intrusion north of the project site.

7.2.1 Description of the HNC Lock Complex

Figure 7-1 is a conceptual drawing of the HNC lock complex. Features shown in figure 7-1 appear in bold in the following text:

- The HNC lock complex is generally oriented in a north-south direction approximately 3,000 ft south of the intersection of the HNC with Bayou Grand Caillou and is located in a **bypass channel** adjacent to the HNC on its west side.
- The lock structure consists of two lock gate monoliths (**gulf side lock gates and inland lock gates**), which house two sets of sector gates, and five U-frame **lock chamber** monoliths. A floodgate monolith adjoins the **gulf side lock gate** monolith and houses a **sector gate**, which is separated from the **gulf side lock gates** to the west by 59 ft. The five lock monoliths and the floodgate monolith are made of cast-in-place, reinforced concrete, and are pile supported.
- T-walls extend from both sides of the lock and floodgate to tie into the proposed Morganza to the Gulf hurricane system at **levee reach F-1** to the west and **levee reach G-1** to the east, transitioning to levee elevations +23.5 and +24 ft NAVD88 (in year 2085), respectively. Within the T-walls, there are a total of ten 5-ft wide by 10-ft high sluice gates—four between the floodgate and Levee Reach F-1, two between the lock and floodgate, and four between the lock chamber and closure dam.
- Guide walls and guard walls with steel sheet pile dolphin cells help align marine traffic to the lock and floodgate on both the north and south approaches.
- The lock and floodgate sector gates are normally remotely operated from a single **control house**, which is located at the south end of the lock chamber, on its east side. Below the **control house** is a visitor's platform from where the lock operations can be observed. On the east side of the lock, there is an earthen reservation area that is built up above existing grade to +8 ft NAVD88. The lock can be accessed from this reservation area by either of two bridges that connect the lock gate monoliths to the reservation or by a driveway on the tie-in T-walls. Access to the floodgate is from the gulf side lock gate monolith or by boat. The reservation area contains an office building, an operation and maintenance building, a generator building, a perimeter road to access both ends of the lock, and a boat launch and dock. The maintenance dewatering structural systems for the lock and floodgate monoliths are stored on a nearby platform. Site utilities (electricity and potable water) are routed beneath the HNC and tie into the reservation area. Sewage is treated by a package unit on site.
- A **closure dam** closes the existing HNC channel near the confluence of Bayou Platte and the HNC. The dam is underlain by a grid of soil-cement columns installed with the dry method of deep-soil mixing. The closure dam is a rock dam constructed to + 8 ft NAVD88 with a T-wall on top that provides protection to +30.5 ft NAVD88.

The project would be constructed “in-the-dry,” inside an earthen cofferdam excavation. Once the major project features are complete, the site would be re-watered and the last sections of the bypass channel dredged. Marine traffic would be rerouted through the lock and floodgate, and the HNC would be permanently closed by the rock dam.



Figure 7-1. Conceptual Drawing of HNC Lock Complex

7.2.2 Deepening the Lock Complex as a Sponsor Funded Additional Work Item

The non-Federal sponsor has requested that, in lieu of constructing the HNC lock sill to an elevation of -18 ft NAVD88 as would be required by the currently authorized HNC project depth, the USACE construct the lock sill to an elevation of -23 ft NAVD88. Although this additional depth is not required for implementation of the Morganza to the Gulf project, the USACE could consider undertaking this additional work on the non-Federal sponsor's behalf if the non-Federal sponsor pays all incremental costs of this additional work, currently estimated at \$32 million as shown in table 7-1. The USACE received a letter from the non-Federal sponsor on 18 May 2012 agreeing to pay for the full incremental cost of the deeper sill, as well as any incremental OMRR&R costs.

Table 7-1. Benefits and Costs for Authorized vs. Locally Preferred HNC Lock Complex Sill Depths

Feature	HNC Lock Complex Design Options Based on HNC Depths		Difference With and Without Sponsor Funded Additional Work Item
	As Currently Authorized	As Possibly Authorized in the Future	
Channel Depth	-15 ft	-20 ft	5 ft deeper
HNC Lock Complex Sill Elevation (3 ft below channel depth to allow for over-dredge)	-18 ft	-23 ft	
HNC Lock Complex Wall Elevation	30.5 ft	30.5 ft	Same
HNC Lock Complex Cost*	\$622 million	\$654 million	\$32 million

*Costs are in October 2012 price levels. October 2012 cost estimates were escalated by a factor of 1.011 (1.1%) from originally estimated costs, which were in October 2011 price levels; costs include contingencies; the total cost increment could be higher than the HNC lock complex cost increment if the deeper sill requires higher PED and S&A costs.

The sponsor funded additional work item does not change the Morganza to the Gulf project's hurricane and storm damage risk reduction benefits, nor would it substantially change environmental impacts. The benefit of the deeper sill is that it would have the potential to meet future navigational needs for increases in channel depths.

The deeper sill adds approximately \$32 million, which is a minor increase to the total project cost, so it would only negligibly lower the Morganza PAC benefit-cost ratio, and the project is still economically justified. The sponsor funded additional work item would prevent having to replace the HNC lock complex in the event that the HNC is deepened in the future. Conversely, if the lock sill elevation is built to -18 ft NAVD88 as part of the Federal plan, and the HNC is later deepened, most of the lock complex would need to be demolished and replaced. A detailed cost estimate to demolish and replace the -18 ft NAVD88 sill depth lock with a -23 ft NAVD88 sill depth lock has not been developed, but it is estimated that a fairly substantial portion of the original project cost (estimated 50 to 75 percent, or approximately \$250 to \$350 million) would be required to build the deeper lock complex. There would also be demolition costs to tear out portions of the old -18 ft NAVD88 sill HNC lock complex.

The OMRR&R of the HNC lock complex and the GIWW floodgate features that provide for inland waterway transportation is a Federal responsibility; however, the non-Federal sponsor will be responsible for any incremental OMRR&R costs associated with a deeper sill, which may require higher dredging costs. At this time, the annual OMRR&R costs in the PAC report are not at a level of detail to be able to differentiate between the annual OMRR&R cost difference with and without the deeper sill. Incremental OMRR&R costs will be developed during the follow on PED phase.

7.3 Other Structures

In addition to the HNC lock complex, dozens of structures are located throughout the levee system including floodgates on navigable waterways, environmental water control structures, road/railroad gates, and fronting protection for existing pumping stations.

7.3.1 Floodgates on Navigable Waterways

In addition to the HNC lock and 250-ft sector gate described in the previous section, the post-authorization Morganza to the Gulf project includes 21 other floodgates on navigable waterways ranging in size from 20-ft stop-log gates to 125-ft sector gates. Figure 7-2 is a conceptual drawing of a 56-ft sector gate and figure 7-3 is an example site plan for the same type of floodgate.

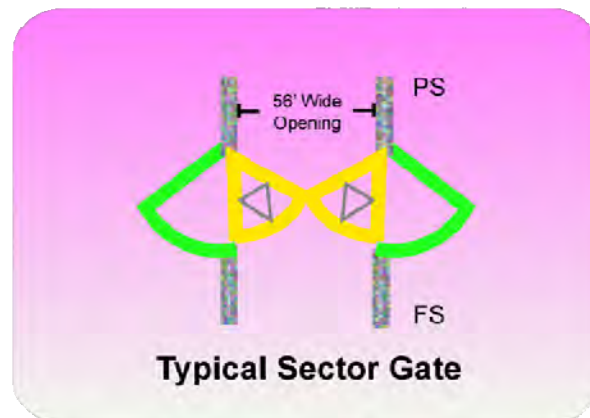


Figure 7-2. Conceptual Drawing of a Typical Sector Gate
PS = Protected Side; FS = Flood Side

Structures were designed to provide enough width for vessel passage and enough flow cross sectional area at the gate sites so that the constricted flow velocities would neither exceed the navigational criteria nor result in channel scouring problems. The assumption for the PAC report is that all currently navigable waterways must remain so after the project is put in place, however, the number/sizes of gates may be able to be reduced during PED with additional data on navigation.

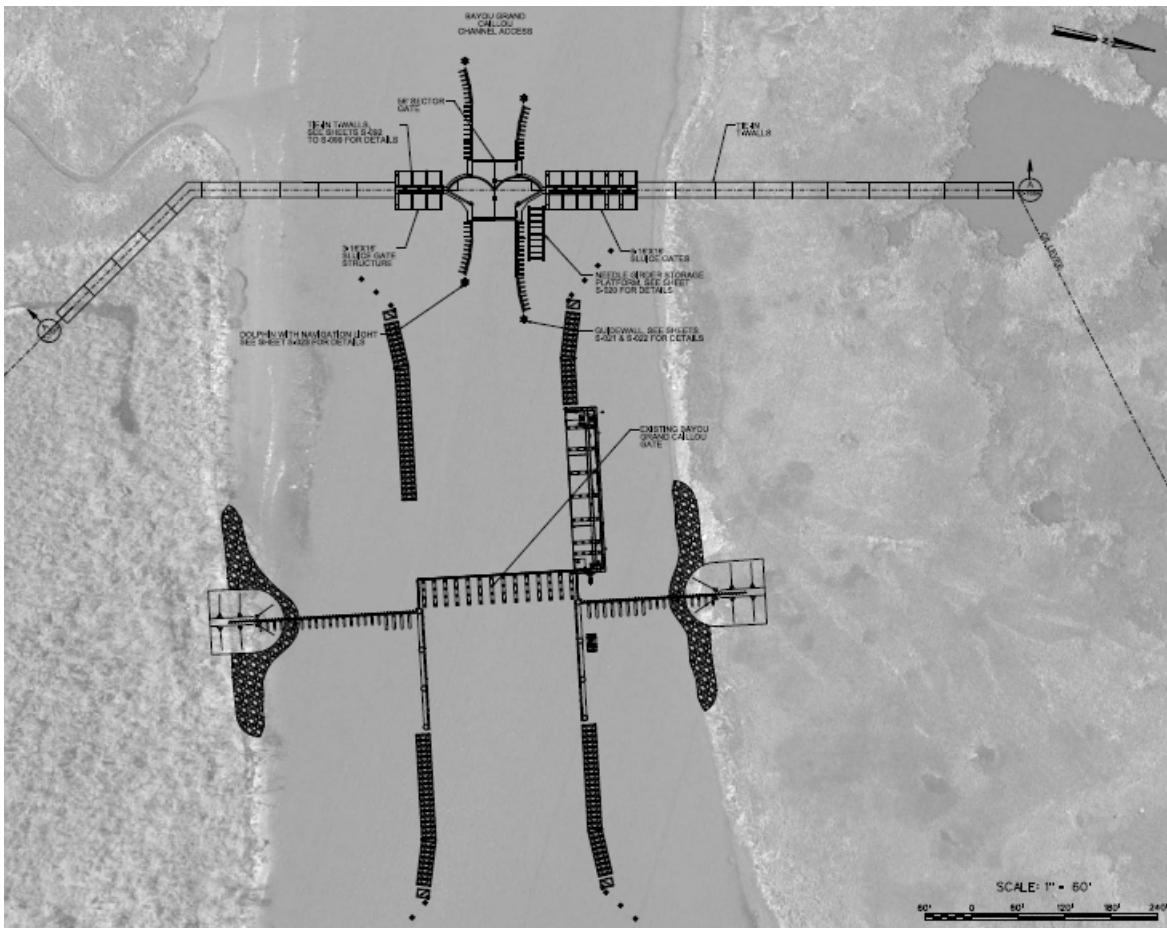


Figure 7-3. Example 56-ft Sector Gate Site Plan (Bayou Grand Caillou)

7.3.2 Environmental Control Structures

Environmental control structures are located at 23 locations within the levee system. The purpose of the environmental control structures is to provide hurricane and storm damage reduction during storm conditions and to match existing drainage patterns during non-storm conditions. Environmental control structures consist of box culverts and sluice gates allowing tidal exchange. The number of 6-ft by 6-ft or 5-ft by 10-ft culverts at each location varies from one to nine. The typical configuration is six 6-ft by 6-ft box culverts as noted in the conceptual drawing in figure 7-4.

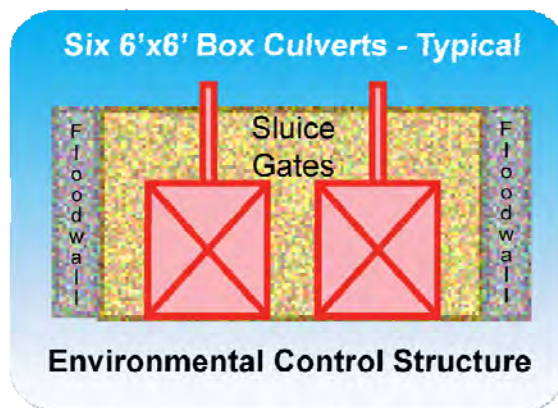


Figure 7-4. Conceptual Drawing of a Typical Environmental Control Structure

Refer to the Attachment 1 project map for the environmental control structure locations and to Table 146 in the Engineering Appendix for the number and size of structures at each location.

7.3.3 Pump Stations

Fronting protection is provided for several existing pumping stations, including the Madison, Pointe aux Chenes, Elliot Jones (Bayou Black), and Hanson Canal pump stations. Features associated with the construction of fronting protection include T-walls and butterfly gate valves as shown in figure 7-5. All fronting protections would be constructed on the flood side of the existing protection. Based on site visits, the discharge pipes extend far enough that additional pipes are not needed. Butterfly valves would be opened to allow pumping discharge for interior drainage or closed to prevent backflow during storm conditions.

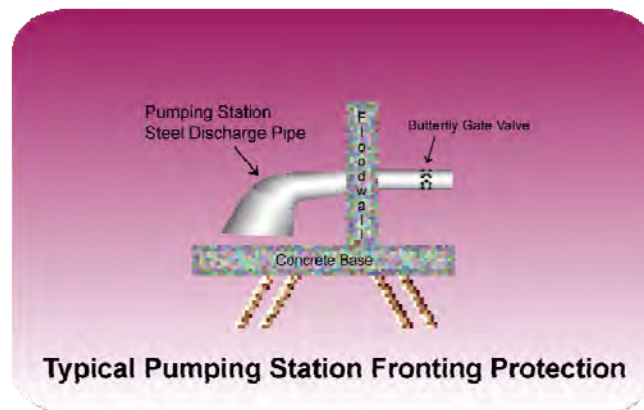


Figure 7-5. Conceptual Drawing of Typical Pumping Station Fronting Protection

7.3.4 Roadway Gates

The levee alignment impacts several state and parish highways and roads and the Union Pacific Railroad. At the points of intersection with the levee, the options are either to construct ramps over the levee or permanent floodgates. The decision to use a swing gate or ramp is based on a variety of factors, including cost, relocations, existing structures, environmental impacts, and access requirements (e.g. consideration of evacuation routes). The use of gates versus ramps at each location will be revisited during PED as designs are further refined. Roadway structures would remain open except for times of anticipated flooding, which at that time they would be closed and remain closed until the flood threat subsided. Roadways affected by this project include LA Highway 1, LA Highway 25, LA Highway 182 (Bayou Black Drive), LA Highway 315 (Bayou Dularge Road), Four Point Road, LA Highway 56, LA Highway 55, LA Highway 665 (Point aux Chenes Road), LA Highway 24, LA Highway 3235, and a private road on NAFTA property. All roadways and the railroad would have a swing gate, except LA 182 which would have a ramp. For LA 182, alternate access for locals will need to be made available during the construction of the earthen ramp, which will need to be raised each time the levee is raised. The features associated with construction of each roadway gate structure are a steel swing gate, concrete monolith, and traffic control devices.

7.4 Structure Operation Plans

In response to comments on the Draft PAC/RPEIS from Federal and State resource agencies, the USACE, non-Federal sponsors, and Habitat Evaluation Team modified preliminary structure operation plans to clarify opening and closure triggers for each structure. The preliminary operation plan assumptions for all water control structures, which are included in section 4.3.8 of the RPEIS, were developed for the sole purpose of estimating indirect impacts for the constructible features. Detailed operation plans for each structure will be prepared during PED and in future NEPA documents for the programmatic structures.

The number of times closure occurs each year depends on the frequency of tropical storm events and location of the structures. Table 7-2 summarizes recent historical closures and frequency of closure by location and year. Most closure durations were for less than 48 hours. The longest closure was during Tropical Storm Alex in 2010 when the Humble Canal and Little Caillou floodgates were closed 10 to 12 days.

Table 7-2. Number of Gate Closures Between 2001 and 2012

Gate	Total Number of Closures from 2001 to 2012	Maximum Number of Closures Per Year
Bayou Terrebonne	45	8
Little (Petit) Caillou	29	9
Lower Bayou Dularge	5	2
Upper Little Caillou Barge	4	1
Humble Canal	9	5

Source: Terrebonne Levee and Conservation District

Under future conditions, structure closure frequencies could increase if closure triggers are not adjusted to account for sea level rise. For example, under existing conditions, if the HNC floodgate were to be closed based on a 2.5 ft stage (for illustrative purposes only), closure could occur approximately 1.5 days per year. If the 2.5 ft trigger remained the same through 2085,

- Low RSLR could require closure 5 days per year by 2035, and 168 days per year by 2085.
- Intermediate RSLR could require closure for 15 days per year by 2035, and 354 days per year by 2085.
- High RSLR could require closure for 24 days per year in 2035, and 365 days per year in 2085.

Refer to section 10.3.3, Indirect Environmental Impact and Mitigation Plan Uncertainties, for a discussion of unresolved issues associated with operating structures under future sea level conditions.

7.5 Real Estate Plan

The Non-Federal Sponsor has responsibility for and receives credit for obtaining Lands, Easements, Rights-of-Way, Relocations, and Disposal Areas (LERRDs). The Real Estate Plan, which is provided as an appendix to this report, presents the real estate requirements and costs for the PAC Report, in accordance with E.R. 405-1-12 (Chapter 12).

7.5.1 Lands, Easements, and Rights-of-Way

The majority of the acreage affected by the project consists of marsh or wooded wetlands. Other lands impacted include woodland, agricultural (cane land), industrial waterfront on the GIWW, residential waterfront lots at the community of Waterproof, and mixed-use waterfront lots on Bayou Petit Caillou and Bayou Dularge ("Mixed-use" refers to recreational "camps" or residential waterfront lots). The Right-of-Way in Lafourche Parish consists mostly of marsh and open water. The majority of the staging areas for construction of this project would be located within the Right-of-Way for the levee footprint or existing Right-of-Way.

The Real Estate Plan references LERRDs for three different types of acquisitions: 1) The LERRDs required for construction and OMRR&R of the project (affecting approximately 580 landowners), 2) the LERRDs required for future lift borrow (affecting approximately 325 landowners), and 3) the LERRDs required in areas affected by induced flooding (affecting approximately 1,010 landowners).

Estates required for the project would include Fee, Excluding Minerals (With Restriction on Use of Surface), perpetual Flood Protection Levee Easements, Temporary Work Area Easements, and Temporary Access Easements (Non-Material Deviation from Standard Estate).

7.5.2 Utility Relocations

Facility/Utility Relocation data was collected and detailed by the USACE New Orleans District, Engineering Division, Design Services Branch Relocations Team. A separate Relocations Report, containing relocation costs, was submitted as a reference to the Engineering Appendix of the PAC Report.

There are multiple pipeline crossings throughout the project. Some pipeline owners have directionally drilled pipeline crossings for currently planned local levees and with anticipation of this project in mind. During the next phase of design, as more information becomes available, alternatives for pipeline crossings will be further evaluated. Directional drilling is the preferred alternative, but many times more expensive than other methods. Other alternatives may include bridging over the levee or laying the pipe over the levee slope and crown support with temporary saddles or short piles until it can be incorporated into future lifts that keep the pipe above the storm still water level. Abandoned pipelines should be removed, but in some cases may be grouted and capped on both ends within the levee right-of-way. Oil and gas wells would not be relocated; instead, the levee alignment would be changed, or T-walls used, during the project Plans and Specifications phase to avoid them.

In addition to underground lines, the proposed highway gate closures and ramp would require relocation of overhead lines (poles, electric, cable, telephone). For the floodwalls, it includes passing the gas and water lines through a sleeve. For the ramp at LA 182, it includes directionally drilling the gas and water lines.

7.6 Borrow Materials

Levees will be constructed using a combination of sidecast and hauled-in borrow materials. Adjacent sidecast was used for the pre-load section only. Haul in scenarios were used for the initial (first) lift and projected subsequent lifts. Borrow pits are oversized to offset the potential for encountering organics, expected losses, etc.

7.7 Mitigation Plan

USACE policy is to ensure that adverse impacts to significant resources have been avoided or minimized to the extent practicable and that remaining, unavoidable impacts have been compensated to the extent justified. The appropriate application of mitigation is to formulate an alternative that first avoids, then minimizes, and lastly, compensates for unavoidable adverse impacts. In the development of the project, features that were incorporated to avoid and minimize potential adverse environmental effects included, where practical, the placement of levees at locations that would avoid or minimize effects on wetlands or other significant features of the project area. The sizing of floodgates and environmental control structures was done to minimize indirect impact to wetlands in the interior of the system.

7.7.1 Mitigation Determinations

An interagency Habitat Evaluation Team was formed to use Wetland Value Assessment (WVA) methodology to assess the quality of wetlands of the area, make a determination of the effects various aspects of the project on future conditions, and calculate the amount of mitigation required to compensate for impacts caused by the constructible features of the project. A description of the WVA methodology, analysis, and assumptions made by the HET may be found in Appendix F of the RPEIS.

Environmental mitigation features for the project authorized in WRDA 2007 included creation of 1,352 acres of marsh habitat. At this time, mitigation features for the post-authorization project have only been identified for the constructible features (i.e. levee reaches F-1, F-2, and G-1; the HNC lock complex; and the Bayou Grand Caillou floodgate). Mitigation for direct and indirect impacts of the constructible features includes approximately 394 acres intermediate marsh restoration, 358 acres brackish marsh restoration, and 883 acres saline marsh restoration. For the remaining programmatic features, mitigation costs and land requirements were estimated, but the exact number of acres will be determined in the future as more specific designs are completed and impacts are assessed in future supplemental NEPA documents.

Mitigation is discussed in more detail in section 6.19 of the RPEIS. Also refer to section 10.3.3 of the PAC for unresolved issues related to Indirect Environmental Impacts and Mitigation Plan Uncertainties.

7.7.2 Compensatory Mitigation Alternatives

For the constructible features, compensatory mitigation alternatives considered the purchase of mitigation credits from an approved mitigation bank and USACE constructed in-kind mitigation. The WRDA of 2007 requires that the USACE first consider using commercial mitigation banks to provide compensation for environmental impacts to wetlands. The USACE determined that the use of mitigation banks for the constructible features was not feasible for the following reasons: (1) No mitigation banks for intermediate, brackish, or saline marsh are available in the vicinity of the project area; (2) project structures would be constructed using clay material dredged from areas adjacent to the proposed structures; however, the overburden consists of

approximately 5 ft of organic material unsuitable for use as construction material. To reduce project costs, the USACE proposes to use this organic material to create/restore coastal marsh habitat to compensate for losses resulting from the project. If the amount of the overburden material is insufficient, additional material would be obtained from offsite sources. There are two mitigation banks in the area that would be considered for the programmatic features. They may potentially provide credits for fresh marsh, cypress/tupelo gum swamp, and bottomland hardwoods.

7.7.3 Proposed Mitigation Actions

The proposed mitigation actions include construction of marsh to restore eroded and subsided wetlands in the project area. The mitigation work plan includes the following features, which are further described in the RPEIS:

- **Containment Dikes:** Dikes would be used at each marsh restoration site to contain placed earthen materials until the materials have consolidated and wetland vegetation has become established.
- **Dike Degradation:** The dikes around mitigation sites and cells would be designed to slowly deteriorate and subside to the level of the adjacent marsh substrate, thereby promoting the tidal exchange of water.
- **Target Elevations:** The target elevations of placed and consolidated fill at each site would be determined through geotechnical analyses. The final result of the material placement would be a combination of wetlands and shallow open water habitat within the site. Slurry would be allowed to overflow over existing emergent marsh vegetation within the proposed disposal areas, but would not be allowed to exceed a height of about one foot above the existing marsh elevation.
- **Vegetation:** The establishment of vegetation on marsh areas would provide stability and reduce erosion.
- **Access Corridors:** Access corridors to mitigation sites would be a maximum of about 200 feet wide and would cross over uplands, wetlands, and shallow open water as necessary.
- **Flotation Access Corridors:** Channels would be excavated as needed in shallow open water areas to allow construction equipment to access sites.
- **Existing Levee Access Corridors:** If construction equipment and discharge pipelines are placed across or along the crown of existing levees in the project vicinity, the levees may be refurbished using borrow material from adjacent shallow open water to facilitate their use as access corridors for construction equipment and discharge pipelines.
- **Staging Areas:** The construction or designation of staging areas may be necessary for construction equipment and for the unloading of pipeline and other equipment necessary to perform disposal operations.
- **Board Roads:** Temporary board roads may be constructed along access corridor alignments and staging areas wherever emergent marsh exists. Board roads would be removed when work is completed.

7.7.4 Mitigation OMRR&R

The non-Federal sponsor would be responsible for OMRR&R of functional portions of work as they are completed. On a cost-shared basis, the USACE would monitor completed mitigation to determine whether additional construction, invasive species control, and/or planting are necessary to achieve mitigation success. The USACE would undertake additional actions necessary to achieve mitigation success in accordance with cost sharing applicable to the project and subject to the availability of funds. Once the USACE determines that the mitigation has achieved initial success criteria, monitoring would be performed by the non-Federal sponsor as part of its OMRR&R obligations. If, after meeting initial success criteria, the mitigation fails to meet its intermediate and/or long-term ecological success criteria, the USACE would consult with other agencies and the non-Federal sponsor to determine whether operational changes would be sufficient to achieve ecological success criteria. If instead, structural changes are deemed necessary to achieve ecological success, the USACE would evaluate and take appropriate actions, subject to cost sharing requirements, availability of funding, and current budgetary and other guidance; as well as coordination with the local non-Federal sponsor and resource agencies.

7.8 Plan Costs

Table 7-3 shows the cost breakout of the plan features and/or categories.

Table 7-3. Costs by Civil Works Feature

Work Breakdown Structure No. & Civil Works Feature Description	Estimated Cost (\$Millions)
02 Relocations	291
05 Locks	622
06 Fish & Wildlife Facilities	941
11 Levees & Floodwalls	5,351
15 Floodway Control & Diversion Structures	1,068
Construction Estimate Totals:	\$8,273
01 Lands and Damages	355
30 Planning, Engineering & Design	1,006
31 Construction Management	631
Project Cost Totals:	\$10,265

Note: Costs are in October 2012 prices and rounded to the nearest \$million. Lock costs do not include sponsor funded additional work item.

The **02 Relocations** category refers to utility relocations described in section 7.5.2.

The **05 Locks** category includes the cost of the HNC lock complex as described in section 7.2.1.

The **06 Fish & Wildlife Facilities** category includes both the cost of the environmental control structures described in section 7.3.2 and a portion of the wetland mitigation costs. Of the \$941 million shown in table 7-3, approximately \$513 million is for the environmental control structures and \$428 million is for the remaining compensatory wetland mitigation after all of the levee overburden is used for mitigation. The top 5 ft of borrow for first lift levees that is not suitable for levee building (approximately 12,305,000 cubic yards) would be available for marsh creation. Using Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) program marsh creation assumptions and water depths of between -2.25 and -3.5 (varies by reach), the 12,305,000 cubic yards could create approximately 1,175 acres of marsh. Since more

than 1,175 acres of marsh mitigation is needed, the 1,175 acres were subtracted from the total marsh acres needed (approximately 4,000 acres) to calculate the remaining mitigation costs.

The **11 Levees & Floodwalls** category, which is the largest cost component, includes all levees, and floodwalls (i.e. T-walls). Also included are structures that tie directly into the levees and floodwalls such as road/railroad gates and fronting protection for pump stations.

The **15 Floodway Control & Diversion Structures** category refers to the floodgates described in section 7.3.1. Also included in the category are road gates that are adjacent to floodgates.

The **01 Lands and Damages** category includes land payments as well as administrative costs and incremental costs associated with acquiring the real estate interests. These estimates include costs of acquiring mitigation lands for both environmental mitigation and the preliminary buyout plan to mitigate for induced damages flood side of the levee.

The **30 Planning, Engineering & Design** category includes such costs as project management, engineering, planning, designs, investigations, studies, reviews, value engineering and engineering during construction. The estimated cost for Planning, Engineering, & Design is 12 percent of the total construction costs.

The **31 Construction Management** category (also sometimes referred to as Supervision & Administration) refers to costs associated with management of the project during construction.

7.9 Annual OMRR&R Costs

The project authorization for the Morganza to the Gulf project stipulates that all costs of Operation, Maintenance, Repair, Rehabilitation and Restoration (OMRR&R) are the 100 percent responsibility of the non-Federal Sponsor, with the exception of the HNC lock complex and GIWW structures. In accordance with that statutory requirement, when the project or a portion of the project construction is complete, the USACE is required by law to provide the non-Federal Sponsor with a notice of completion of construction and the commencement of the period of OMRR&R. For example, once a levee lift for a particular reach is constructed and covered in grass, maintenance (i.e. mowing) would start. Based on the assumed implementation schedule, the first feature of the project to be completed would be first-lift levees on reaches F-1, F-2, and I-1 by 2016. Table 7-4 presents the estimated annual OMRR&R costs.

Table 7-4. Annual OMRR&R costs for the 1% AEP Plan

Project Feature	Federal	Non-Federal	Total
Structures	1,590,000	1,570,000	3,160,000
Levees	0	3,970,000	3,970,000
Mitigation	See note	See note	<270,000
Total	\$1,700,000	\$5,700,000	\$7,400,000

Note: Annual OMRR&R costs for structures and levees are in October 2012 prices with a 25 percent contingency and are rounded up to nearest ten thousand dollars. See description of annual OMRR&R costs for mitigation below.

Structures. The Federal OMRR&R costs in table 7-4 are for the GIWW and HNC lock complex structures. With the sponsor funded additional work item, the HNC lock complex OMRR&R costs could be slightly higher; any additional costs attributable to the deeper sill (e.g. higher dredging costs) would be the responsibility of the non-Federal sponsor. The OMRR&R for all structures, with the exception of the GIWW and HNC lock complex structures, is the responsibility of the non-Federal Sponsor.

Levees. Levee OMRR&R costs in table 7-4 are based on mowing 98 miles of earthen levees and dewatering and refurbishing numerous floodgates and a lock every 10 to 15 years. Future levee lifts are considered construction costs, not OMRR&R costs. The OMRR&R for levees is the responsibility of the non-Federal Sponsor.

Mitigation. In accordance with the project's statutory authority, the proposed mitigation actions will include construction, with the non-Federal Sponsor responsible for OMRR&R of functional portions of work as they are completed. On a cost shared basis, USACE will monitor completed mitigation to determine whether additional construction, invasive species control and/or additional plantings are necessary to achieve mitigation success. USACE will undertake additional actions necessary to achieve mitigation success in accordance with cost sharing applicable to the project and subject to the availability of funds. Once USACE determines that the mitigation has achieved initial success criteria, monitoring will be performed by the non-Federal sponsor as part of its OMRR&R obligations. If, after meeting initial success criteria, the mitigation fails to meet its intermediate and/or long-term ecological success criteria, USACE will consult with other agencies and the non-Federal Sponsor to determine whether operational changes would be sufficient to achieve ecological success criteria. If, instead, structural changes are deemed necessary to achieve ecological success, USACE will instruct the non-Federal sponsor to implement appropriate adaptive management measures in accordance with the contingency plan and subject to OMRR&R cost sharing requirements, availability of funding, and current budgetary and other guidance.

8 Plan Implementation

The following sections describe division of plan responsibilities, work in kind credit, and non-Federal sponsor financing.

8.1 Federal and Non-Federal Cost-Sharing

The CPRAB and TLCD have indicated their desire to act as non-Federal sponsors for this project and to perform work-in-kind in order to provide interim flood protection, expedite project completion and satisfy a portion of the non-Federal cost share. The non-Federal share of project costs is approximately \$3,592,785,000 (October 2012 dollars), which would be provided over a 50 to 60 year construction period. The non-Federal sponsor would assume responsibility for OMRR&R of the hurricane and storm damage reduction system, except for those features identified as Federal responsibilities in section 8.2 of this report.

The non-Federal sponsor is required to provide all LERRDs for the project. The non-Federal sponsor requests that the entire remaining non-Federal share (other than LERRD requirements) be provided as work-in-kind rather than cash. Any levees or structures that are part of the Morganza to the Gulf post-authorization project and conform to USACE standards could be possible work-in-kind. The construction cost of this potential work in kind is estimated to be approximately \$2,947,262,000 (October 2012 dollars). The estimates in table 8-1 are subject to change as the design progresses and features become more refined.

Table 8-1. Federal and Non-Federal Cost-Sharing Summary

Cost Share Feature	Project Costs (\$1000s)
Total Project Cost	\$10,265,100
Federal Share (65 percent of Total Project Cost)	6,672,315
Non-Federal Share (35 percent of Total Project Cost)	3,592,785
Value of Proposed Work-in-Kind (non-Fed share minus LERRDs)	2,947,262
LERRDs	645,523
Additional Cash Required	0

Costs are in October 2012 price levels and are rounded to nearest hundred thousand dollars. Does not include sponsor funded additional work item.

8.2 Federal Responsibilities

The Federal government will be responsible for planning, engineering, design, and construction of the project in accordance with the applicable provisions of Public Law 99-662 (WRDA of 1986). The Government, subject to Congressional authorization and the availability of funds and using those funds provided by the non-Federal sponsor, shall expeditiously construct the project, applying those procedures usually applied to Federal projects, pursuant to Federal laws, regulations, and policies. In accordance with WRDA 2007, Section 1001(24), the Government shall operate, maintain, repair, rehabilitate, and replace the two floodgate structures along the GIWW and all components of the HNC lock complex, at no cost to the non-Federal sponsor.

8.3 Non-Federal Responsibilities

Federal implementation of the 1% AEP project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to the following:

a. Provide 35 percent of total project costs as further specified below:

1. Provide the required non-Federal share of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs;

3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;

4. Provide, during construction, any additional funds necessary to make its total contribution equal to 35 percent of total project costs;

b. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

c. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

d. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;

f. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

- h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;
- i. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace (OMRR&R) the project or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government (except the HNC lock complex and the GIWW floodgate features of the project for which the responsibility for OMRR&R is assigned to the Government under Section 1001(24) of WRDA 2007);
- j. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;
- k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;
- l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;
- m. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);
- n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or

under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

o. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

p. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

r. Shall not use any project features or lands, easements, and rights-of-way required for such features as a wetlands bank or mitigation credit for any other project;

s. Pay all costs due to any project betterments or any additional work requested by the sponsor, subject to the sponsor's identification and request that the Government accomplish such betterments or additional work, and acknowledgement that if the Government in its sole discretion elects to accomplish the requested betterments or additional work, or any portion thereof, the Government shall so notify the Non-Federal Sponsor in writing that sets forth any applicable terms and conditions.

8.4 Implementation Sequencing and Requirements

Subject to project authorization, funding, and regulatory approval, construction is scheduled to begin in 2015 as shown in table 8-2. The schedule assumes a complete risk reduction system in place by 2024, with additional levee lifts so that the entire system meets 1% AEP standards by year 2035, and final levee lifts to account for sea level rise and subsidence completed by around 2070. The Morganza to the Gulf project requires construction authorization and the appropriation of construction funds. A continuous funding stream is needed to complete this project within the anticipated timeline, which requires continuing appropriations from Congress and the State of Louisiana in order to fund the detailed design phase and fully fund construction contracts.

Table 8-2. Implementation Milestones

Milestone	Dates
Public Review Draft	Jan 2013
Civil Works Review Board	May 2013
State and Agency Review	May – June 2013
Sign the Report of the Chief of Engineers	2013
Chief’s Report sent to the Assistant Secretary of the Army (Civil Works)	2014
PED Phase Continues	2014 – 2015
Real Estate Acquisition and Construction Contracts Advertising and Award	2014 – 2015
Project Construction Starts	2015

The Morganza to the Gulf project does not start to function as a system or achieve its benefits until all first lift levees and structures are in place. Preliminary construction sequencing is based on availability of information required for construction, such as detailed plans and specifications, identified borrow sources, and environmental clearances. The HNC lock complex is one of the first work items. Preconstruction Engineering and Design on the lock was initiated in January 2000, and the lock is a critical component of both the Morganza to the Gulf risk reduction project and the authorized LCA project, Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock (see section 10.1.7, LCA Program Uncertainties).

Given the size and complexity of the Morganza to the Gulf project, and the fact that not all borrow sources have been identified, most of the RPEIS is at a broad, programmatic level; however, the RPEIS includes a more in-depth analysis of features for which borrow sources have been identified and that could be constructed in the near future, including the HNC lock complex, the Bayou Grand Caillou floodgate, and levee reaches F and G-1. Borrow materials from construction of the lock would be used to construct adjacent levee reaches F and G-1. For these features, the RPEIS provides sufficient detail so that no further environmental clearances would be needed upon signing a Record of Decision. The remaining features would require supplemental NEPA documents before they could be constructed.

The non-Federal sponsor has requested that it be allowed to design and construct portions of the Morganza to the Gulf project as work-in-kind. The non-Federal sponsor would focus their effort on earthen levee construction (multiple lifts) concentrated between Reach E-2 and Reach L. The non-Federal sponsor would also construct floodgates on some typical bayous within the same geographical area, such as Bush Canal, Placid Canal, Bayou Pointe aux Chenes, Bayou Terrebonne, Humble Canal and Bayou Petit Caillou. Details regarding specific features and schedules for work-in-kind will continue to be coordinated between the USACE and the non-Federal sponsor throughout the design and construction phase of the project.

Districts are eligible to initiate PED upon the Division Engineer's transmittal of the final report to HQUSACE. PED normally begins before the completion of the Chief's Report if funds are available and a Design Agreement has been executed. In accordance with EC 1165-2-208, an in-kind Memorandum of Understanding (MOU) can be executed to allow work-in-kind (design only) even prior to execution of the Design Agreement. The USACE and non-Federal sponsor

are currently in the process of negotiating a design work-in-kind MOU; however, any work performed in advance of the MOU is not eligible for credit.

Once construction funds are appropriated for this project, the non-Federal sponsor and the Department of the Army will enter into a PPA. After the signing of the PPA, the non-Federal sponsor can begin to acquire the necessary land, easements and rights of way to construct the project. Since project features cannot be advertised for construction until the appropriate real estate interests have been acquired, obtaining the necessary real estate in a timely fashion is critical to achieving the project schedule. At the completion of construction, project features would be turned over to the non-Federal sponsor, which would then be fully responsible for their OMRR&R.

9 Review of the PAC Report and RPEIS

In compliance with USACE policies and NEPA, input on projects is solicited from technical reviewers, other government agencies, and the public. The following sections briefly describe coordination and review of the Morganza to the Gulf PAC report and RPEIS.

9.1 Types of Reviews

The PAC report and RPEIS have been subjected to three major types of technical review as described in the August 2011 Review Plan (USACE, 8/2011). The first review, District Quality Control, assures accountability for the technical quality of the PAC report. District Quality Control incorporates a team of reviewers similar in experience and structure to the project team, but who have not worked on the project prior to the review.

The second component, Agency Technical Review, is similar in structure to District Quality Control, but is performed outside of the New Orleans District by other USACE districts in coordination with the Mississippi Valley Division and the National Planning Center of Expertise for Coastal Storm Damage Reduction. The Agency Technical Review team includes about 15 reviewers from various technical fields.

Finally, an Independent External Peer Review (IEPR) Panel acts as a completely outside evaluation of the economic, engineering, and environmental analysis performed for the study, including the panel's assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used. The IEPR panel began reviewing the preliminary draft PAC report in June 2012 and provided their final report in March 2013.

In addition to the technical reviews described above, the report must undergo USACE legal and policy reviews at the draft and final report stages. Final policy comments on the Draft reports were received in February 2013, but additional legal and policy reviews will continue until the Final PAC/RPEIS is provided to the public during the 30-day State and Agency review period.

Once all required reviews are complete, the report will ultimately be reviewed by the Assistant Secretary of the Army (Civil Works) and coordinated with the Office of Management and Budget as appropriate for submission to Congress.

9.2 Value Engineering

In accordance with ER 11-1-321, the appropriate Value Engineering action has been completed for the PAC phase of this project. The Value Engineering study conducted in November 2010 (SVS, 2010) is valid for up to 6 years and must be re-addressed as appropriate beyond that period. All proposals indicating savings greater than \$1 Million impacting plan formulation have been addressed in a document indicating whether the Value Engineering recommendation has been accepted and resolved, rejected, or will be evaluated at a later time, e.g. during final design. A number of recommendations should be deferred to design, and additional Value Engineering workshops will be completed on detailed designs. At least two Value Engineering workshops will be needed—one for levees and one for structures, but given the complexity of the HNC lock complex, it is estimated that a total of five workshops will be needed at a cost of \$90,000 for each workshop or an estimated \$450,000 for Value Engineering on the total project.

9.3 Planning Model Certification

EC 1105-2-412, Assuring Quality of Planning Models, requires certification of planning models used in USACE studies. Planning models are models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternatives to address the problems and take advantage of the opportunities, to evaluate potential effects of alternatives, and to support decision-making. EC 1105-2-412 does not cover engineering models used in planning, which are certified under a separate process. A summary and status of model certification for the PAC are shown in table 9-1.

Table 9-1. Planning Model Certification Status

Name	Purpose	Status of Certification
HEC-FDA Version 1.2.5a	Calculate flood damages and benefits for structures, contents and vehicles and part of emergency cost damages and benefits.	Certified
Economic Benefit Spreadsheet Tools	Calculate emergency cost damages and benefits (debris removal and highways/streets) and analytical tool to use statistical bootstrapping to adjust CSVs.	Approved for use on 24 April 2013
RECONS	Capture the impacts to income, output, and employment for the regional economy that are associated with construction spending on each of the alternatives.	Certified
Wetland Value Assessment Models - Coastal Marsh Module Version 1.0	Evaluate coastal marsh impacts and benefits for the project alternatives and mitigation.	Approved on 28 February 2012*
Wetland Value Assessment Bottomland Hardwood and Swamp Models	Evaluate swamp and bottomland hardwood impacts and benefits for the project alternatives and mitigation.	Approved on 8 November 2011*

*WVA approval memos are included in Appendix F of the RPEIS.

9.4 Public Review of the Draft PAC/RPEIS

Since the start of the feasibility study and the scoping meeting in May 1993, there has been an ongoing public outreach program to the Terrebonne and Lafourche Parish communities through public meetings, media day events, briefings to Parish Council Board Meetings, and other public presentations and discussions. The CPRAB and TLCD have expressed their support for the project and their intent to act as the non-Federal sponsors. Close coordination with the CPRAB and the TLCD has been maintained throughout the planning process and they are involved in the key decisions discussed and developed by the team.

The RPEIS has generated significant interagency interest with the full involvement of the Louisiana CPRA, CPRAB, DOTD, TLCD, SLLD, and the Morganza Habitat Evaluation Team. The Morganza Habitat Evaluation Team consists of representatives from CPRA, USEPA, USFWS, NMFS, NRCS, USGS, LDWF, LDNR, and other Federal and state agencies.

The Draft PAC/RPEIS documents were open to public comment from January 4, 2013 to February 19, 2013. A public meeting was held in Houma, LA on January 31, 2013. In addition to individuals and the non-Federal sponsors (CPRA and TLCD), the following agencies and NGOs commented on the Draft RPEIS:

- United States Environmental Protection Agency (USEPA)
- United States Fish and Wildlife Service (USFWS)
- National Marine Fisheries Service (NMFS)
- United States Coast Guard
- Natural Resources Conservation Service (NRCS) State Conservationist in Alexandria, LA and Assistant State Conservationist in Lafayette, LA
- Louisiana Department of Environmental Quality (LDEQ)
- Louisiana Department of Natural Resources (LDNR)
- Louisiana Department of Wildlife and Fisheries (LDWF)
- National Wildlife Federation
- Lafourche Parish Council
- Gulf Intracoastal Canal Association (GICA)
- Louisiana Environmental Action Network (LEAN)
- Louisiana Audubon Council
- Gulf Restoration Network
- Atchafalaya Basinkeeper
- Delta Chapter, Sierra Club

USFWS concerns and recommendations are also documented in the USFWS Coordination Act Report, which is part of the RPEIS.

The most common concern in the top 10 comment themes (representing over 50 percent of the comments) are the potential environmental impacts of the project and associated mitigation requirements. Federal and State agencies noted that in the future there is a potential for adverse indirect and cumulative impacts to wetlands, fisheries, water quality, and navigation assuming there would be increased frequency and duration of water control structure closures as sea level rise accelerates. In response to these concerns, the Final PAC/RPEIS includes a quantitative analysis of the range of potential indirect impacts, including a mitigation plan, for the constructible features, and a qualitative analysis of the potential impacts for the entire project.

The remaining 9 of the top 10 comment themes (from most common to least common with each theme representing less than 10 percent of the total comments) were related to communication, coordination, and consideration of socioeconomic/cultural impacts; plan realignment or reformulation; design standards, RSLR, & constructability; project economics; nonstructural measures; the relationship of Morganza to other plans or projects, such as the State Master Plan and Louisiana Coastal Area (LCA) projects; GIWW floodgate size change, modeling, and impacts; non-Federal contributions; and general support for the project.

Refer to RPEIS section 8 for a more detailed discussion of Public Involvement, and RPEIS Appendix E, Public Comments, for all public and agency comments received during the 45-day public review period along with USACE responses.

10 Conclusions

The plan to provide hurricane and storm damage reduction to portions of Terrebonne and Lafourche Parishes in south Louisiana as updated in this PAC report is based on a thorough analysis and evaluation of all practicable alternatives, in view of applicable economic, engineering, and environmental criteria. Based on the data analyzed, of the two alternatives the 1% AEP alternative has the highest net benefits.

10.1 Planning Assumptions and Uncertainties

Given the complexity of this type of water resources project, analysts and decision makers do not have access to perfect information. Making simplifying assumptions in the face of large uncertainties is part of the normal planning process; however, decision makers need to be aware that conditions may change and planning assumptions could become invalid over time.

Key sources of risk and uncertainty are described in this section. Some types of risk and uncertainty can never be fully eliminated; however, measures or actions can be taken to reduce some risk and uncertainty, such as taking additional soil borings during detailed engineering design, monitoring sea level rise and subsidence to ensure the project continues to perform as designed into the future, monitoring and adaptively managing wetland mitigation projects, developing and rehearsing emergency operation and evacuation plans, and educating the public on residual risks of the levee system.

10.1.1 Non-Federal Levees

The without-project condition accounts for the existence of non-Federal levees within the Morganza project area (approximately 92 miles total; not all contiguous). Their performance was modeled using fragility curves. Most of the local levees are located close to development and are only intended to prevent tidal flooding from small tropical storm events, so they provide some benefit for the more frequent, lower flooding events, but tend to perform poorly at the 3% and 1% AEP surge events for which the Federal hurricane and storm damage risk reduction alternatives were formulated.

In the with-project condition, the performance of the local levees is not quantified. Once the Federal levee is in place, local levees are no longer subjected to direct hurricane surge. If a hurricane event is large enough to cause a breach in the project levees, then it is assumed the local levees would breach as well; therefore, the impact of not including the local levees in the analysis is minor.

Approximately 9 of the 92 miles of local levees are located along the Morganza to the Gulf PAC alignment. The non-Federal sponsor designed and constructed those 9 miles of levees with the intent of meeting HSDRRS standards so that the levees could eventually be incorporated into the Morganza Federal levee project. Per USACE policy, all local levees built without a signed PPA are part of the without-project conditions. Based on preliminary review of non-Federal levee designs, the assumption was made for the PAC report that the 9 miles of local levees would meet HSDRRS criteria and could be incorporated as a foundation to the Federal levees in those reaches. The approval process to incorporate the non-Federal levees into the Federal project would require detailed evaluation of plans and specifications and additional soil borings. Since that detailed review has not yet occurred, final determination of their suitability for integration into the Federal project cannot be made at this time. If the non-Federal levees are found to be incompatible with the Federal project, the Morganza PAC total project cost estimate may

increase based on additional costs to degrade and rebuild the non-Federal levees, or to realign the Federal project.

10.1.2 Economic Risk Analysis

Benefits modeled in HEC-FDA are expected to sufficiently replicate economic benefits of the alternatives. The risk-based analysis meets the intent of EC 1105-2-101 because all key variables, parameters, and components of the hurricane and storm damage reduction study have been subjected to probabilistic analysis. The key variables include stage-damage functions; stage-probability functions; length of record used to determine stage-probability confidence bands; and structural/geotechnical performance of levees.

Rainfall is not included in the HEC-FDA model because rainfall damages would be the same with or without the proposed Federal project. Inhabited areas are generally behind local drainage levees, and local drainage improvements are outside the scope of the project purpose and authority. In the uninhabited wetlands areas, environmental water control structures are sized to address issues related to isolated ponding areas that are created by the construction of the proposed Federal levee.

The without-project HEC-FDA model includes fragility curves that describe the reliability of the local levees. These fragility curves were developed using limited available data, stability analyses, and erosion evaluation. Wave overtopping was not considered; if the local levee does not fail, no damages are computed by the HEC-FDA model, even though wave overtopping could result in without-project damages. These assumptions resulted in overstating the performance of the local levee system and thus reduced the without-project damages that were used to compute project benefits.

The economic analysis performed for the with-project conditions represent the Federal levee performance by a single point fragility curve that has a zero percent probability of failure until a wave overtopping rate of 2 cfs/ft is reached, at which time, failure is considered likely. For all events where the wave overtopping is less than 2 cfs/ft, no damages are computed by the HEC-FDA model. The failure point chosen on the Federal levee would overstate residual damages and therefore understate benefits.

Recent full scale wave overtopping simulation research at Colorado State University (CSU) and simulation research projects on levees were performed to determine the need for armoring. This specific analysis forms the basis for the assumed performance of the proposed Federal grass-covered earthen levees. The upper estimate in the CSU tests was 2.0 cfs/ft. Levees could fail if armoring is not present and overtopping is greater than 2.0 cfs/ft. With the likelihood more certain, the failure probability for 2.0 cfs/ft was set at 95 percent.

A sensitivity analysis was performed on an economic reach for the with-project Federal levee with three test cases. Test Case A has a typical fragility curve developed from geotechnical and hydraulic analyses, Test Case B is the single point failure with the 100 percent probability at a surge elevation that results in 2 cfs/ft wave overtopping, and Test Case C is a single point failure with the 100 percent probability surge elevation at the top of levee. The sensitivity analysis demonstrated that the single point failure is a proxy for a typical fragility curve that meets the intent of the ER 1105-2-101 to address risk and obtain economic consequences. The with-project economic analysis using a single point fragility curve with a failure point at 2 cfs/ft wave overtopping understates the performance of the levee, calculating higher residual damages and therefore understating the benefit-cost ratio.

In the HEC-FDA model, once the wave overtopping reaches 2 cfs/ft, the Federal levees fail and interior stage becomes the without-project stage and residual damages are computed. A breach analysis for the with-project Federal levee demonstrated the interior stage with a breach is likely to be lower than the exterior stage and the without-project stage; the interior/exterior relationships used in the Federal levee analysis therefore understates the performance of the levee again understating the benefit-cost ratio.

In reviewing each of these assumptions, the USACE Risk Management Center concluded that the methodology used in this study resulted in underestimating the without-project damages. The analysis performed on the with-project conditions understated the performance of the Federal levees as well as overstated the residual damages due to the interior/exterior relationships used in the economic model.

10.1.3 Sea Level Rise and Subsidence (Relative Sea Level Rise)

There is widespread consensus in the international scientific community that sea levels will continue to rise and could accelerate. Coastal Louisiana's low elevation, high rate of subsidence, and increased rate of wetland loss make it vulnerable to changes in climate. Sea level change is defined and evaluated in terms of "relative sea level rise," which includes the effects of global and local sea level change as well as local subsidence. Although subsidence and sea level rise are independent processes, the net effect of the two processes results in local relative sea level rise, which is what matters for planning.

Unlike the 2002 report, the PAC structure inventory was not lowered to account for subsidence; rather, the surge and wave model accounts for both sea level rise and subsidence. Project designs in the PAC are based on the Intermediate RSLR scenario, which equates to increased water levels of 0.7 ft in the PAC base year (2035) and 2.4 ft in the PAC future year (2085). In the 2002 feasibility report analysis, to account for future sea level rise and subsidence, portions of the structure inventory fronted by healthy marsh were lowered by approximately 0.5 ft in the base year (2008) and 2.3 ft in the future year (2057). Portions of the structure inventory fronted by unhealthy marsh were lowered by approximately 0.7 ft in the base year and 3.1 ft in the future year. Note: The 2002 feasibility report evaluated a different 50-year period of analysis than the PAC report.

Based on storm surge and wave modeling for this study, the impact of sea level change on surge and waves is non-linear. Surge propagation over broad, shallow, wetland areas is highly sensitive to sea level rise. As wetlands deteriorate, it is likely that water depths will increase further and sea level rise will impact surge levels to an even greater extent, compared to the base case estimates. Waves also generally increased significantly for all sea level rise cases. The wave height increases are significant, but less dramatic than the surge increases.

For a discussion of uncertainties associated with RSLR and indirect environmental impacts, refer to section 10.3.3, Indirect Environmental Impact and Mitigation Plan Uncertainties.

10.1.4 Geotechnical Considerations for Multi-Lift Levee Construction

Multiple lifts are necessary to achieve and maintain levee design elevations over the 50-yr period of analysis. Levee designs represent the size/configuration required to attain the specified level of risk reduction (1% or 3% AEP) by the base year (2035) and the end of the analysis period (2085) accounting for settlement and the Intermediate RSLR scenario. Given the long construction period for this project, the final levee lifts could be adjusted to account for higher or lower levels of actual RSLR.

Constructing multiple levee lifts in a coastal environment with unstable sediments can present challenges. The project area contains large amounts of open water and many bayous, which results in heterogeneous soil foundations. As a result, parts of levees built on existing ridges or levees are expected to have much less settlement than connecting features. The USACE has a long history of working in the weak, compressible soils of southeast Louisiana and has incorporated this knowledge into the PAC feasibility-level levee and structure designs. About one-third of the subsurface exploration required for construction of the project has been completed. Data from each soil boring had to be extrapolated over a large area, which can result in inexact assumptions; however, efforts were made to provide a conservative, yet realistic design, that does not underestimate or overestimate costs because of limited data, or place significantly more emphasis on data that was retrieved from the bored locations. These designs are the basis for a representative PAC cost estimate, but are not intended to be the final engineering designs. Additional geotechnical exploration and testing is planned during the detailed design phase (plans and specs).

10.1.5 Levee Armoring

The selected method for increasing resilience of the Morganza to the Gulf levees in the case of wave overtopping is grass. The with-project economic analysis included the reliability of the constructed project with HSDRRS standards for grass and no additional armoring. Armoring with more resilient material, such as high performance turf reinforcement, involves a cost and performance tradeoff analysis between levee elevation (and associated overtopping rates) and armoring. For example, where sufficient overtopping storage exists behind the levee, levee elevations could be lowered if more robust armoring, e.g. concrete mats, were used to prevent erosion in the case of overtopping. For the Morganza PAC, a test case was run on one such levee reach to determine whether or not it would be more cost effective to add armoring and reduce the height of the levee. The preliminary results did not show a cost savings. The determination of whether or not additional armoring is necessary or cost effective should be made on a reach-by-reach basis; therefore, additional analysis on armoring should be conducted during PED.

10.1.6 LCA Program Uncertainties

Several LCA projects authorized by WRDA 2007 are located within the Morganza study area, including but not limited to: (1) Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock (2) Modification of Davis Pond Diversion and (3) Land Bridge between Caillou Lake and Gulf of Mexico. By letters dated 20 August 2012 and 16 October 2012, CPRAB has notified USACE that it desires to suspend study and design on these projects. The decision of CPRAB to suspend these projects results in some degree of uncertainty regarding implementation of these projects as part of the authorized Federal LCA.

The only LCA project with a direct link to a feature of the Morganza project is the Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock project. The HNC lock complex to be constructed as part of the Morganza to the Gulf project for storm surge and salinity control could also be operated for ecosystem restoration purposes, such as distribution of freshwater. Proposed operational changes for LCA ecosystem restoration purposes, and associated impacts, are documented in the *Final Integrated Feasibility Study and Environmental Impact Statement for the Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of*

Houma Navigation Lock (USACE, 2010). The LCA plan relies on the operation of the HNC lock for environmental purposes after 2025 and proposes the modification of the operational plan for the lock complex structure authorized under Morganza to the Gulf, in order to maximize potential environmental benefits, both in terms of avoiding saltwater intrusion and optimizing flow distribution. For the multipurpose operation to occur, the LCA project would need an OMRR&R plan that considers operation of the lock beyond the current authorization of the Morganza to the Gulf project. A detailed multipurpose OMRR&R plan including these environmental purposes has not yet been developed.

10.1.7 Sponsor Funded Additional Work Item to Address Future HNC Depth

Considering the uncertainties associated with potential future deepening of the HNC, the benefits of building a more flexible lock complex are significant for the Nation. The non-Federal sponsor would assume all incremental costs and incremental OMRR&R of the sponsor funded additional work item. The overall benefits of implementing the sponsor funded additional work item outweigh the additional costs that result from the deeper sill depth. Thus, the New Orleans District has included the -23 ft NAVD88 sill elevation as part of the 1% AEP post-authorization plan as a sponsor funded additional work item. Significant coordination with the resource agencies has been undertaken on both the 1% AEP alternative and the sponsor funded additional work item. No issues have been raised at this stage in the planning process that would preclude implementation of either project.

10.1.8 Price Levels and Interest Rates for Economic Evaluations

Price levels and interest rates change over time and impact the economic viability of projects. The long-term implementation approach carries with it significant risks for Federal and local funding shortfalls. The long implementation time also increases the probability that the levees could be damaged by storms before they are completed.

Benefits and costs for the economic analysis of the *initial array* of alternatives are in October 2008 price levels and based on a 4.875 percent interest rate. Benefits and costs for the economic analysis of the *final array* alternatives was initially performed using October 2011 price levels, but was later updated to October 2012 price levels and a 3.75 percent interest rate.

10.2 Residual Risk

No alternative plan can eliminate risk and uncertainty, and tradeoffs must be made among engineering performance, economic performance, and project costs. These benefit and cost tradeoffs are often expressed as local and Federal project costs, flood damage reduced, and residual risk. It is vital that the non-Federal sponsor and residents understand these tradeoffs and the residual risks in order to fully participate in an informed decision-making process. Figure 10-1 illustrates how everyone has a role in reducing risk and residual risk can never fully be eliminated.

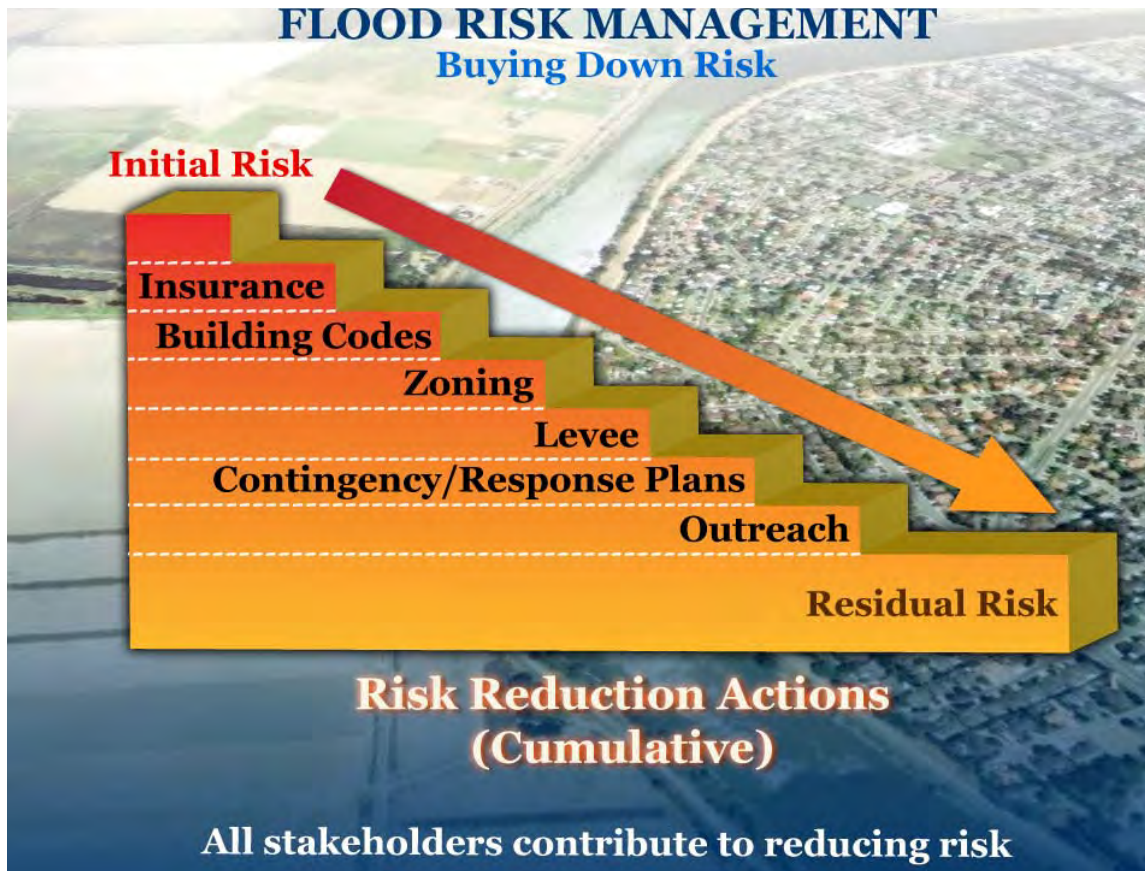


Figure 10-1. Flood Risk Management: Buying Down Risk

At the top of the steps in Figure 10-1 is the initial risk of flooding. Individuals who purchase flood insurance buy down some of their initial risk. The next step shows how parish and state governments can further reduce flood risk by proactively setting and enforcing building codes and zoning regulations. Note that levees are only one of many steps to reduce risk. Even with the Morganza project in place, some risk of flooding remains, as well as other residual risks such as wind damage. An important step is for parish and state governments to develop evacuation plans and for individuals to heed them. If everyone contributes to the effort, there will be a smaller amount of risk at the bottom of the stair steps.

10.2.1 Insurance, Building Codes, and Zoning to Reduce Property Damage Risk

The National Flood Insurance Program enables property owners to purchase insurance as a protection against flood losses in exchange for state and community floodplain management regulations that reduce future flood damages. Local building ordinances, reflecting the floodplain regulations mandated by participation in the National Flood Insurance Program, require that new residential or commercial structures be constructed with first-floor elevations placed 1 foot above the base flood elevation (BFE) as indicated in the prevailing flood insurance rate maps (FIRMs), published by FEMA. As FEMA periodically updates its flood insurance rate studies and associated FIRMs, the BFEs are expected to change over time.

Prior to the impacts of Hurricane Juan in 1985, Terrebonne Parish residents often requested variances on minimum structural elevations. After the storm, the Flood Appeals Board was disbanded, and since then residents have not been allowed to vary from required elevations. General practice in the study area based on local parish recommendations is to build 2 ft above

the FEMA recommendation. In some cases these elevations are 4 ft higher than observed in Juan (1985). Terrebonne Parish is the most active county in the nation in pursuing non-structural flood control. They have elevated over 1,000 structures since 2001, and bought out some structures largely through grant programs. Substantially damaged structures from any storm are required to elevate. The Parish has been updating zoning laws to work towards a sustainable community. The National Flood Insurance Program's (NFIP) Community Rating System (CRS) has a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements; the Terrebonne Parish CRS number is the best in the state and results in lower insurance rates.

The economic analysis in this report was conducted consistent with this expectation as the lower portion of the first-floor level of future (without-project) structures are added to the structure inventory at elevations that are at or above the stage associated with the 1% ACE (equivalent to the BFE). In this way, structures placed into service in the future are compliant with flood plain regulations. Also, these structures are expected to be subject to flood risk for events less probable than the 1% ACE. Under with-project conditions, the FEMA-established BFEs in future updates of the FIRMs are not expected to be as high as would have been established under without-project conditions, owing to the performance of the structural plans in place. The potential damage to these residential or commercial structures is expected to be higher for storm surge events that exceed the performance of the structural alternative in place. This conclusion is based upon the observation that the BFE under without-project conditions is likely to be higher than under with-project conditions. Also, under the without-project condition, structures subject to repetitive loss were elevated in future analysis years, while structures behind the proposed levee project in the with-project condition were not. As a result, residual risk is higher under with-project conditions relative to without-project conditions should the Federal levee not perform as intended.

The 1% AEP standard is important within the National Flood Insurance Program because a levee certified to the 1% AEP (100-year) design level could reduce National Flood Insurance Program insurance premiums within the levee system. The 1% AEP levee design is intended to meet FEMA 100-year levee certification requirements. Project design and performance by levee reach would be verified during PED to assure compliance with FEMA certification criteria.

10.2.2 National Levee Safety Program

The National Committee on Levee Safety (NCLS) was established by the WRDA of 2007, specifically Title IX, also known as the "National Levee Safety Act of 2007." Members of the NCLS were invited to a hearing of the House Transportation and Infrastructure Subcommittee on Water Resources and the Environment in May 2009, where the recommendations for a National Levee Safety Program were addressed. In November 2010, the NCLS was invited to testify before the Senate Committee on Environment and Public Works on levee safety issues. A National Levee Safety Program hinges on shared responsibility at all levels of government and from the public. For more information, visit www.leveesafety.org.

10.2.3 Evacuation Planning and Outreach to Reduce Loss of Life

As population grows, the population at risk to flooding is also expected to increase. The growth in population and housing that has been observed within the study area in past decades, as documented in U.S. Census data, is expected to continue under both without-project and with-project conditions. Between 2010 and 2085, the population at risk in Terrebonne and Lafourche parishes is expected to grow from 133,700 to 165,000 residents. These projections of population

and housing growth were based upon the results of a macroeconomic analysis conducted by Moody's Economy.com that links population growth (and associated demand for housing and commercial services) to an underlying growth in employment demand in the region.

The 1% AEP plan will not result in a change in the level of employment within the study area since the presence of a storm surge risk reduction system will not promote further growth within the major employment sectors comprised of oil and gas exploration and development, commercial fishing, and agriculture. Rather, the structural plans are expected to preserve economic activities that exist, or would be expected to exist in the future, under without-project conditions.

Insofar as the structural plans do not induce development of population and housing, there is no further change in the number of persons exposed to residual risk than would have existed under without-project conditions. Yet, in cases where the surge events exceed the design of the structural projects, the additional population that is counted within the study area beyond the base year will be exposed to increased flood hazard.

All coastal parishes, Terrebonne and Lafourche in particular, exercise aggressive evacuation plans which are mandatory by state law and coordinated by the State of Louisiana according to the state's emergency operations plan that is put into effect 72 hours prior to expected landfall of tropical storms. Whether the current effectiveness of evacuation response of the affected population (generally in the 80 to 95 percent range for Hurricane Gustav) would change with the project in place is uncertain; it is possible that the percentage of the population evacuating could be lower than is currently the case. An increase in population in the study area in the future corresponds to an increase in the number of individuals that may remain in the study area after an evacuation order is issued, and thus an increase in the number of individuals exposed to residual risk associated with storm surges that exceed the project design. This means that for the approximately 8,900 persons added to the population between the years 2035 (the base year of the project) and 2085, most of whom would evacuate in advance of an approaching storm, an additional 445 to 1,780 persons would face life-loss risks in the event of project exceedance. Under such conditions, the parishes' emergency recovery plans would become operational to facilitate cleanup and repair of public facilities, to ensure public safety as population returns to the area in managed phases, and to coordinate relief services with state and federal officials. While the requirement to respond to the needs of additional population under such catastrophic conditions places additional burden on parish law enforcement, relief personnel and facilities, and financial resources, the plans themselves are not expected to be altered to accommodate the change in scope of emergency operations.

Within the last 10 to 20 years, there have only been two known drowning deaths during hurricanes, including one in 2008 during Ike (the only drowning since 1928). The community is inherently prepared for hurricanes as a consequence of a water-based culture (fishing, hunting, oil industry, etc). Many of those in the oil industry that work on off-shore platforms receive early forecasts. Unlike in the case of Hurricane Katrina and New Orleans, the proposed Federal levee alignment is an average of 25 miles from the main population center (Houma), with ring levees and large basins available for storage.

Terrebonne and Lafourche Parish officials have taken an active role in communicating the need to evacuate to the public regardless of the presence of levees or not. Post-Hurricane Katrina willingness to evacuate has greatly increased, which is typical after major hurricanes. If time passes without another major hurricane event, willingness to evacuate may decline, but officials

indicate that they will continue to educate the public and encourage evacuation after the construction of the proposed levee alignment.

10.2.4 Compliance with Executive Order 11988 and Policy Guidance Letter 25

Executive Order 11988, 24 May 1977, Floodplain Management outlines the responsibilities of Federal agencies in the role of floodplain management such that each agency shall evaluate the potential effects of actions on floodplains and should not undertake actions that directly or indirectly induce growth in the floodplain, unless there is no practical alternative. USACE Policy Guidance Letter 25 further specifies that structural plans will be formulated to protect “existing development and vacant property that is interspersed with existing development... and for vacant property that is not interspersed with existing development if it can be demonstrated that the vacant property would be developed without the project and benefits are based on savings in future flood proofing costs or reduction in damages to future development.” Compliance with Executive Order 11988 is accomplished by following the eight general procedures outlined in ER 1165-2-26 (30 Mar 1984), paragraph 8, subparagraphs (a – h). The manner in which these procedures were observed for the Morganza to the Gulf 1% AEP plan is summarized below:

a. Determine if the proposed action is in the base flood plain.

The proposed action is located in the base flood plain.

b. If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.

In addition to the No Action Alternative, several action alternatives within the base flood plain were evaluated in the original 2002 feasibility study and the current PAC study, including both structural and nonstructural alternatives (refer to section 4 of the main PAC report). Nonstructural alternatives were not found to be feasible in the 2002 feasibility report (refer to section 4.2 of the main PAC report). Since the majority of the study area is in the base flood plain, all structural alternatives impact the base flood plain to some extent. In the PAC analysis, the authorized alignment was reconfirmed as the alignment that best meets Federal objectives, i.e. most effective, efficient (cost-effective), complete, and acceptable. Alternative locations of the proposed action outside of the base flood plain would not achieve the flood risk reduction goals of the action, and thus were not considered.

c. If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.

The general public was advised of the proposed action during the 2002 feasibility report public meetings and 45-day Draft and 30-day Final public review periods, and more recently, during a 45-day public review and comment period for the 2013 Draft PAC Report and RPEIS. A public meeting for the Draft PAC Report was held in Houma, LA on January 31, 2013.

d. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.

The proposed action is designed to enhance flood plain values in the form of flood risk reduction. Beneficial and adverse impacts to the natural and aquatic flood plain values due to the proposed action are addressed in the environmental impact statement that supports the PAC report.

e. If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.

The action is not expected to induce development in the base flood plain since the action is not expected to increase the availability of natural resources which is the driver of employment and population. Also, the limits to development are observed as most of the areas behind the proposed Federal levee are wetlands and/or open water areas subject to tidal influence that will remain subject to tidal influence, or they are behind pumped drainage levees that are already developed. Therefore, no practicable non-flood plain alternatives have been identified.

f. As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.

The proposed action is expected to have beneficial and adverse impacts to the base flood plain and measures to avoid, minimize and mitigate those adverse impacts are identified in detail in the environmental impact statement that supports the PAC report.

g. If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.

The general public in the affected area was advised of the proposed action through a news release followed by a 45-day review and comment period for the Draft PAC Report and RPEIS. A public meeting for the Draft PAC Report was held in Houma, LA on January 31, 2013.

h. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.

The Final PAC report identifies the 1% AEP hurricane and storm damage risk reduction system as the alternative that has the highest net benefits and is most responsive to planning objectives by maximizing the Federal investment and minimizing residual risk. The 1% AEP plan is designed to minimize the impact of floods on human safety, health and welfare, and it preserves the natural and beneficial values of the base flood plain to the greatest extent possible through the use of environmental control structure and floodgates that will remain open except during tropical storm events.

10.2.5 Narrative Future Scenario

Some risk and uncertainty factors associated with the Morganza to the Gulf project are difficult to quantify. The following future scenario for the year 2035 is included to help communicate risk.

By 2035, after two decades of additional wetland degradation and sea level rise, water levels in the Gulf of Mexico and waterways throughout the area may be almost a foot higher than they are today, resulting in even higher storm surges than have been seen in the past. Should Houma and surrounding communities in Terrebonne and Lafourche Parishes be threatened by a hurricane, over 181,000 individuals would be faced with the decision of when to begin voluntary evacuations. Approximately 50 hours before the onset of tropical storm winds, the State of Louisiana and local officials would begin mandatory evacuations.

If the Morganza to the Gulf hurricane levee system were never built, the 100-year surge event (which has a 1 percent chance of occurring each year) could overtop and breach most of the existing local levees resulting in over 18 ft of flooding in some areas and potentially impacting over 134,000 structures, including homes, businesses, boats, and automobiles that could not be evacuated. Because of the lack of natural drainage in some areas, flood water would likely remain in low-lying areas for 2 weeks or more, as seen in the aftermath of Hurricane Katrina.

Alternately, if a system of earthen levees ranging in elevations of 10.5 to 24 ft were in place in 2035, it is expected that the project would most likely be able to withstand a 1 percent chance event and structures within the levee system would remain undamaged by storm surge (structures would still be subject to wind damage). Even with the 1% AEP Plan, the project area could still flood in extremely rare events, but would have reduced risk of flooding up to the 500-year or 0.2 percent annual chance flood event.

10.3 Unresolved Issues

Given the size and complexity of the Morganza to the Gulf project, some issues could not be fully resolved at a feasibility-level of detail within the PAC timeframe. Issues that should be resolved at a greater level of detail as the project moves forward include the potential for induced flooding outside the levee system; the future level of risk reduction for the Larose to Golden Meadow project; and future operation of floodgates and water control structures as sea level rises. These plan components would be further addressed through detailed design and supplemental NEPA documents.

10.3.1 Induced Flooding Outside the Project

An indirect impact of the construction of the project is the potential to raise water levels outside the levees by several feet during storm events causing induced flooding to several communities located outside of the proposed levee alignment. These areas include portions of the communities of Gibson, Bayou Dularge, Dulac, and all of Cocodrie and Isle de Jean Charles.

Presently, information is not available on the specific details on the differences in frequency, depth, and duration of the flooding between the future without-project and future with-project conditions. This detailed information typically would be assessed in light of the uses to which the particular land is zoned, and the appropriate mitigation methods, if any, would be implemented to address the effects of the Federal project. Because of the vast scope of this project and the limited amount of available information at this time, the USACE did not look at each affected parcel individually in order to determine potential impacts to property rights from the proposed Federal action that may give rise to compensation. For example, without more information, it is impossible to rule out the possibility of takings for all of the structures in these communities. Due to this concern, the USACE for purposes of this report, has assumed the

worst case compensation scenario (most expensive option), a 100 percent buy-out of all of the structures in the impacted areas. The cost and associated benefits with this scenario has been incorporated into the 1% AEP post-authorization plan (see PAC section 6.5.1).

Socioeconomic considerations associated with the potential buyouts are described in RPEIS section 5.2.13, and Environmental Justice is discussed in RPEIS section 6.14.8 and RPEIS Appendix J.

10.3.2 Larose to Golden Meadow Project Future Elevations

The future-without condition for the Larose to Golden Meadow levee system is uncertain since the Larose PAC analysis is ongoing and future levee elevations for the existing Larose ring levee system have not yet been determined. If the Morganza project is re-authorized to the 1% AEP level of risk reduction, but the Larose project is (a) not re-authorized; (b) re-authorized to less than a 2% AEP level of risk reduction; or (c) is authorized but not supported by a financially capable Non-Federal Sponsor willing to execute a PPA, the Morganza project would have added costs to both offset induced stages on the existing Larose system and to complete the Morganza system to ensure no overtopping of the Larose C-North levees that could impact the Morganza risk reduction area. Therefore, the Morganza to the Gulf PAC analysis assumes no further upgrades to the Larose to Golden Meadow system to ensure that all potential costs to complete the Morganza system are considered.

10.3.3 Indirect Environmental Impacts and Mitigation Plan Uncertainties

As identified in comment letters from several Federal and State agencies that reviewed the January 2013 Draft RPEIS document, creation of impounded wetlands, disruption of sediment deposition and sheet flow, circulation changes, induced development in wetlands, and other indirect impacts to wetlands have been and continue to be controversial issues within the environmental community of southern Louisiana. For example, existing road dumps and canal spoil banks, in combination with construction of the proposed levees, may create small unintentional impoundments that could result in adverse impacts to enclosed wetlands. Such problems exist within the proposed Barrier Reach levees, Reach A levees, the Larose reaches, and other areas. Any such problems will be addressed during the PED of those levee reaches and will be documented in a supplemental NEPA document.

Of greater concern to the agencies and NGOs is the potential for adverse indirect and cumulative impacts to wetlands, fisheries, water quality, and navigation assuming increased frequency and duration of water control structure closures due to future accelerated sea level rise. Although the project includes environmental control structures throughout the levee to maintain tidal ebb and flow, continuing to maintain ecosystem hydrology could be challenging in the future if the intermediate or high relative sea level rise scenarios become a reality. Indirect impacts as described in this report are preliminary, highly speculative, and subject to change. One of the reasons that quantification of project indirect impacts is highly speculative is that wetland loss rates will be impacted by relative sea level rise either with or without the Morganza project in place. Preliminary structure operation plan assumptions and indirect impacts for the constructible features have been determined using the best available information. Indirect impacts for the programmatic features will be addressed in supplemental NEPA documents (refer to RPEIS section 3.5.3 for more information). Mitigation plans will be subject to monitoring and adaptive management.

10.4 Cost and Schedule Risk

The cost and schedule risk analysis is intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. These conclusions were reached by identifying and assessing risk items for use in the risk analysis. The quantitative impacts of these risk items are then analyzed using a combination of professional judgment, empirical data, and analytical techniques. The total project cost contingency is computed using the Crystal Ball software.

10.4.1 Project Confidence and Cost Contingencies

Based on the cost and schedule risk analysis, the recommended total project contingency is approximately 35 percent for the structural features and 26 percent for the levees and all other features, based on an 80 percent confidence level. This contingency of almost \$2.3 billion was applied to the estimate for the Morganza to the Gulf post-authorization 1% AEP plan.

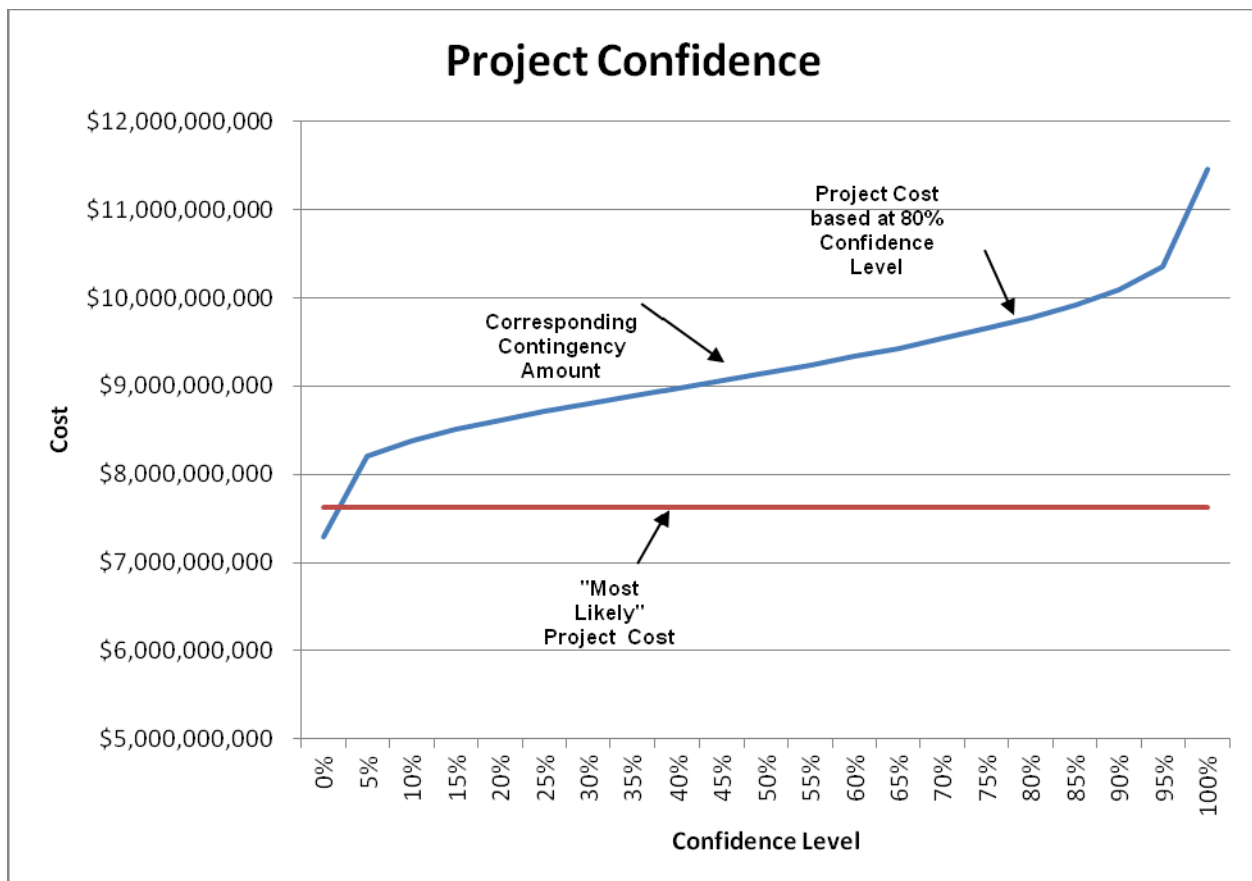


Figure 10-2. Graph of Project Cost vs. Confidence Level

Note: Real estate costs not included because real estate contingencies were computed separately.

10.4.2 High Risk Cost and Schedule Items

An important outcome of the cost and schedule risk analysis is the communication of high risk areas which have a high potential to affect the project cost and/or schedule. For the Morganza to the Gulf PAC project, the high risk cost items are the structural and geotechnical uncertainty, steel cost, fuel cost, unidentified borrow pit for hauled in material, and construction

modifications. Some of these risk items can be mitigated, reducing the risk of an increased project cost. Mitigation measures for structural and geotechnical uncertainty cannot be determined until further studies and engineering data are obtained.

The risk and cost contingency associated with the current level of geotechnical information is considered acceptable for the purpose of the PAC report; there is always some geotechnical uncertainty associated with limited data available during feasibility studies, and the post-authorization feasibility-level design is based on a typical amount of site data for a feasibility report. The Morganza to the Gulf plan contained in the PAC report is not intended to be the final design, but to be a basis for a cost estimate which would be within 25 percent of the actual cost. A detailed cost risk analysis has been conducted, and although there is a risk that costs could be underestimated, there is also the risk that costs could be overestimated. For example, for the 1% AEP plan, contingencies range from 26 to 35 percent, which results in a contingency of around \$2.3 billion as shown in figure 10-2.

The risk analysis already includes a conservative view of the trends for fuel and steel costs based on input from suppliers, research of the market and professional judgment.

Construction modifications are very common and often inevitable on a project of this magnitude. No cost for modifications was included in the base cost estimate and the amount of additional cost due to modifications can be mitigated by ensuring QA/QC guidance is followed and quality products are advertised for construction.

Borrow pit locations for some levee reaches and future levee lifts are unknown at this time. The geology of southeast Louisiana is sufficiently known, however, to reasonably assume that sufficient clay borrow sources would exist within an average distance of 20 to 25 miles to project sites. Encouraging the non-Federal sponsor to find suitable borrow at closest possible distance can mitigate for this risk.

The highest risk schedule item is funding availability. The project schedule was developed based on a reasonable timeframe to establish a level of risk reduction for the area. The USACE has little to no control over the congressional appropriation process other than to fully and timely execute the monies provided in an attempt to show the urgency and importance of the project.

10.5 Site-Adapting HSDRRS Criteria for the Morganza to the Gulf Project

This PAC report reflects the current estimated costs based on a project designed using the HSDRRS guidelines, which are the best available and compliant with current standards. In addition to the PAC analysis, the USACE Risk Management Center and New Orleans District jointly evaluated the proposed Morganza to the Gulf levee system to assess whether HSDRRS criteria could be “site-adapted” to reduce project costs without significantly increasing risk. Based on the preliminary results from the evaluation, the RMC and MVN recommend that the following site-adaptations of the HSDRRS criteria for the Morganza to the Gulf project be considered by the USACE’s Chief of Engineering and Construction.

- 1. Reduce the Factor of Safety (FoS) for end of construction global stability from 1.5 to 1.3.** The risk assessment team concluded that there is inconsequential change in post-project residual risk for a levee 800 ft wide (associated with global stability FoS = 1.5) versus a 600 ft wide (associated with a global stability FoS = 1.3). This reduction in end of construction factor of safety does increase the likelihood of slope stability failures during construction, which is often unacceptable in an urban environment. However, for the non-urban setting of

this project, slope stability failures during construction can be mitigated during construction at relatively low costs and are unlikely to cause loss of life or significant property damage.

2. **Change the Design Overtopping Rate for well-maintained grass covered levee slopes from 0.1 to 0.5 cfs/ft.** This change could result in reduction of levee and structure elevations by several feet. Based on tests conducted to assess USACE HSDRRs designs, the grass cover on clay levee slopes are generally not expected to fail at average overtopping rates of less than 1 cfs/ft.
3. **Elimination of the structural superiority requirement.** Reducing top elevations of structures to match adjacent levee heights would lead to significantly shorter structures, i.e. reducing structure elevations by 2 ft in addition to the reductions in elevation resulting in the change in design overtopping rate. Desired structure resiliency would be attained through less expensive means.

Additional risk assessment findings specific to the Morganza levee system are as follows:

- **Wave and/or surge overtopping is the predominant source of risk.** Other failure modes such as slope instability, internal erosion through the foundation, front-side erosion on levee slopes, closure structure failure, floodwall failure do not significantly contribute to the amount of risk.
- **Consequences on the western side of the project area are higher than on the eastern side.** Even if levees were overtopped and/or breached, reduced flood depths and delay of flood arrival could result in lower loss of life and property damage, generally in proportion to the distance from the overtopping/breach locations. For a reasonable worst case scenario, the population at risk on the west side is 70,000. On the east side, where the population at risk is further from the proposed alignment, an extreme event with overtopping and breach would likely impact fewer than 1,000 people.
- **From a life safety perspective, risks for both HSDRRS and site-adapted HSDRRS levees exceed tolerable risk guidelines.** The proposed Morganza system would likely reduce life safety risk from existing conditions, however, the post project residual risk for the system using either design approach is likely to remain above the tolerable risk guidelines suggested in ER 1110-2-1156.

Risk-based modifications to current design criteria have the potential to reduce the total project cost estimates reflected in the PAC report. Such modifications would be made to designs and costs during the next phase of implementation, Pre-construction Engineering and Design (PED). The USACE is also conducting a national risk assessment to ensure risk is addressed consistently across the country.

10.6 Post-Authorization Project Changes in Costs and Benefits

Both project costs and benefits have increased significantly since authorization. As shown in table 10-1, project first costs have increased by an order of magnitude. As described in the previous section, the primary reasons for the cost increases are changes in predicted surge elevations and more robust post-Katrina HSDRRS guidelines. As a result, levee lengths, levee and structure heights, and levee widths have increased significantly.

As shown in table 10-2, benefits have increased proportionately to costs, because the same, updated storm surge modeling indicates that more structures have a higher probability of getting

flooded. The 1% AEP surge elevations have increased from 4 to 6 ft, to 12 to 14 ft, so the 1% AEP floodplain is now larger and incorporates more structures. The 2009/2010 PAC inventory included approximately 53,000 structures, which is over twice the number of structures in the original 1997/1998 feasibility study inventory, which included approximately 26,000 structures. Emergency cost reductions for the authorized project were based on pre-Hurricane Katrina/Rita information, and the emergency cost reductions for the post-authorization project were based on post-Hurricane Katrina/Rita information. Also, the emergency cost reductions for the post-authorization project include damages to transportation infrastructure, while these damages were not included in the emergency cost reductions for the authorized project.

The project benefit-to-cost ratio in the 2002 feasibility report was 1.43 based on 2000 price levels and an interest rate of 6.625 percent. The benefit-to-cost ratio of the post-authorization 1% AEP plan is 1.43 based on 2012 price levels and a 3.75 percent interest rate. The benefit-to-cost ratio based on 2012 price levels and a 7.0 percent interest rate is 0.69 (required by ER 1105-2-100, Appendix H, Exhibit H-11).

Table 10-1. Changes in Project First Costs (\$ Millions) by Project Feature

Work Breakdown Structure No. & Civil Works Feature Description	Project as Authorized by Congress (WRDA 2007)	Authorized Project (Updated)	3% AEP PAC Alternative	1% AEP PAC Alternative
Effective Price Level	Oct 2006	Oct 2012	Oct 2012	Oct 2012
02 Relocations	43	51	274	291
05 Locks	169	228	530	622
06 Fish & Wildlife Facilities	55	66	619	941
11 Levees & Floodwalls	253	314	2,467	5,351
15 Floodway Control & Diversion Structures	219	262	763	1,068
Construction Totals:	\$739	\$921	\$4,652	\$8,273
01 Lands and Damages	10	11	339	355
30 Planning, Engineering & Design	87	115	574	1,006
31 Construction Management	50	67	385	631
Project Cost Totals:	\$887	\$1,113	\$5,950	\$10,265

Note: Authorized project costs in 2006 and 2012 price levels developed using Form 17 (project cost estimates used to support budget submissions).

Table 10-2. Changes in Annual Costs and Benefits (\$ Millions)

(All costs and benefits in \$millions)	Project as Authorized by Congress in WRDA 2007	Authorized Project (Updated)	3% AEP PAC Alternative	1% AEP PAC Alternative
Effective Price Level, Interest Rate:	Oct 2006, 5.125%	Oct 2012, 3.75%	Oct 2012, 3.75%	Oct 2012, 3.75%
Structures, Contents and Vehicles	91	98	609	959
Emergency Costs	9.6	10	37	54
Boats	1.6	2	<1	<1
Agricultural	2	2	N/A	N/A
Water Supply	0.3	0.3	<1	<1
Avoided Structure Raising Costs	N/A	N/A	10	10
Total Equivalent Annual Benefits	104	113	657	1,023
Annual Costs	49	36	442	716
Benefit-Cost Ratio	2.12	3.16	1.48	1.43
Net Benefits	55	77	214	307

Note: Benefits for boats in 2006 price levels updated to 2012 price levels using the Energy Information Administration Diesel Fuel Price on Gulf Coast; Agricultural benefits updated using the National Agricultural Statistical Service ratio of prices received and paid; all other benefit categories updated using the Composite Index Civil Works Construction Cost Index System. Agricultural benefits were calculated for the 2002 authorized plan, but not for the PAC because a certified model was not available to incorporate risk analysis, and the agricultural benefits were a small percentage of the total PAC benefits.

No changes in cost allocation have occurred since authorization; all costs are for hurricane and storm damage reduction. The post-authorization project does not include any changes in the local cooperation requirements or changes in Federal/non-Federal cost share percentages. The cost apportionment would be 65 percent Federal and 35 percent non-Federal for construction.

The non-Federal sponsor requests that the entire non-Federal share be provided as work-in-kind rather than cash. The non-Federal sponsor would focus their effort on earthen levee construction (multiple lifts) concentrated between Reach E-2 and Reach L. The non-Federal sponsor would also construct floodgates on some bayous within the same geographical area, such as Bush Canal, Placid Canal, Bayou Pointe aux Chenes, Bayou Terrebonne, Humble Canal and Bayou Petit Caillou. Details regarding specific features and schedules for work-in-kind would continue to be coordinated between the USACE and the non-Federal sponsor throughout the design and construction phase of the project. Table 10-3 compares the Federal and non-Federal cost-share of the authorized project and post-authorization project.

Table 10-3. Changes in Cost Apportionment (Costs in \$1000s)

(All costs in \$1000s)	Authorized Project		Post Authorization 1% AEP Plan
	Authorized in WRDA 2007	Updated Price Levels	
Effective Price Level:	Oct 2006	Oct 2012	Oct 2012
Total Project Cost	\$886,700	\$1,113,000	\$10,265,100
Federal Share (65%)	576,355	723,450	6,672,315
Non-Federal Share (35%)	310,345	389,550	3,592,785
Value of Proposed Work-in-Kind	139,655	177,934	2,947,262
LERRDs	51,970	60,357	645,523
Additional Cash Required	118,720	151,259	0

Note: Authorized project costs (including LERRDs) in 2006 and 2012 price levels developed using Form 17 (project cost estimates used to support budget submissions). Authorized project work-in-kind and cash breakdown in 2006 and 2012 price levels estimated based on percentage from 2002 feasibility report (work-in-kind was 45% of non-Federal share).

10.7 Project Benefits, Costs, and BCR Risk and Uncertainty

Although the costs, benefits, and project benefit-to-cost ratio are presented as “most likely” values in this report, there are large uncertainties surrounding single values. Uncertainty and variability are intrinsic in water resources planning, modeling, and design. Risk and uncertainty arise from measurement errors and from the underlying variability of complex natural, social, and economic situations. Major sources of uncertainty associated with the Morganza to the Gulf project that could impact the benefit-cost ratio include the following:

- Uncertainty surrounding engineering models and inputs.** The uncertainty surrounding three key engineering parameters (ground elevations, stage-probability curves, and performance of existing and proposed levees) was quantified in the HEC-FDA model. Uncertainty in these engineering inputs arises from imperfect data and coastal storm damage models that represent complex meteorological and hydrologic conditions across a highly variable and changing coastal landscape. In general, the standard deviation associated with estimated still water elevations is greater than a foot. In reviewing the HEC-FDA risk analysis, the USACE Risk Management Center concluded that the lack of data on existing levees resulted in underestimating the without-project damages. The analysis performed on the with-project conditions understated the performance of the Federal levees as well as overstated the residual damages due to the interior/exterior relationships used in the economic model. The net effect of understating the without-project damages and overstating the with-project residual damages is that the benefit-cost ratio is understated.
- Uncertainty surrounding economic inputs.** The uncertainty surrounding four key economic variables (structure values, contents-to-structure value ratios, first floor elevations, and depth-damage relationships) was quantified in the HEC-FDA model. Uncertainties arise from measurement errors associated with collection of this economic input data and extrapolation of a small set of samples to a large, highly variable study area. The samples used to develop the contents-to-structure value ratios (CSVs) for the various residential and non-residential damage categories could not be randomly selected due to the difficulty in obtaining volunteers to participate in the surveys. Consequently, there is the risk that the CSVs used in the economic analysis may not accurately reflect the true mean CSVs of the population of residential and non-residential properties in the evaluation area. The uncertainty surrounding the first floor elevations assigned to structures is less than a third of a foot; however, adjustments were made to the structure

inventory assuming that structures that are repetitively damaged (i.e. in the 10-yr damage floodplain) will be rebuilt over time to higher elevations such that they are outside of the 100-yr floodplain. If more structures than expected are removed from the floodplain, the benefits would be lower than estimated. If fewer structures than expected are removed from the floodplain, the benefits would be higher than estimated.

- **Changes in the discount rate.** The 2013 discount rate of 3.75 percent is at a record low. All other variables being equal, the breakpoint for project justification is around a discount rate of 5.25 percent, meaning that if the discount rate rises above 5.25 percent and all other variables remain unchanged, the project would no longer have a benefit-cost ratio greater than unity.
- **RSLR uncertainty.** The National Research Council predicts that eustatic sea level (not accounting for subsidence) could increase 1 to 4 feet by 2085. Assuming that historic, local subsidence rates continue into the future, the amount of RSLR (sea level rise plus subsidence) for the Morganza to the Gulf area could range from 1.7 to 4.8 ft. The RSLR scenario selected for calculating the benefit-cost ratio assumes an intermediate level of approximately 2.4 ft RSLR by 2085. If the combined effect of RSLR is lower than expected, project benefits and costs would both be lower than estimated. If actual RSLR is higher than 2.4 ft, project benefits and costs would be higher than estimated. Based on a sensitivity analysis, the net effect on the benefit-cost ratio is minimal (a few tenths of a point) and the project would still be justified under any RSLR scenario (holding all other variables the same).
- **Total project cost uncertainties.** For the Morganza to the Gulf project, the high risk cost items are the structural and geotechnical uncertainty, steel cost, fuel cost, unidentified borrow pit for hauled in material, and construction modifications. A detailed cost risk analysis has been conducted and resulting project feature contingencies range from 26 to 35 percent, which results in a total project contingency of around \$2.3 billion. Although there is a risk that costs could be underestimated, there is also the risk that costs could be overestimated.
- **Mitigation cost uncertainties for indirect impacts.** Compensatory mitigation costs for the 1% AEP plan are based on direct construction impacts assuming that tidal ebb and flow would be maintained by the environmental control structures designed throughout the levee alignment such that there would be minimal indirect impacts. However, if future sea level rise predictions come to fruition, these environmental control structures would have to be closed more frequently resulting in indirect impacts. Based on this assumption, the Habitat Evaluation Team estimates the constructible features could impact an additional 721 to 1,442 acres (216 to 418 AAHUs), which would require additional compensatory mitigation at a cost of \$60 million to \$120 million. Mitigation costs resulting from additional indirect impacts from the programmatic features would be covered in future supplemental NEPA documents.
- **Site-adapting the HSDRRS standards.** Estimated project costs in the PAC report are the best available and compliant with current HSDRRS standards. Based on a risk assessment of the Morganza to the Gulf project conducted after the PAC analysis was complete, risk-based modifications to current design criteria have the potential to reduce the total project cost estimates reflected in the PAC report. The USACE is also conducting a risk assessment to ensure risk is addressed consistently across the country.

Once this assessment is complete, the results may be applied to the Morganza to Gulf project area. Such modifications would be made to designs and costs during the next phase of implementation, Pre-construction Engineering and Design (PED). Any decrease in costs would increase the benefit-cost ratio assuming the benefit remain unchanged.

11 Findings

The District Commander has updated the Morganza to the Gulf of Mexico, Louisiana authorized project and finds that the updated 1% AEP plan is economically justified, environmentally acceptable and engineeringly sound. Post-Katrina engineering design criteria and standards for gulf coast communities were applied to reduce the potential of loss of life and property from coastal storms. These engineering practices were developed using the findings of the *Interagency Performance Evaluation Task Force* including key lessons learned from Hurricane Katrina and their implications for future hurricane preparedness and planning for south Louisiana. Project modifications were also found necessary to address developments after the project was authorized, including community resettlement patterns after Katrina, to incorporate improved water control elements and floodgates, and to update other outmoded aspects of the authorized project to more effectively provide the utility of function originally intended by Congress.

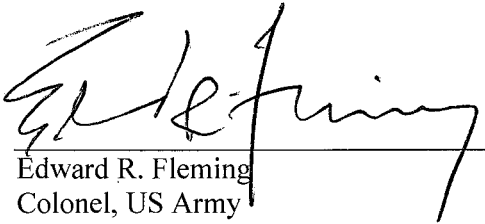
The District Commander has considered all the significant aspects of this study including the environmental, social, and economic effects, the engineering feasibility, and the comments received from other resource agencies, the non-Federal sponsors, and the public and has determined that the updated authorized project presented in this report remains in the overall public interest and is a justified expenditure of Federal funds. In coordination with other Federal, State of Louisiana, and parish agencies, USACE planned and would design a project that serves the needs of the nation.

The updated total cost for the project is \$10,265,100,000 (October 2012 dollars) inclusive of associated investigation, environmental, engineering and design, construction, supervision and administration, and contingency costs (and exclusive of OMRR&R costs). The fully funded total project cost (includes inflation) is approximately \$12,872,846,000. The project would be funded 65 percent by the Federal Government and 35 percent by the non-Federal sponsors, and subject to the implementation requirements specified in section 8 of this report.

The OMRR&R costs of this project are estimated to be approximately \$7,400,000 annually. Approximately \$1,700,000 annually would be a Federal responsibility, including OMRR&R for the GIWW floodgates and the HNC lock complex and a portion of cost-shared mitigation OMRR&R. The remaining annual OMRR&R costs of approximately \$5,700,000 would be the responsibility of the non-Federal sponsor, including OMRR&R for all project features (except the GIWW floodgates and HNC lock complex), the sponsor funded additional work item, a portion of cost-shared mitigation OMRR&R, and the remainder of mitigation OMRR&R once USACE determines that the mitigation has achieved initial success criteria.

The benefit-to-cost ratio for the post-authorization project is 1.43 based on October 2012 price levels and a 3.75 percent interest rate.

The findings contained herein reflect the information available at the time and current Department of the Army policy and guidance and specific guidance provided for the Morganza to the Gulf of Mexico, Louisiana project. They do not reflect programming and budgeting priorities inherent in the formulation of national civil works construction program nor the perspective of higher review levels within the executive branch. Consequently, the findings may be modified before they are transmitted to Congress. However, prior to the transmission to Congress, the sponsor, State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.



Edward R. Fleming
Colonel, US Army
District Commander

12 References

This section includes the list of references cited in the report, a glossary of terms, and list of acronyms. Many of the report documents are available online at www.mvn.usace.army.mil/prj/mtog/.

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12.2 Glossary

Alternative or Alternative Plan – A set of one or more management measures functioning together to address one or more objectives.

Annual Chance Exceedance (ACE) – A measure of the likelihood (expressed as a probability) of a flood event reaching or exceeding a particular magnitude. A one percent (ACE) flood event has a one percent (or 1 in 100) chance of occurring or being exceeded at a location in any year.

Annual Exceedance Probability (AEP) – The probability that flooding will occur in any given year considering the full range of possible annual floods (ER 1105-2-101), or the chance of an event of a given size (or larger) occurring in any one year, usually expressed as a percentage (EC 1110-2-6066).

Anthropogenic – Caused by human activity.

Assurance – The probability that a target stage will not be exceeded during the occurrence of a specified flood. Assurance is also interchangeable with the term **conditional non-exceedance probability** (EC 1110-2-6066).

Benefits – Valuation of positive performance measures.

Bottomland Hardwood Forest – Low-lying forested wetlands found along streams and rivers.

Brackish Marsh – Intertidal plant community typically found in the area of the estuary where salinity ranges between 4 and 15 ppt.

Coastal – Characterization of a structure or system that is situated in an environment subject to water level fluctuations and wave action. Coastal structures or systems must typically be designed to take into account storm surge and wave loadings (EC 1110-2-6066).

Conditional Non-exceedance Probability (CNP) – The probability that a target stage will not be exceeded during the occurrence of a specified flood. Conditional non-exceedance probability is also interchangeable with the term **assurance** (EC 1110-2-6066).

Control Structure – A gate, lock, or weir that controls the flow of water.

Cumulative Impacts – The combined effect of all direct and indirect impacts to a resource over time.

Datum – A point, line, or surface used as a reference, as in surveying, mapping, or geology.

Direct Impacts – Those effects that result from the initial construction of a measure. Contrast with “Indirect Impacts.”

Economic – Of or relating to the production, development, and management of material wealth, as of a country, household, or business enterprise.

Economic Analysis Period – The period of time over which the flood risk management system would have significant beneficial or adverse effects. Usually this period does not exceed 50 years except for major multi purpose reservoir projects (EC 1110-2-6066).

Ecosystem – An organic community of plants and animals viewed within its physical environment (habitat); the ecosystem results from the interaction between soil, climate, vegetation and animal life.

Ecosystem Restoration – Activities that seek to return an organic community of plants and animals and their habitat to a previously existing or improved natural condition or function.

Endangered Species – Animals and plants that are threatened with extinction.

Environmental Impact Statement (EIS) – A document that describes the positive and negative environmental effects of a proposed action and the possible alternatives to that action. The EIS is used by the federal government and addresses social issues as well as environmental ones.

Estuary – A semi-enclosed body of water with freshwater input and a connection to the sea where fresh water and salt water mix.

Estuarine – Related to an estuary.

Feasibility Report – A description of a proposed action previously outlined in a general fashion in a Reconnaissance Report that will satisfy the Federal interest and address the problems and needs identified for an area. It must include an assessment of impacts to the environment (either in an Environmental Assessment, or the more robust Environmental Impact Statement), an analysis of alternative methods of completion, and the selection of a Recommended Plan through the use of a cost-effectiveness analysis.

Feature – A constructible increment of an alternative plan.

Final Array – The final grouping of alternative plans from which a final recommendation can be made.

Floodgate – The term "floodgate" is applied to a flood risk reduction structure that opens and closes. During non-flood conditions, a floodgate remains in an "open" position and allows for vehicle passage. Floodgates are erected across roads, railroads and navigable waterways.

Forced drainage levee system – A levee and pump system that provides controlled drainage for an area, normally to allow the area to remain dry at or below sea level under normal tidal conditions.

Fresh Marsh – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 0 to 3 ppt.

Goals – Statements on what to accomplish and/or what is needed to address a problem without specific detail.

Gradient – A slope; a series of progressively increasing or decreasing differences in a system or organism.

Habitat – The place where an organism lives; part of physical environment in which a plant or animal lives.

Habitat Loss – The disappearance of places where target groups of organisms live. In coastal areas, usually refers to the conversion of marsh or swamp to open water.

Hazardous, Toxic, and Radioactive Wastes (HTRW) – Projects features must be examined to ensure that their implementation will not result in excessive exposure to pollutants possibly located in the study area.

Herbaceous – A plant with no persistent woody stem above ground.

Hydraulics - The scientific study of water and other liquids, in particular their behavior under the influence of mechanical forces and their related uses in engineering (from The American Heritage® Science Dictionary.)

Hydrodynamics – The continuous change or movement of water.

Hydrology – The pattern of water movement on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Indirect Impacts – Those effects that are not as a direct result of project construction, but occur as secondary impacts due to changes in the environment brought about by the construction. Contrast with “Direct Impacts.”

Infrastructure – The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons.

Intermediate Marsh – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 2 to 5 ppt.

Intertidal – Alternately flooded and exposed by tides.

I-Wall – A slender cantilever wall, deeply embedded in the ground or in an embankment that rotates when loaded and is thereby stabilized by reactive lateral earth pressures (EC 1110-2-6066).

Levee – A linear mound of earth or concrete floodwall built to stop or slow down storm surge.

Levee System – A levee system comprises one or more levee segments which collectively provide flood damage reduction to a defined area. The levee system is inclusive of all features that are interconnected and necessary to ensure protection of the associated separable floodplain (EC 1110-2-6066).

Level-of-Protection – The recurrence interval of the flood event that, with a high level of assurance, will be safely contained within the capacity of the protection system (EC 1110-2-6066). For example, a system could be deemed a 100-year Level-of-Protection system if it can contain the 1 percent annual chance exceedance flood with a high degree of assurance, e.g. 90 percent.

Sponsor Funded Additional Work Item – Alternative feature preferred by non-Federal sponsor for which the non-Federal sponsor agrees to pay the full cost increment.

Management Measure (or Measure) – A feature (a structural element that requires construction or assembly on-site) or an activity (a nonstructural action) that can be implemented at a specific geographic site that is to address one or more planning objectives. Management measures are the building blocks of alternative plans (Planning Guidance Notebook, 2-4).

Methodology – A set of practices, procedures, and rules.

Modes of Failure – The mechanism by which a system or structure ceases to perform its intended function (EC 1110-2-6066).

National Environmental Policy Act (NEPA) – Ensures that Federal agencies consider the environmental impacts of their actions and decisions. NEPA requires all Federal agencies to consider the values of environmental preservation for all significant actions and prescribes procedural measures to ensure that those values are fully respected.

No Action Alternative – An alternative that describes the without-project condition if no action is taken.

Objectives – More specific statements than “Goals,” describing how to achieve the desired targets.

Organic – Composed of or derived from living things.

Overtopping – A static and/or dynamic event that occurs when the height of the stillwater level and/or associated waves exceed the top of a structure or levee embankment.

Prime Farmland – Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion. One of the categories of concern in the EIS.

Probability – A measure of the likelihood, chance, or degree of belief that a particular outcome or consequence will occur. A probability provides a quantitative description of the likelihood of occurrence of a particular event. This is expressed as a value between 0 and 1 (EC 1110-2-6066).

Probability Function – A discharge-exceedance or stage-exceedance probability relationship for a reach developed by traditional, site-specific, hydrologic engineering analysis procedures (EC 1110-2-6066).

Programmatic Environmental Impact Statement (PEIS) – An Environmental Impact Statement that supports a broad authorization for action, contingent on more specific detailing of impacts from specific measures.

Project – A constructible increment of an alternative plan.

Quantitative – Able to assign a specific number; susceptible to measurement.

Reach – The term Reach is used to describe two distinct features in the PAC analysis. (1) Levee Reach refers to a segment of the proposed Morganza to the Gulf levee alignment that has similar levee elevations, ground surface elevations, soil types, and foundation strengths. The ten primary Levee Reaches are Barrier, A, B, E, F, G, H, I, J, K, and L. (2) Hydraulic and/or Economic Reach refers to an area that has similar water surface elevations and is used to aggregate economic damages and benefits. The Morganza study area has been divided into 276 Hydraulic/Economic Reaches, which are also sometimes referred to as Storage Areas.

Reconnaissance Report – A document prepared as part of a major authorization that examines a problem or need and determines if sufficient methods and Federal interest exists to address the problem/need. If so, then a “Feasibility Report” is prepared, which details the solution and its impacts further.

Redundancy – The duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe (EC 1110-2-6066).

Relative Sea Level Rise (RSLR) – The sum of the sinking of the land (subsidence) and eustatic sea level change; the change in average water level with respect to the surface.

Reliability – The probability of a component, unit or system adequately performing its intended purpose, for a specified period of time, under given operating conditions (EC 1110-2-6066).

Residual Risk – The flood risk that remains in the floodplain after a proposed flood risk reduction project is implemented. Residual risk includes the consequence of capacity exceedance as well as consideration of project performance.

Resilience – The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or manmade, under all circumstances of use (EC 1110-2-6066).

Risk – The probability an area will be flooded, resulting in undesirable consequences (ER 1105-2-101).

Risk Analysis – An approach to evaluation and decision making that explicitly, and to the extent practical, analytically, incorporates considerations of risk and uncertainty in a flood damage reduction study (ER 1105-2-101).

Robustness – The ability of a system to continue to operate correctly across a wide range of operational conditions (the wider the range of conditions, the more robust the system), with minimal damage, alteration or loss of functionality, and to fail gracefully outside of that range (EC 1110-2-6066).

Safety – Commonly thought of as the condition of being free from danger, risk, or injury; however, safety is not something that can be absolutely achieved or guaranteed. Instead safety is the condition to which risks are managed to tolerable levels. Therefore, safety is a subjective concept based upon individual perceptions of risks and their tolerability.

Saline Marsh – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 12 to 32 ppt.

Salinity – The concentration of dissolved salts in a body of water, commonly expressed as parts per thousand (ppt). The salinity of ocean water is approximately 35 ppt.

Scoping – Soliciting and receiving public input to determine issues, resources, impacts, and alternatives to be addressed in the draft EIS.

Social – Relating to human society and its modes of organization.

Socioeconomic – Involving both social and economic factors.

Still Water Level or Elevation – The height of the water surface measured above a datum without waves.

Storm Surge – An abnormal and sudden rise of the sea along a shore as a result of the winds of a storm.

Structural Superiority – All new structures that are difficult to construct due to their nature, such as railroad and highway gate monoliths that require detours causing disruptions to traffic, pumping station fronting protection that require cofferdams within their discharge basins causing reductions to pumping capacity, sector gated structures causing disruptions to navigation, large utility crossings, etc., shall be designed with a minimum of 2 ft. of additional wall height.

Subsidence – The gradual downward settling or sinking of the Earth's surface with little or no horizontal motion.

Tainter Gate - Radial gate most commonly used on navigational projects. In its simplest form, a tainter gate is a segment of a cylinder mounted on radial arms that rotate on trunnions anchored to the piers. Because of its simple design, relatively light weight, and low hoist-capacity requirements, the tainter gate is considered one of the most economical and most suitable gates for controlled spillways.

T-wall – A cantilever T-type reinforced concrete floodwall consists of a concrete stem and base slab which form an inverted T. The structural members are fully reinforced to resist applied moments and shears. As necessary to resist under seepage during a flood event, a steel sheet pile cutoff wall is cast into the base slab of the T-Wall. The T-wall may need to be supported on a pile foundation if soft soils exist. The piles can be made of either steel or concrete and derive their support to the T-wall from friction of the soil surrounding the pile or through end bearing at a deeper stronger soil strata.

Uncertainty – A measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, geotechnical, and economic aspects of a project plan (ER 1105-2-101).

Unique Farmland – Land other than Prime Farmland (see “Prime Farmland”) that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, fruits, and vegetables.

Upland – A general term for non-wetland elevated land above low areas along streams or between hills.

Water Resources Development Act (WRDA) – A bill passed by Congress that provides authorization and/or appropriation for projects related to the conservation and development of water and related resources.

12.3 Measurement Abbreviations

AAHU	Average Annual Habitat Unit
cfs	cubic feet per second
cfs/ft	cubic feet per second per linear foot
ft	foot or feet
ppm	parts per million
ppt	parts per thousand

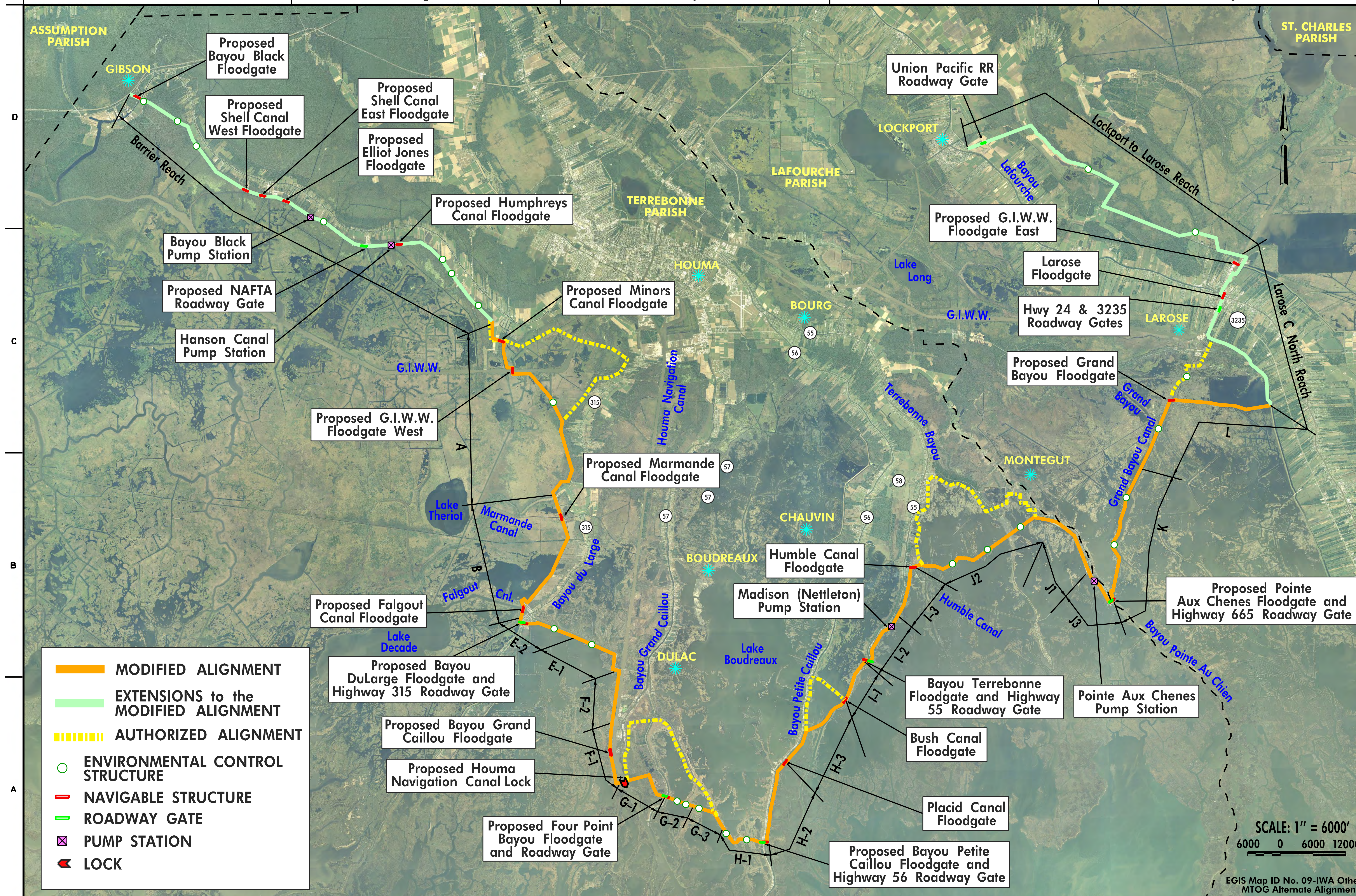
12.4 Acronyms

Acronyms used in the RPEIS are not listed here because the RPEIS has its own list of acronyms.

ACE	Annual Chance Exceedance
AEP	Annual Exceedance Probability
BFE	Base Flood Elevation
BLH	Bottomland Hardwood
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CPRA	Coastal Protection and Restoration Authority (formerly the Office of Coastal Protection and Restoration)
CPRAB	Coastal Protection and Restoration Authority Board (formerly the CPRA)
CSV	Content-to-Structure Value Ratio (see Economic Appendix)
CWCCIS	Composite Index Civil Works Construction Cost Index System
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
DNR	Department of Natural Resources
DOTD	Department of Transportation and Development
EC	Engineering Circular
EIS	Environmental Impact Statement
ER	Engineering Regulation
FEMA	Federal Emergency Management Agency (see Economic Appendix)
FIRM	Flood Insurance Rate Map
GIS	Geographic Information System

GIWW	Gulf Intracoastal Waterway
HEC-FDA	Hydrologic Engineering Center - Flood Damage Analysis
HNC	Houma Navigation Canal
HSDRRS	Hurricane and Storm Damage Risk Reduction System
LACPR	Louisiana Coastal Protection and Restoration
LCA	Louisiana Coastal Area
LERRD	Lands, Easements, Rights-Of-Way, Relocation, and Disposal Areas
LiDAR	Light Detection and Ranging
MLODS	Multiple Lines of Defense Strategy
MOU	Memorandum of Understanding
NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NGO	Non-Governmental Organization
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
OMRR&R	Operation and Maintenance, Repair, Replacement and Rehabilitation
OSE	Other Social Effects (see Economic Appendix)
PAC	Post Authorization Change
PED	Preconstruction Engineering and Design
PEIS	Programmatic Environmental Impact Statement
PL	Public Law
PPA	Project Partnership Agreement
RED	Regional Economic Development (see Economic Appendix)
RPEIS	Revised Programmatic Environmental Impact Statement
RSLR	Relative Sea Level Rise
SLLD	South Lafourche Levee District
TLCD	Terrebonne Levee Conservation District
TSP	Tentatively Selected Plan
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WMA	Wildlife Management Area
WRDA	Water Resources Development Act
WVA	Wetland Value Assessment

Attachment 1 – Project Map

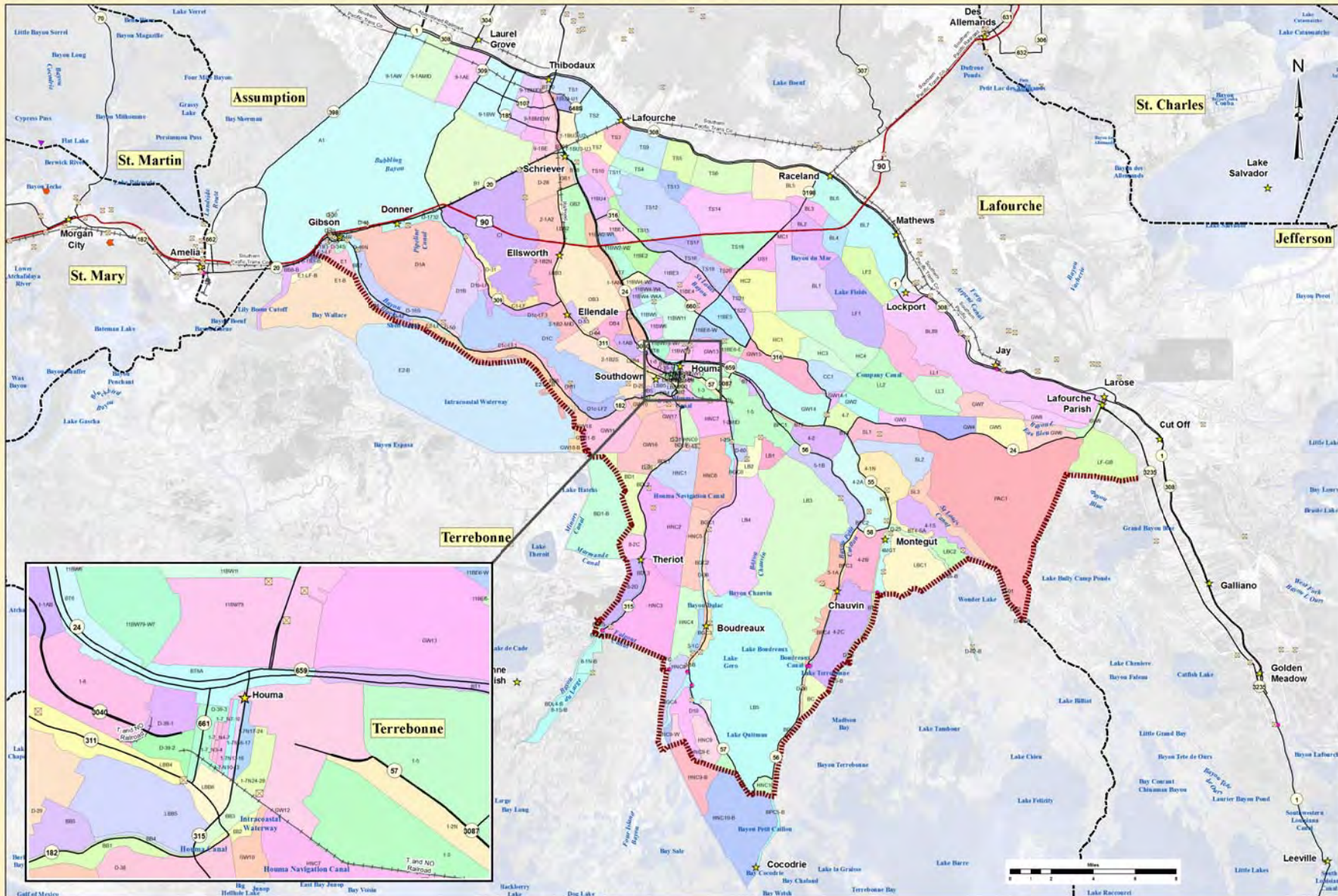


- MODIFIED ALIGNMENT
- EXTENSIONS to the MODIFIED ALIGNMENT
- AUTHORIZED ALIGNMENT
- ENVIRONMENTAL CONTROL STRUCTURE
- NAVIGABLE STRUCTURE
- ROADWAY GATE
- PUMP STATION
- LOCK

SCALE: 1" = 6000'
 6000 0 6000 12000
 EGIS Map ID No. 09-IWA Other MTOG Alternate Alignments

Attachment 2 – Economic Reach Maps

MTOG Economic Reaches



- Legend**
- MTOG Construction Reaches
 - Lock
 - Federal Water Control Structure
 - Interim Control Structure
 - Sector Gate
 - Channel Floodgate
 - Weir
 - Control Structure
 - Division Structure
 - Drainage Structure
 - Navigable Structure
 - Cities
 - Parishes

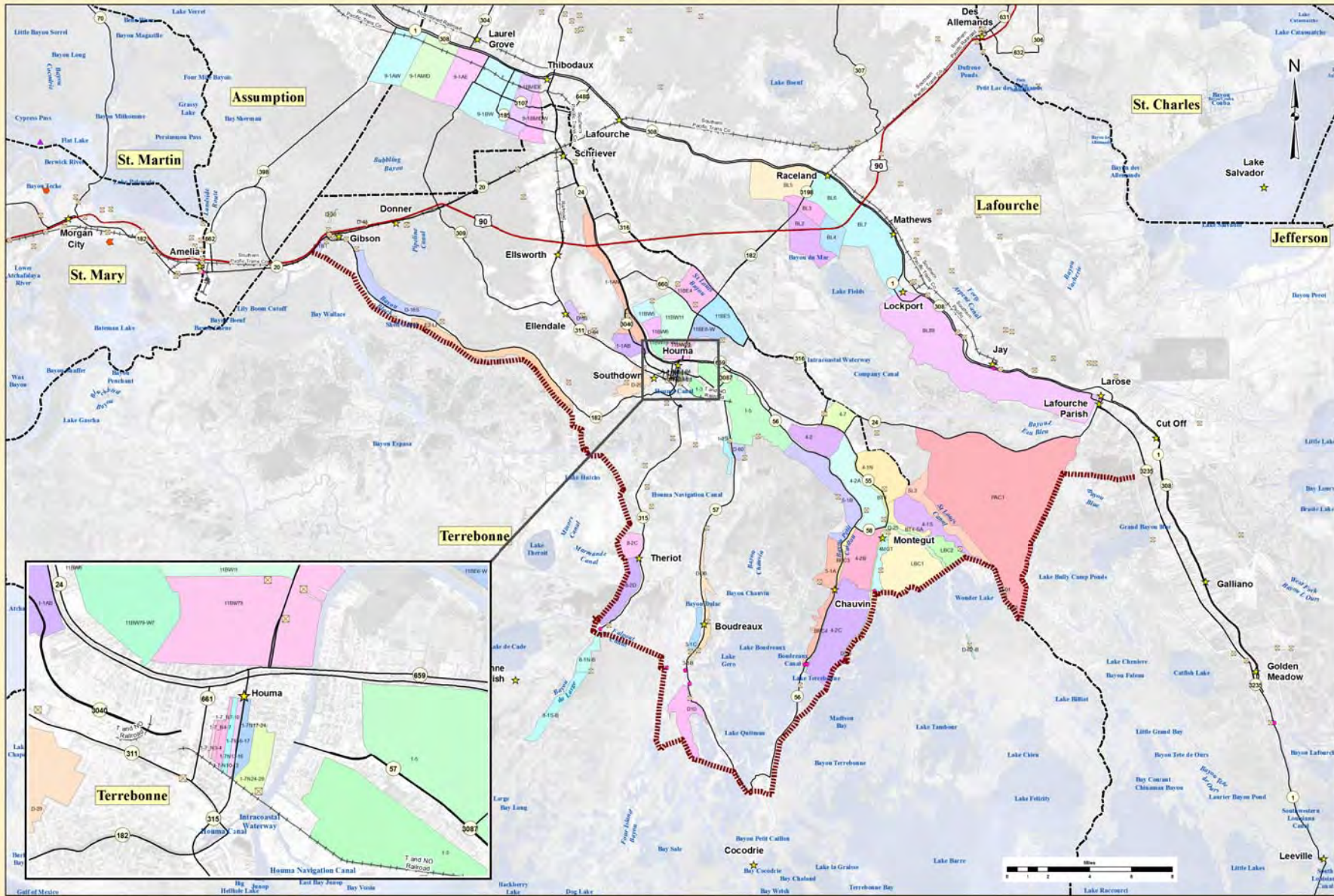
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Location Map

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Morganza to The Gulf
MTOG Economic Reaches

MTOG Economic Reaches Behind Local Levees



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- Legend**
- - - MTOG Construction Reaches
 - Lock
 - Federal Water Control Structure
 - Interim Control Structure
 - Sector Gate
 - Channel Floodgate
 - Weir
 - Control Structure
 - Diversion Structure
 - Drainage Structure
 - Navigable Structure
 - Cities
 - Parishes

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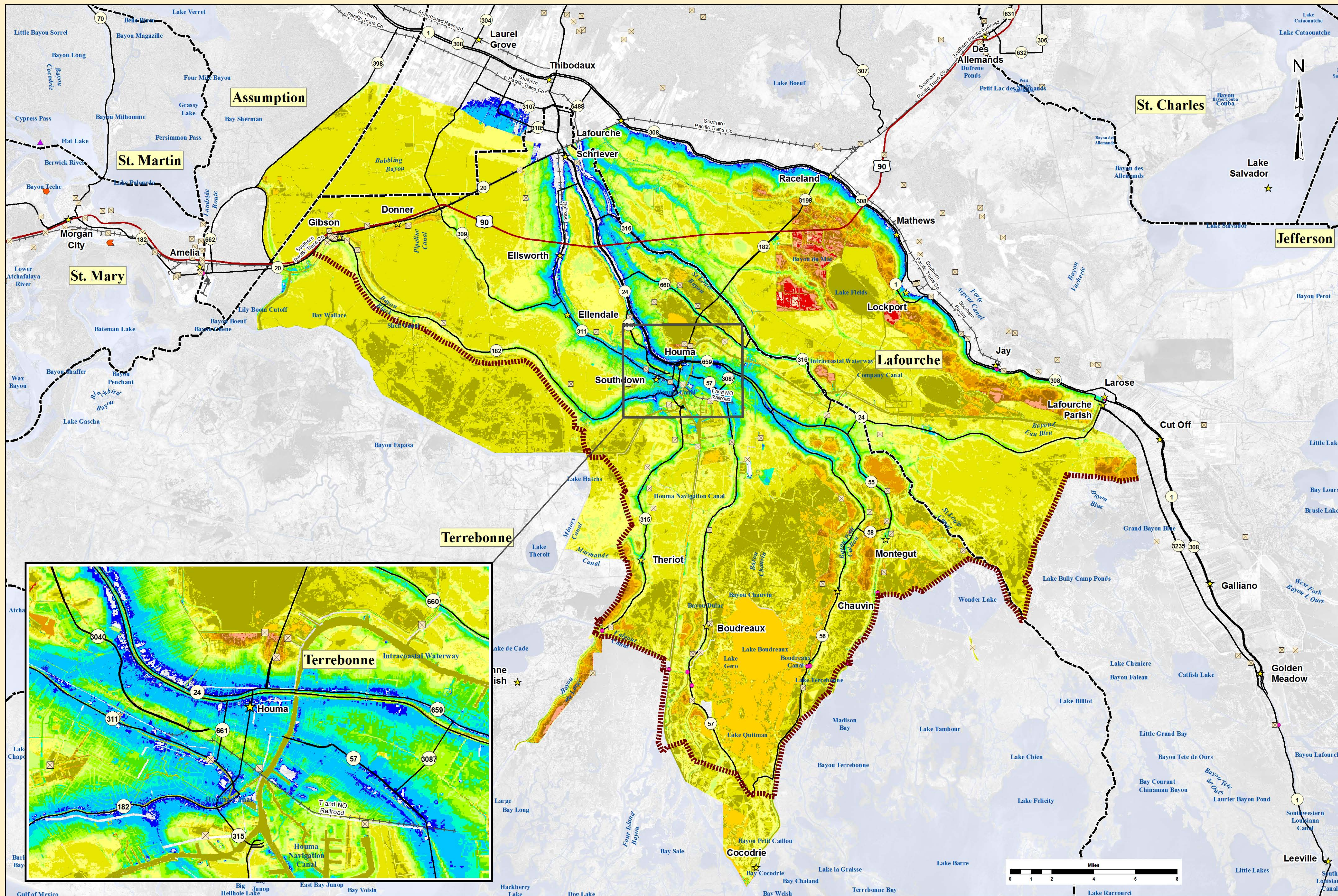
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Morganza to The Gulf
 MTOG Economic Reaches Behind Local Levees

Attachment 3 – Inundation Depth Maps

MTOG Inundation Depth Grid 2010 50-Year



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Legend

Inundation Depth Map 2010 50-yr

- 0 ft - 1 ft
- 1 ft - 2 ft
- 2 ft - 3 ft
- 3 ft - 4 ft
- 4 ft - 5 ft
- 5 ft - 6 ft
- 6 ft - 7 ft
- 7 ft - 8 ft
- 8 ft - 9 ft
- 9 ft - 10 ft
- 10 ft - 11 ft
- 11 ft - 12 ft
- 12 ft - 13 ft
- 13 ft - 14 ft
- 14 ft - 15 ft
- 15 ft - 60 ft

- MTOG Construction Reaches
- Lock
- Federal Water Control Structure
- Interim Control Structure
- Sector Gate
- Channel Floodgate
- Weir
- Control Structure
- Diversion Structure
- Drainage Structure
- Navigable Structure
- Cities
- Parishes

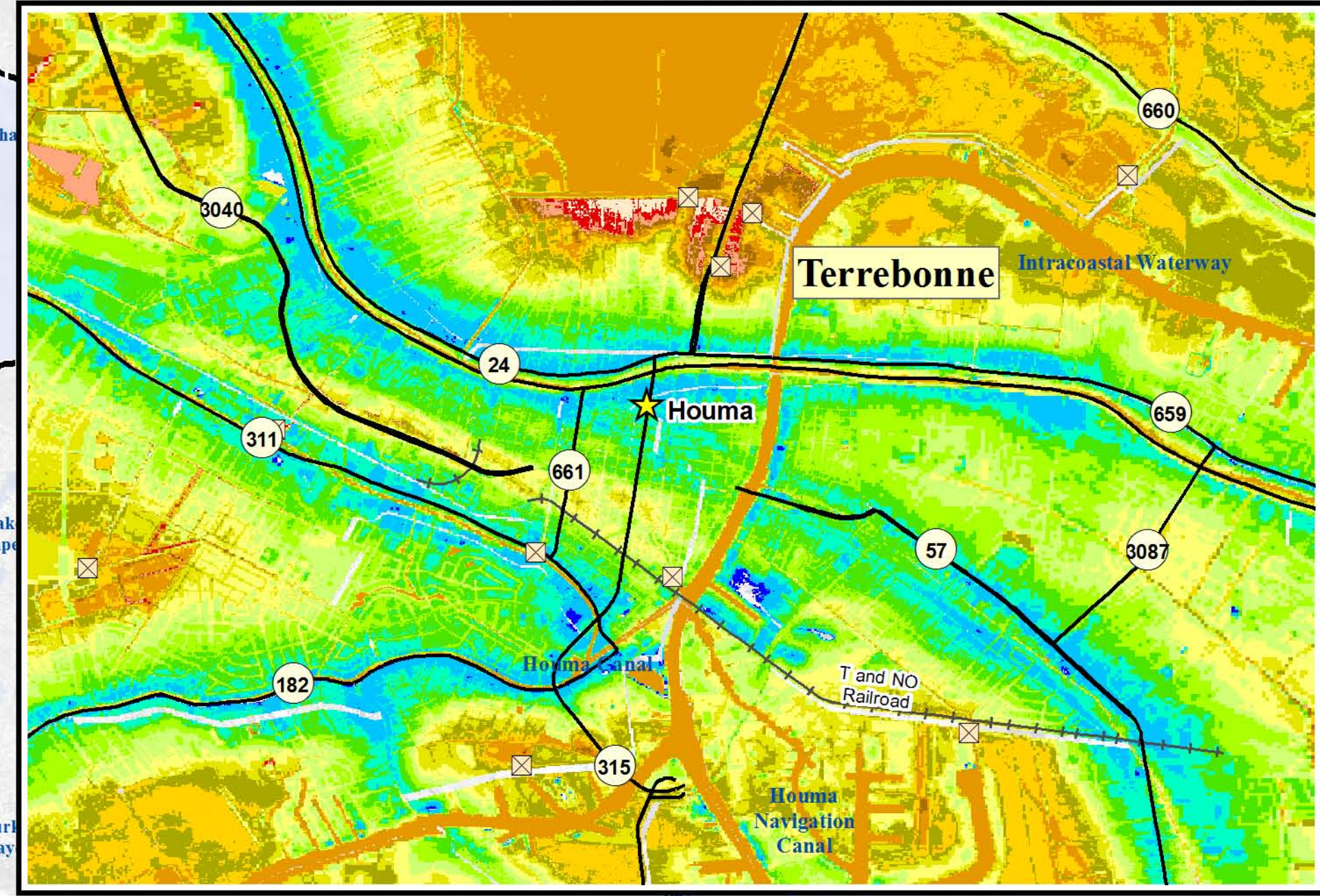
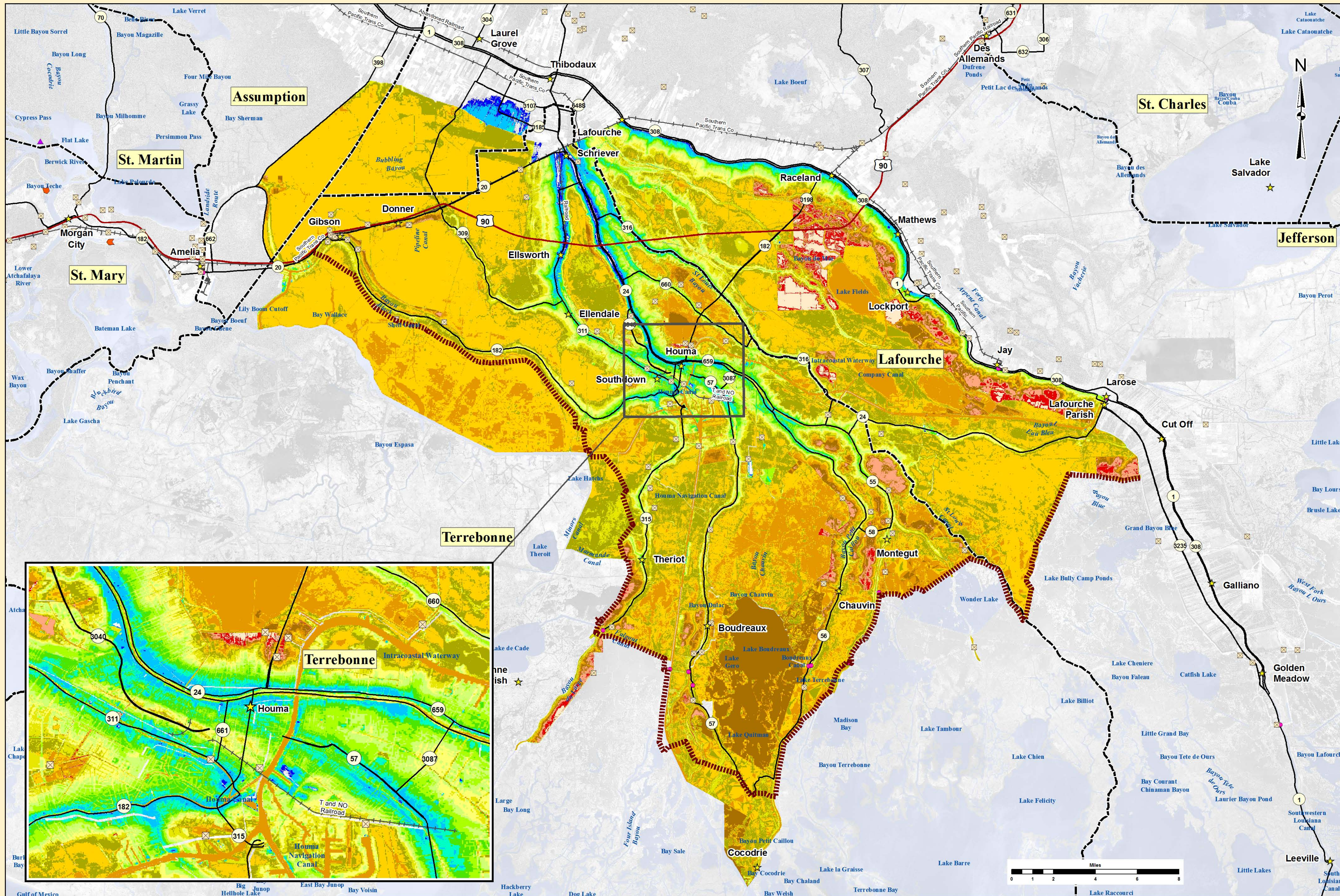
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Morganza to The Gulf
 Inundation Depth Grid
 2010 50-Year

MTOG Inundation Depth Grid 2010 100-Year



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Legend

Inundation Depth Map 2010 100-yr

- 0 ft - 1 ft
- 1 ft - 2 ft
- 2 ft - 3 ft
- 3 ft - 4 ft
- 4 ft - 5 ft
- 5 ft - 6 ft
- 6 ft - 7 ft
- 7 ft - 8 ft
- 8 ft - 9 ft
- 9 ft - 10 ft
- 10 ft - 11 ft
- 11 ft - 12 ft
- 12 ft - 13 ft
- 13 ft - 14 ft
- 14 ft - 15 ft
- 15 ft - 60 ft

- MTOG Construction Reaches
- Lock
- Federal Water Control Structure
- Interim Control Structure
- Sector Gate
- Channel Floodgate
- Weir
- Control Structure
- Diversion Structure
- Drainage Structure
- Navigable Structure
- Cities
- Parishes

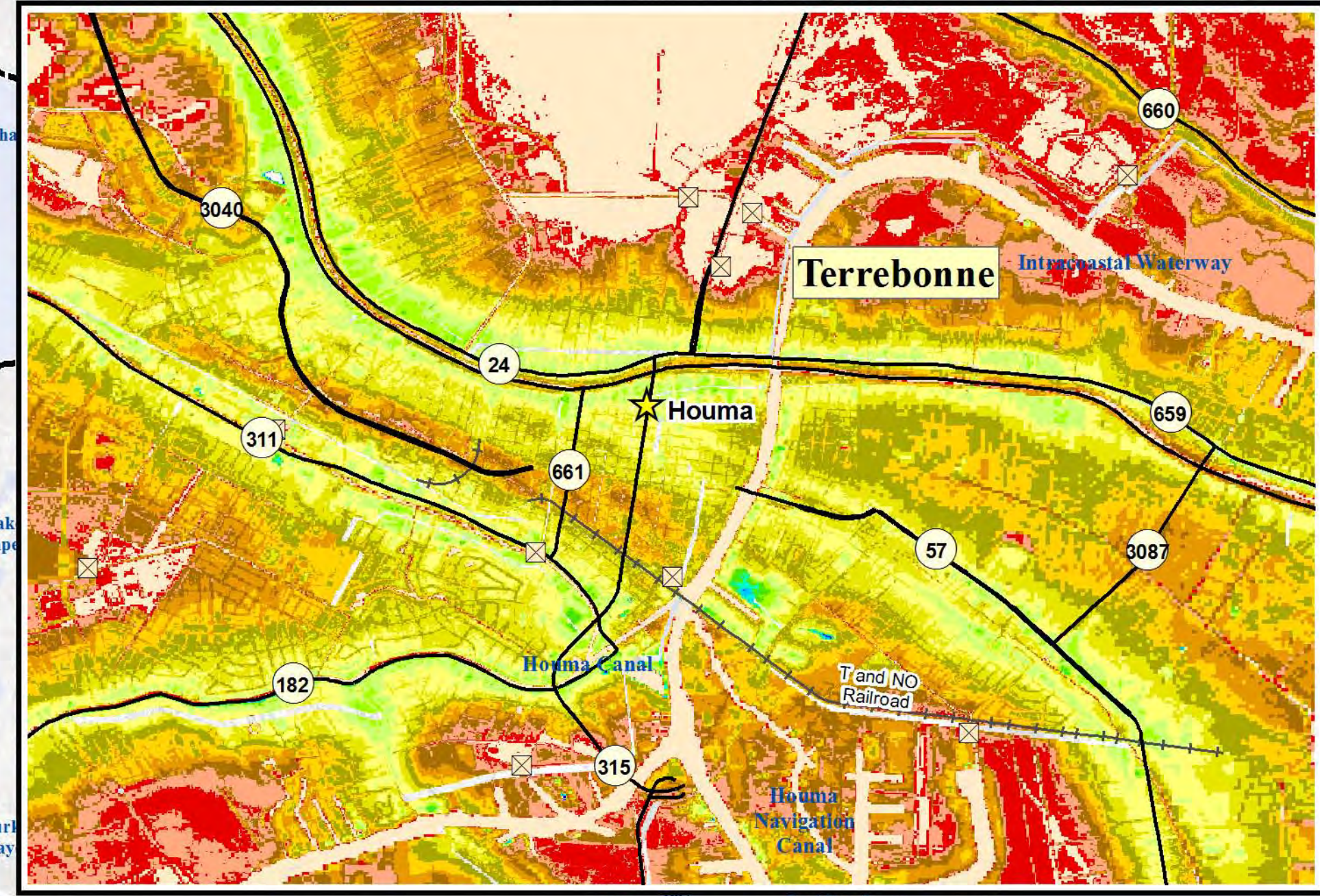
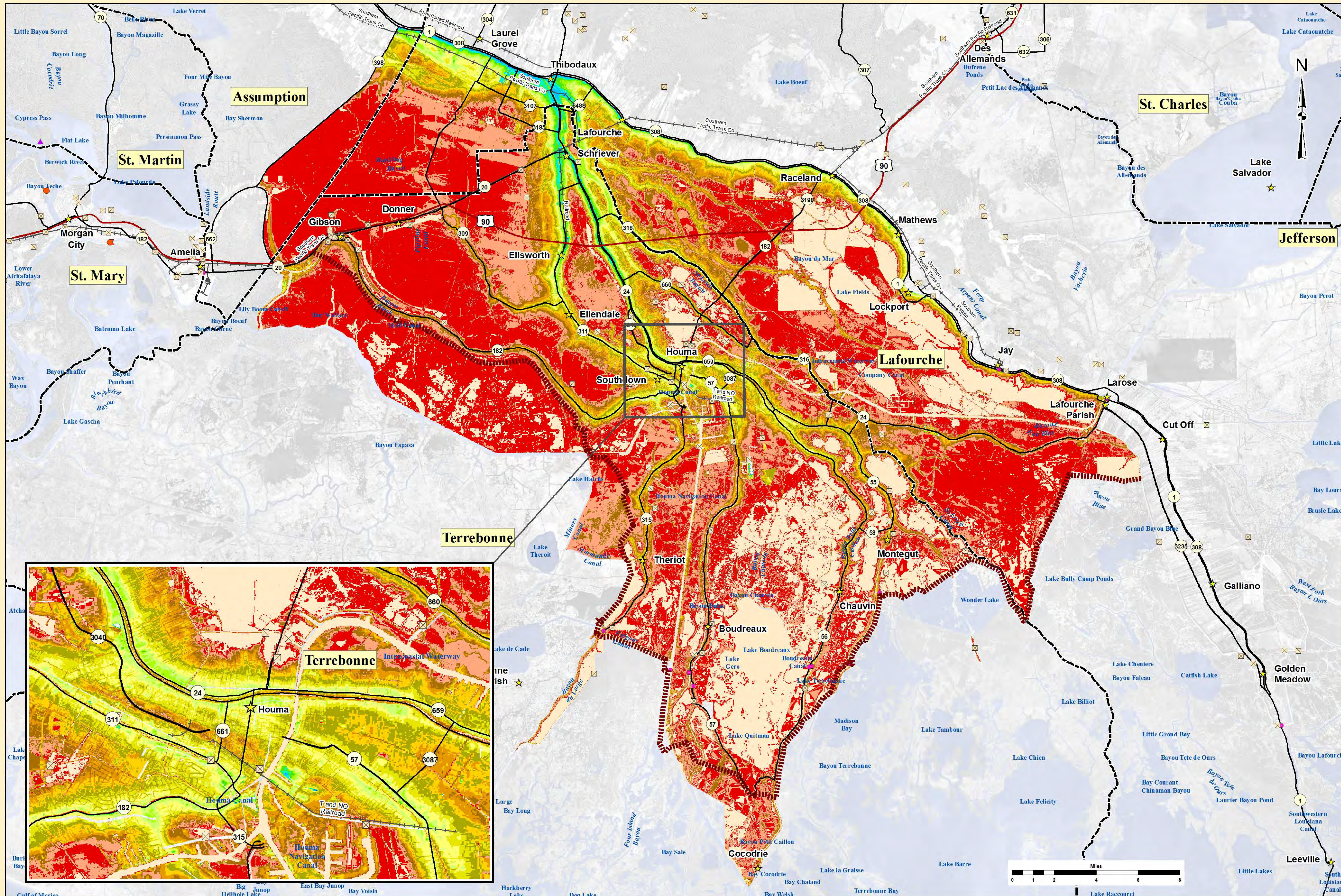
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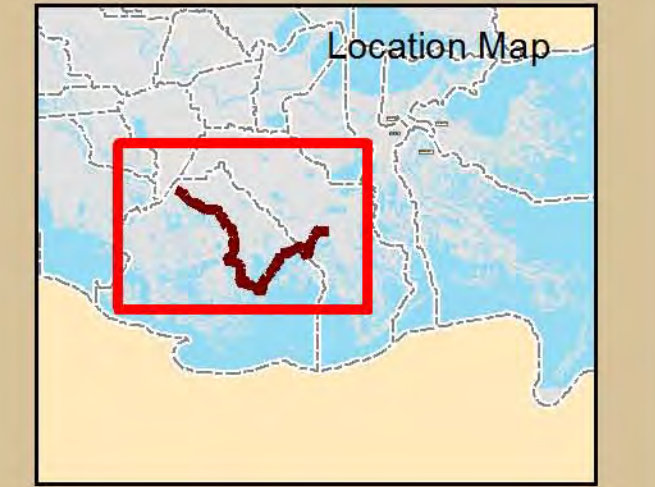
Morganza to The Gulf
 Inundation Depth Grid
 2010 100-Year

MTOG Inundation Depth Grid 2010 500-Year



- Legend**
- Inundation Depth Map 2010 500-yr**
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 - 1 ft - 2 ft
 - 2 ft - 3 ft
 - 3 ft - 4 ft
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 - 5 ft - 6 ft
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 - 9 ft - 10 ft
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 - 11 ft - 12 ft
 - 12 ft - 13 ft
 - 13 ft - 14 ft
 - 14 ft - 15 ft
 - 15 ft - 60 ft
- MTOG Construction Reaches
 - 🔒 Lock
 - 🏗️ Federal Water Control Structure
 - 🏗️ Interim Control Structure
 - 🌊 Sector Gate
 - 🌊 Channel Floodgate
 - 🌊 Weir
 - 🏗️ Control Structure
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 - 🏗️ Drainage Structure
 - 🏗️ Navigable Structure
 - ★ Cities
 - 🗺️ Parishes

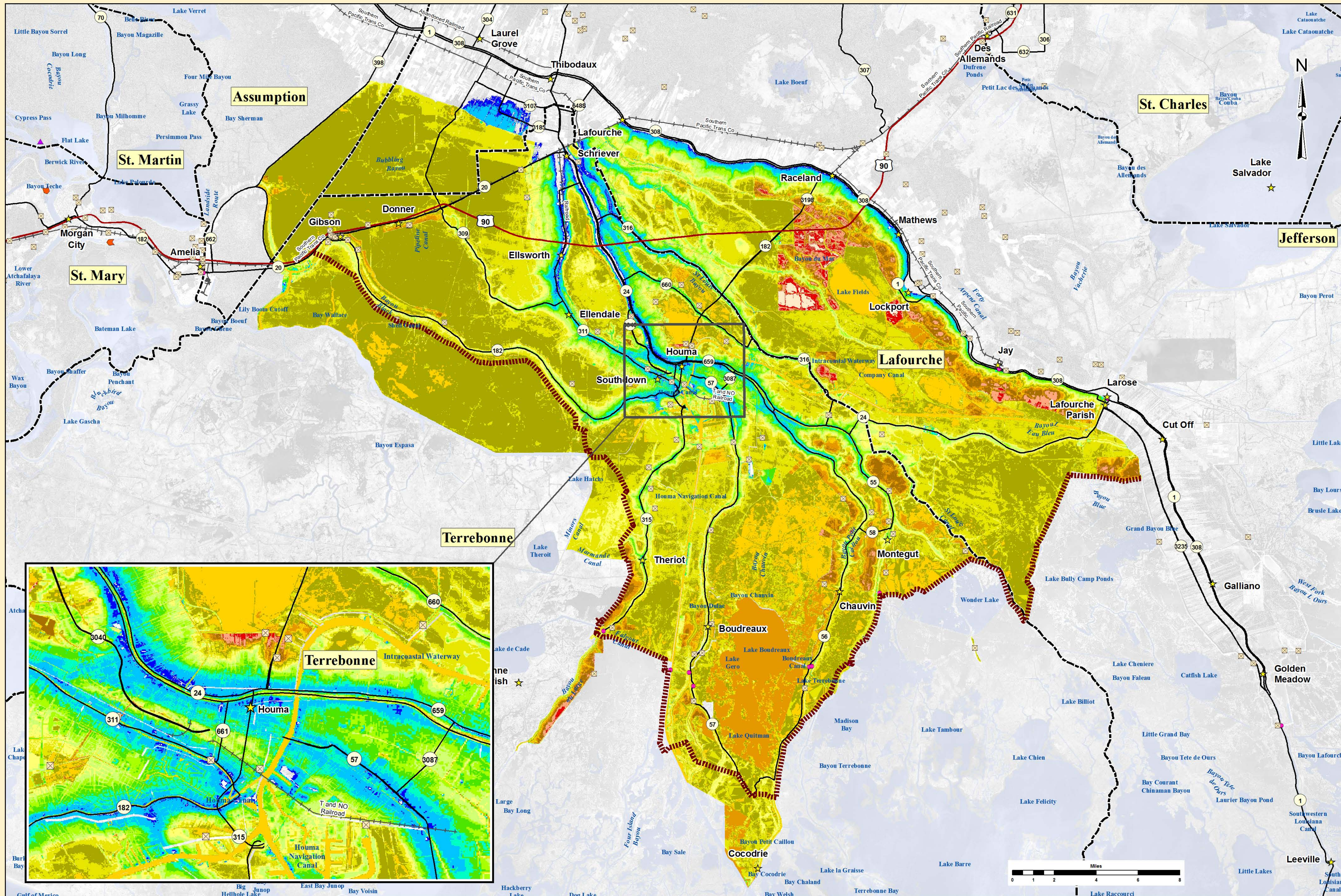
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Morganza to The Gulf
 Inundation Depth Grid
 2010 500-Year

MTOG Inundation Depth Grid 2035 50-Year





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Engineering Office

Legend


Inundation Depth Map 2035 50-yr

- 0 ft - 1 ft
- 1 ft - 2 ft
- 2 ft - 3 ft
- 3 ft - 4 ft
- 4 ft - 5 ft
- 5 ft - 6 ft
- 6 ft - 7 ft
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- 8 ft - 9 ft
- 9 ft - 10 ft
- 10 ft - 11 ft
- 11 ft - 12 ft
- 12 ft - 13 ft
- 13 ft - 14 ft
- 14 ft - 15 ft
- 15 ft - 60 ft

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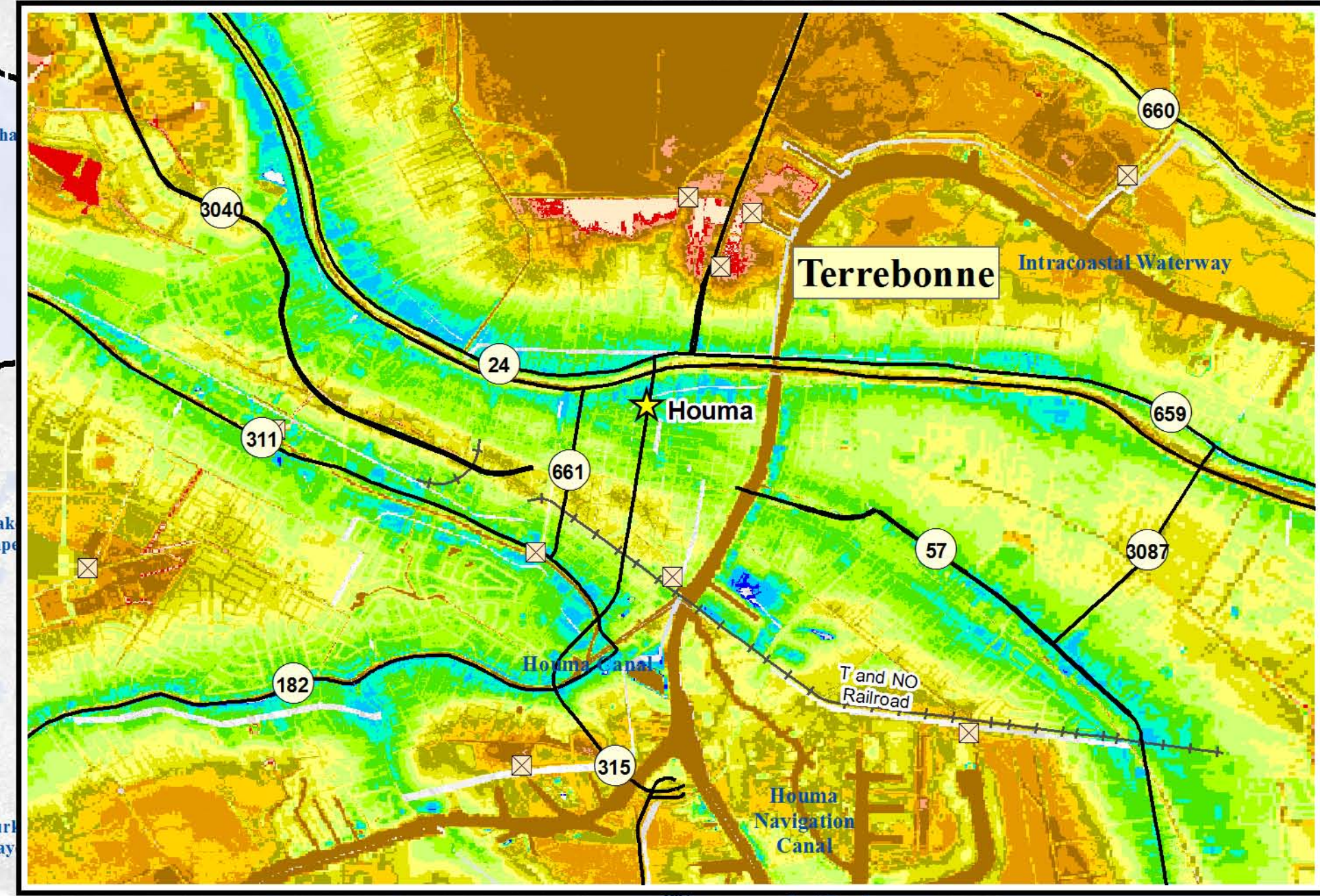
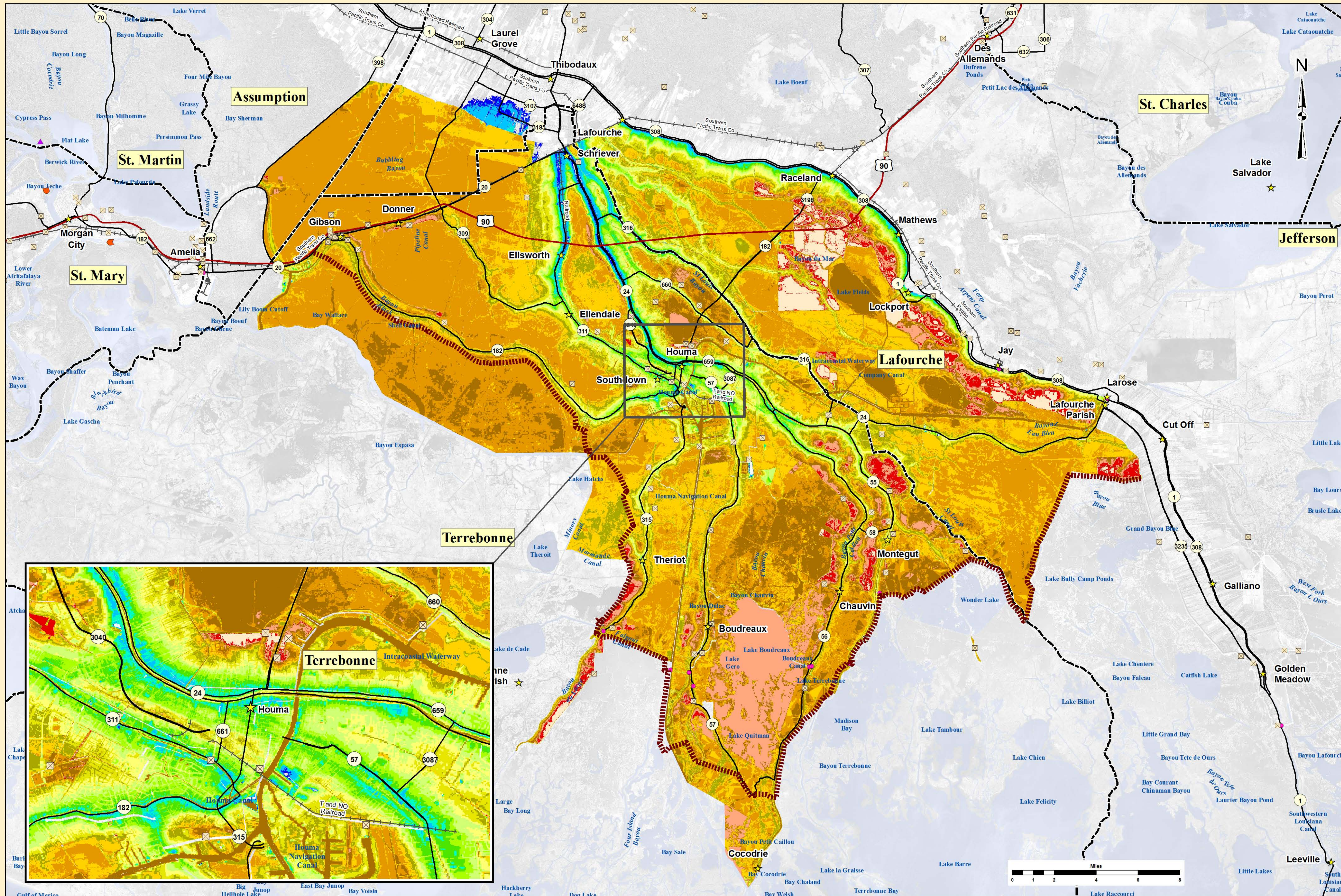
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Inundation Depth Grid
2035 50-Year

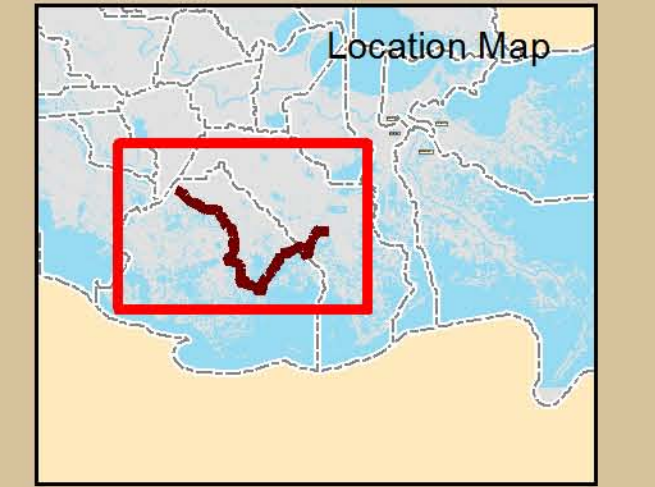
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- Legend**
- Inundation Depth Map 2035 100-yr**
- 0 ft - 1 ft
 - 1 ft - 2 ft
 - 2 ft - 3 ft
 - 3 ft - 4 ft
 - 4 ft - 5 ft
 - 5 ft - 6 ft
 - 6 ft - 7 ft
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 - 10 ft - 11 ft
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 - 12 ft - 13 ft
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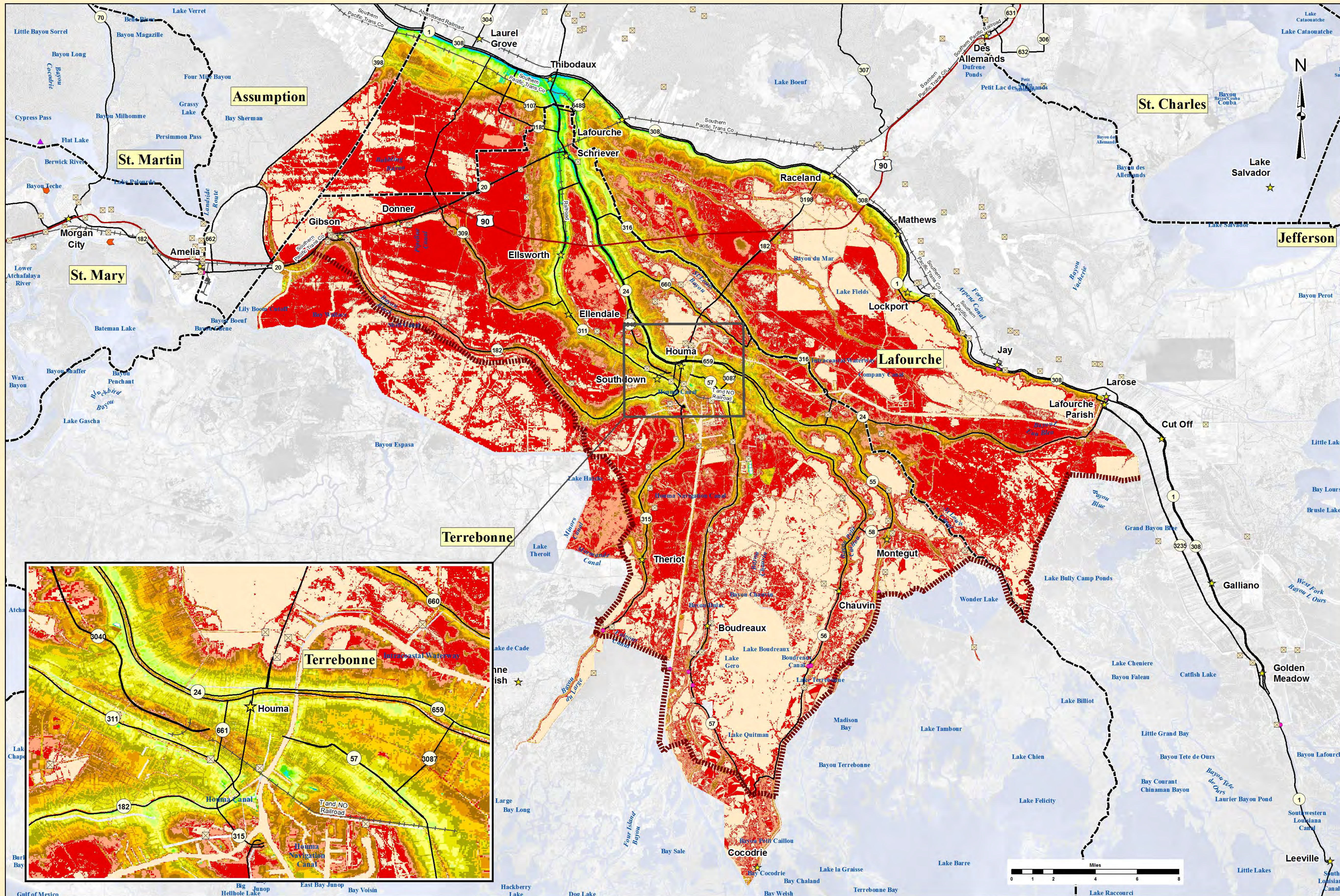
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Morganza to The Gulf
 Inundation Depth Grid
 2035 100-Year

MTOG Inundation Depth Grid 2035 500-Year



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Legend

Inundation Depth Map 2035 500-yr

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- 1 ft - 2 ft
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- 5 ft - 6 ft
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- 8 ft - 9 ft
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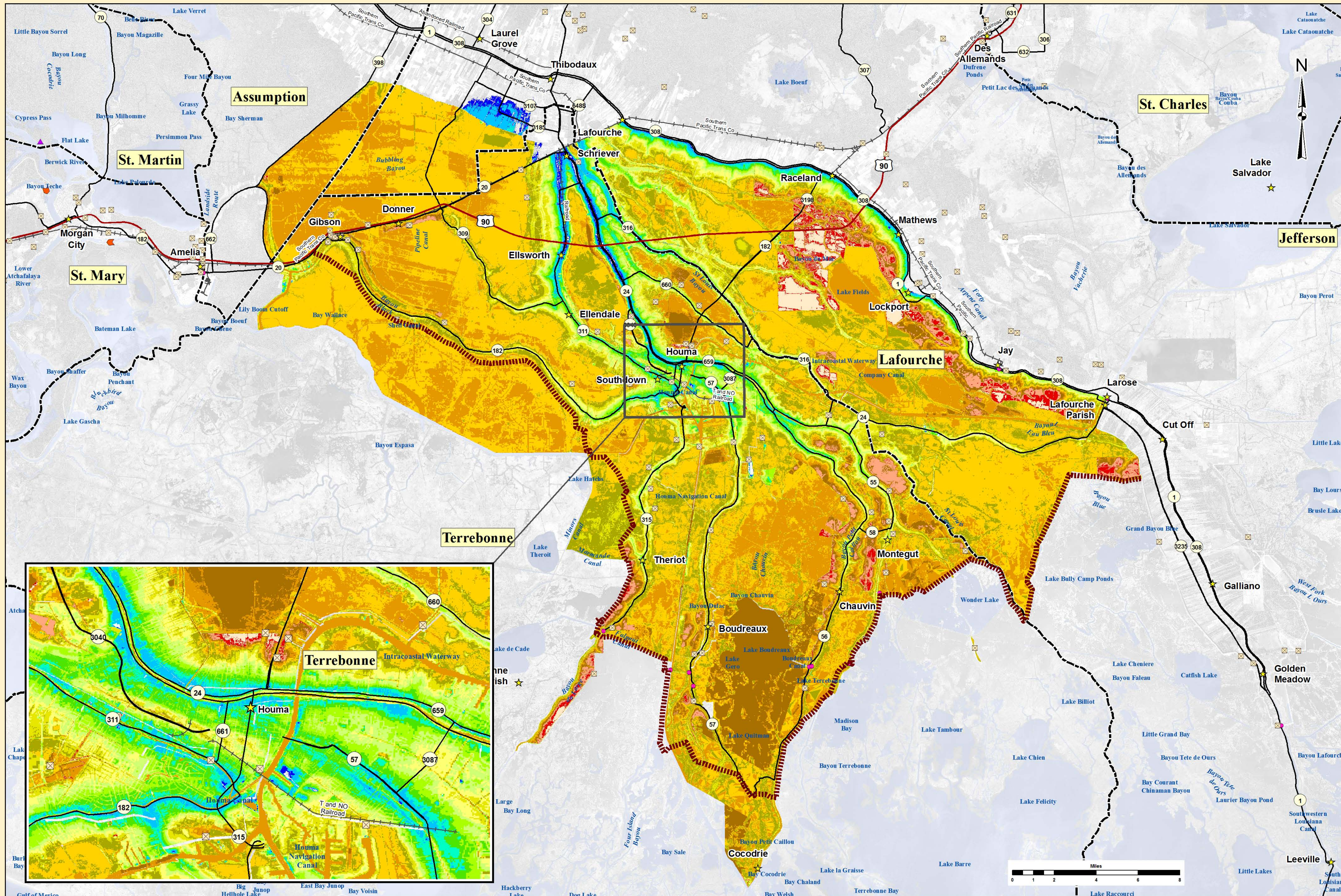
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Morganza to The Gulf
 Inundation Depth Grid
 2035 500-Year

MTOG Inundation Depth Grid 2085 50-Year





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Engineering Office

Legend


Inundation Depth Map 2085 50-yr

- 0 ft - 1 ft
- 1 ft - 2 ft
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- 10 ft - 11 ft
- 11 ft - 12 ft
- 12 ft - 13 ft
- 13 ft - 14 ft
- 14 ft - 15 ft
- 15 ft - 60 ft

- MTOG Construction Reaches
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- 🗺️ Parishes

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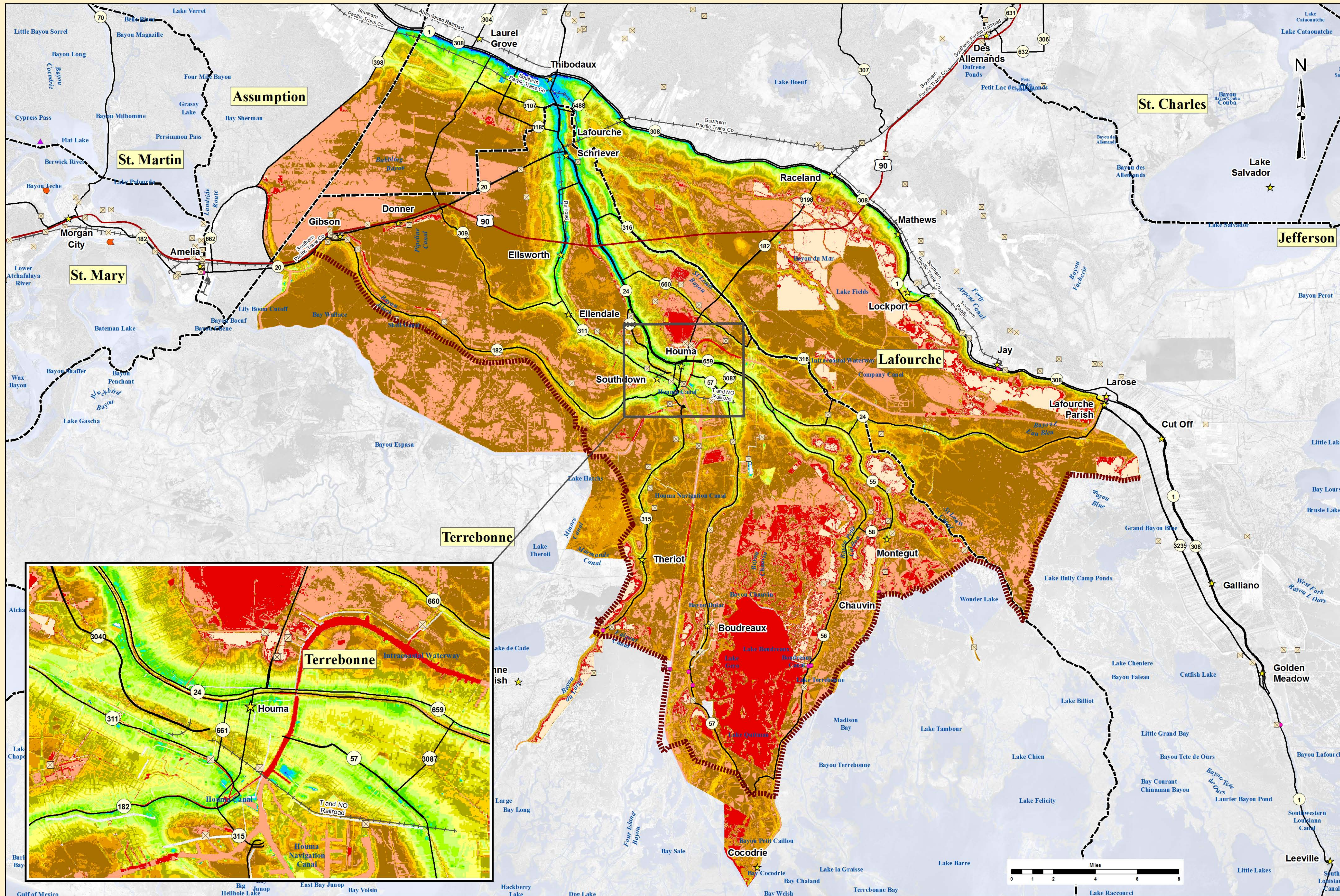
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Morganza to The Gulf
Inundation Depth Grid
2085 50-Year

MTOG Inundation Depth Grid 2085 100-Year



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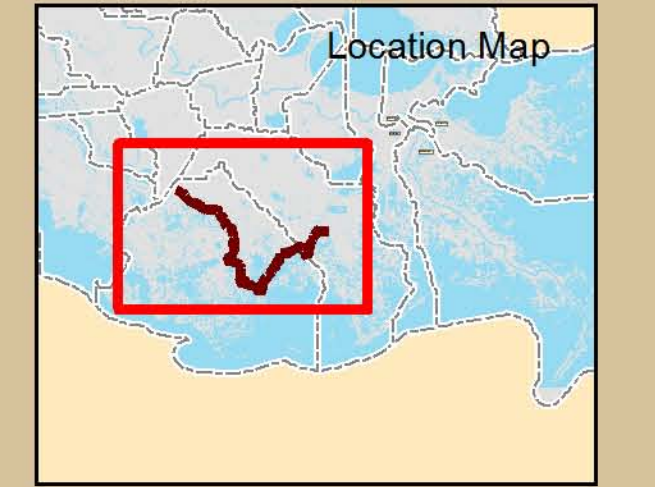
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Inundation Depth Map 2085 100-yr

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- 11 ft - 12 ft
- 12 ft - 13 ft
- 13 ft - 14 ft
- 14 ft - 15 ft
- 15 ft - 60 ft

- MTOG Construction Reaches
- 🔒 Lock
- 🏗️ Federal Water Control Structure
- 🏗️ Interim Control Structure
- 🚪 Sector Gate
- 🚪 Channel Floodgate
- 🚪 Weir
- 🏗️ Control Structure
- 🏗️ Diversion Structure
- 🏗️ Drainage Structure
- 🏗️ Navigable Structure
- ★ Cities
- 🗺️ Parishes

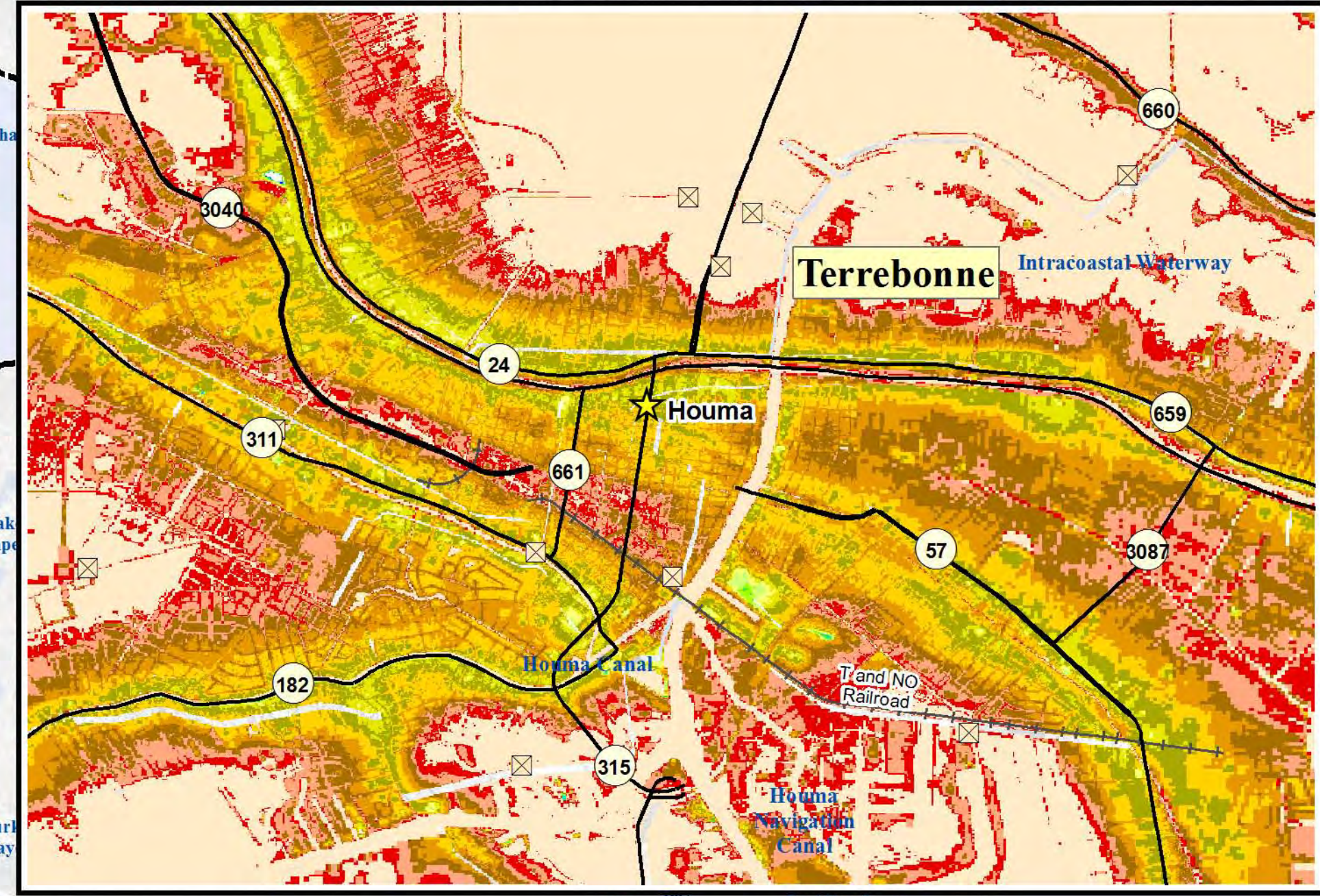
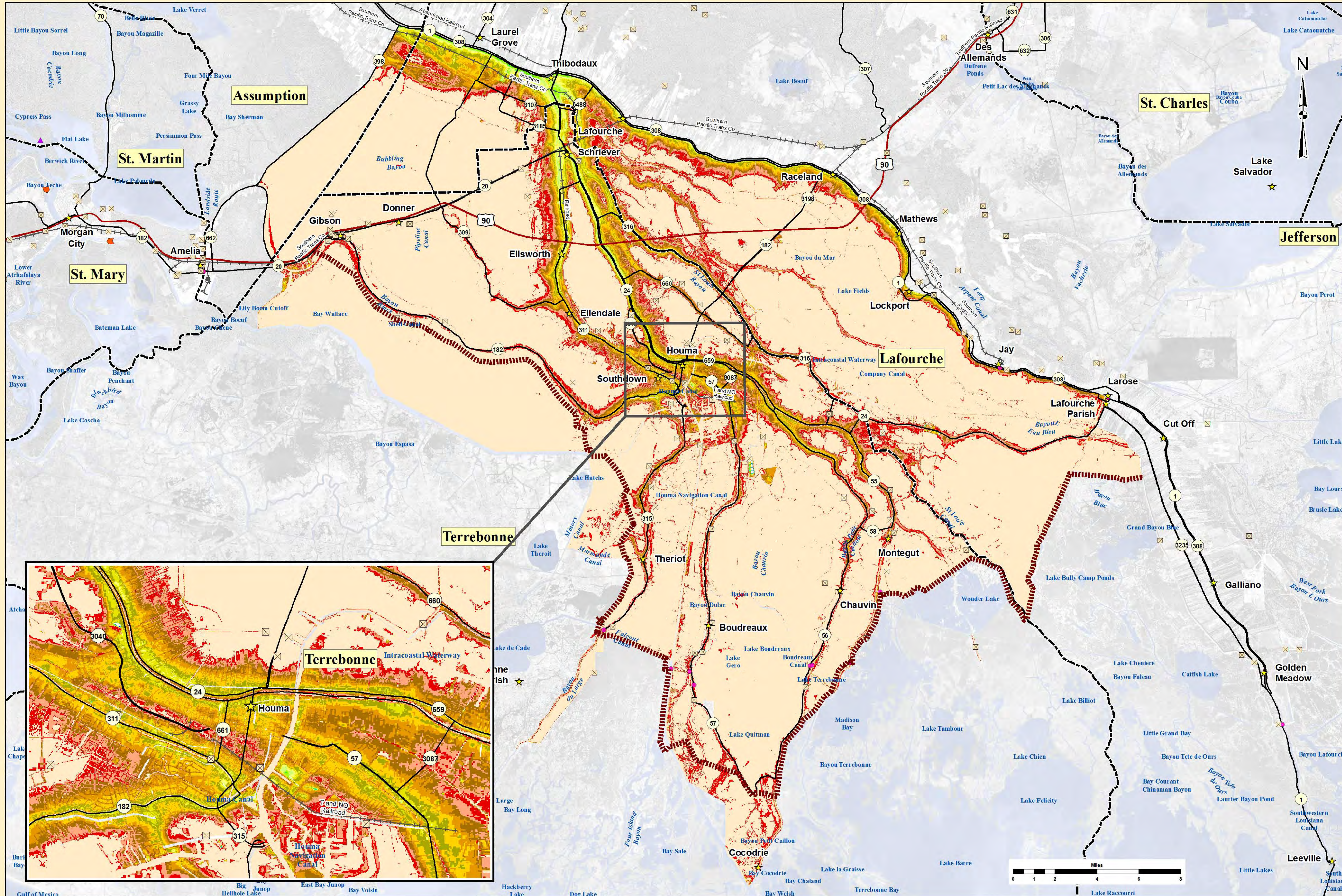
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IMAGERY
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 NAD_1983_UTM_Zone_15N
 Geographic coordinate system name:
 GCS_North_American_1983
 Resolution: 1.000000

Morganza to The Gulf
 Inundation Depth Grid
 2085 100-Year

MTOG Inundation Depth Grid 2085 500-Year





U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
Engineering Office

Legend

Inundation Depth Map 2085 500-yr

- 0 ft - 1 ft
- 1 ft - 2 ft
- 2 ft - 3 ft
- 3 ft - 4 ft
- 4 ft - 5 ft
- 5 ft - 6 ft
- 6 ft - 7 ft
- 7 ft - 8 ft
- 8 ft - 9 ft
- 9 ft - 10 ft
- 10 ft - 11 ft
- 11 ft - 12 ft
- 12 ft - 13 ft
- 13 ft - 14 ft
- 14 ft - 15 ft
- 15 ft - 60 ft

- MTOG Construction Reaches
- 🔒 Lock
- 🏗️ Federal Water Control Structure
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- 🟡 Channel Floodgate
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Morganza to The Gulf
Inundation Depth Grid
2085 500-Year

