High Water Mark Collection for Hurricane Katrina in Louisiana

FEMA-1603-DR-LA, Task Orders 412 and 419

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Abbreviations and Acronyms

Acronym	Definition
cfs	Cubic feet per second
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GPS	Global Positioning System
HMGP	Hazard Mitigation Grant Program
HMTAP	Hazard Mitigation Technical Assistance Program
HWM	High Water Mark
HWM ID	High Water Mark Identification Number
IA	Individual Assistance
LA	State of Louisiana
LA DNR	Louisiana Department of Natural Resources
LAT	Latitude
LON	Longitude
mb	Millibar
mph	Miles Per Hour
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NGS	National Geodetic Survey
NGVD 29	National Geodetic Vertical Datum of 1929
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PA	Public Assistance
QA	Quality Assurance
RV	Recreational Vehicle
SLOSH	Sea, Lake and Overland Surges from Hurricanes
TBM	Temporary Bench Mark
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

Glossary of Terms

Term	Definition
Astronomical Tide	The periodic rising and falling of the earth's ocean waters resulting from the gravitational attraction of the Moon, Sun and other astronomical bodies acting upon the rotating earth.
Building Performance Assessment	The structural assessments of how buildings hold up during a storm event.
Coastal Flooding	Onshore rush of water piled higher than normal as a result of high winds on an open water body's surface.
Debris Line	Defines the extent of flooding where debris such as parts of houses, docks, cars, or other non-natural materials are carried by flood waters with some velocity and then dropped as the flood waters lose velocity and begin to recede.
Disaster declaration	The formal action by the President that makes a State eligible for major disaster or emergency assistance under the Stafford Act.
Flagging	Marking or otherwise documenting the horizontal and vertical location of a high water mark so that the high water mark data is preserved for future surveying. This data will then be available even if the homeowner cleans the property or it rains and therefore eliminates the visible high water mark.
Flood recovery map	High-resolution maps that show flood impacts, including high water mark flood elevations, flood inundation limits, the inland limit of waterborne debris (trash lines), and storm surge elevation contours based on the high water marks. The maps also show existing FEMA Flood Insurance Rate Map (FIRM) flood elevations for comparison to hurricane data.
Hazard Mitigation Grant Program	A FEMA program that provides grants to States and local government to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster.

Term	Definition
High Water	The maximum elevation that flood waters reach as a result of a storm event.
High Water Mark	A physical mark, such as a mud line, that designates the location and elevation of flood waters from a storm event.
Individual Assistance	Federal assistance provided to families or individuals following a major disaster or emergency declaration. Under a major disaster declaration, assistance to individuals and families is available through grants, loans, and other services offered by various Federal, State, local, and voluntary agencies.
Inundation Maps	Maps that delineate the areas flooded during a storm.
Levee-related flooding	Flooding that is a result of the severe overtopping, breach, leaking, or failure of the hurricane surge protection system, including levees, floodwalls, floodgates, pumps, etc.
Millibar	A unit of atmospheric pressure equal to one thousandth of a bar. Standard atmospheric pressure at sea level is about 1,013 millibars.
Mitigation	Any measure that reduces or eliminates the long-term risk to life and property from a disaster event.
National Flood Insurance Program	The Federal program created by an Act of Congress in 1968 that makes flood insurance available in communities that enact and enforce satisfactory floodplain management regulations.
National Geodetic Vertical Datum of 1929	Vertical control datum that was widely used in the U.S. prior to the establishment of NAVD 88.
North American Datum of 1983	Used as the standard map horizontal coordinate system default by the majority of GPS devices.
North American Vertical Datum of 1988	The most widely used vertical control datum in the U.S. today. It was established by the minimum-constraint adjustment of the Canadian-Mexican-U.S. leveling observations. The general adjustment of NAVD 88 was completed in June 1991.
Point	A point associated with a discrete geographic location where data pertaining to the study were taken.
Public Assistance	Federal assistance provided to State and local governments, Native American Tribes, and certain non-profit organizations after a disaster declaration. The assistance is for the repair, replacement, or restoration of

Term	Definition
	disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations. The Federal share of assistance is not less than 75 percent of the eligible cost for emergency measures and permanent restoration. The State determines how the non-Federal share (up to 25 percent) is split with the applicants.
Riverine Flooding	Flooding that is a result of elevated levels of a river due to heavy rainfall. This term is also used in Louisiana to reference flood levels influenced by coastal surge but contained by the Mississippi River levee system.
SLOSH	Stands for "Sea, Lake and Overland Surges from Hurricanes," a computer model used by coastal scientists and engineers to predict the level of coastal flooding during a hurricane.
Stage	A term used by water resource professionals to indicate the elevation of the water.
Surge-only	A rise in the normal water level of a coastal body, also referred to as Stillwater flooding.
Temporary Bench Mark	A point (often a nail or stake) set near a high water mark. The vertical distance between the high water mark and temporary bench mark is measured by the personnel setting the temporary bench mark. Surveyors then survey the location and elevation of the temporary bench mark. The measured vertical distance between the high water mark and temporary bench mark is added to the temporary bench mark elevation to compute the elevation of the high water mark.
Water mark	A mark, usually on structures, left by flood waters.
Wave Height	Represents the coastal high water mark elevation due to direct wave action.
Wave Runup	Represents the height of water rise above the surge-only level due to water rush up from a breaking wave.
Wind Water Line	An approximate boundary to delineate the inland extent of the area where structures were damaged as a result of flooding from storm surge from a particular event. Landward of the line, most of the damage is attributable to winds and/or wind-driven rain. Sometimes, the wind water line is located along the debris line, but in some cases, inundation and flood damage extends beyond the area where major debris was deposited.

Term	Definition
Wrack line	Defines the extent of flooding where organic type debris such as grass and weeds are carried by flood waters and left behind as the flood waters recede.

Executive Summary

Introduction and Purpose of the Study

The Federal Emergency Management Agency (FEMA) contracted URS Group, Inc. (URS) under Rapid Response Task Orders 412 and 419 of the Hazard Mitigation Technical Assistance Program (HMTAP) contract to assist in the disaster recovery in Louisiana following Hurricane Katrina by collecting high water marks (HWMs). HWMs collected were classified as either a result of coastal flooding (caused by storm surge), riverine flooding (caused by rainfall), or related to levee issues. This study documents the HWM survey conducted in Louisiana Parishes along the coast and streams following Hurricane Katrina, which began affecting the area on August 29, 2005.

The purpose of this study was to document maximum flooding elevations that occurred as a result of Hurricane Katrina by collecting HWMs in affected areas. HWM data collection helps accurately document a flooding event and assists in response, recovery, and mitigation, for future disasters. These HWM data help place the event within a historical context, improve estimates of current flood risk, and enable governments to make cost-effective decisions about mitigation efforts.

Methodology

HWMs are perishable, and it was important to quickly capture HWM information before the HWMs disappeared. Consequently, field work first involved locating and flagging representative HWMs. Flagging captured information regarding the location and description of the HWM so that it could be surveyed, even if the markings had been cleaned.

URS flagged approximately 380 HWMs during the rapid response field assignment, which began on August 30, 2005 with a Notice to Proceed from FEMA. URS initiated data collection to determine the HWM study area on August 31, 2005. An orientation meeting was held for Louisiana field staff on September 8, 2005 in Baton Rouge. URS deployed field staff to the accessible areas of Louisiana on September 9, 2005.

After receiving the Notice to Proceed, URS placed calls to Federal, State, and parish emergency managers in Louisiana; reviewed available gage information; and obtained preliminary coastal storm surge elevation modeling prepared by the National Hurricane Center. The data indicated that the 13 southeast parishes of Louisiana received the most significant flooding; therefore, these parishes became the study area.

Two-person flagging teams were assigned a geographic area in which to identify and flag HWMs, as indicated by mud lines, water lines, debris lines (i.e., man-made materials), or wrack lines (i.e., plant materials). In coastal areas, multiple HWMs were flagged in the same area to document different coastal flood types (i.e., surge-only, wave height, or wave runup) or to better determine flood elevation. The height of flood waters can be affected by outside forces such as wind and shielding by other structures. Therefore, in significantly damaged areas, and if available, multiple HWMs were obtained in the same area to provide better flood elevation data. In many areas, Hurricane Katrina caused extensive damage, leaving few structures standing, and in these areas it was difficult to find HWMs.

In addition, the U.S. Geological Survey (USGS) flagged approximately 100 HWMs. The URS team surveyed the HWMs flagged by both URS and the USGS. The survey crews used static global positioning system (GPS) methods and conventional leveling to determine the HWM elevations and post-processed mapping-grade GPS receiver data to establish the horizontal coordinates (latitude and longitude). HWMs were surveyed in the North American Datum of 1983 (NAD 83), Louisiana State Plane Coordinates (South Zone) and North American Vertical Datum of 1988 (NAVD 88). The HWMs were surveyed to an accuracy of 0.25 foot vertically and 10 feet horizontally with a 95% confidence accuracy level. The newly released set of 86 National Geodetic Survey controls was used to address the subsidence issues in Louisiana.

Coastal and Levee HWM Observations

The coastal flooding for Hurricane Katrina was significant and brought widespread devastation along the Louisiana coast. Overall the storm surge in south-central Louisiana was low because the storm made landfall in the eastern part of the state. The areas of greatest impact were those where the highest winds generated in the right-front quadrant of the storm, pushing the water toward the coast where the topography of the land surface was such that it caused a piling up of the water. The following observations pertain to elevations that are referenced to NAVD 88. It should be noted that in most of the leveed portions of Louisiana, the land elevation is negative, perhaps as low as several feet below sea level. Therefore, the depth of flooding may be higher than the surveyed flooding elevation.

Lake Pontchartrain Area

The topography of the area created a situation in which storm winds blowing from the east forced water into Lake Pontchartrain from the Gulf of Mexico. This caused the elevation of the lake to rise as Hurricane Katrina made landfall. Hurricane Katrina caused levee-related flooding in several parishes due to either internal flood control issues or breaches in the levee system. Along both the northern and southern shorelines there was a general pattern of higher elevations on the eastern end of Lake Pontchartrain trending to lower elevations on the western end. Recorded elevations range from 16.6 feet on the eastern end down to 6.6 feet on the western end.

Northern Shore: St. Tammany and Tangipahoa Parishes

The increased volume of water was forced into Lake Pontchartrain by hurricane winds. This caused water to pile up on the north shore of the lake and resulted in storm surge extending north as far as US Highway 190 in Slidell and to Interstate 12 north of Mandeville. HWMs recorded flooding elevations ranging from 7 to 16 feet, with the general trend of the highest values on the east end of the north shore working westward to lower surge values. Coastal flooding elevations of 10.5 to 13.5 feet were recorded in the Slidell vicinity.

Western Shore: Livingston, St. John the Baptist, and St. Charles Parishes

More moderate storm surge elevations were noted on the western shore of Lake Pontchartrain. Storm surge was dampened by a network of natural, road, and railroad embankments and extensive marsh and swampland in this area. The presence of marsh and swampland limited the collection of reliable HWMs. Flooding elevations in this area ranged from 2.8 feet inland west of Lake Maurepas in Livingston Parish to 6.4 feet in St. Charles Parish.

Southern Shore: East Jefferson, Orleans and St. Bernard Parishes

Orleans and St. Bernard Parishes, as well as part of Jefferson Parish, are protected by a levee system consisting of four main basins, which are each protected by its own perimeter levee system and dewatering pumps. These basins are generally referred to as East Jefferson, Orleans East Bank, New Orleans East, and St. Bernard. HWMs elevations in the Orleans East Bank area, which includes the portion of Old Metairie in Jefferson Parish south of Metairie Road, ranged from 2.3 to 2.7 feet. HWMs elevations in the New Orleans East area ranged from -1.1 to -1.5 feet north of the Chef Meneur Highway Ridge and 2.0 to 2.5 feet south of the ridge. In the St. Bernard Basin, which includes the Lower Ninth Ward in Orleans Parish, HWMs elevations ranged from 10 to 11 feet. HWMs in East Jefferson (North of the Mississippi River) ranged from -3.3 to -4.1 feet.

Gulf Coast Area

Coastal St. Bernard and Plaquemines Parishes

Locating HWMs outside of the levee system in St. Bernard Parish was difficult due to the level of devastation and lack of structures. Two HWMs were located with surveyed elevations of 17.1 feet (Reggio) and 17.7 feet (Yscloskey).

Plaquemines Parish is divided by the Mississippi River. Large levees were constructed along both sides of the Mississippi River and back/hurricane levees were constructed on the coastal side of communities located along the river to protect them from hurricane surges from the Gulf of Mexico. During Hurricane Katrina, Plaquemines Parish was flooded by the coastal surge. In some areas, the back/hurricane levees were significantly overtopped. In other locations, it appears that there was less overtopping of the back/hurricane levees.

West Jefferson, Lafourche, and Terrebonne Parishes

The southern coastal parishes were less affected by Hurricane Katrina because they were in the southwest (left and trailing) quadrant of the wind field created by the storm. West Jefferson (south of the Mississippi River), Lafourche, and Terrebonne Parishes are sparsely populated with few roads giving access and are extensively covered by marshland and swamp. This marshland and swamp area has a dampening effect on coastal surges as they move inland; marshes and swamps also reduce access to obtain quality HWMs. As Hurricane Katrina tracked farther inland on its northeastern path, the water in Barataria Bay was pushed southward over Grand Isle in Jefferson Parish. HWM elevations were the highest in this portion of the coastal area, measuring between 5.8 and 8.9 feet.

Riverine HWM Observations

North of Lake Pontchartrain

The HWMs from riverine flooding were found in St. Tammany, Tangipahoa, and Washington Parishes north of Lake Pontchartrain and along the Mississippi River in Louisiana. However, most of these HWMs were found near the stream channel. It appears that riverine flood elevations resulting from Hurricane Katrina were typically low and therefore had limited impact on buildings.

Mississippi River

HWMs were identified within the levees containing the Mississippi River in Jefferson, Plaquemines, St. Charles, St. James, and St. John the Baptist Parishes. In these parishes, the Mississippi River HWMs ranged from 12.9 to 17.9 feet. The higher elevations in Jefferson Parish show the impact of the hurricane surge up the river. It appears that generally the Mississippi River was contained within the river levees, since flooding of structures from the Mississippi River was not observed.

1. Introduction

1.1 General

The Federal Emergency Management Agency (FEMA) contracted URS Group, Inc. (URS) under Task Orders 412 and 419 of the Hazard Mitigation Technical Assistance Program (HMTAP) contract to assist in the disaster recovery in Louisiana following Hurricane Katrina by collecting high water marks (HWMs). Consequently, this study documents the HWM survey conducted in Louisiana Parishes along the coast and streams following Hurricane Katrina. The effects of Hurricane Katrina were first observed on August 29, 2005, as the storm made landfall along the Gulf Coast of the United States.

This study was performed as part of the Rapid Response Task Orders issued to help FEMA assess storm conditions for its Mitigation Program. The study was conducted in 13 of Louisiana's Parishes: Jefferson, Lafourche, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Tammany, Tangipahoa, Terrebonne, and Washington (Figure 1). The URS team for these Task Orders includes URS and its subconsultants ESP Associates, Michael Baker Jr., Inc., and Watershed Concepts.

Figure 1 – Louisiana Parishes Where HWMs Were Collected

This report provides information on coastal, riverine, and levee-related flooding. Although FEMA provided separate Task Orders for coastal and riverine flooding, URS combined the data into one report because the significant riverine flooding and levee-related flooding during Hurricane Katrina occurred in the coastal counties. As such, it was often difficult to distinguish HWMs resulting from the three flooding types.

Section 1 of this report summarizes the purpose of the Task Orders and provides an overview of related projects and an overview of Hurricane Katrina. The remaining sections of the report discuss the methodology used to collect the HWMs, explain the types of flooding, summarize the FEMA Rapid Response Task Orders, and condense the results from the HWM collection efforts. The appendices include the detailed results from the HWM survey.

1.2 Purpose

After significant flooding from a hurricane, it is imperative to collect data rapidly to: document the event; assist in response, recovery, and mitigation; and improve disaster preparedness and prevention for future disasters. HWM data collection is an initial step in accurately documenting an event. These data help place the event within a historical context, improve estimates of current flood risk, and enable government agencies to make predictions about potential future flooding to assist with mitigation efforts.

Collection of site-specific high water data along rivers, bays, coasts and levees has numerous applications. The purpose of this study was to document the maximum flooding elevations that occurred as a result of Hurricane Katrina. There are a number of uses of the HWM elevation data, including:

- Estimate storm frequency and severity
- Assess accuracy of the Flood Insurance Rate Maps (FIRMs)
- Assist in preparation of Wind Water Line Maps
- Prepare Inundation Maps
- Share information for Building Performance Assessments
- Share information for calibrating models that simulate the storm
- Assist in prioritizing mitigation projects and preparing their benefit/cost analysis
- Determine depth of flooding of structures

Specific FEMA programs that directly benefit from post-disaster flood data collection include:

- Individual Assistance – provides Unmet Needs and Temporary Disaster Housing Grants;
- Public Assistance – identifies appropriate flood mitigation measures to pursue when providing Federal grants to repair publicly owned infrastructure;
- Hazard Mitigation Grant Program – ensures that accurate benefit/cost analysis is performed; and
- National Flood Insurance Program – provides insurance claim information, floodplain management, and flood hazard identification.

1.3 Overview of Related Projects

After Hurricane Katrina, FEMA issued several Task Orders under the HMTAP contract, which are referred to as "Rapid Response Task Orders." The purpose of these Task Orders was to allow FEMA contractors to move quickly into disaster-stricken areas to collect perishable data for use in defining the parameters of the event; these parameters can be used for future studies and flood mitigation activities. In addition to the HWM Task Orders, there were several other Rapid Response Task Orders, including Aerial Imagery Data Collection and Wind Water Line Data Collection Task Orders. HWM survey findings are used to define the extent of flooding, and therefore can be used in conjunction with field findings from Wind Water Line Task Orders to determine the location of the wind water line. Aerial imagery is also used to estimate the wind water line. Post-event imagery can be used to identify areas affected by flood damage, as well as the approximate inland extent of storm-surge flooding. Topographic data collected with the aerial imagery was also used to evaluate the HWM elevations.

In response to Katrina, FEMA issued several Rapid Response Task Orders. This included HMTAP Task Order 412, *Rapid Response, Hurricane Katrina Coastal High Water Mark Survey – Louisiana* and HMTAP Task Order 419, *Rapid Response, Hurricane Katrina Riverine High Water Mark Survey – Louisiana.* Task Orders 412 and 419 are the focus of this report. In addition, the following related Task Orders were issued.

- HMTAP Task Order 411 *Rapid Response, Aerial Radar – Louisiana, Mississippi and Alabama*. Under Task Order 411, cartographic analysts were tasked with using post-event aerial imagery to delineate areas affected by flooding along the Louisiana Coast, with a focus on New Orleans.
- HMTAP Task Order 415, *Rapid Response, Hurricane Katrina, Wind Water Debris Line – Louisiana*. Under Task Order 415, visual surveys and data collection were used to determine the location of the debris line and extent of flooding to identify the wind water line.
- HMTAP Task Order 436, *Flood Data Analysis – Louisiana*. Under Task Order 436, maps were developed to show the extent and magnitude of Hurricane Katrina's surge, as well as information on advisory flood elevations to guide rebuilding efforts in eight coastal Louisiana Parishes. These maps show preliminary HWMs surveyed after the storm, an inundation limit developed from these surveyed points, and FEMA's Advisory Base Flood Elevations. As of March 2006, Katrina-based maps were created for portions of St. Charles (East Bank), portions of St. John the Baptist (East Bank), St. Tammany, and Tangipahoa Parishes.[1] Flood recovery guidance and equivalent recovery maps for the four parishes flooded most severely by Hurricane Katrina (i.e., Jefferson, Orleans, Plaquemines, St. Bernard) are still in production and will be posted upon completion. Note that the data on these maps for the initial parishes were published prior to the final quality review and submission of the HWM data (see Section 2.9). Consequently, minor differences between the website and this report exist; the website is being updated.

[1] These maps and data are published at http://www.fema.gov/hazards/floods/recoverydata/katrina_la_index.shtm.

1.4 Overview of Hurricane Katrina

Hurricane Katrina was the eleventh named tropical storm and the fourth hurricane in the 2005 Atlantic hurricane season and was one of the strongest storms to impact the coast of the United States during the last 100 years. According to the National Oceanic and Atmospheric Administration (NOAA) National Hurricane Center (NHC), the storm began as Tropical Depression 12 over the southeastern Bahamas on August 23, 2005. On August 24, 2005, the cyclone became Tropical Storm Katrina. The storm strengthened, and it is estimated that Katrina reached hurricane status on August 25, 2005. Katrina made its first landfall in Florida as a Category 1 hurricane on the Saffir-Simpson Hurricane Scale, with maximum sustained winds of 70 knots (80 mph). Katrina continued west-southwestward, spent only 6 hours over land, and weakened to a tropical storm with maximum sustained winds of 60 knots (70 mph) as it emerged into the Gulf of Mexico.

Katrina continued northward over the Gulf of Mexico, quickly regaining hurricane status and strengthening to a Category 5 hurricane on the morning of August 28, 2005. Katrina attained its peak intensity of 150 knots (173 mph) about 170 miles southeast of the mouth of the Mississippi River. Katrina remained a significantly large, sustained storm and impacted a broad area of the Gulf Coast. By the morning of August 29, Katrina weakened to a Category 3 storm, making landfall near Buras, Louisiana, with estimated maximum sustained winds of 110 knots (126 mph).[2] Heading northward, Katrina was downgraded to a tropical depression near Clarksville, Tennessee, and dissipated on August 31 in southeastern Canada. The Hurricane Katrina storm track is shown in Figure 2.[3]

[2] "Tropical Cyclone Report, Hurricane Katrina, 23-30 August 2005, Richard D. Knabb, Jamie R. Rhome, and Daniel P. Brown, National Hurricane Center, 20 December 2005."
[3] http://cimss.ssec.wisc.edu/tropic/archive/2005/storms/katrina/katrina.html

Figure 2 – Hurricane Katrina Storm Track

Figure 3 shows a composite image of Hurricane Katrina. This image is Advanced Very High Resolution Radiometer/Multi-Channel Visible and Infrared Radiometer composite imagery provided by the Cooperative Institute for Meteorological Satellite Studies as provided by NOAA and the Joint Typhoon Warning Center.[4]

[4] http://cimss.ssec.wisc.edu/tropic/archive/2005/storms/katrina/avhrr/avhrr.katrina.html

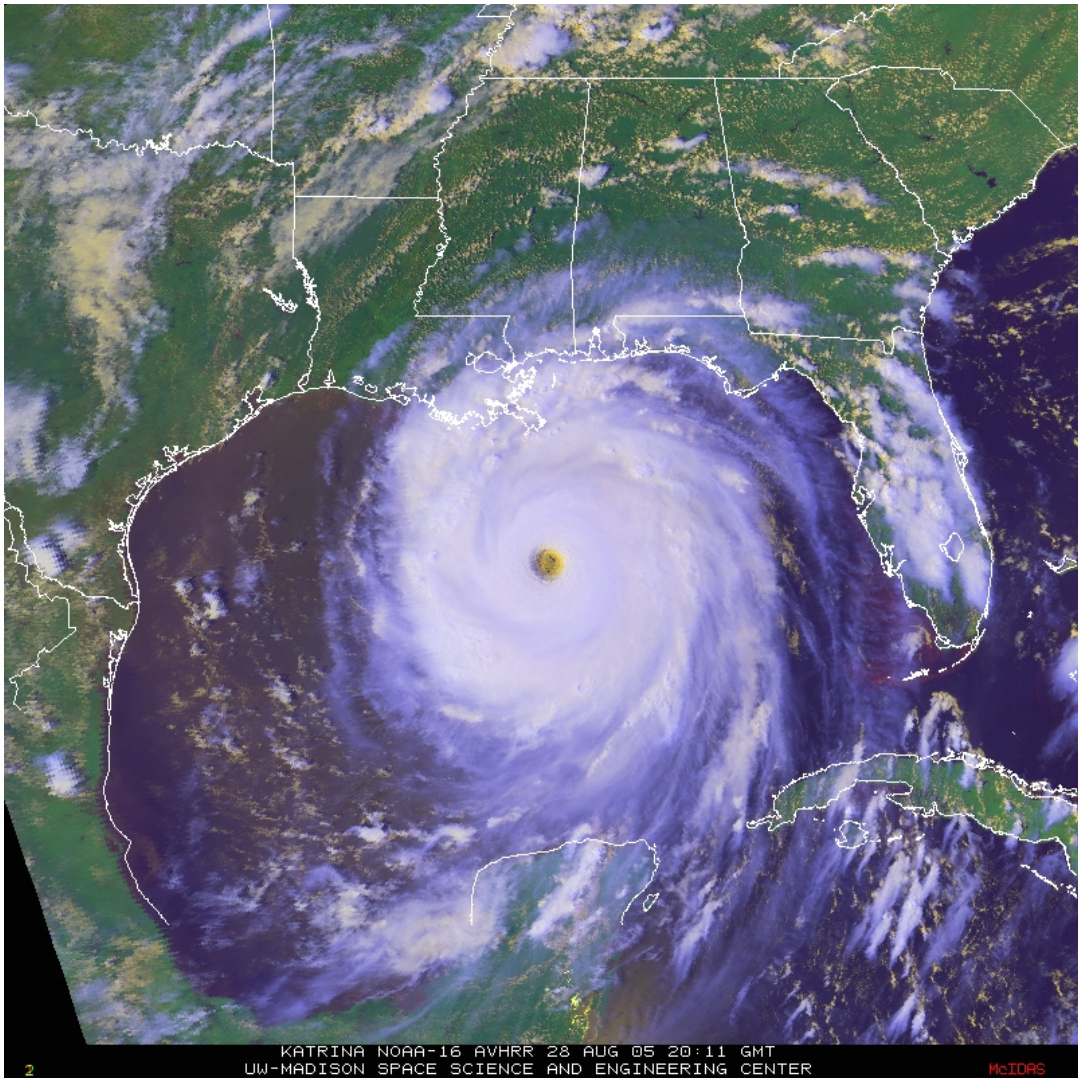

Figure 3 – Hurricane Katrina Composite Imagery

President George W. Bush issued a major disaster declaration on August 29, 2005, under the authority of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), for damage in certain areas of Louisiana resulting from Hurricane Katrina (FEMA-1603-DR-LA).[5] Katrina caused widespread devastation along the central Gulf Coast states, including the coastal regions of Louisiana, Mississippi, and Alabama. Katrina was the most destructive and costliest natural disaster in the history of the United States because of the extent of damage caused by the storm. According to NOAA, the storm surge along the Mississippi coast was the highest storm surge ever recorded in the United States.[6]

Hurricane Katrina made its way up the eastern Louisiana coastline, where most communities in Plaquemines Parish and St. Bernard Parish, and Slidell in St. Tammany Parish, were severely

[5] http://www.fema.gov/news/dfrn.fema?id=4506
[6] "Tropical Cyclone Report, Hurricane Katrina, 23-30 August 2005, Richard D. Knabb, Jamie R. Rhome, and Daniel P. Brown, National Hurricane Center, 20 December 2005."

damaged by storm surge and the strong winds of the hurricane eye wall. As a result of the strong winds, heavy rainfall, and storm surge, several failures in the Lake Pontchartrain flood protection system occurred,, flooding most (approximately 80 percent) of the City of New Orleans.

As the storm moved inland and weakened to a tropical storm on August 29, rainfall became the primary impact. Rainfall amounts exceeded 2 to 4 inches across a large area from the Gulf Coast to the Ohio Valley. As a result, flood watches and warnings were common across these regions.

2. Methodology

2.1 General

This section summarizes the methodology used to flag and survey the HWMs. It should be noted that it is important to quickly mark or flag HWMs after a disaster so that the HWMs are captured before residents clean up or it rains, thereby potentially eliminating the HWM. Every effort is made to quickly flag HWMs because they are often perishable. Once they are flagged, HWMs can be surveyed later to determine the HWM elevation.

URS received a notice to proceed for this HWM Task Order on August 30, 2005. On that same day, notices to proceed were also received for HWM collection in Mississippi and Alabama, which were also significantly impacted by Hurricane Katrina. In addition to coastal flooding, there were reports of significant riverine flooding. In response, FEMA issued to URS Task Orders for both coastal and riverine HWM collection. These two Task Orders (Task Orders 412 and 419) have been combined in this report.

It was determined that there was a large overlap in the field work between the HWM Task Orders and the Wind Water Line Task Order. To increase efficiency and address the lack of available lodging in the affected area, it was decided to combine the field collection for the HWM Task Orders and the Wind Water Line Task Order. Additional information regarding the Wind Water Line Task Order can be found in the "Hurricane Katrina Rapid Response Wind Water Line Report – Louisiana, Task Order 415."

2.2 Pre-Field Deployment

Immediately after receipt of the HWM Task Orders, URS began to arrange the logistics for the HWM collection. This included arranging travel and lodging for field staff, modifying the HWM database and forms (based on comments from FEMA regarding previous Task Orders), finalizing training/orientation material, obtaining equipment (e.g., hand-held Global Positioning System [GPS] units, cameras, and health and safety equipment), obtaining vaccinations and blood work for field staff (due to concerns about standing water), and obtaining FEMA badges for field staff.

A training/organization meeting was held for approximately 30 staff in Tallahassee, Florida on September 1, 2005. Field staff was initially deployed to Alabama and Mississippi rather than Louisiana. Deployment to Louisiana was not feasible due to poor communication and damaged infrastructure in impacted areas. The earliest URS could book flights into Baton Rouge after communication was established with personnel in the impacted areas of Louisiana was September 7. Training for approximately 25 additional staff was subsequently held on September 8 in URS' Baton Rouge office. Flaggers, data collectors, quality assurance staff, and managers attended the September 8 meeting. The meeting included discussions on selecting HWM locations, collecting wind water line data, review of field processes (including data capture, documentation, and information transfer), distribution of equipment, and a health and safety briefing. On September 9, 2005, URS deployed field staff to the accessible areas of Louisiana.

2.3 Data Sources

On August 31, 2005, URS began to collect available information on the extent of flooding in Louisiana to assist in identifying locations for the HWM collection. By September 7, 2005, URS placed calls to all parish emergency managers in the impacted areas of Louisiana to determine the extent of flooding in their parish and receiving input on priority locations for collecting HWMs. Due to the limited availability of phone lines in the impacted areas, URS was successful in contacting only three emergency managers. Ascension Parish reported no flooding of homes; Terrebonne Parish reported minor riverine and coastal flooding in the southern portion of the parish; and St. John the Baptist Parish reported that 12 homes were damaged by flooding resulting from rainfall immediately before the hurricane struck. Note that these initial reports were based on the best available information at that time, and the actual damage in these parishes may be different.

Over the next several days, URS contacted several other agencies to determine available data sources and information that could be used to determine the best HWM locations. URS contacted the New Orleans District of the U.S. Army Corps of Engineers (USACE), which indicated no preference for HWM collection locations. The Louisiana Office of Homeland Security and Emergency Operations, National Weather Service (NWS), and Louisiana State University indicated they had no information related to HWMs at that time. URS also coordinated with the U.S. Geological Survey (USGS). Refer to Section 2.7 for a complete discussion of URS and USGS collaboration on HWM data collection.

URS downloaded forecasted coastal storm surge levels from Crownweather.com (Figure 4) and obtained a preliminary Sea, Lake and Overland Surges from Hurricanes (SLOSH) model prepared by the NOAA NHC. Through USGS, NHC provided output from the SLOSH model[7] dated September 9, 2005, and shown in Figure 5. This figure includes graphical, color-designated maximum surge-only levels that occurred during the modeled storm. According to NHC, the SLOSH model is generally accurate within plus or minus 20 percent. The model accounts for astronomical tides (which can add significantly to the water height) by specifying an initial tide level, but does not include rainfall amounts, river flow, or wind-driven waves.

[7] http://marine.usgs.gov/response/katrina/stormsurge/

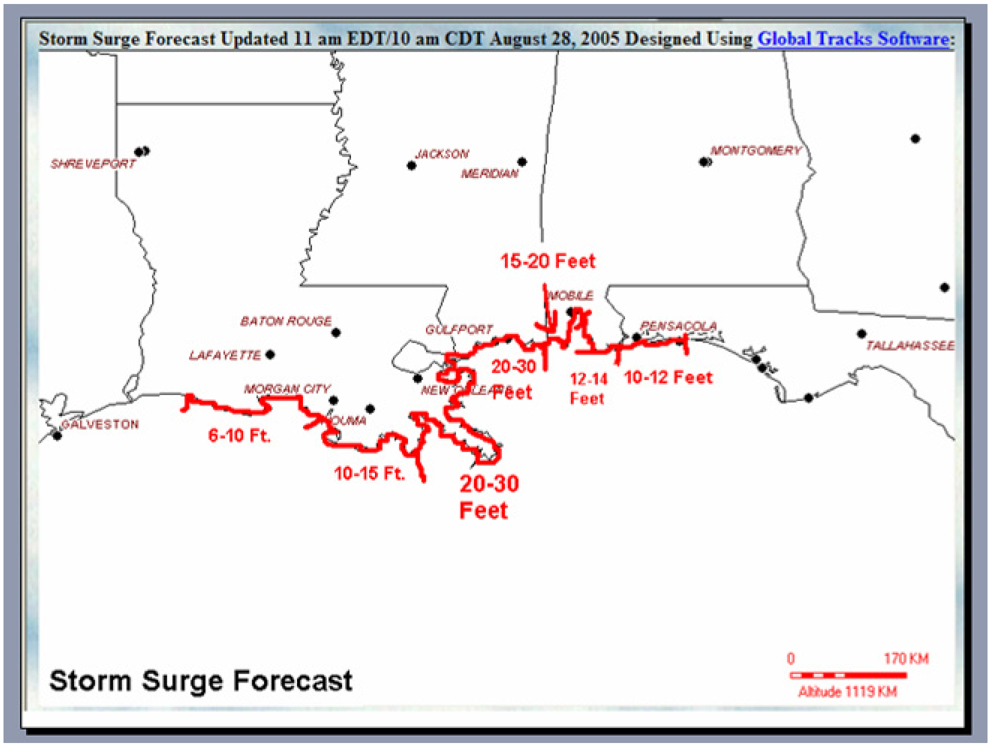

Figure 4 – Forecast Katrina Storm Surge from www.Crownweather.com

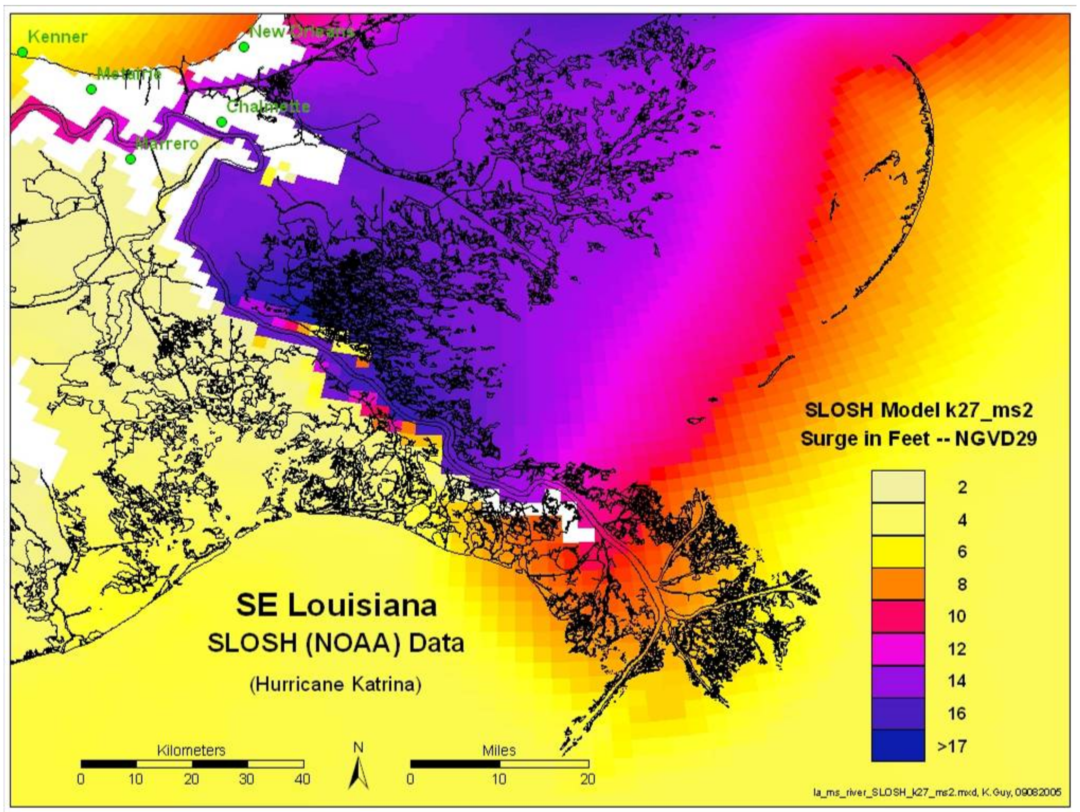

Figure 5 – NOAA Katrina Louisiana Coast SLOSH Data

USGS stream gages in Louisiana were also reviewed. As of September 1, 2005, four USGS gages recorded elevations higher than the NWS flood stage. A summary of these gages and their elevation in relation to flood stage is shown in Table 1. This table shows that only minor to moderate riverine flooding had occurred at that time and that the flooding was limited to the St. Tammany and Washington Parish area.

Table 1. USGS Hurricane Katrina Stream Gage Flood Stage and Discharges as of September 1, 2005

USGS Station ID	USGS Station Name	Peak (or Most Recent) Stage (ft)	Status	NWS Flood Stage (ft)	Peak (or Most Recent) Discharge (cfs)	Highest Historic Peak Discharge (cfs)	Feet Above Flood Stage	Flooding Level	Parish
02489500	Pearl River near Bogalusa, LA	19.48	peaked	18	27,700	129,000	1.5	minor	Washington
02492000	Bogue Chitto River near Bush, LA	11.20	near peak	11	11,900	131,700	0.2	minor	St. Tammany
02492600	Pearl River at Pearl River, LA	14.53	rising	14	N/A	230,000	0.5	minor to moderate	St. Tammany
07375175	Bogue Falaya River at Boston St. at Covington, LA	11.70	peaked	6	N/A	N/A	5.7	N/A	St. Tammany

2.4 Identification of the Study Area

URS prepared a Work Plan for Hurricane Katrina Louisiana HWMs, which was submitted to FEMA on September 7, 2005. The purpose of the Work Plan was to outline the general locations where URS would collect HWMs. This plan was based on discussions with other agencies and data collected, as well as discussions with FEMA. Based on the discussions and collected information (see Section 2.3), URS focused the HWM collection in the 13 southeast parishes of Louisiana (see Section 4.1).

2.5 Flagging Field Data Collection Procedures

The field work for the Louisiana HWM flagging began on September 9, 2005. However, at that time there were safety concerns about entering Orleans, Plaquemines, and St. Bernard Parishes; as a result, flaggers did not visit these locations until the following week.

Two-person teams were used to flag the HWMs. The number of two-person flagging teams in Louisiana varied daily during the project, typically ranging from 7 teams to 9 teams. By September 17, 2005, most of the flagging was completed and many of the flagging teams were demobilized. A couple of flagging teams remained in the field until September 22, 2005 but were then demobilized due to evacuations required by Hurricane Rita. Some teams were redeployed from October 12 through October 17, 2005, to visit areas previously inaccessible or to fill in gaps of information.

Data collectors and field coordinators were in the field with the flaggers. The data collectors collected the data from the flagging teams and delivered it to a URS office where the data was entered into a database. Use of the data collectors was required because electricity and working phone lines in the impacted areas were intermittent. Field coordinators met daily with the flaggers to review the HWMs collected that day and to discuss the next day's assignments. Field managers in the URS Baton Rouge and Tallahassee offices reviewed and mapped the compiled data daily and directed the field coordinators to the general areas of HWMs collection locations.

Each day the two-person flagging teams were given a general geographic area in which to identify and flag HWMs. The flagging teams visited these areas and searched for structures with mud or water lines and areas with debris lines (i.e., man-made materials) or wrack lines (i.e., plant materials). Upon visiting the assigned geographic area, the flaggers would first determine whether the area appeared impacted by flooding. If the area did not appear to be impacted by flooding, then the flaggers noted this for their daily briefing with the field coordinator and proceeded to the next area. If the area appeared to be impacted by flooding, then the flagger searched for a visible HWM to be flagged.

A building is the preferred location for a HWM to be flagged. However, there were few remaining buildings in those areas severely impacted by Hurricane Katrina's flooding and high winds. When impacted buildings were still standing, the flagger searched for visible HWMs. The preferred HWM location is inside the building; therefore, the flaggers searched inside for a visible HWM when access into the building was available. If no inside HWM could be obtained, an exterior HWM was flagged. In areas where there were no visible HWMs on buildings, the flaggers searched for other signs of high water, such as debris lines or wrack lines on the ground, vegetation, bridge embankments, or fences. Visible HWMs are often difficult to find because coastal flooding typically enters and exits a site quickly, receding before a water mark is left. For illustrative purposes, examples of the typical types of HWMs collected during a HWM project are shown in Figures 6 through 9.

Figure 6 – Interior Mud Line HWM

Figure 7 – Exterior Mud Line HWM

Figure 8 – Debris Line HWM

Figure 9 – Wrack Line HWM

The spacing of the flagged HWMs was irregular. More HWMs were flagged in areas that were significantly impacted by flooding than in areas of minor flooding. Consequently, more HWMs were flagged in New Orleans. However, coastal and inland HWMs were also flagged to determine the extent of flooding. HWMs were flagged to document different coastal flood types (e.g., surge-only, wave height, wave runup), riverine flooding, and flooding from levee issues (such as levee breaks or interior levee flooding).

Evaluation of site conditions where HWMs were flagged is based on the flaggers' best judgment of the height of flood waters. In addition, the height of flood waters can be affected by outside forces such as wind and shielding by other structures. Therefore, in significantly damaged areas, multiple HWMs were obtained in the same area to provide better flood elevation data. Fewer HWMs were flagged in areas that received less flooding or where there were fewer buildings.

On a daily basis, URS reviewed the areas where HWMs were flagged and sent flaggers to fill in apparent data gaps. Often there was no access to these areas or there was no evidence of flooding.

It should be noted that FEMA initially identified 11 parishes for riverine HWM collection. Based on URS' field investigations, HWMs for significant riverine flooding were not present in most of these parishes. HWMs were collected in parishes where flooding resulted from levee-related flooding.

URS flagged approximately 380 HWMs. For each identified HWM, the flaggers completed a standardized form including detailed data about the HWM (Figure A.1 in Appendix A). The flaggers documented the HWM's approximate latitude and longitude coordinates using hand-held GPS units to help surveyors find the HWM. The flaggers used their judgment regarding the source of the flood water (coastal flooding, riverine flooding, or levee issue). In some instances, flaggers obtained anecdotal information from residents as to the source of the flooding. The flaggers used the location of the HWM in relation to other land features to estimate of the type of coastal flooding (e.g., surge-only, wave height, and wave runup). For example, a debris or wrack line on a stretch of open coast is the result of wave run-up. However, when significant amounts of vegetation block or dampen the wave effect, these marks are identified as surge-only instead.

URS submitted the Preliminary Louisiana Field Summary Report, dated October 12, 2005. This report showed the location of flagged HWMs. A coastal water body was not within sight of most HWMs, and therefore URS could not provide a visual estimate of the HWM elevation based on the estimated distance above the coastal water body, as URS has done for other HWM projects.

2.6 Survey Procedures

Due to the necessity to quickly obtain surveyed HWM information, the URS team surveyors began the survey field work shortly after the HWMs were flagged. During the week of September 20, 2005, ESP, URS' surveyor, began to research and establish the Louisiana Department of Natural Resources (LA DNR) control monuments for use as the primary control for the HWM surveys. Due to the disturbance of existing LA DNR benchmarks as a result of Hurricane Katrina, additional days were required to shift the surveying efforts to the north side of Lake Ponchartrain in order to continue with the HWM survey efforts and allow time for the coastal waters to subside.

To address subsidence conditions in Louisiana, different control networks were used to survey the HWMs. In the coastal areas of Louisiana, where there has been subsidence, survey control was originally set up using LA DNR primary and secondary GPS control. This control network conveniently encompassed the HWM study area. The LA DNR monuments were accurately referenced and easily found. Choice of survey control was further discussed with the LA DNR and NGS. On October 3, 2005, after the survey work had started, the NOAA National Geodetic Survey (NGS) released the newly established elevations on approximately 86 NGS monuments / CORS stations to ESP. In discussions with FEMA, NGS, and LA DNR, it was decided to use the NGS benchmarks for the HWM survey. The original LA DNR control was tied into and adjusted to the new NGS control via static GPS to ensure that all elevations and positions were based on the new NGS benchmark control network. A new geoid file provided by NGS was used to process the GPS data using the elevations established on the new NGS benchmarks. This new geoid model differs from the original 2003 Geoid Model, in that it is reportedly isolated to work primarily with the newly published NGS control network in the coastal Louisiana area. NGS indicated that the relative accuracy of the newly established NGS benchmarks is roughly 5 cm (0.16 foot).

Survey of the HWMs began after the surveyors returned from being evacuated for Hurricane Rita and after the survey network was established. Several teams started surveying HWMs on September 29, 2005, and up to six survey teams worked concurrently in Louisiana. The field surveying of all points initially flagged was completed on October 16, 2005. The field survey for the previously inaccessible points flagged from October 12 through October 17, 2005, was conducted from November 6 through November 9, 2005. After the survey field work, the surveyor conducted the office computations to calculate the HWM elevations.

URS survey crews surveyed the HWMs identified and flagged by URS flagger teams and the HWMs identified separately by the USGS, as discussed in Section 2.7. The survey crews used static GPS methods and conventional leveling to determine the HWM elevations and post-processed mapping-grade GPS receiver data to establish the horizontal coordinates (latitude and longitude) HWMs were surveyed on the North American Datum of 1983 (NAD 83) - Louisiana State Plane Coordinates (South Zone) horizontal datum, on the North American Vertical Datum of 1988 (NAVD 88). The final survey unit for the HWM data was U.S. Survey Feet. The HWMs were surveyed to an accuracy of 0.25 feet vertically and 10 feet horizontally with a 95% confidence accuracy level.

Data were recorded on standardized forms as shown in the example, Surveyor High Water Mark Data Collection Report Form (Figure A.2 in Appendix A). Static GPS was performed directly on the HWM whenever possible. The survey crews used conventional leveling techniques from a static GPS reference point when the HWM location would not support direct GPS observations. Wherever possible, a building floor elevation was surveyed on structures where a HWM was observed. These floor elevations were taken adjacent to the HWM where available and may or may not represent the first floor of the structure. This information was obtained for later use in damage assessments or HMGP applications.

2.7 USGS-Flagged HWMs

During URS' discussions with the USGS in early September, the USGS indicated that they were flagging HWMs in Louisiana (assisted by the USACE). The USGS preserved HWMs with weather-proof ink or paint, nails, and surveyors' tape. The USGS requested that FEMA survey the HWMs that they flagged. FEMA agreed and tasked URS with surveying USGS/USACE-flagged HWMs. On September 27, 2005, the USGS provided URS with longitude, latitude, HWM description, and temporary bench mark (TBM) descriptions for approximately 100 HWMs in Louisiana. URS provided the longitude, latitude, and HWM description to the surveyor. The USGS HWM points were surveyed by URS based on location information and photographs provided by the USGS.

The USGS also conducted quality-assurance checks of 11 selected HWMs. In conducting these checks, the USGS surveyed elevations using line-of-site or conventional leveling for HWMs that the USGS had previously flagged and that URS had surveyed. The following summarizes the ranges of difference between the URS-surveyed and the USGS-surveyed elevations:

- 7 were less than or equal to 0.25 foot;
- 2 were greater than 0.25 foot and less than or equal to 0.30 foot;
- 1 was greater than 0.30 foot and less than or equal to 0.40 foot; and
- 1 was greater than 1.0 foot.

Consequently, there were two points with greater than 0.30-foot discrepancies between the URS-surveyed elevation and the USGS expected elevation. These two points were deleted from the database.

There were also seven HWMs flagged by the USGS that were not surveyed by URS because either the surveyor could not find the HWM or access to the property for surveying was denied by the owner. In addition, USGS flagged 12 points that were provided after the URS surveyor had mobilized, and therefore these points were not surveyed.

It should be noted that URS flaggers did not visit the USGS-flagged HWMs. Since USGS flaggers did not use the same data collection form as URS, several data fields were not collected (such as flooding source and flooding type), and therefore those data are not included.

2.8 Elevation Conversion from NAVD 88 to NGVD 29 Using Corpscon

As indicated, the surveyor computed the HWM elevations in the vertical datum of NAVD 88. However, since many of the FEMA FIRMs are in National Geodetic Vertical Datum of 1929 (NGVD 29), each elevation was converted and also reported in NGVD 29. This conversion was completed using the Corpscon program version 5.11.08[8]. The Corpscon program uses the VERTCON software internally. The VERTCON software was developed by the National Geodetic Survey (NGS) office to convert data between different vertical data scales. VERTCON is available as an element of the NGS Geodetic Toolkit and can be downloaded from the NGS website[9].

The VERTCON software allows the user to compute the modeled difference, or datum shift, in orthometric height for a given location specified by its latitude and longitude. Applying the computed datum difference value to a specific elevation converts from one datum to another.

For converting elevations in the NAVD 88 datum to the NGVD 29 datum, the datum shift has to be subtracted from the NAVD 88 elevation. This can be demonstrated by two examples, one with a positive shift and one with a negative shift:

	Case 1	Case 2
NAVD 88 Elevation	5.33	5.33
Datum shift	+0.50 feet	-1.17 feet (negative shift)
NGVD 29 Elevation	5.33 – (0.50 feet)	5.33 – (-1.17)
	= 4.83	= 6.50

Due to local subsidence conditions and the age of many previous elevation measurements, extreme care should be taken when comparing the HWM elevations in this report to other reported elevations of other marks or structures.

8 http://www.cae.wisc.edu/site/software/?title=app199
9 http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html

2.9 Quality Assurance Review

Upon receipt of the data from the surveyor, URS began the quality assurance (QA) process. The QA process involved checking each data field in the database, including HWM elevation and flood type. As requested by FEMA, URS provided FEMA, the USGS, and the USACE the raw survey data sets (i.e., no QA review) on November 16, 2005, for all parishes except Orleans and St. Bernard. On December 1, 2005, URS provided the raw survey data sets for Orleans and St. Bernard Parishes. URS provided FEMA a partially QA reviewed data set on December 22, 2005.

URS' QA review of the data included checking the surveyed elevation for reasonableness based on other nearby HWMs and available topography. If a discrepancy was found, it was sent back to the surveyor for their review. If the point continued to be inconsistent, then URS made a judgment regarding continued use of the point. The survey point was removed from the database if it appeared that it may not actually represent a valid HWM. An example of this is when a resident provides a personal account indicating the maximum level of the water, which is then surveyed. If this personal account does not match nearby HWMs with physical evidence (such as a mud line) that is surveyed, then the point was deleted from the database. Approximately 15 HWMs flagged and surveyed by URS were removed from the database due to concerns regarding reasonableness.

URS QA review also included examination of the flooding type. While the flaggers made their best estimate of the flooding type based on observed field conditions, sometimes the flooding type can be better identified after the HWM locations and elevations are mapped. Therefore, the flooding type for each HWM was reviewed based on mapped locations and elevations of the surveyed HWMs.

The determination of whether a point was from coastal, riverine, or levee flooding was based on review of all of the HWMs in the area and the location of levees and the estimated wind-water line. HWMs in areas protected by levees were typically indicated as being caused by levee flooding. However, in areas along the Mississippi River with back/hurricane levees that were significantly overtopped or breached, HWMs were designated as coastal flooding since their elevations were affected by both the coastal influence and the level of levee protection. A determination of whether the back/hurricane levee was significantly overtopped or breached was based on *Preliminary Report on Performance of New Orleans Levee System in Hurricane Katrina on August 29, 2005* [10] and an analysis of the HWM elevations collected in an area. HWMs on the river side of the Mississippi levee were indicated as being riverine flooding, however Mississippi River was impacted by coastal surge levels. This description was maintained to provide some clarification between the HWM levels noted on either side of the Mississippi River levees. In Jefferson Parish, for example, KLAC-06-11 has an elevation of 17.9 feet and nearby KLAC-01-14 has an elevation of -1.2 feet, see Figure B.7.

[10]Seed, R.B., Nicholson, P.G., Dalrymple, R.A., Battjes, J., Gea, R.G., Boutwell, G., Bray, J.D., Collins, B.D., Harder, L.F., Headland, J.R., Inamine, M., Kayen, R.E., Kuhr, R., Pestana, J.M., Sanders, R., Silva-Tulla, F., Storesund, R., Tanaka, S., Wartman, J., Wolff, T.F., Wooten, L., and Zimmie, T., 2005, Preliminary Report on the Performance of the New Orleans Levee Systems in Hurricane Katrina on August 29, 2005: Report no. UCB/CITRIS—05/01, November 17, 2005 (URL http://hsgac.senate.gov/_files/Katrina/Preliminary_Report.pdf).

For the areas not protected by levees, the wind-water line was used to assist in determining whether a point was coastal or riverine. The wind-water line is the estimated boundary that delineates the inland extent of the area where structures were damaged as a result of flooding from coastal surge. Landward of the line, most of the damage is attributable to winds and/or wind-driven rain, and HWMs in this area were typically designated as riverine. On the water body-side of the line, HWMs were typically designated as coastal flooding. Due to the coastal influences of Lake Pontchartrain, HWMs along the lake were indicated as coastal flooding. The analysis of flooding type was conducted based on the approximate location of the wind water-line because it is difficult to determine the exact location of the wind-water line. URS also considered the coastal HWM elevation at the inland extent of coastal flooding. The elevation of the coastal flooding at the inland extent should be relatively consistent in an area. Therefore, if a HWM elevation near the wind-water line was higher than the estimated coastal surge elevation in the area, then the HWM was identified as riverine flooding.

The HWMs designated as coastal flooding were further identified as representing surge-only, wave height, and wave runup (see Section 3 for discussions of these flooding types). The QA review included evaluation of the coastal flooding types that the flaggers identified. HWMs collected inside a building or within other protected areas were designated as surge-only HWMs. URS evaluated the HWM's associated photograph, the location of the HWM relative to other land features, and other nearby HWM elevations to confirm the coastal flooding type.

Other QA checks included reviewing the flooding source, nearest municipality, parish/county, photographs, consistency of data, and similar factors. After the QA review of the data was completed, URS prepared the Draft Report. However, since the QA review showed inconsistency in USGS-flagged data, URS worked with the USGS to resolve these issues. The Draft Report was submitted to FEMA on January 27, 2006. FEMA provided comments on February 8 and February 9, 2006. FEMA's comments required a major reorganization and rewrite of the report, and a sample revised report was provided to FEMA on February 28, 2006.

3. Flood Types

3.1 General

HWMs were collected for three types of flooding: coastal, riverine and levee-related. Consequently, each HWM was classified as either a result of coastal flooding (caused by storm surge), riverine flooding (caused by rainfall) or levee-related (caused by levee breaks or by levee interior flooding). The conditions that compose these flood types are described in the following sections. It should be noted that while Hurricane Katrina was a significant coastal flooding and levee-related flooding event, a much smaller number of properties were affected by riverine flooding.

This project was a Rapid Response Task Order and required that the HWMs be flagged, surveyed, and reported on quickly. Flooding types were designated based on observations made during the flagging field work that were later reviewed based on mapping the data. A detailed analysis of land conditions, such as topography, bathymetry, locations of dunes, sloped water surface, overwash, or breaching, was not performed; this level of analysis was not part of the scope of work or even possible due to the time limitations. Therefore, all classifications are estimates based on the best available data at the time.

3.2 Coastal Flooding

Coastal flooding is caused when coastal waters are driven inland by waves and wind. Coastal flooding conditions are more varied in their origin than those associated with riverine flooding. The coastal flooding types are discussed below and presented graphically in Figures 10 through 16. These figures illustrate ideal situations of coastal flooding, which will not necessarily occur in any one location or one particular storm event. Each of the three basic types of coastal HWMs—surge only, wave height, and wave runup—are often found close to each other, but can differ in elevation. Each coastal flood type provides information that helps characterize the nature and behavior of the coastal flooding event.

It is beneficial to collect HWM for the different types of coastal flooding because each type offers a different set of information. Table 2 shows the typical coastal flooding type needed for each of the uses of the HWM data.

Table 2. Coastal Flooding Type Required For Various Uses of HWM Data

HWM Data Use	Coastal Flooding Type Required
Quickly estimate event frequency and severity for different areas	Surge-Only and Wave Height
Assess Flood Insurance Rate Maps	Surge-Only and Wave Height
Assist in preparation of wind-water line maps	Any type
Prepare inundation maps	Surge-Only (typical), Wave Height and Wave Runup
Share information for building performance assessment	Wave Height
Share information for modeling	Surge-Only
Provide public and agencies with elevations for prioritizing mitigation and benefit/cost analysis	Wave Height
Determine depth of flooding of structures	Surge-Only

3.2.1 Surge-Only

Figure 10 shows the simplest form of coastal flooding (surge-only). In this type of flooding, as the water level during the storm rises to a maximum level, it can leave marks on both the interior and exterior walls of a structure that are of equal elevation. Both of these water marks indicate a coastal flooding level that is not complicated by other factors, such as waves. However, these situations occur only where the structure is at a location sheltered from waves.

Ideally, surge-only flooding has maximum elevations that are either level or have a slight slope that is not easy to detect visually. This is shown schematically in Figure 11. However, this is not always the case in the coastal zone. As shown in Figure 12, coastal surges can also have sloped water surfaces. High water caused by a hurricane storm surge is due to the combination of rapidly changing factors such as wind speed, wind direction, lowered barometric pressure and the storm track. Surge-only represents the rise in the water level where the location was shielded from waves. In some cases the surge develops in open water areas and spreads inland over large distances because the coastal lands have minimal topographic change. The overland flow can be retarded by inland marsh areas and other obstructions so that the flood water surface slopes downward towards the inland shore, as shown as Case A in Figure 12. Under other circumstances, a strong onshore wind can force the overland coastal flood waters further inland, forming an upward slope towards the inland shore, as shown in Case B in Figure 12.

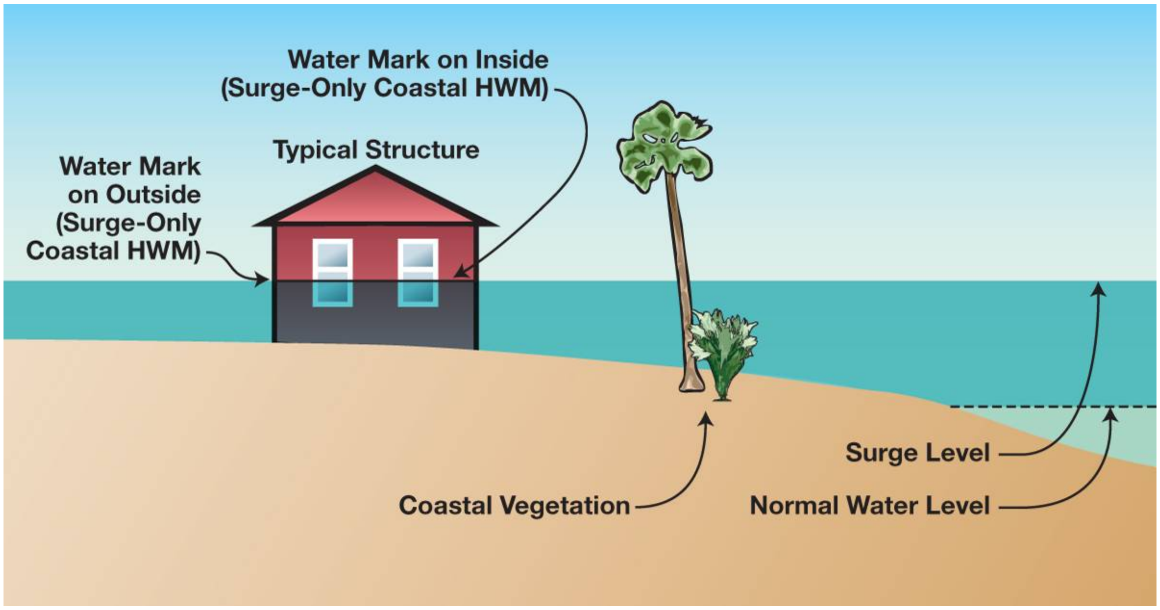

Figure 10 – Coastal HWM Resulting from Surge-Only

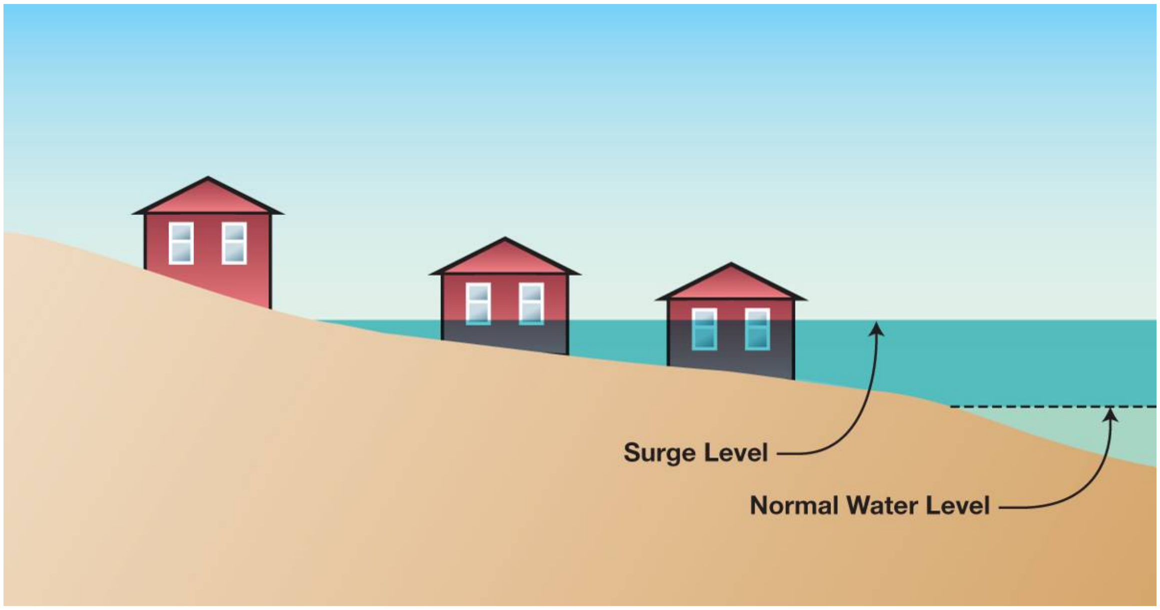

Figure 11 – A Coastal Storm Surge With a Level Water Surface

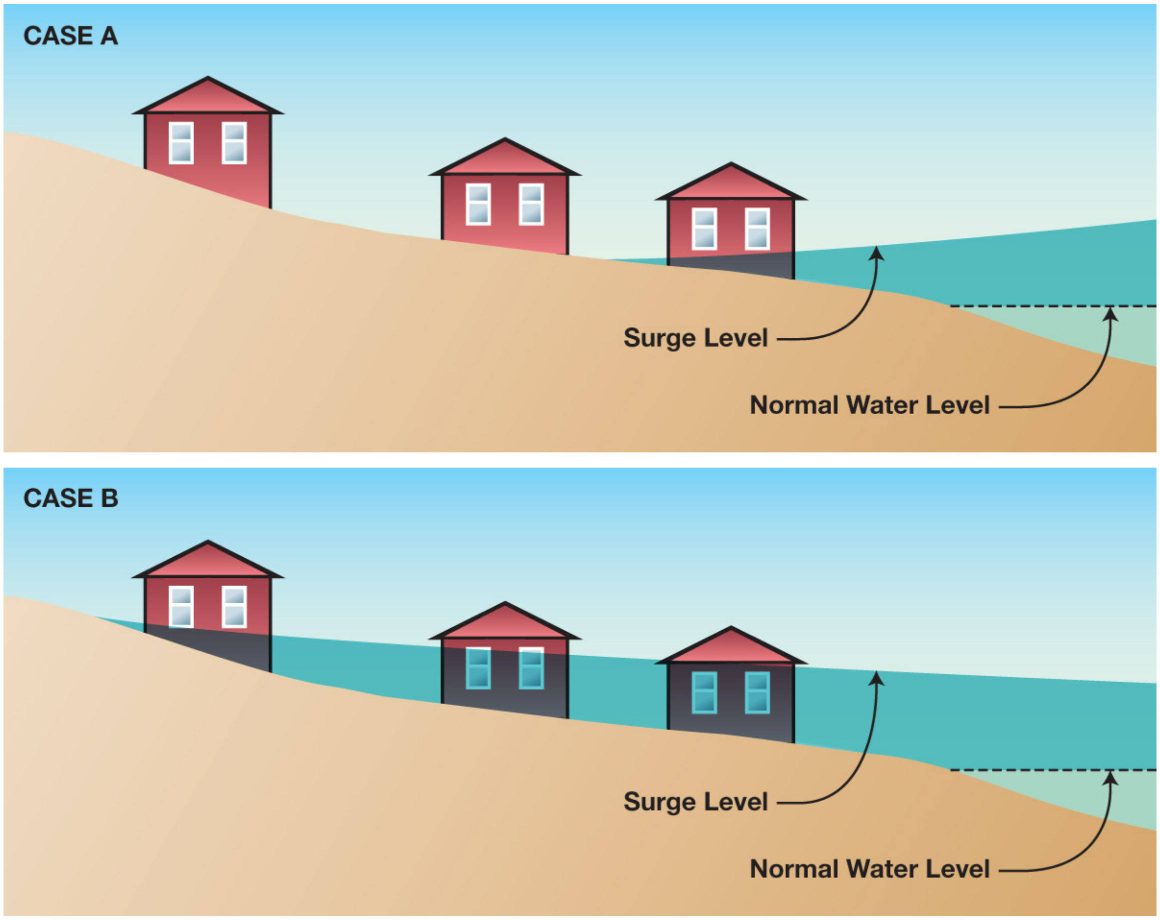

Figure 12 – Two Cases of Storm Surges With Sloped Water Surfaces

3.2.2 Wave Height

The second type of coastal flooding includes action due to waves, or coastal wave height flooding. As coastal flood waves propagate, high water conditions on structures and land vary. Coastal wave height flooding is created by the crest of the wave riding on the surge. Figure 13 shows how HWMs found inside and outside of a structure can differ considerably if they are impacted by waves. HWMs corresponding to the conditions shown on the exterior wall in Figure 13 are designated as wave height flooding because the crests of the waves that are riding on the surge leave the highest mark. HWMs corresponding to the situation shown on the interior wall in Figure 13 are designated as surge-only flooding because the structure blocks the wave action, and therefore the HWM corresponds to a water level unaffected by the waves.

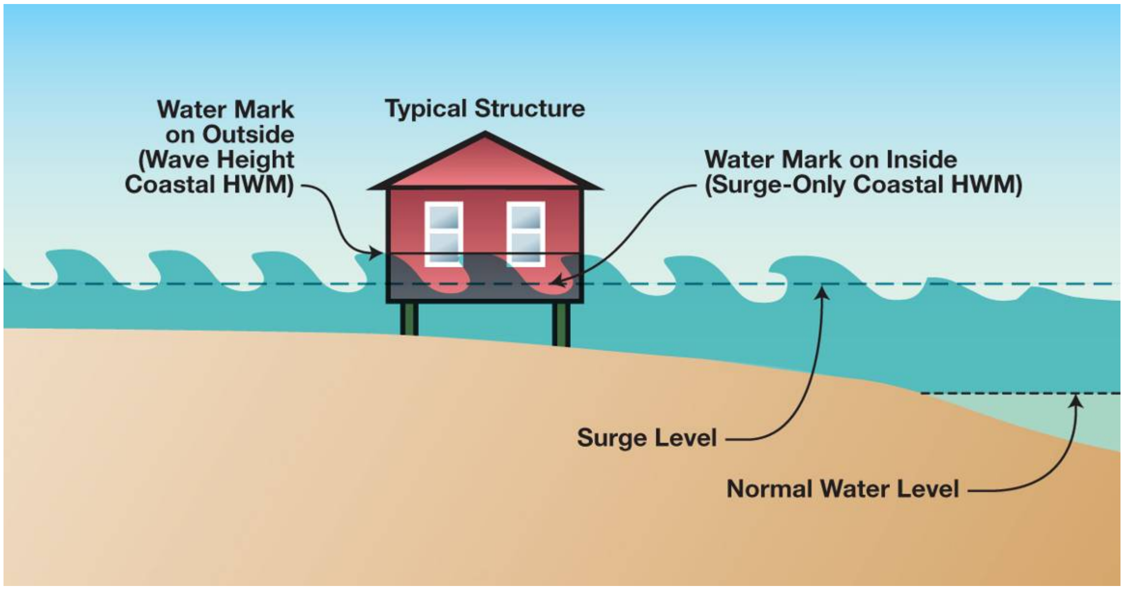

Figure 13 – Coastal HWM Resulting from Wave Height

3.2.3 Wave Runup

The third type of coastal flooding includes wave action runup, or coastal wave runup, as illustrated in Figure 14. With coastal wave runup, the situation is complicated by the presence of a surf zone, which is the broad zone of spilling and breaking waves between the open water body and the beach. At the very top of the surf zone, the remaining energy of the wave causes the waves to wash up the beach slope. The result is referred to as wave runup. Wave runup often pushes debris to its maximum limit where it is left as a wrack line. HWMs of this type are designated as wave runup flooding.

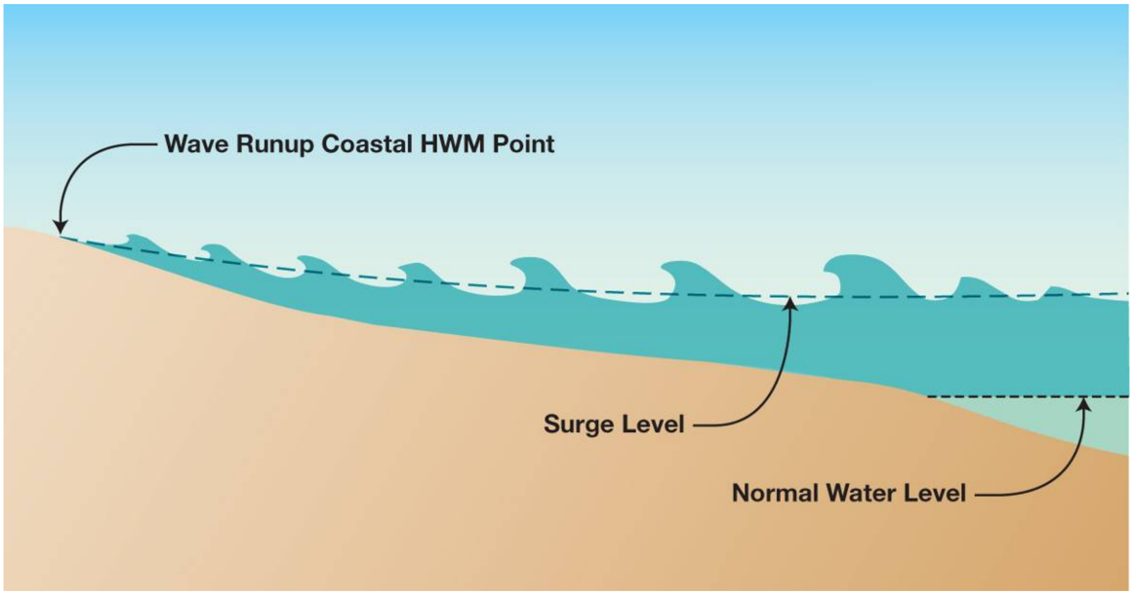

Figure 14 – Coastal HWM Resulting from Wave Runup

3.2.4 Impact of Dunes

Figure 15 shows more variable conditions of coastal flooding caused by land conditions, such as sand dunes. It is not uncommon for the wave runup in a storm to be so large that it completely crosses the beach and flows through gaps in the coastal dunes. These are called "washover channels," and they convey the water over the dunes to low areas behind the dunes. Figure 15 shows three structures at different locations along the dune, each impacted differently by coastal flood waters during the storm. When the corresponding HWMs are found, marked, and surveyed, the elevations can differ up to several feet over a relatively short distance (e.g., 1,000 feet).

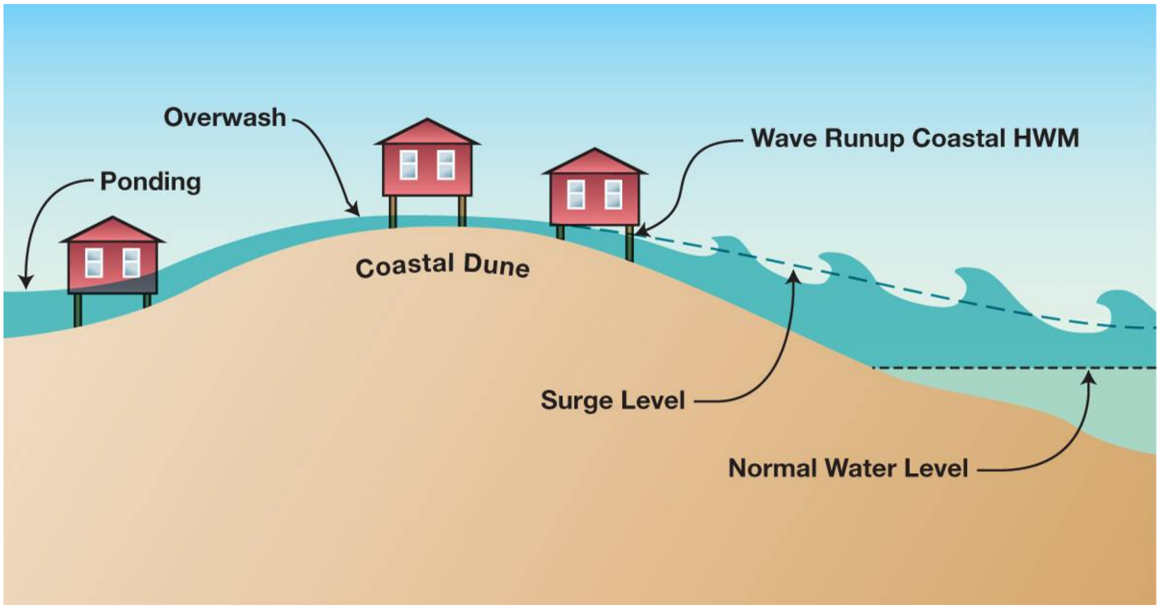

Figure 15 – Variations in Coastal Flooding Levels Due to Washover of Coastal Dunes

During some hurricanes, changes in the shape of the beach and dunes can substantially affect the elevation and extent of the coastal flood waters. Typically, storm conditions cause erosion of beaches and dunes. The combined effects of this erosion and the rise of the water levels can substantially reduce the level of coastal protection. This will inevitably result in inland inundation and flooding that would not have occurred if the coastal dunes had not eroded. These conditions are illustrated in Figure 16. Coastal flooding elevations in these areas can depend on how long the dune line held the ocean back compared to the rate at which the storm moved inland. If the dunes held back the ocean long enough, then the backshore flooding may have occurred after the maximum surge height.

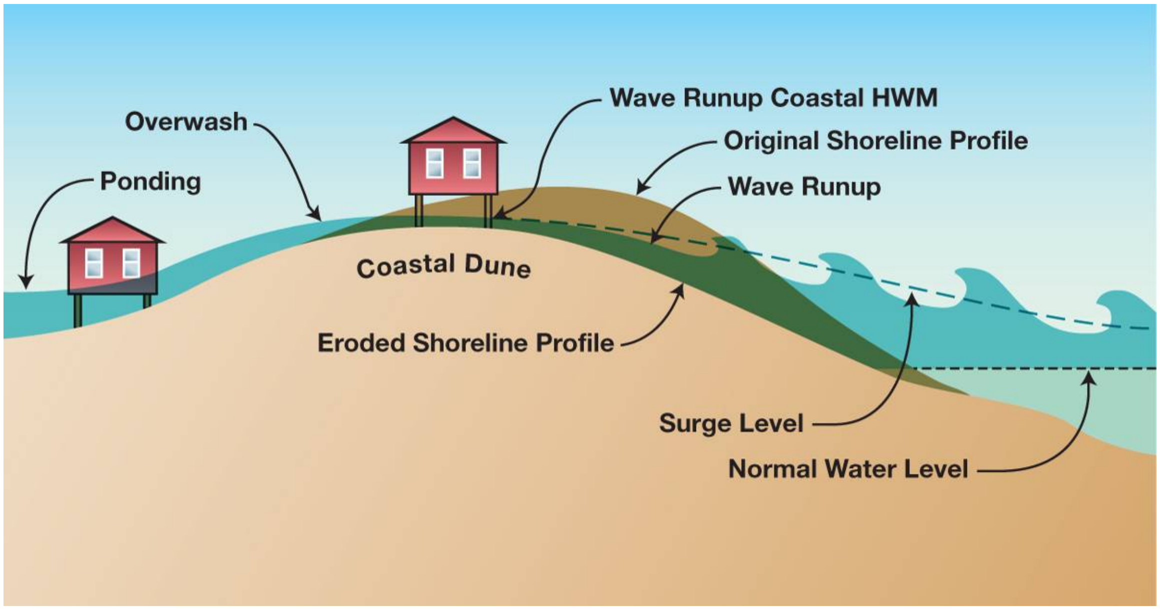

Figure 16 – Interaction of Profile Erosion and Coastal Flooding

There are other factors in coastal flooding to consider related to local conditions. On barrier islands, coastal flooding on the seaward side may differ in elevation from those on the bay side because the maximum surge levels formed at different times during the storm. Within bays, the surge may be amplified by the effect of wind acting on broad, shallow areas. In other cases, the tidal inlet may retard the flow of water into the bay so that its level cannot rise to the level of the ocean. Conversely, it is common to find a funneling action that amplifies the surge level where the shorelines of the bay converge toward the head of the bay.

3.3 Riverine Flooding

Riverine flooding occurs when heavy rainfall causes river levels to rise. The origin of riverine flood conditions vary less than coastal flooding, as riverine conditions do not undergo the coastal forces of wind and waves. High water levels from riverine flooding are mainly driven by the amount of rainfall based on the intensity, speed, and progression of a hurricane as it moves inland. Often the peak water elevations from riverine flooding along major rivers occurs one or more days after the hurricane has made landfall. Flooding occurs as the rainfall from the hurricane impacts the watershed and makes its way through downstream rivers. Riverine high water levels near coastal water bodies could also be affected by backwater, which occurs when the river cannot discharge into elevated coastal waters.

3.4 Levee-Related Flooding

The third type of flooding is levee-related flooding. Levee-related flooding involves high water conditions in areas protected by systems of levees, floodwalls, floodgates, seals, etc., further distinguished as levee-break flooding and interior flooding. The levee-related flooding types are discussed below and presented graphically in Figures 17 through 19.

3.4.1 Levee-Break Flooding

Flooding from levee breaks include both areas where the protection system was structurally breached and areas where the structure was overtopped. In these situations, the water levels will equalize within the associated basin, although higher water levels will occur outside the levee. Figure 17 shows a levee being overtopped, and Figure 18 shows a levee breach. Both show elevated flood waters on the outside of the levee and flooded, yet lower, waters in the levee interior.

In coastal areas with hurricane protection systems that are significantly overtopped or breached, the flooding type may be designated as coastal where high water is affected by both the coastal influence and the provided level of protection. This condition occurred in many areas in Louisiana along the back/hurricane levees along the Mississippi River.

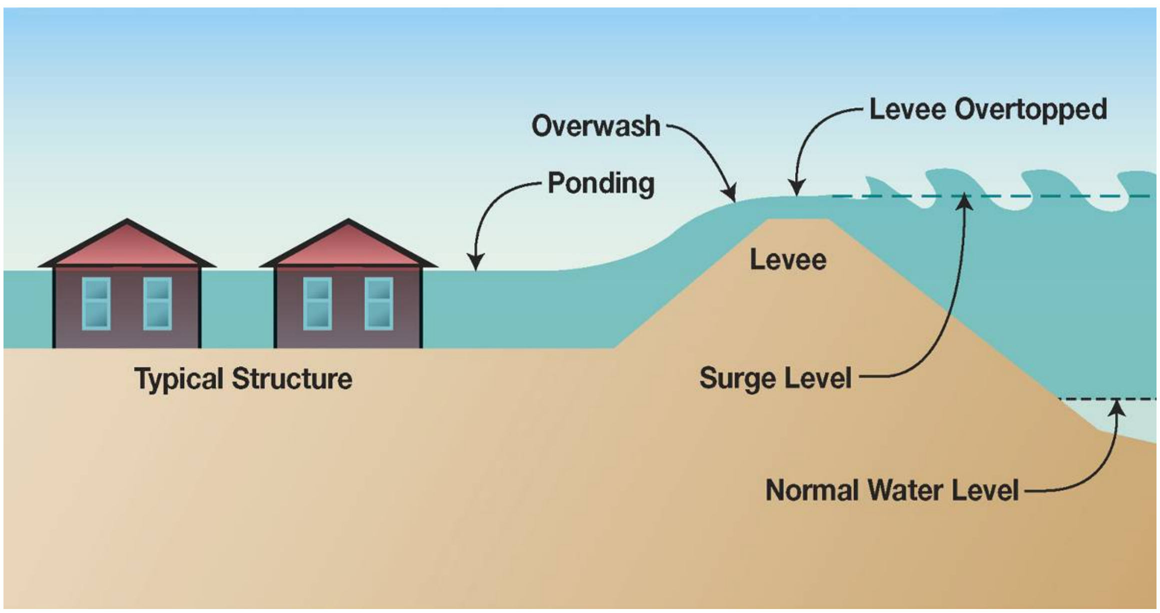

Figure 17 – Levee Break Flooding Due to Levee Overtopping

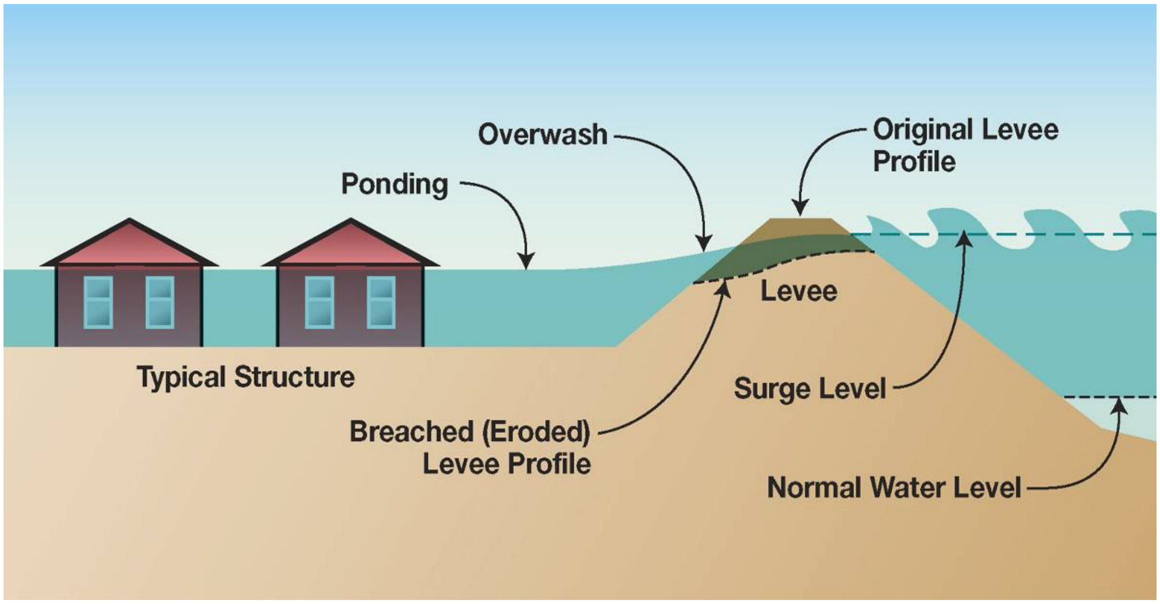

Figure 18 – Levee Break Flooding Due to Levee Breach

3.4.2 Levee-Interior Flooding

Interior flooding occurs inside the levee when the interior drainage pumps fail, were shut down, or were inadequate. Figure 19 shows a levee system with flooding in the interior areas. In most areas identified as levee-interior flooding, a basin with a reasonably consistent water level can be defined. Variations in flood levels will likely occur due to activity in the basin (e.g., local flow blockages, boat wakes). Levee-interior flood levels will generally, depending on timing, have minimal relation with the water levels outside of the levee and may show increased variation due to more localized conditions.

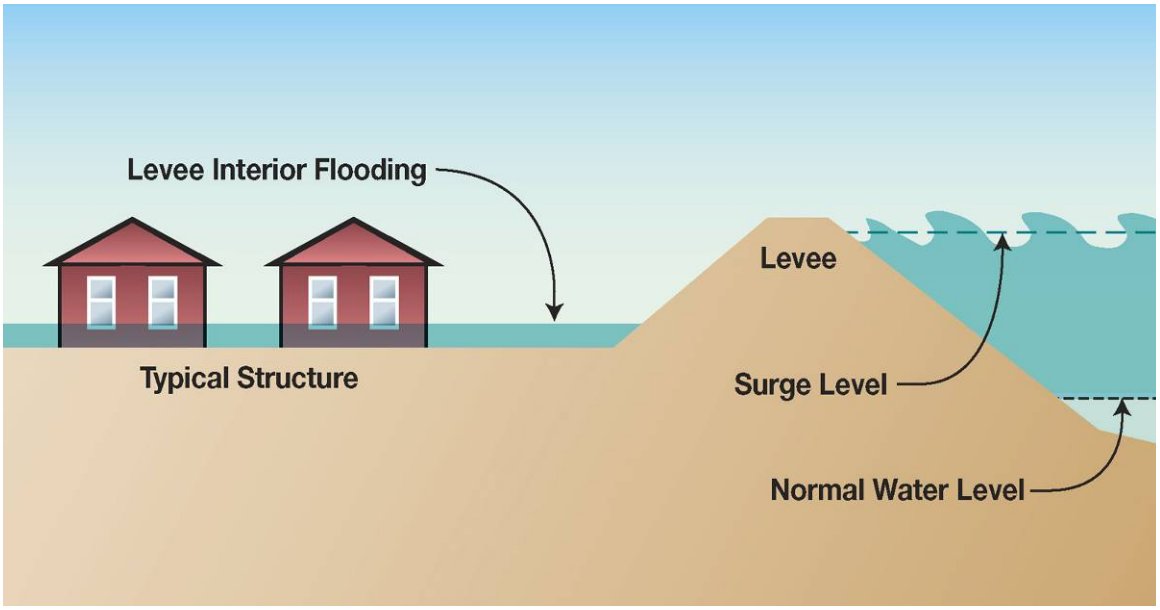

Figure 19 – Levee Interior Flooding

4. Observations and Conclusions

The HWM data collected for this study demonstrate that the Hurricane Katrina coastal storm surge and wave-related high water conditions reached historical proportions and affected a significant portion of the Louisiana study area. This section discusses the data that was collected as well as characteristics of the HWM elevations throughout eastern Louisiana.

4.1 High Water Mark Data Collected

High water marks were collected in coastal and riverine areas of 13 Louisiana parishes in the southeastern portion of the state. As shown in Tables 3 and 4, approximately 480 HWMs were surveyed in these 13 parishes; 381 HWMs were flagged by URS, and 101 HWMs were flagged by the USGS. All HWMs were surveyed by the URS team. Four points in St. Tammany Parish were originally identified as Mississippi points (see Table 5). Two of these HWMs were flagged by the USGS and two were flagged by URS. Because these points were originally identified as located in Mississippi, they were surveyed by a surveyor licensed in Mississippi, using Mississippi East State Plane Coordinates. These points are identified in Table 5 and no certified surveyor sheet is provided in the Appendices. HWMs flagged and surveyed by the URS team and the USGS are shown graphically in Figure 20.

Table 3. URS Team HWMs Surveyed by Parish

Parish	Number of HWMs Surveyed
Jefferson	47
Lafourche	3
Livingston	5
Orleans	162
Plaquemines	29
St. Bernard	62
St. Charles	7
St. James	1
St. John the Baptist	5
St. Tammany*	52
Tangipahoa	3
Terrebonne	1
Washington	4
Total	381

* St Tammany Parish includes two points originally identified as Mississippi points.

Table 4. USGS-Located HWMs Surveyed by Parish

Parish	Number of HWMs Surveyed
Livingston	3
Plaquemines	23
St. Bernard	19
St. John the Baptist	1
St. Tammany*	45
Tangipahoa	9
Terrebonne	1
Total	101

* St. Tammany Parish count includes two points originally identified as Mississippi points.

Table 5. URS and USGS St. Tammany HWMs Identified and Surveyed as Mississippi HWMs*

HWM_ID	County	Flood Type	NAVD 88	Surv_Lat	Surv_Lon
KMS_USGS_01	St. Tammany	N/A	15.9	30.2978027	-89.697958
KMS_USGS_20	St. Tammany	N/A	15.0	30.3804211	-89.739145
KMSR-10-12	St. Tammany	Riverine - Hurricane	14.9	30.3814973	-89.737895
KMSR-10-13	St. Tammany	Riverine - Hurricane	20.0	30.4623626	-89.695746

* Survey based on Mississippi East State Plane Coordinates.

HWMs are based on the flagger teams' best judgment of the flood waters' height. Many structures were severely damaged during Katrina, which often made locating HWMs difficult. In addition, the height of flood waters can be impacted by outside forces such as wind and shielding by other structures. Therefore, HWMs should be used to identify trends and not to extrapolate exact height of water throughout the area. In addition, severe damage to structures, trees, and other features made it difficult to find good indicators of the combined surge and wave height maximum water level. It is also important to note that because of subsidence issues in the Louisiana coastal areas, actual ground elevations may be negative; therefore surveyed elevations of HWMs are not an indication of water depth.

Data collected for the HWMs are stored in a digital database and presented on one-page forms that are sorted by parish in the appendices of this report. Forms for HWMs that were flagged by URS are included as Appendices C through O. Points investigated and located by the USGS are shown on forms in Appendix P. The HWMs are identified with a unique point number, the High Water Mark Identifier (HWM ID), as shown on the one-page HWM form. The one-page HWM forms include data for the storm event, flood type, location, point description, surveyed point coordinates (LAT/LON), and elevations. A summary of basic data for all HWMs collected are sorted by parish and HWM sheet number and presented in Table 6. A second summary table with HWM data sorted by HWM ID is provided in Appendix B as Table B-2.

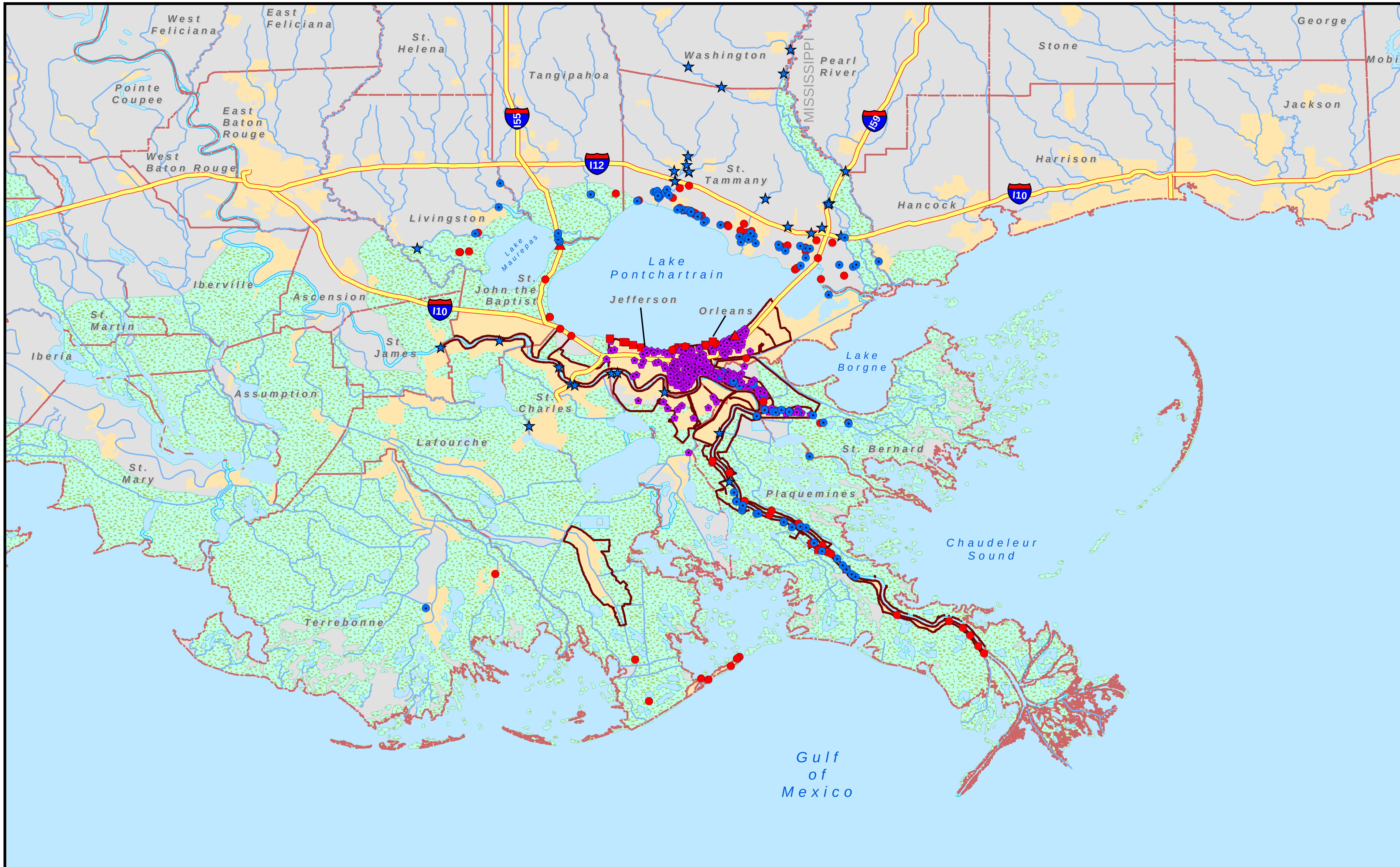

Figure 20: Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations

Coastal- Surge Only
Coastal- Wave Height
Coastal- Wave Runup
Riverine- Hurricane
USGS HWM
Levee Issue

Municipalities
Parish Boundaries
Water Body
Hydrology
Swamp or Marsh
Levees
Road Classification
Highway

Map feature locations are approximate.

FEMA

N

0 5 10 20
Miles
0 5 10 20
Kilometers

HWM location maps and a second summary table of HWM data are provided in Appendix B. HWMs collected for Hurricane Katrina Louisiana, including URS Team and USGS flagged points, are shown spatially on HWM location maps, Figures B.1 through B.8. These figures present the location, HWM ID, and the field-surveyed HWM elevation in feet referenced in NAVD 88. The symbol representing the HWM point on the map is graphically coded and designates whether the HWM is a URS Team or USGS point, and whether it is riverine or coastal (i.e., surge, wave height, or wave runup). Table B-1 lists parishes in which the data were collected and the corresponding HWM Report Sheet Number. on which they are shown. Table B-2 provides the HWM summary data provided in Table 6, however, the data is sorted by the HWM ID value for referencing convenience.

Table 6. Hurricane Katrina Louisiana HWM Data Summary

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
URS Team Flagged Points						
KLAC-01-14	Jefferson	Levee - Interior	-1.2	29.893883	-90.144871	Jeffers-1
KLAC-01-15	Jefferson	Levee - Interior	1.2	29.876847	-90.134363	Jeffers-2
KLAC-01-16	Jefferson	Levee - Interior	2.4	29.768640	-90.082523	Jeffers-3
KLAC-01-17	Jefferson	Levee - Interior	-1.8	29.854061	-90.070304	Jeffers-4
KLAC-02-35	Jefferson	Coastal - Surge Only	5.8	29.265225	-89.957349	Jeffers-5
KLAC-02-36	Jefferson	Coastal - Surge Only	8.5	29.241738	-89.978814	Jeffers-6
KLAC-03-30	Jefferson	Levee - Interior	5.5	29.999022	-90.284746	Jeffers-7
KLAC-04-07	Jefferson	Levee - Interior	-4.3	30.042867	-90.274929	Jeffers-8
KLAC-04-08	Jefferson	Levee - Interior	-4.1	30.019869	-90.274156	Jeffers-9
KLAC-04-09	Jefferson	Levee - Interior	-4.0	30.023151	-90.265552	Jeffers-10
KLAC-04-10	Jefferson	Coastal - Wave Runup	9.4	30.040061	-90.238090	Jeffers-11
KLAC-04-11	Jefferson	Coastal - Wave Runup	11.6	30.032774	-90.219619	Jeffers-12
KLAC-04-12	Jefferson	Levee - Interior	-3.6	30.011045	-90.195617	Jeffers-13
KLAC-04-13	Jefferson	Levee - Interior	-3.9	29.994800	-90.194420	Jeffers-14
KLAC-04-14	Jefferson	Levee - Interior	-3.7	29.984246	-90.198763	Jeffers-15
KLAC-04-15	Jefferson	Levee - Interior	-3.8	29.995970	-90.216290	Jeffers-16
KLAC-04-33	Jefferson	Coastal - Wave Runup	8.5	30.049191	-90.276670	Jeffers-17
KLAC-04-34	Jefferson	Coastal - Wave Runup	9.4	30.040810	-90.243065	Jeffers-18
KLAC-04-35	Jefferson	Coastal - Wave Runup	6.8	30.027021	-90.198977	Jeffers-19
KLAC-05-10	Jefferson	Levee - Interior	0.4	29.884566	-90.099468	Jeffers-20
KLAC-05-11	Jefferson	Levee - Interior	0.9	29.875315	-90.109900	Jeffers-21
KLAC-05-12	Jefferson	Levee - Interior	0.4	29.854456	-90.117160	Jeffers-22
KLAC-05-14	Jefferson	Levee - Interior	-4.3	29.894341	-90.014498	Jeffers-23
KLAC-05-15	Jefferson	Levee - Interior	-3.7	29.906414	-90.022410	Jeffers-24
KLAC-05-16	Jefferson	Levee - Interior	-5.7	29.879582	-90.034295	Jeffers-25
KLAC-06-10	Jefferson	Riverine - Hurricane	17.9	29.965889	-90.258175	Jeffers-26
KLAC-06-11	Jefferson	Riverine - Hurricane	17.9	29.917806	-90.141784	Jeffers-27
KLAC-06-13	Jefferson	Levee - Interior	-3.6	29.897037	-90.206959	Jeffers-28
KLAC-07-14	Jefferson	Levee - Interior	-3.4	30.022910	-90.187433	Jeffers-29
KLAC-07-15	Jefferson	Levee - Interior	-3.5	30.020022	-90.174296	Jeffers-30
KLAC-07-16	Jefferson	Levee - Interior	-3.6	30.018831	-90.159174	Jeffers-31
KLAC-07-18	Jefferson	Levee - Break	2.4	29.983684	-90.142651	Jeffers-32
KLAC-07-19	Jefferson	Levee - Break	2.5	29.976499	-90.140491	Jeffers-33
KLAC-07-20	Jefferson	Levee - Break	2.6	29.976465	-90.126808	Jeffers-34
KLAC-07-21	Jefferson	Levee - Interior	-3.2	30.012813	-90.123723	Jeffers-35
KLAC-07-23	Jefferson	Levee - Interior	-3.3	30.016298	-90.143372	Jeffers-36
KLAC-07-24	Jefferson	Levee - Interior	-3.1	30.011497	-90.134864	Jeffers-37
KLAC-07-25	Jefferson	Levee - Interior	-3.3	30.014168	-90.168266	Jeffers-38
KLAC-07-28	Jefferson	Levee - Interior	-3.8	30.014035	-90.185925	Jeffers-39

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-07-29	Jefferson	Levee - Interior	-3.6	29.989979	-90.164545	Jeffers-40
KLAC-07-30	Jefferson	Levee - Interior	-3.4	29.992000	-90.157755	Jeffers-41
KLAC-07-31	Jefferson	Levee - Interior	1.5	29.960933	-90.210735	Jeffers-42
KLAC-07-32	Jefferson	Levee - Interior	4.3	29.956418	-90.219183	Jeffers-43
KLAC-08-01	Jefferson	Coastal - Surge Only	8.6	29.208757	-90.033853	Jeffers-44
KLAC-26-01	Jefferson	Coastal - Surge Only	7.6	29.260584	-89.963170	Jeffers-45
KLAC-88-04	Jefferson	Coastal - Surge Only	6.6	30.040939	-90.238578	Jeffers-46
KLAC-88-05	Jefferson	Coastal - Surge Only	10.9	30.021010	-90.122967	Jeffers-47
KLAC-03-01	Lafourche	Coastal - Surge Only	8.9	29.211475	-90.051541	Lafourc-1
KLAC-03-02	Lafourche	Coastal - Surge Only	7.5	29.156245	-90.180386	Lafourc-2
KLAC-08-02	Lafourche	Coastal - Surge Only	4.1	29.257687	-90.214356	Lafourc-3
KLAC-02-06	Livingston	Coastal - Surge Only	3.1	30.262079	-90.646197	Livings-1
KLAC-02-07	Livingston	Coastal - Surge Only	2.8	30.261999	-90.647581	Livings-2
KLAC-02-08	Livingston	Coastal - Surge Only	3.3	30.263901	-90.623945	Livings-3
KLAC-02-09	Livingston	Coastal - Surge Only	5.4	30.310067	-90.602358	Livings-4
KLAC-07-01	Livingston	Riverine - Hurricane	4.0	30.271941	-90.751523	Livings-5
KLAC-01-18	Orleans	Levee - Break	2.6	29.993873	-90.100315	Orleans-1
KLAC-01-19	Orleans	Levee - Break	2.6	29.993859	-90.117045	Orleans-2
KLAC-01-20	Orleans	Levee - Break	0.7	29.986634	-90.102085	Orleans-3
KLAC-01-21	Orleans	Levee - Break	2.4	29.986863	-90.087302	Orleans-4
KLAC-01-22	Orleans	Levee - Break	2.1	29.991654	-90.084224	Orleans-5
KLAC-01-23	Orleans	Levee - Break	2.4	29.972796	-90.091926	Orleans-6
KLAC-01-24	Orleans	Levee - Break	1.8	29.991871	-90.076471	Orleans-7
KLAC-01-25	Orleans	Levee - Break	2.8	29.978922	-90.067231	Orleans-8
KLAC-01-26	Orleans	Levee - Break	2.4	29.968307	-90.066752	Orleans-9
KLAC-01-27	Orleans	Levee - Break	2.4	29.979253	-90.075412	Orleans-10
KLAC-01-28	Orleans	Levee - Break	2.7	29.987004	-90.082823	Orleans-11
KLAC-01-29	Orleans	Levee - Break	3.1	29.984352	-90.122208	Orleans-12
KLAC-01-30	Orleans	Levee - Break	2.5	29.942190	-90.084509	Orleans-13
KLAC-01-31	Orleans	Levee - Break	1.2	29.936390	-90.088888	Orleans-14
KLAC-01-32	Orleans	Levee - Break	2.6	29.927393	-90.094766	Orleans-15
KLAC-01-33	Orleans	Levee - Break	2.3	29.942651	-90.077960	Orleans-16
KLAC-01-34	Orleans	Levee - Break	7.2	29.960985	-90.020957	Orleans-17
KLAC-01-35	Orleans	Levee - Break	10.3	29.953198	-90.010822	Orleans-18
KLAC-01-39	Orleans	Levee - Break	7.5	29.962709	-90.013226	Orleans-19
KLAC-01-40	Orleans	Levee - Break	8.7	29.954032	-90.015063	Orleans-20
KLAC-02-10	Orleans	Levee - Break	2.1	29.990358	-90.110050	Orleans-21
KLAC-02-11	Orleans	Levee - Break	1.9	29.985831	-90.110528	Orleans-22
KLAC-02-12	Orleans	Levee - Break	2.9	30.018905	-90.095364	Orleans-23
KLAC-02-13	Orleans	Levee - Break	1.6	30.019020	-90.097882	Orleans-24
KLAC-02-14	Orleans	Levee - Break	1.4	30.023763	-90.097788	Orleans-25
KLAC-02-15	Orleans	Levee - Break	2.2	30.021567	-90.112928	Orleans-26
KLAC-02-16	Orleans	Coastal - Wave Runup	10.7	30.023155	-90.113175	Orleans-27
KLAC-02-17	Orleans	Coastal - Wave Runup	14.5	30.026717	-90.108023	Orleans-28
KLAC-02-18	Orleans	Coastal - Wave Runup	12.9	30.027252	-90.098456	Orleans-29
KLAC-02-19	Orleans	Levee - Break	2.3	30.025849	-90.111054	Orleans-30
KLAC-02-20	Orleans	Levee - Break	1.8	30.021737	-90.099432	Orleans-31
KLAC-02-21	Orleans	Levee - Break	1.7	30.019575	-90.098801	Orleans-32
KLAC-02-22	Orleans	Coastal - Wave Runup	12.6	30.027855	-90.089186	Orleans-33
KLAC-02-23	Orleans	Levee - Break	2.2	29.941290	-90.123572	Orleans-34
KLAC-02-24	Orleans	Levee - Break	1.5	29.933939	-90.112644	Orleans-35
KLAC-02-25	Orleans	Levee - Break	2.1	29.935016	-90.096632	Orleans-36
KLAC-02-26	Orleans	Levee - Break	1.4	29.927913	-90.096958	Orleans-37
KLAC-02-27	Orleans	Levee - Break	2.5	29.938780	-90.109033	Orleans-38
KLAC-02-28	Orleans	Levee - Break	2.5	29.933777	-90.102596	Orleans-39
KLAC-03-11	Orleans	Levee - Break	2.4	29.991046	-90.109842	Orleans-40

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-03-12	Orleans	Levee - Break	2.4	29.982494	-90.109802	Orleans-41
KLAC-03-14	Orleans	Levee - Break	2.4	30.020426	-90.104834	Orleans-42
KLAC-03-15	Orleans	Levee - Break	2.2	30.023225	-90.101497	Orleans-43
KLAC-03-16	Orleans	Levee - Break	2.8	29.999931	-90.089522	Orleans-44
KLAC-03-17	Orleans	Levee - Break	2.3	30.004097	-90.098971	Orleans-45
KLAC-03-18	Orleans	Levee - Break	2.6	29.994576	-90.100559	Orleans-46
KLAC-03-19	Orleans	Levee - Break	1.4	30.020791	-90.083810	Orleans-47
KLAC-03-20	Orleans	Levee - Break	2.1	30.024105	-90.083555	Orleans-48
KLAC-03-21	Orleans	Levee - Break	2.6	29.943609	-90.097165	Orleans-49
KLAC-03-22	Orleans	Levee - Break	2.5	29.944630	-90.103927	Orleans-50
KLAC-03-23	Orleans	Levee - Break	1.5	29.941178	-90.107024	Orleans-51
KLAC-03-25	Orleans	Levee - Break	2.4	29.945435	-90.124320	Orleans-52
KLAC-04-16	Orleans	Levee - Break	1.3	30.027518	-90.054973	Orleans-53
KLAC-04-18	Orleans	Coastal - Wave Runup	16.6	30.033719	-90.041892	Orleans-54
KLAC-04-19	Orleans	Levee - Break	2.3	29.987848	-90.067639	Orleans-55
KLAC-04-20	Orleans	Levee - Break	2.5	29.970660	-90.077545	Orleans-56
KLAC-04-21	Orleans	Levee - Break	1.5	29.982684	-90.090947	Orleans-57
KLAC-04-22	Orleans	Levee - Break	2.4	29.975356	-90.083980	Orleans-58
KLAC-04-23	Orleans	Levee - Break	3.0	29.936543	-90.092225	Orleans-59
KLAC-04-24	Orleans	Levee - Break	1.8	29.942776	-90.093619	Orleans-60
KLAC-04-25	Orleans	Levee - Break	1.0	29.932419	-90.087119	Orleans-61
KLAC-04-26	Orleans	Levee - Break	1.7	29.936553	-90.081185	Orleans-62
KLAC-05-19	Orleans	Levee - Break	2.8	29.995878	-90.078121	Orleans-63
KLAC-05-20	Orleans	Levee - Break	2.6	30.001183	-90.081248	Orleans-64
KLAC-05-21	Orleans	Levee - Break	1.5	30.007019	-90.082341	Orleans-65
KLAC-05-22	Orleans	Levee - Break	2.8	30.012504	-90.076960	Orleans-66
KLAC-05-23	Orleans	Levee - Break	1.4	30.016459	-90.075170	Orleans-67
KLAC-05-24	Orleans	Levee - Break	2.9	30.007128	-90.070245	Orleans-68
KLAC-05-25	Orleans	Levee - Break	2.8	30.000777	-90.072038	Orleans-69
KLAC-05-26	Orleans	Levee - Break	2.7	29.995359	-90.068977	Orleans-70
KLAC-05-27	Orleans	Levee - Break	3.0	29.998317	-90.064052	Orleans-71
KLAC-05-28	Orleans	Levee - Break	1.9	30.000915	-90.064341	Orleans-72
KLAC-05-30	Orleans	Coastal - Wave Runup	15.3	30.031421	-90.038513	Orleans-73
KLAC-05-31	Orleans	Levee - Break	-1.3	30.029053	-89.992436	Orleans-74
KLAC-05-32	Orleans	Levee - Break	-1.3	30.027460	-90.000252	Orleans-75
KLAC-05-33	Orleans	Levee - Break	-1.4	30.032334	-89.973003	Orleans-76
KLAC-05-34	Orleans	Levee - Break	-1.6	30.033226	-89.968415	Orleans-77
KLAC-05-35	Orleans	Levee - Break	-1.4	30.040248	-89.961665	Orleans-78
KLAC-05-36	Orleans	Levee - Break	-1.4	30.033504	-89.951188	Orleans-79
KLAC-05-37	Orleans	Levee - Break	-1.1	30.041876	-89.950630	Orleans-80
KLAC-06-25	Orleans	Levee - Break	-1.4	30.033022	-90.025296	Orleans-81
KLAC-06-26	Orleans	Levee - Break	0.7	30.036767	-90.014753	Orleans-82
KLAC-06-27	Orleans	Coastal - Surge Only	12.0	30.036884	-90.014808	Orleans-83
KLAC-06-28	Orleans	Levee - Break	-1.4	30.043497	-89.995622	Orleans-84
KLAC-06-29	Orleans	Levee - Break	-1.6	30.049428	-89.983252	Orleans-85
KLAC-06-30	Orleans	Levee - Interior	-1.6	30.056162	-89.970125	Orleans-86
KLAC-06-31	Orleans	Levee - Break	-1.9	30.065669	-89.955639	Orleans-87
KLAC-06-32	Orleans	Levee - Break	0.3	30.074338	-89.944923	Orleans-88
KLAC-06-33	Orleans	Levee - Break	-2.2	30.056748	-89.945215	Orleans-89
KLAC-06-34	Orleans	Levee - Break	-1.5	30.048059	-89.959128	Orleans-90
KLAC-06-35	Orleans	Levee - Break	-1.5	30.038429	-89.977054	Orleans-91
KLAC-06-36	Orleans	Levee - Break	-1.5	30.031377	-89.994363	Orleans-92
KLAC-06-37	Orleans	Levee - Break	-1.4	30.027660	-90.015203	Orleans-93
KLAC-06-38	Orleans	Levee - Break	-1.6	30.017828	-89.982840	Orleans-94
KLAC-06-49	Orleans	Levee - Break	2.8	30.014536	-89.999017	Orleans-95
KLAC-06-50	Orleans	Levee - Break	-1.4	30.021934	-89.959512	Orleans-96

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-06-51	Orleans	Levee - Break	2.5	30.008423	-89.992803	Orleans-97
KLAC-06-52	Orleans	Levee - Break	2.0	30.018307	-89.930539	Orleans-98
KLAC-07-33	Orleans	Levee - Break	2.7	29.966548	-90.038379	Orleans-99
KLAC-07-34	Orleans	Levee - Break	2.7	29.968528	-90.048521	Orleans-100
KLAC-07-35	Orleans	Levee - Break	2.7	29.970246	-90.057182	Orleans-101
KLAC-07-36	Orleans	Levee - Break	2.6	29.976899	-90.057160	Orleans-102
KLAC-07-37	Orleans	Levee - Break	1.4	29.982597	-90.057495	Orleans-103
KLAC-07-38	Orleans	Levee - Break	3.4	29.990477	-90.057982	Orleans-104
KLAC-07-39	Orleans	Levee - Break	2.6	29.980149	-90.048693	Orleans-105
KLAC-07-40	Orleans	Levee - Break	3.2	29.989839	-90.049453	Orleans-106
KLAC-07-41	Orleans	Levee - Break	2.6	29.974059	-90.049001	Orleans-107
KLAC-07-42	Orleans	Levee - Break	2.8	29.971987	-90.038794	Orleans-108
KLAC-07-43	Orleans	Levee - Break	2.6	29.969304	-90.029645	Orleans-109
KLAC-07-44	Orleans	Levee - Break	2.6	29.964977	-90.029156	Orleans-110
KLAC-07-45	Orleans	Levee - Break	1.9	29.978703	-90.029617	Orleans-111
KLAC-07-46	Orleans	Levee - Break	2.6	29.979128	-90.036583	Orleans-112
KLAC-07-47	Orleans	Levee - Break	3.0	29.965862	-90.041988	Orleans-113
KLAC-07-48	Orleans	Levee - Break	3.0	29.967949	-90.057066	Orleans-114
KLAC-07-49	Orleans	Levee - Break	2.7	29.946740	-90.074960	Orleans-115
KLAC-07-50	Orleans	Levee - Break	2.0	29.950163	-90.087857	Orleans-116
KLAC-07-51	Orleans	Levee - Break	2.6	29.962029	-90.094450	Orleans-117
KLAC-07-52	Orleans	Levee - Break	2.4	29.955977	-90.095870	Orleans-118
KLAC-07-53	Orleans	Levee - Break	2.7	29.948563	-90.094213	Orleans-119
KLAC-07-54	Orleans	Levee - Break	2.5	29.955683	-90.073097	Orleans-120
KLAC-07-55	Orleans	Levee - Break	2.6	29.950951	-90.075724	Orleans-121
KLAC-07-56	Orleans	Levee - Break	2.8	29.955626	-90.086697	Orleans-122
KLAC-07-57	Orleans	Levee - Break	2.5	29.961796	-90.082197	Orleans-123
KLAC-07-58	Orleans	Levee - Break	2.5	29.957368	-90.069406	Orleans-124
KLAC-08-19	Orleans	Levee - Break	-1.4	30.026014	-90.025569	Orleans-125
KLAC-08-20	Orleans	Levee - Break	-1.4	30.028813	-90.014087	Orleans-126
KLAC-08-21	Orleans	Levee - Break	-2.0	30.033235	-90.003006	Orleans-127
KLAC-08-22	Orleans	Levee - Break	-3.8	30.062793	-89.948767	Orleans-128
KLAC-08-23	Orleans	Levee - Break	-1.8	30.068128	-89.940925	Orleans-129
KLAC-08-24	Orleans	Levee - Break	-2.0	30.038939	-89.988281	Orleans-130
KLAC-08-25	Orleans	Levee - Break	-1.5	30.046632	-89.972388	Orleans-131
KLAC-08-26	Orleans	Levee - Break	-1.5	30.058282	-89.955038	Orleans-132
KLAC-08-27	Orleans	Levee - Break	-1.5	30.017604	-90.021657	Orleans-133
KLAC-09-02	Orleans	Levee - Break	1.9	30.025492	-90.056868	Orleans-134
KLAC-09-03	Orleans	Levee - Break	1.4	30.021333	-90.075571	Orleans-135
KLAC-09-04	Orleans	Levee - Break	1.4	30.019022	-90.089940	Orleans-136
KLAC-09-05	Orleans	Levee - Break	2.8	30.003373	-90.095982	Orleans-137
KLAC-09-06	Orleans	Levee - Break	1.9	30.002844	-90.054981	Orleans-138
KLAC-09-07	Orleans	Levee - Break	1.4	30.008381	-90.055428	Orleans-139
KLAC-09-08	Orleans	Levee - Break	1.8	30.002958	-90.046459	Orleans-140
KLAC-09-09	Orleans	Levee - Break	1.7	30.010685	-90.047117	Orleans-141
KLAC-09-10	Orleans	Levee - Break	1.7	29.997180	-90.054532	Orleans-142
KLAC-09-11	Orleans	Levee - Break	1.4	29.993101	-90.039379	Orleans-143
KLAC-09-12	Orleans	Levee - Break	2.4	29.967512	-90.111703	Orleans-144
KLAC-09-13	Orleans	Levee - Break	1.8	29.967078	-90.119451	Orleans-145
KLAC-09-14	Orleans	Levee - Break	2.0	29.966981	-90.127291	Orleans-146
KLAC-09-15	Orleans	Levee - Break	2.6	29.960412	-90.119374	Orleans-147
KLAC-09-16	Orleans	Levee - Break	2.2	29.961058	-90.111858	Orleans-148
KLAC-09-17	Orleans	Levee - Break	2.5	29.958750	-90.103130	Orleans-149
KLAC-09-18	Orleans	Levee - Break	2.0	29.954072	-90.103905	Orleans-150
KLAC-09-19	Orleans	Levee - Break	1.4	29.951070	-90.108852	Orleans-151
KLAC-09-20	Orleans	Levee - Break	2.5	29.951726	-90.118797	Orleans-152

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-09-21	Orleans	Levee - Break	1.8	29.953681	-90.127727	Orleans-153
KLAC-09-22	Orleans	Levee - Break	2.7	29.962238	-90.127849	Orleans-154
KLAC-88-03	Orleans	Coastal - Surge Only	15.0	30.000991	-89.940955	Orleans-155
KLAC-88-06	Orleans	Coastal - Surge Only	11.8	30.029783	-90.091199	Orleans-156
KLAC-88-07	Orleans	Coastal - Surge Only	11.8	30.033801	-90.040233	Orleans-157
KLAC-88-08	Orleans	Coastal - Wave Height	13.8	30.057677	-89.969006	Orleans-158
KLAC-88-15	Orleans	Coastal - Wave Height	13.0	30.057932	-89.968537	Orleans-159
KLAC-88-20	Orleans	Coastal - Surge Only	11.4	30.036790	-90.017013	Orleans-160
KLAC-99-01	Orleans	Coastal - Wave Runup	11.7	30.041787	-90.023215	Orleans-161
KLRL-27-05	Orleans	Levee - Break	11.6	29.960971	-90.026233	Orleans-162
KLAC-05-17	Plaquemines	Coastal - Surge Only	2.9	29.743390	-90.024501	Plaquem-1
KLAC-05-18	Plaquemines	Riverine - Hurricane	16.3	29.817290	-90.006881	Plaquem-2
KLAC-06-14	Plaquemines	Coastal - Wave Runup	13.2	29.480648	-89.693675	Plaquem-3
KLAC-06-15	Plaquemines	Coastal - Surge Only	11.9	29.524854	-89.739953	Plaquem-4
KLAC-06-17	Plaquemines	Coastal - Surge Only	3.2	29.638149	-89.948467	Plaquem-5
KLAC-06-18	Plaquemines	Riverine - Hurricane	17.0	29.697418	-89.982336	Plaquem-6
KLAC-06-19	Plaquemines	Coastal - Surge Only	5.4	29.747804	-90.023973	Plaquem-7
KLAC-06-20	Plaquemines	Coastal - Surge Only	12.5	29.540295	-89.752529	Plaquem-8
KLAC-06-21	Plaquemines	Coastal - Surge Only	12.0	29.585034	-89.806325	Plaquem-9
KLAC-06-22	Plaquemines	Coastal - Surge Only	13.7	29.615051	-89.882991	Plaquem-10
KLAC-06-23	Plaquemines	Coastal - Surge Only	16.1	29.647733	-89.945611	Plaquem-11
KLAC-06-24	Plaquemines	Coastal - Surge Only	4.3	29.718877	-89.981940	Plaquem-12
KLAC-08-08	Plaquemines	Coastal - Surge Only	7.1	29.522635	-89.740998	Plaquem-13
KLAC-08-09	Plaquemines	Riverine - Hurricane	3.0	29.543527	-89.778084	Plaquem-14
KLAC-08-10	Plaquemines	Coastal - Surge Only	8.3	29.518947	-89.732026	Plaquem-15
KLAC-08-11	Plaquemines	Coastal - Wave Runup	5.9	29.527769	-89.762985	Plaquem-16
KLAC-08-12	Plaquemines	Coastal - Wave Runup	5.8	29.543150	-89.779094	Plaquem-17
KLAC-08-13	Plaquemines	Coastal - Surge Only	0.4	29.625983	-89.949704	Plaquem-18
KLAC-08-14	Plaquemines	Coastal - Surge Only	4.2	29.625942	-89.950431	Plaquem-19
KLAC-08-15	Plaquemines	Coastal - Surge Only	15.7	29.593466	-89.811625	Plaquem-20
KLAC-08-16	Plaquemines	Coastal - Surge Only	13.6	29.624711	-89.878333	Plaquem-21
KLAC-08-17	Plaquemines	Coastal - Surge Only	8.9	29.648495	-89.944562	Plaquem-22
KLAC-08-18	Plaquemines	Coastal - Surge Only	16.2	29.648567	-89.944674	Plaquem-23
KLAC-29-01	Plaquemines	Coastal - Surge Only	5.1	29.273584	-89.354106	Plaquem-24
KLAC-29-02	Plaquemines	Coastal - Surge Only	4.4	29.290896	-89.368476	Plaquem-25
KLAC-29-03	Plaquemines	Coastal - Surge Only	4.8	29.318055	-89.388678	Plaquem-26
KLAC-29-04	Plaquemines	Coastal - Surge Only	6.5	29.336085	-89.406724	Plaquem-27
KLAC-29-05	Plaquemines	Coastal - Surge Only	7.3	29.352654	-89.440705	Plaquem-28
KLAC-29-07	Plaquemines	Coastal - Surge Only	2.4	29.367829	-89.569263	Plaquem-29
KLAC-01-36	St. Bernard	Levee - Break	10.4	29.954800	-90.003893	St. Ber-1
KLAC-01-37	St. Bernard	Levee - Break	8.6	29.954864	-89.994656	St. Ber-2
KLAC-01-38	St. Bernard	Levee - Break	10.4	29.950690	-90.006295	St. Ber-3
KLAC-02-29	St. Bernard	Levee - Break	10.9	29.930352	-89.930483	St. Ber-4
KLAC-02-30	St. Bernard	Levee - Break	10.6	29.931828	-89.935829	St. Ber-5
KLAC-02-31	St. Bernard	Levee - Break	10.7	29.936127	-89.921286	St. Ber-6
KLAC-02-32	St. Bernard	Levee - Break	10.9	29.946932	-89.921561	St. Ber-7
KLAC-02-33	St. Bernard	Levee - Break	10.3	29.931295	-89.948093	St. Ber-8
KLAC-02-34	St. Bernard	Levee - Break	10.5	29.937716	-89.960173	St. Ber-9
KLAC-03-26	St. Bernard	Levee - Break	5.5	29.862818	-89.781835	St. Ber-10
KLAC-04-27	St. Bernard	Levee - Break	4.1	29.967424	-90.019830	St. Ber-11
KLAC-04-28	St. Bernard	Levee - Break	4.6	29.965940	-90.014121	St. Ber-12
KLAC-04-29	St. Bernard	Levee - Break	3.9	29.963503	-90.005880	St. Ber-13
KLAC-04-30	St. Bernard	Levee - Break	9.8	29.946767	-89.921476	St. Ber-14
KLAC-04-31	St. Bernard	Levee - Break	10.5	29.970211	-89.997887	St. Ber-15
KLAC-04-32	St. Bernard	Levee - Break	10.0	29.962731	-89.990968	St. Ber-16
KLAC-05-38	St. Bernard	Levee - Break	11.3	29.907335	-89.906557	St. Ber-17

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-05-39	St. Bernard	Levee - Break	12.1	29.913047	-89.899305	St. Ber-18
KLAC-05-40	St. Bernard	Levee - Break	11.4	29.905706	-89.895124	St. Ber-19
KLAC-05-41	St. Bernard	Levee - Break	9.8	29.916301	-89.912116	St. Ber-20
KLAC-05-42	St. Bernard	Levee - Break	10.8	29.922763	-89.902248	St. Ber-21
KLAC-06-39	St. Bernard	Levee - Break	11.0	29.866900	-89.803919	St. Ber-22
KLAC-06-40	St. Bernard	Levee - Break	11.6	29.867923	-89.825791	St. Ber-23
KLAC-06-41	St. Bernard	Levee - Break	10.4	29.865145	-89.842511	St. Ber-24
KLAC-06-42	St. Bernard	Levee - Break	10.2	29.868054	-89.864807	St. Ber-25
KLAC-06-43	St. Bernard	Levee - Break	10.5	29.868316	-89.885116	St. Ber-26
KLAC-06-44	St. Bernard	Levee - Break	10.6	29.879348	-89.895626	St. Ber-27
KLAC-06-45	St. Bernard	Levee - Break	11.0	29.878557	-89.878265	St. Ber-28
KLAC-06-46	St. Bernard	Levee - Break	10.3	29.873169	-89.867391	St. Ber-29
KLAC-06-47	St. Bernard	Levee - Break	9.3	29.873593	-89.835018	St. Ber-30
KLAC-06-48	St. Bernard	Levee - Break	11.8	29.877521	-89.812687	St. Ber-31
KLAC-06-53	St. Bernard	Levee - Break	10.2	29.963679	-89.952610	St. Ber-32
KLAC-06-54	St. Bernard	Levee - Break	11.6	29.981529	-89.945356	St. Ber-33
KLAC-07-59	St. Bernard	Levee - Break	10.0	29.954119	-89.958510	St. Ber-34
KLAC-07-60	St. Bernard	Levee - Break	10.3	29.958308	-89.965734	St. Ber-35
KLAC-07-61	St. Bernard	Levee - Break	8.9	29.950363	-89.968375	St. Ber-36
KLAC-07-62	St. Bernard	Levee - Break	10.7	29.945164	-89.971341	St. Ber-37
KLAC-07-63	St. Bernard	Levee - Break	9.8	29.949174	-89.962772	St. Ber-38
KLAC-07-64	St. Bernard	Levee - Break	10.2	29.942926	-89.965123	St. Ber-39
KLAC-07-65	St. Bernard	Levee - Break	10.2	29.938115	-89.966792	St. Ber-40
KLAC-07-66	St. Bernard	Levee - Break	10.6	29.940645	-89.974455	St. Ber-41
KLAC-07-67	St. Bernard	Levee - Break	10.5	29.944681	-89.982199	St. Ber-42
KLAC-07-68	St. Bernard	Levee - Break	10.0	29.952141	-89.979169	St. Ber-43
KLAC-07-69	St. Bernard	Levee - Break	9.4	29.959332	-89.978905	St. Ber-44
KLAC-07-70	St. Bernard	Levee - Break	10.8	29.968344	-89.985666	St. Ber-45
KLAC-07-71	St. Bernard	Levee - Break	10.6	29.959404	-89.992553	St. Ber-46
KLAC-07-72	St. Bernard	Levee - Break	10.5	29.950316	-89.993292	St. Ber-47
KLAC-27-04	St. Bernard	Coastal - Surge Only	17.7	29.842576	-89.689238	St. Ber-48
KLAC-88-01	St. Bernard	Coastal - Surge Only	12.0	29.860420	-89.913023	St. Ber-49
KLAC-88-02	St. Bernard	Coastal - Surge Only	17.1	29.840585	-89.757925	St. Ber-50
KLRL-27-01	St. Bernard	Coastal - Surge Only	10.6	29.894428	-89.898608	St. Ber-51
KLRL-27-02	St. Bernard	Levee - Break	12.1	29.924996	-89.911154	St. Ber-52
KLRL-27-03	St. Bernard	Levee - Break	11.6	29.942210	-89.952472	St. Ber-53
KLRL-27-07	St. Bernard	Levee - Break	12.5	29.963170	-89.971364	St. Ber-54
KLRL-28-01	St. Bernard	Levee - Break	11.5	29.919897	-89.906412	St. Ber-55
KLRL-28-02	St. Bernard	Levee - Break	10.4	29.943974	-89.927901	St. Ber-56
KLRL-28-03	St. Bernard	Levee - Break	11.5	29.958577	-89.971980	St. Ber-57
KLRL-28-04	St. Bernard	Levee - Break	12.6	29.868570	-89.815673	St. Ber-58
KLRL-28-05	St. Bernard	Levee - Break	14.4	29.916635	-89.896237	St. Ber-59
KLRL-28-06	St. Bernard	Levee - Break	13.0	29.966306	-90.005487	St. Ber-60
KLRL-28-07	St. Bernard	Levee - Break	11.1	29.963951	-90.000883	St. Ber-61
KLRL-28-08	St. Bernard	Levee - Break	11.2	29.956537	-90.019127	St. Ber-62
KLAC-02-02	St. Charles	Riverine - Hurricane	13.6	29.938693	-90.374965	St. Cha-1
KLAC-02-03	St. Charles	Riverine - Hurricane	15.7	29.935227	-90.363427	St. Cha-2
KLAC-02-04	St. Charles	Riverine - Hurricane	17.8	29.963860	-90.273558	St. Cha-3
KLAC-02-05	St. Charles	Riverine - Hurricane	3.5	29.834727	-90.475951	St. Cha-4
KLAC-03-29	St. Charles	Coastal - Surge Only	6.4	30.055665	-90.371799	St. Cha-5
KLAC-03-31	St. Charles	Coastal - Surge Only	9.3	30.072671	-90.399370	St. Cha-6
KLAC-20-01	St. Charles	Riverine - Hurricane	13.5	29.979332	-90.402671	St. Cha-7
KLAC-20-03	St. James	Riverine - Hurricane	13.6	30.028047	-90.694202	St. Jam-1
KLAC-03-06	St. John the Baptist	Coastal - Wave Height	6.0	30.281138	-90.399966	St. Joh-1
KLAC-03-07	St. John the Baptist	Coastal - Surge Only	2.8	30.194538	-90.435975	St. Joh-2
KLAC-03-09	St. John the Baptist	Coastal - Surge Only	3.9	30.101686	-90.425410	St. Joh-3

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-03-10	St. John the Baptist	Coastal - Surge Only	5.7	30.101597	-90.424877	St. Joh-4
KLAC-20-02	St. John the Baptist	Riverine - Hurricane	12.9	30.044764	-90.549558	St. Joh-5
KLAC-01-01	St. Tammany	Coastal - Surge Only	9.7	30.301813	-89.938861	St. Tam-1
KLAC-01-02	St. Tammany	Coastal - Surge Only	9.7	30.301163	-89.943654	St. Tam-2
KLAC-01-03	St. Tammany	Coastal - Wave Runup	7.6	30.309747	-89.939823	St. Tam-3
KLAC-01-05	St. Tammany	Coastal - Surge Only	10.5	30.328688	-89.987372	St. Tam-4
KLAC-01-06	St. Tammany	Riverine - Hurricane	27.9	30.394586	-89.893528	St. Tam-5
KLAC-01-07	St. Tammany	Coastal - Surge Only	9.7	30.299328	-89.934764	St. Tam-6
KLAC-01-09	St. Tammany	Coastal - Surge Only	9.7	30.293306	-89.935446	St. Tam-7
KLAC-01-10	St. Tammany	Coastal - Surge Only	9.8	30.314372	-89.927285	St. Tam-8
KLAC-01-11	St. Tammany	Coastal - Surge Only	9.6	30.331819	-89.945904	St. Tam-9
KLAC-01-12	St. Tammany	Coastal - Surge Only	9.8	30.315155	-89.954774	St. Tam-10
KLAC-01-13	St. Tammany	Coastal - Surge Only	10.8	30.326294	-89.984678	St. Tam-11
KLAC-04-01	St. Tammany	Riverine - Hurricane	12.8	30.477691	-90.087241	St. Tam-12
KLAC-04-02A	St. Tammany	Riverine - Hurricane	9.7	30.461502	-90.081745	St. Tam-13
KLAC-04-02	St. Tammany	Riverine - Hurricane	6.1	30.460596	-90.082856	St. Tam-14
KLAC-04-03	St. Tammany	Riverine - Hurricane	7.7	30.438345	-90.115926	St. Tam-15
KLAC-04-04	St. Tammany	Riverine - Hurricane	8.1	30.437713	-90.116280	St. Tam-16
KLAC-04-05	St. Tammany	Coastal - Surge Only	6.9	30.398989	-90.155788	St. Tam-17
KLAC-05-01	St. Tammany	Coastal - Surge Only	13.2	30.219233	-89.819947	St. Tam-18
KLAC-05-02	St. Tammany	Coastal - Surge Only	11.4	30.275539	-89.853008	St. Tam-19
KLAC-05-03	St. Tammany	Coastal - Surge Only	11.2	30.278714	-89.838555	St. Tam-20
KLAC-05-04	St. Tammany	Coastal - Surge Only	11.0	30.272160	-89.795137	St. Tam-21
KLAC-05-05	St. Tammany	Coastal - Surge Only	10.5	30.272963	-89.794737	St. Tam-22
KLAC-05-06	St. Tammany	Coastal - Surge Only	11.4	30.263776	-89.793520	St. Tam-23
KLAC-05-07	St. Tammany	Coastal - Surge Only	15.3	30.195716	-89.756186	St. Tam-24
KLAC-05-09	St. Tammany	Coastal - Surge Only	16.0	30.203851	-89.699580	St. Tam-25
KLAC-05-43	St. Tammany	Coastal - Surge Only	7.8	30.389975	-90.205244	St. Tam-26
KLAC-06-01	St. Tammany	Coastal - Surge Only	12.8	30.222620	-89.815969	St. Tam-27
KLAC-06-02	St. Tammany	Riverine - Hurricane	17.1	30.325798	-89.837902	St. Tam-28
KLAC-06-03	St. Tammany	Riverine - Hurricane	12.6	30.309997	-89.779832	St. Tam-29
KLAC-06-04	St. Tammany	Coastal - Surge Only	12.1	30.285462	-89.728436	St. Tam-30
KLAC-06-05	St. Tammany	Riverine - Hurricane	15.2	30.381480	-89.737359	St. Tam-31
KLAC-06-06	St. Tammany	Riverine - Hurricane	15.2	30.384245	-89.734828	St. Tam-32
KLAC-06-07	St. Tammany	Riverine - Hurricane	22.5	30.323686	-89.753897	St. Tam-33
KLAC-06-08	St. Tammany	Coastal - Surge Only	12.4	30.247756	-89.763806	St. Tam-34
KLAC-06-09	St. Tammany	Coastal - Surge Only	13.4	30.290653	-89.767705	St. Tam-35
KLAC-07-02	St. Tammany	Coastal - Surge Only	8.8	30.351446	-90.050334	St. Tam-36
KLAC-07-03	St. Tammany	Coastal - Surge Only	9.2	30.354669	-90.067620	St. Tam-37
KLAC-07-04	St. Tammany	Coastal - Surge Only	9.3	30.359690	-90.070840	St. Tam-38
KLAC-07-05	St. Tammany	Coastal - Surge Only	9.1	30.362328	-90.079797	St. Tam-39
KLAC-07-07	St. Tammany	Coastal - Wave Runup	6.6	30.364935	-90.091837	St. Tam-40
KLAC-07-08	St. Tammany	Coastal - Surge Only	9.2	30.363178	-90.077562	St. Tam-41
KLAC-07-09	St. Tammany	Coastal - Surge Only	10.3	30.357811	-90.065489	St. Tam-42
KLAC-07-10	St. Tammany	Coastal - Surge Only	8.4	30.371039	-90.104908	St. Tam-43
KLAC-07-11	St. Tammany	Coastal - Surge Only	7.8	30.396049	-90.121701	St. Tam-44
KLAC-07-12	St. Tammany	Coastal - Surge Only	7.8	30.419672	-90.104286	St. Tam-45
KLAC-07-13	St. Tammany	Coastal - Surge Only	9.0	30.425247	-90.081520	St. Tam-46
KLAC-25-01	St. Tammany	Coastal - Surge Only	8.0	30.409188	-90.140448	St. Tam-47
KLAR-25-05	St. Tammany	Riverine - Hurricane	8.5	30.463462	-90.118189	St. Tam-48
KLAR-26-01	St. Tammany	Riverine - Hurricane	18.2	30.499589	-90.084433	St. Tam-49
KLAR-31-01	St. Tammany	Riverine - Hurricane	7.2	30.303100	-89.706707	St. Tam-50
KLAC-03-03	Tangipahoa	Coastal - Surge Only	6.0	30.404156	-90.323376	Tangipa-1
KLAC-03-04	Tangipahoa	Coastal - Surge Only	5.6	30.405803	-90.262036	Tangipa-2
KLAC-03-05	Tangipahoa	Coastal - Surge Only	3.5	30.290135	-90.401377	Tangipa-3
KLAC-02-01	Terrebonne	Coastal - Surge Only	2.1	29.469424	-90.559291	Terrebo-1

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAR-25-01	Washington	Riverine - Hurricane	95.2	30.720711	-90.083432	Washing-1
KLAR-25-02	Washington	Riverine - Hurricane	67.4	30.761990	-89.831306	Washing-2
KLAR-25-03	Washington	Riverine - Hurricane	62.4	30.703549	-89.848047	Washing-3
KLAR-25-04	Washington	Riverine - Hurricane	76.5	30.670099	-90.001615	Washing-4
USGS Flagged Points						
KLA-USGS-28	Livingston	N/A	3.9	30.307745	-90.608591	U-Livings-1
KLA-USGS-29	Livingston	N/A	5.7	30.372860	-90.551176	U-Livings-2
KLA-USGS-30	Livingston	N/A	6.8	30.431380	-90.547055	U-Livings-3
KLA-USGS-73	Plaquemines	N/A	3.8	29.626077	-89.951343	U-Plaquem-1
KLA-USGS-74	Plaquemines	N/A	4.4	29.633632	-89.949389	U-Plaquem-2
KLA-USGS-75	Plaquemines	N/A	4.2	29.670619	-89.970904	U-Plaquem-3
KLA-USGS-76	Plaquemines	N/A	4.2	29.649179	-89.965662	U-Plaquem-4
KLA-USGS-77	Plaquemines	N/A	7.0	29.583893	-89.828095	U-Plaquem-5
KLA-USGS-78	Plaquemines	N/A	5.6	29.617380	-89.915642	U-Plaquem-6
KLA-USGS-79	Plaquemines	N/A	5.4	29.595853	-89.848673	U-Plaquem-7
KLA-USGS-80	Plaquemines	N/A	5.6	29.597849	-89.848681	U-Plaquem-8
KLA-USGS-81	Plaquemines	N/A	3.5	29.618379	-89.910538	U-Plaquem-9
KLA-USGS-82	Plaquemines	N/A	3.2	29.638149	-89.948467	U-Plaquem-10
KLA-USGS-83	Plaquemines	N/A	4.3	29.647637	-89.963690	U-Plaquem-11
KLA-USGS-84	Plaquemines	N/A	14.8	29.462508	-89.671123	U-Plaquem-12
KLA-USGS-85	Plaquemines	N/A	11.8	29.468431	-89.680300	U-Plaquem-13
KLA-USGS-87	Plaquemines	N/A	11.8	29.480121	-89.693192	U-Plaquem-14
KLA-USGS-88	Plaquemines	N/A	15.0	29.490806	-89.702664	U-Plaquem-15
KLA-USGS-89	Plaquemines	N/A	12.1	29.506911	-89.715938	U-Plaquem-16
KLA-USGS-91	Plaquemines	N/A	7.0	29.525419	-89.753345	U-Plaquem-17
KLA-USGS-92	Plaquemines	N/A	11.4	29.545586	-89.773668	U-Plaquem-18
KLA-USGS-101	Plaquemines	N/A	12.8	29.586328	-89.806839	U-Plaquem-19
KLA-USGS-102	Plaquemines	N/A	13.1	29.586142	-89.807530	U-Plaquem-20
KLA-USGS-103	Plaquemines	N/A	13.4	29.583721	-89.792962	U-Plaquem-21
KLA-USGS-106	Plaquemines	N/A	7.2	29.858856	-89.914975	U-Plaquem-22
KLA-USGS-107	Plaquemines	N/A	7.0	29.858770	-89.914978	U-Plaquem-23
KLA-USGS-62	St. Bernard	N/A	16.4	29.758632	-89.784467	U-St. Ber-1
KLA-USGS-63	St. Bernard	N/A	9.0	29.867845	-89.868162	U-St. Ber-2
KLA-USGS-64	St. Bernard	N/A	11.6	29.868332	-89.834880	U-St. Ber-3
KLA-USGS-65	St. Bernard	N/A	11.1	29.867531	-89.813785	U-St. Ber-4
KLA-USGS-66	St. Bernard	N/A	11.4	29.859845	-89.775653	U-St. Ber-5
KLA-USGS-67	St. Bernard	N/A	10.5	29.873446	-89.895142	U-St. Ber-6
KLA-USGS-68	St. Bernard	N/A	11.3	29.892341	-89.898341	U-St. Ber-7
KLA-USGS-70	St. Bernard	N/A	10.6	29.932132	-89.956962	U-St. Ber-8
KLA-USGS-71	St. Bernard	N/A	10.6	29.941266	-89.973720	U-St. Ber-9
KLA-USGS-72	St. Bernard	N/A	11.3	29.958216	-90.006024	U-St. Ber-10
KLA-USGS-93	St. Bernard	N/A	19.2	29.839902	-89.688303	U-St. Ber-11
KLA-USGS-94	St. Bernard	N/A	16.9	29.842661	-89.750731	U-St. Ber-12
KLA-USGS-95	St. Bernard	N/A	11.8	29.873418	-89.853565	U-St. Ber-13
KLA-USGS-96	St. Bernard	N/A	12.0	29.911314	-89.898268	U-St. Ber-14
KLA-USGS-97	St. Bernard	N/A	11.7	29.936323	-89.923365	U-St. Ber-15
KLA-USGS-98	St. Bernard	N/A	11.9	29.945682	-89.971762	U-St. Ber-16
KLA-USGS-99	St. Bernard	N/A	10.7	29.960582	-90.001226	U-St. Ber-17
KLA-USGS-100	St. Bernard	N/A	10.4	29.965577	-89.999144	U-St. Ber-18
KLA-USGS-108	St. Bernard	N/A	11.3	29.868294	-89.875042	U-St. Ber-19
KLA-USGS-42	St. John the Baptist	N/A	16.8	30.157315	-89.737728	U-St. Joh-1
KLA-USGS-01	St. Tammany	N/A	7.9	30.399072	-90.157097	U-St. Tam-1
KLA-USGS-03	St. Tammany	N/A	7.5	30.404488	-90.158156	U-St. Tam-2
KLA-USGS-04	St. Tammany	N/A	7.6	30.410498	-90.168527	U-St. Tam-3
KLA-USGS-05	St. Tammany	N/A	7.5	30.409486	-90.162145	U-St. Tam-4
KLA-USGS-06	St. Tammany	N/A	7.6	30.413102	-90.159872	U-St. Tam-5

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLA-USGS-07	St. Tammany	N/A	7.7	30.406241	-90.155311	U-St. Tam-6
KLA-USGS-08	St. Tammany	N/A	7.9	30.400375	-90.152972	U-St. Tam-7
KLA-USGS-09	St. Tammany	N/A	12.8	30.408792	-90.140096	U-St. Tam-8
KLA-USGS-10	St. Tammany	N/A	8.6	30.367210	-90.097600	U-St. Tam-9
KLA-USGS-11	St. Tammany	N/A	7.9	30.415975	-90.135863	U-St. Tam-10
KLA-USGS-12	St. Tammany	N/A	8.1	30.402588	-90.130998	U-St. Tam-11
KLA-USGS-13	St. Tammany	N/A	8.8	30.369432	-90.107317	U-St. Tam-12
KLA-USGS-14	St. Tammany	N/A	8.8	30.366710	-90.110850	U-St. Tam-13
KLA-USGS-15	St. Tammany	N/A	8.7	30.364880	-90.083016	U-St. Tam-14
KLA-USGS-16	St. Tammany	N/A	9.3	30.358349	-90.078546	U-St. Tam-15
KLA-USGS-17	St. Tammany	N/A	9.1	30.361793	-90.076332	U-St. Tam-16
KLA-USGS-19	St. Tammany	N/A	9.4	30.350002	-90.060104	U-St. Tam-17
KLA-USGS-20	St. Tammany	N/A	10.0	30.339285	-90.039780	U-St. Tam-18
KLA-USGS-21	St. Tammany	N/A	8.4	30.335535	-90.044980	U-St. Tam-19
KLA-USGS-22	St. Tammany	N/A	9.5	30.329096	-90.004008	U-St. Tam-20
KLA-USGS-23	St. Tammany	N/A	9.6	30.300184	-89.957295	U-St. Tam-21
KLA-USGS-25	St. Tammany	N/A	6.4	30.284085	-89.916991	U-St. Tam-22
KLA-USGS-26	St. Tammany	N/A	11.7	30.273698	-89.859623	U-St. Tam-23
KLA-USGS-27	St. Tammany	N/A	10.2	30.280911	-89.860937	U-St. Tam-24
KLA-USGS-32	St. Tammany	N/A	11.0	30.271359	-89.793486	U-St. Tam-25
KLA-USGS-33	St. Tammany	N/A	10.5	30.270442	-89.783787	U-St. Tam-26
KLA-USGS-34	St. Tammany	N/A	11.3	30.248595	-89.793939	U-St. Tam-27
KLA-USGS-35	St. Tammany	N/A	13.4	30.229114	-89.806735	U-St. Tam-28
KLA-USGS-36	St. Tammany	N/A	11.3	30.277091	-89.807319	U-St. Tam-29
KLA-USGS-37	St. Tammany	N/A	12.2	30.265562	-89.844152	U-St. Tam-30
KLA-USGS-38	St. Tammany	N/A	10.0	30.226541	-89.677548	U-St. Tam-31
KLA-USGS-39	St. Tammany	N/A	15.2	30.230726	-89.711506	U-St. Tam-32
KLA-USGS-40	St. Tammany	N/A	16.0	30.231136	-89.669291	U-St. Tam-33
KLA-USGS-41	St. Tammany	N/A	21.9	30.239215	-89.613944	U-St. Tam-34
KLA-USGS-50	St. Tammany	N/A	6.4	30.396116	-90.157098	U-St. Tam-35
KLA-USGS-51	St. Tammany	N/A	7.8	30.397819	-90.156036	U-St. Tam-36
KLA-USGS-52	St. Tammany	N/A	7.7	30.400775	-90.156962	U-St. Tam-37
KLA-USGS-53	St. Tammany	N/A	6.8	30.401321	-90.158482	U-St. Tam-38
KLA-USGS-56	St. Tammany	N/A	7.6	30.387738	-90.209318	U-St. Tam-39
KLA-USGS-57	St. Tammany	N/A	4.5	30.309137	-89.929698	U-St. Tam-40
KLA-USGS-59	St. Tammany	N/A	9.8	30.286559	-89.953497	U-St. Tam-41
KLA-USGS-60	St. Tammany	N/A	9.6	30.297754	-89.939846	U-St. Tam-42
KLA-USGS-61	St. Tammany	N/A	9.7	30.293306	-89.935446	U-St. Tam-43
KLA-USGS-31	Tangipahoa	N/A	5.0	30.404156	-90.323376	U-Tangipa-1
KLA-USGS-43	Tangipahoa	N/A	3.8	30.289380	-90.402108	U-Tangipa-2
KLA-USGS-44	Tangipahoa	N/A	5.0	30.289241	-90.402013	U-Tangipa-3
KLA-USGS-45	Tangipahoa	N/A	2.9	30.289675	-90.401320	U-Tangipa-4
KLA-USGS-46	Tangipahoa	N/A	2.9	30.289679	-90.401347	U-Tangipa-5
KLA-USGS-47	Tangipahoa	N/A	4.0	30.293711	-90.404156	U-Tangipa-6
KLA-USGS-48	Tangipahoa	N/A	2.4	30.302949	-90.405055	U-Tangipa-7
KLA-USGS-49	Tangipahoa	N/A	2.3	30.308865	-90.404687	U-Tangipa-8
KLA-USGS-54	Tangipahoa	N/A	5.1	30.404078	-90.324010	U-Tangipa-9
KLA-USGS-109	Terrebonne	N/A	6.3	29.384750	-90.730364	U-Terrebo-1

4.2 Coastal and Levee HWM Observations

The coastal flooding for Hurricane Katrina was significant and brought widespread devastation along the Louisiana coast. Overall the storm surge in south-central Louisiana was low because the storm made landfall in the eastern part of the state. As discussed in the following sections, the areas of greatest impact were those where the highest winds generated in the right-front quadrant of the storm, pushing the water towards the coast where the topography of the land surface was such that it caused a piling up of the water. The following observations pertain to elevations that are referenced to NAVD 88. It should be noted that in most of the leveed portions of Louisiana, the land elevation is negative, perhaps as low as several feet negative. Therefore, the depth of flooding may be higher than the surveyed flooding elevation.

4.2.1 Lake Pontchartrain Area

The topography of the area created a situation where storm winds blowing from the east forced water into Lake Pontchartrain from the Gulf of Mexico. This caused the elevation of the lake to rise as Hurricane Katrina made landfall. Hurricane Katrina caused levee-related flooding in several parishes due to either internal flood control issues or breaches in the levee system. Along both the northern and southern shorelines there was a general pattern of higher elevations on the eastern end of Lake Pontchartrain trending to lower elevations on the western end. Recorded elevations range from 16.6 feet on the eastern end (Figure B.9) down to 6.6 feet on the western end (Figure B.2). These HWMs are all found on the lake side of the levee system.

4.2.1.1 Northern Shore: St. Tammany and Tangipahoa Parishes

The increased volume of water was forced into Lake Pontchartrain by hurricane winds. This caused water to piled up on the north shore of the lake and resulted in storm surge extending north as far as US Highway 190 in Slidell (Figure B.4) and to Interstate 12 north of Mandeville (Figure B.3). HWMs recorded flooding elevations ranging from 7 to 16 feet, with the general trend of the highest values on the east end of the north shore working westward to lower flooding elevations. Coastal storm flooding elevations of 10.5 to 13.5 feet were recorded in the Slidell vicinity (Figure B.4).

4.2.1.2 Western Shore: Livingston, St. John the Baptist, and St. Charles Parishes

More moderate storm surge elevations were noted on the western shore of Lake Pontchartrain (Figure B.2). Storm surge was dampened by a network of natural, road, and railroad embankments and extensive marsh and swampland in this area. The presence of marsh and swampland limited the collection of reliable HWMs. Surge elevations in this area ranged from 2.8 feet inland west of Lake Maurepas in Livingston Parish to 6.4 feet in St. Charles Parish.

4.2.1.3 Southern Shore: East Jefferson, Orleans and St. Bernard Parishes

East Jefferson, Orleans, and St. Bernard Parishes are protected by a network of levees. Each parish is divided hydraulically into basins and HWM elevation variations may be noted between the basins. Jefferson and Orleans Parishes have coastline along Lake Pontchartrain. St. Bernard Parish has coastline along the Gulf of Mexico and Lake Borgne. Orleans and St. Bernard Parishes as well as part of Jefferson Parish are protected by a levee system consisting of four main basins, each protected by its own perimeter levee system and dewatering pumps (Figures B.9, B.10, and B.11). These basins are generally referred to as East Jefferson, Orleans East Bank, New Orleans East, and St. Bernard Parish. Access to much of these areas was delayed for several days until flood waters receded. Severe devastation in these areas made it difficult to locate reliable HWMs.

East Jefferson, the portion of Jefferson Parish (north of the Mississippi River) that is not hydrologically connected to Orleans Parish sustained interior flooding due to various causes, including floodwaters from Lake Pontchartrain back-flushing through failed or under-capacity pumps and accumulation of precipitation. HWMs in East Jefferson range from -3.3 to -4.1 feet.

Flooding in Orleans East Bank (which includes the portion of Old Metairie in Jefferson Parish south of Metairie Road) was caused by floodwall failures along the 17th Street Canal and the London Avenue Canal. Other failures were noted throughout the area, including several along the Inner Harbor Navigational Canal. Lakefront levees showed evidence of minor overtopping.[11] HWMs in Orleans East Bank range from elevation 2.3 to 2.7 feet.

Flooding in New Orleans East basin appears to have been caused by overtopping of lakefront levees and localized failures of the levee system which have been documented to have occurred at transitions in the levee wall.[12] HWMs in the New Orleans East Area range from elevation -1.1 to -1.5 feet north of the Chef Meneur Highway Ridge and 2.0 to 2.5 feet south of the ridge.

There is strong evidence that levees in the St. Bernard Basin, which includes the Lower Ninth Ward in Orleans Parish, were overtopped by 5 to 10 feet of water.[13] Collected HWMs support this because the HWMs range from 10 to 11 feet. Two of the most significant breaches occurred on the primary levee system along the western edge of the basin bordering the Inner Harbor Navigational Canal in the Lower Ninth Ward. The first breach was approximately 900 feet long and was located approximately 850 feet north of the Claiborne Avenue Bridge. The breach initially resulted from the Hurricane Katrina storm surge in the Inner Harbor Navigational Canal.[14]

4.2.2 Gulf Coast

4.2.2.1 Coastal St. Bernard and Plaquemines Parishes

Locating HWMs outside of the levee system in St. Bernard Parish was difficult due to the level of devastation and lack of structures. Two HWMs were located with surveyed elevations of 17.1 (Reggio) and 17.7 (Yscloskey) feet (Figure B.11).

Plaquemines Parish is split in half by the Mississippi River (Figures B.7 and B.8). Large levees were constructed along both sides of the Mississippi River and back/hurricane levees were constructed on the 'coastal' side of communities located along the river to protect each community from hurricane surges from the Gulf of Mexico. During Hurricane Katrina, Plaquemines Parish was flooded by the coastal surge. According to *Preliminary Report on Performance of New Orleans Levee System in Hurricane Katrina on August 29, 2005*,[15] several back/hurricane levees in Plaquemines were overtopped by the coastal surge, including the Point a la Hache east back/hurricane levee (which breached in several places); the Myrtle Grove western levee; the Sunrise western levee; and the eastern back/hurricane levee near Hayes Pump Station.

[11] ibid.
[12] ibid.
[13] ibid.
[14] ibid.
[15] ibid.

According to the 2005 report, in some areas the back/hurricane levees were overtopped by 20 feet or more. Based on the HWM study, it appears that in other locations there was less overtopping of the back/hurricane levees.

For the HWM study in Plaquemines Parish, it was typically assumed that HWMs located landward of the Mississippi River levees were caused by coastal flooding, and HWMs located river side of the Mississippi River levees were caused by riverine flooding. However, the HWMs in this area vary considerably, which may be due to the effects of the back/hurricane levees in these areas.

4.2.2.2 West Jefferson, Lafourche, and Terrebonne Parishes

The southern coastal parishes were less affected by Hurricane Katrina because they were in the south west (left and trailing) quadrant of the wind field created by the storm. West Jefferson (south of the Mississippi River), Lafourche, and Terrebonne Parishes are sparsely populated with few roads giving access. As illustrated in Figure B.1, these areas are also extensively covered by marshland and swamp. This marshland and swamp area has a dampening effect on coastal surges as they move inland; marshes and swamps also reduce access to obtain quality HWMs. Figure B.5 illustrates the locations and elevations of the HWMs surveyed in these parishes. Only two HWMs were identified in Terrebonne Parish, and three identified in Lafourche Parish. As Hurricane Katrina tracked farther inland on its northeastern path, the water in Barataria Bay was pushed southward over Grand Isle in Jefferson Parish. HWM elevations were the highest in this portion of the coastal area, measuring between 5.8 and 8.9 feet (Figure B.5)

4.3 Riverine HWM Observations

4.3.1 North of Lake Pontchartrain

The HWMs from riverine flooding were found in St. Tammany, Tangipahoa, and Washington Parishes north of Lake Pontchartrain and along the Mississippi River in Louisiana. However, most of these HWMs were found near the stream channel. It appears that riverine flood elevations resulting from Hurricane Katrina were typically low and therefore had limited impact on buildings.

4.3.2 Mississippi River

HWMs were identified within the levees containing the Mississippi River in Jefferson, Plaquemines, St. Charles, St. James, and St. John the Baptist Parishes (Figures B.2, B.6, and B.7). In these parishes, the Mississippi River HWMs range from 12.9 to 17.9 feet. The higher elevations in Jefferson Parish show the impact of the hurricane surge up the river. Except for one riverine HWM in Plaquemines Parish (KLAC-06-18), it appears that the Mississippi River was contained within the river levees, and therefore flooding of structures from the Mississippi River was not observed.

Appendix A. Field Data Collection Forms

Figure A.1

FLAGGER HIGH WATER MARK – COASTAL and RIVERINE
DATA COLLECTION REPORT FORM
(For Use By Flaggers) HMTAP TO No.____________________

HWM ID (e.g. DFLC-07-01) (Repeat in case forms are separated)		
HWM Street Address		
Rep Loss Number		
Multiple HWM	**(Circle One)**: Yes No	
HWM Area Identifier		
Subdivision / Industrial Park		
Date of Flagging/Interview		
Date of Flood Event		
Type/Name of Storm Event	**(Circle One)**: Hurricane, Tropical Storm, Tropical Depression, Other:	Name of storm event (e.g., Dennis)
Disaster Number (e.g.: DR-1539-FL)		
Date of Peak		
Source for Date of Peak		
Stream Name/Flood Source (Closest/responsible water body)		
Municipality, City or Town (Circle One: Known, closest)		
County		
State		
Type of HWM – **(Circle One)** **If Personal Account or Other, you MUST provide comment**	Mud Line Wrack Line Debris Line Water Line Personal Account Other Comment	
Wind Water Debris Line	**(Circle One)**: Yes No	
HWM Object, Surface (What object, surface is the HWM on? An interior/exterior wall, tree, fence, etc…)		

URS
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Storm: ____________________
FLAGGER FORM Page 1 of 4

Figure A.1 (continued)

FLAGGER HIGH WATER MARK – COASTAL and RIVERINE
DATA COLLECTION REPORT FORM
(For Use By Flaggers) **HMTAP TO No.____________________**

HWM ID (e.g. DFLC-07-01) (Repeat in case forms are separated)			
Location/Directions to HWM Object			
Was a Vertical Offset Measurement used for HWM **(Circle Yes, No. If Yes, enter data)**	Yes No	If Yes: Measurement: Description of offset point:	
Vertical Distance HWM to existing ground (feet) (Required			
HWM Quality – **(Circle One)**	GOOD	FAIR	POOR
Description of Marker Used To Flag HWM **(e.g. red paint, tape. NOTE: HWM IS LINE AT BOTTOM OF TAPE OR PAINT. UNLESS the Flagger indicates that there is a vertical offset from the marked point)**			
Survey of HWM Needed	YES	NO	
Flagger HWM Latitude (Decimal Degrees ex: 29.12345 (5 places))	N		DECIMAL DEGREES
Flagger HWM Longitude (Decimal Degrees ex: 84.12345 (5 places))	W		DECIMAL DEGREES
Flooding Type – **(Circle One)**	**Riverine Choices are**: - Riverine - Heavy Rain - Riverine - Hurricane	**Coastal Choices are:** - Coastal - surge only - Coastal - wave height - Coastal - wave runup	**Breached Levee**
Estimated HWM Surge Level and what is this based on (Coastal HWM Only)	Elevation (Feet) Based On:		
Timestamp of Surge Estimate (Coastal HWM Only)	____ : ____ AM / PM CENTRAL / EASTERN		
Photo ID (HWM ID)-(Photo file name from camera)	Photo 1 (HWM mark from 20 feet away)	Photo 2 (Structure / Area from 50 feet away)	
Photos Location/Orientation			
Photos Description/Subject			
Unit Number (2-digit number)			

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Flagger Form Rev September 1, 2005.doc

Storm: ____________________
FLAGGER FORM Page 2 of 4

Figure A.1 (continued)

FLAGGER HIGH WATER MARK – COASTAL and RIVERINE
DATA COLLECTION REPORT FORM
(For Use By Flaggers) HMTAP TO No.____________________

HWM ID (e.g. DFLC-07-01) (Repeat in case forms are separated)		
Name of Flagger 1/Flagger 2	1	2
Flagger 1 Company/Flagger 2 Company	1	2
Flagger's Comments		
Resident/Eyewitness Information		
Name		
Address		
Obtained Permission to Survey	Yes	No
Phone		
Length of residence or familiarity with area		
Relevant witness Information (Document only if witness is willing to have personal information included in record)		
Wind Damage Data		
Structure Damage **(Circle as applicable)**	1) No Damage; 2) Structure type (use): residential, commercial, agricultural, mobile home; 3) Cause: wind, fallen objects, blown debris; 4) Severity (subjective): light, moderate, severe	
Tree Damage **(Circle as applicable)**	1) No Damage; 2) Tree Species: oak, pine, palm, other; 3) Damage: uprooted, snapped, twisted; 4) Severity (subjective): light (single tree), moderate, severe	
Overhead Utility Damage **(Circle as applicable)**	1) No Damage; 2) Materials: wood, metal, concrete; 3) Utility Type: power, telephone, cable; 4) Cause: wind, fallen objects, blown debris; 5) Severity (subjective): light, moderate, sever	

URS
Flagger Form Rev September 1, 2005.doc

Storm: ____________________
FLAGGER FORM Page 3 of 4

Figure A.1 (continued)

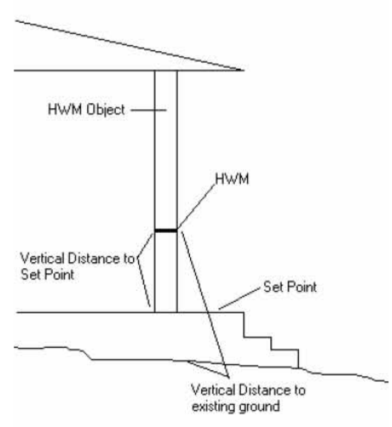
FLAGGER HIGH WATER MARK – COASTAL and RIVERINE
DATA COLLECTION REPORT FORM
(For Use By Flaggers) **HMTAP TO No.**____________________

HWM ID (e.g. DFLC-07-01) (Repeat in case forms are separated)	
Other Damage/Comments	

Required Plan/ Elevation View Sketches (use back if needed)

Required: 1) Sketch/Plan of nearest cross roads, directions to get to the HWM
2) Plan and Elevation views of the HWM

Example Measurements



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Flagger Form Rev September 1, 2005.doc

Storm: ____________________________
FLAGGER FORM Page 4 of 4

Figure A.2

SURVEYOR'S
HIGH WATER MARK (HWM) – COASTAL AND RIVERINE
DATA COLLECTION REPORT FORM HMTAP TO No.______________

HWM ID (Repeat in case forms are separated)		
HWM Street Address		
Municipality, City or Town (Known, closest)		
County		
State		
Exact Mark To Survey		
HWM Flood Elevation (NAVD 88 Datum) (1)		
HWM Flood Elevation (NGVD 29) (1)		
Was Flagger's Vertical Offset Measurement used to survey HWM Elevation (1)		No Yes
If Yes, then:	Flagger Vertical Offset Distance	
	Surveyed Elevation of Reference Point (NAVD 88)	
Survey Latitude Must Use Decimal Degrees (6 Decimal places)		N
Survey Longitude Must Use Decimal Degrees (6 Decimal places)		W
Northing (feet)		
Easting (feet)		
Approx. First Floor Elevation (NAVD 88)		
Map Projection Used During Survey		
Vertical Datum		NAVD 88 NGVD 29 OTHER:
Horizontal Datum		NAD 83 OTHER:
Survey Crew		
Responsible Licensed Professional Land Surveyor Name and Number		PLS Name:
Survey Company / Office Location		

URS Storm______________
Surveyor Form Rev September 1, 2005.doc **SURVEY FORM Page 1 of 2**

Figure A.2 (continued)

SURVEYOR'S
HIGH WATER MARK (HWM) – COASTAL AND RIVERINE
DATA COLLECTION REPORT FORM HMTAP TO No.________________

HWM ID (Repeat in case forms are separated)	
Survey Date (e.g. 07/15/2005)	
Surveyor's Comments	

(1) note that the HWM is the line at the bottom of the tape or paint **UNLESS the Flagger indicates that there is a vertical offset from the marked point**

Surveyor Plan/ Elevation View Sketches (if needed)

URS
Surveyor Form Rev September 1, 2005.doc

Storm__________________
SURVEY FORM Page 2 of 2

APPENDICES

Appendix B. HWM Location Maps and Summary Table

Table B.1. Appendix B Figures

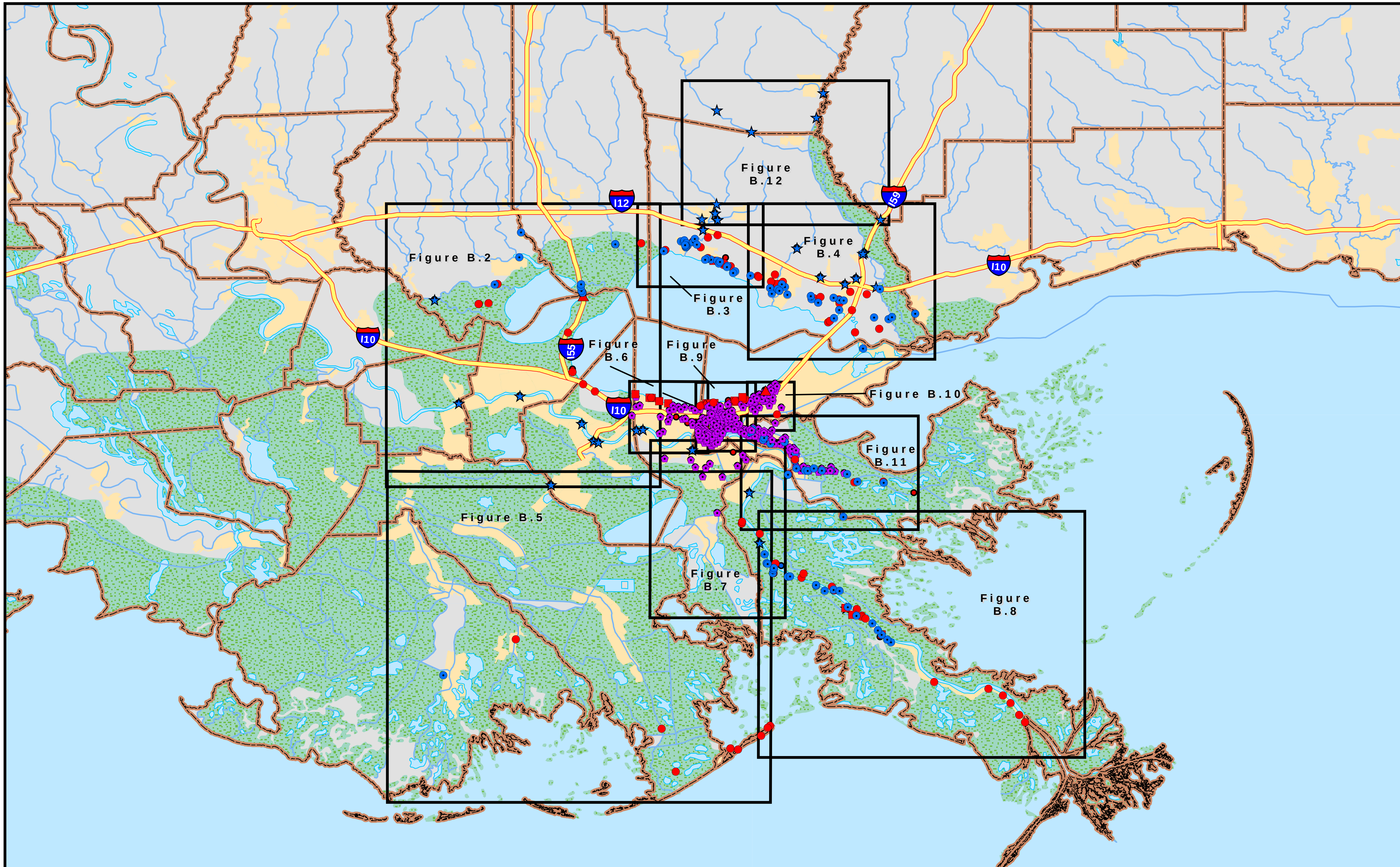


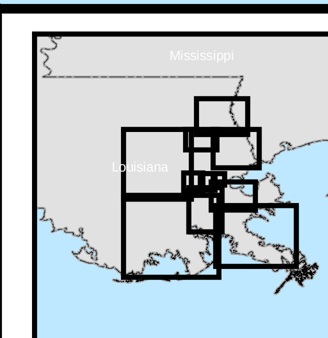
Figure B.1: Overview Map & Figure Index
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations

- Coastal- Surge Only
- Coastal- Wave Height
- Coastal- Wave Runup
- Riverine- Hurricane
- USGS HWM
- Levee Issue

- Inset
- Municipalities
- Parish Boundaries
- Water Body
- Hydrology
- Swamp or Marsh
- Levees

Road Classification
- Highway
- Major Road

Map feature locations are approximate.



FEMA

N

0 5 10 20
Miles
0 5 10 20
Kilometers

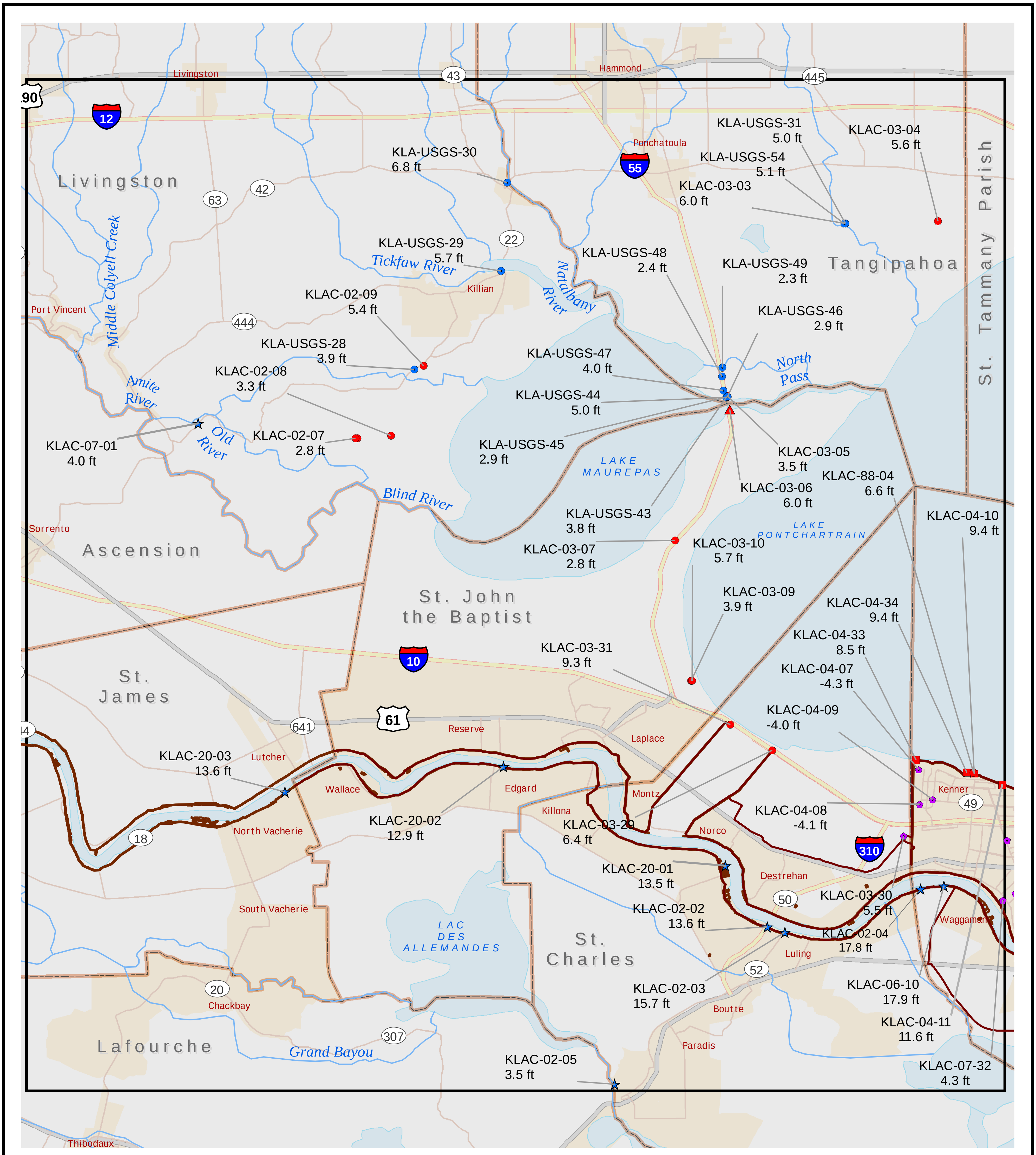
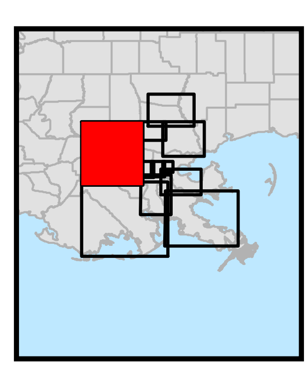


Figure B.2: Livingston, Tangipahoa, Ascension, St. James, St. John, St. Charles & Jefferson Parishes Hurricane Katrina, Louisiana Surveyed High Water Mark (HWM) Elevations



FEMA

N

0 1 2 4 Miles

0 2 4 8 Kilometers

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, ft
● Coastal- Surge Only
▲ Coastal- Wave Height
■ Coastal- Wave Runup

VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83
★ Riverine- Hurricane
● USGS HWM
⬟ Levee Issue

Hydrology
Levees
Inset
Municipalities
Parish Boundaries

Water Body
Swamp or Marsh

Road Classification
Highway
Major Road

Map feature locations are approximate.

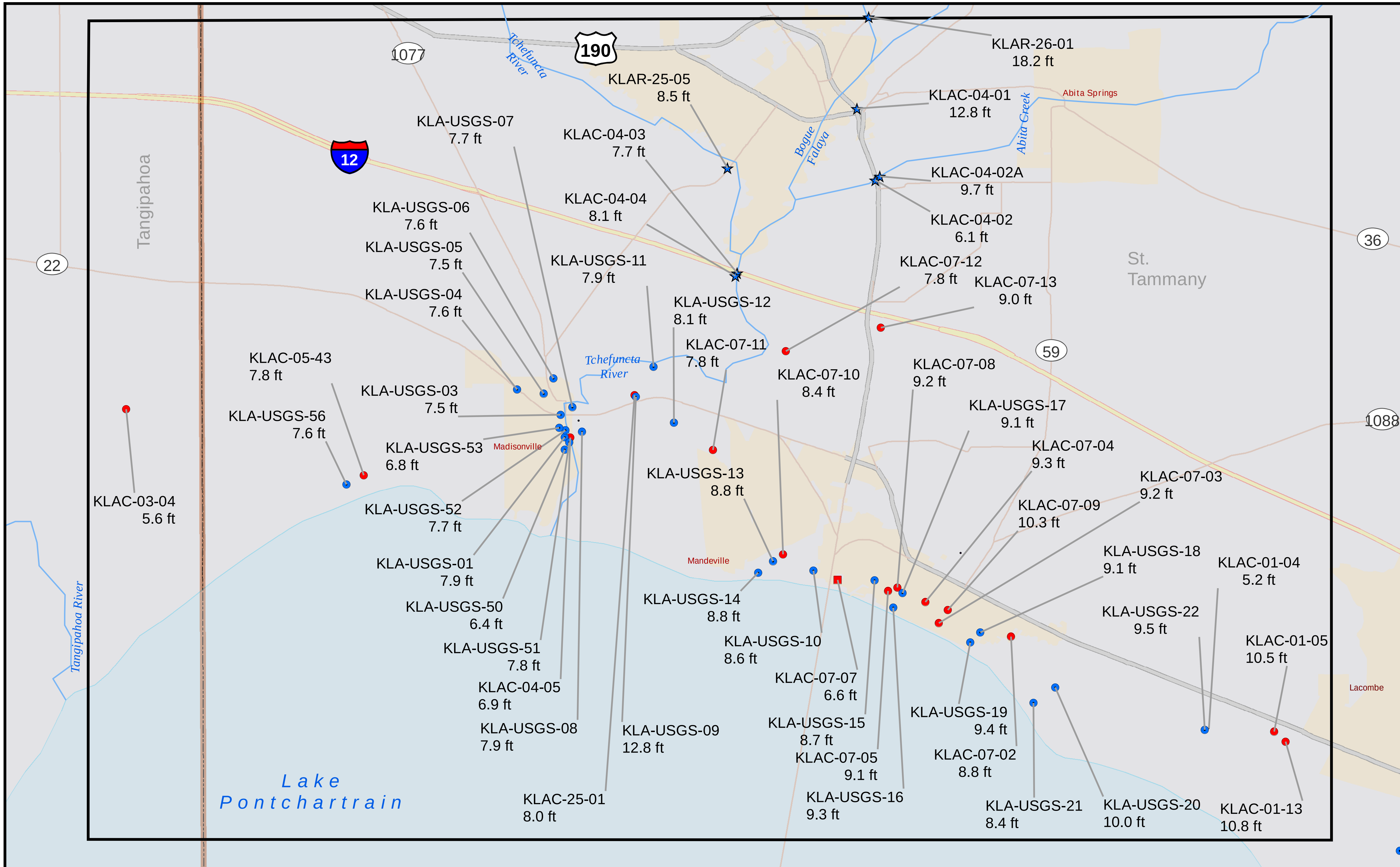


Figure B.3: Western St. Tammany & Tangipahoa Parishes
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations

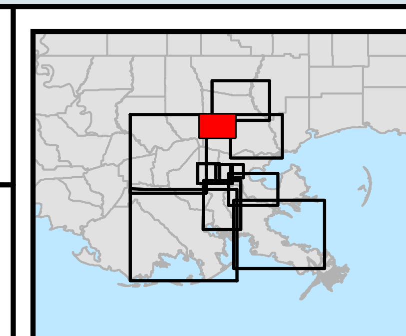
- Coastal- Surge Only
- Coastal- Wave Height
- Coastal- Wave Runup
- Riverine- Hurricane
- USGS HWM
- Levee Issue

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, Feet
VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83

- Inset
- Municipalities
- Parish Boundaries
- Water Body
- Hydrology
- Swamp or Marsh
- Levees

Road Classification
- Highway
- Major Road

Map feature locations are approximate.



FEMA

N

Miles: 0 0.5 1 2
Kilometers: 0 1 2 4

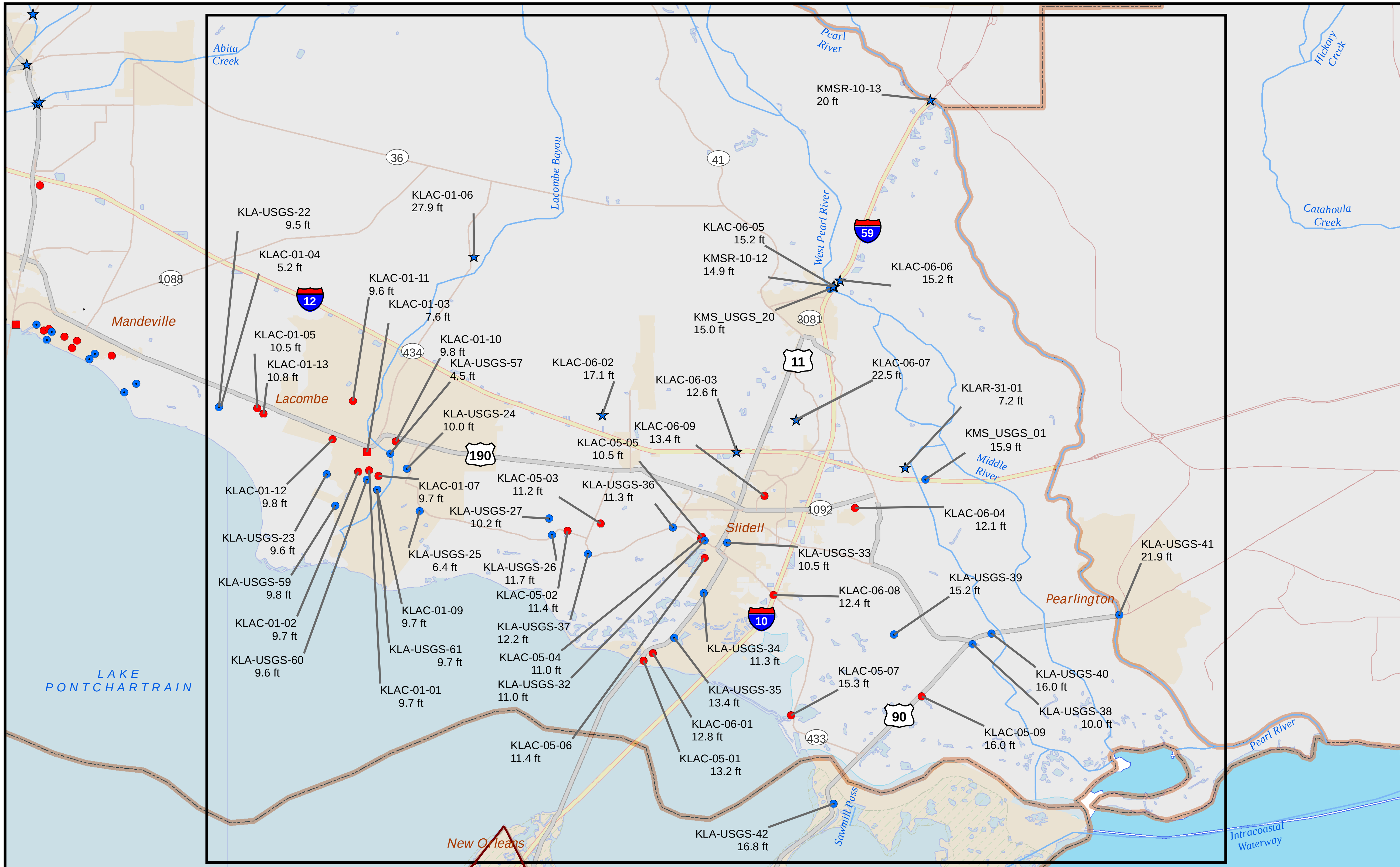
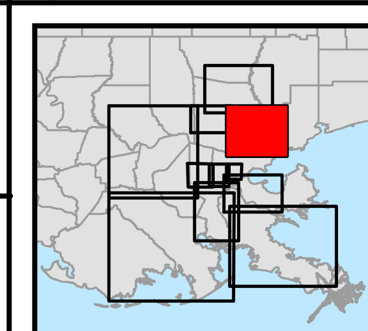


Figure B.4 : Eastern St. Tammany Parish
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations



FEMA

N

Miles: 0 1 2 4
Kilometers: 0 1.5 3 6

- Coastal- Surge Only
- Coastal- Wave Height
- Coastal- Wave Runup
- Riverine- Hurricane
- USGS HWM
- Levee Issue

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, Feet
VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83

- Inset
- Municipalities
- Parish Boundaries
- Water Body
- Hydrology
- Swamp or Marsh
- Levees

Road Classification
- Highway
- Major Road

Map feature locations are approximate.

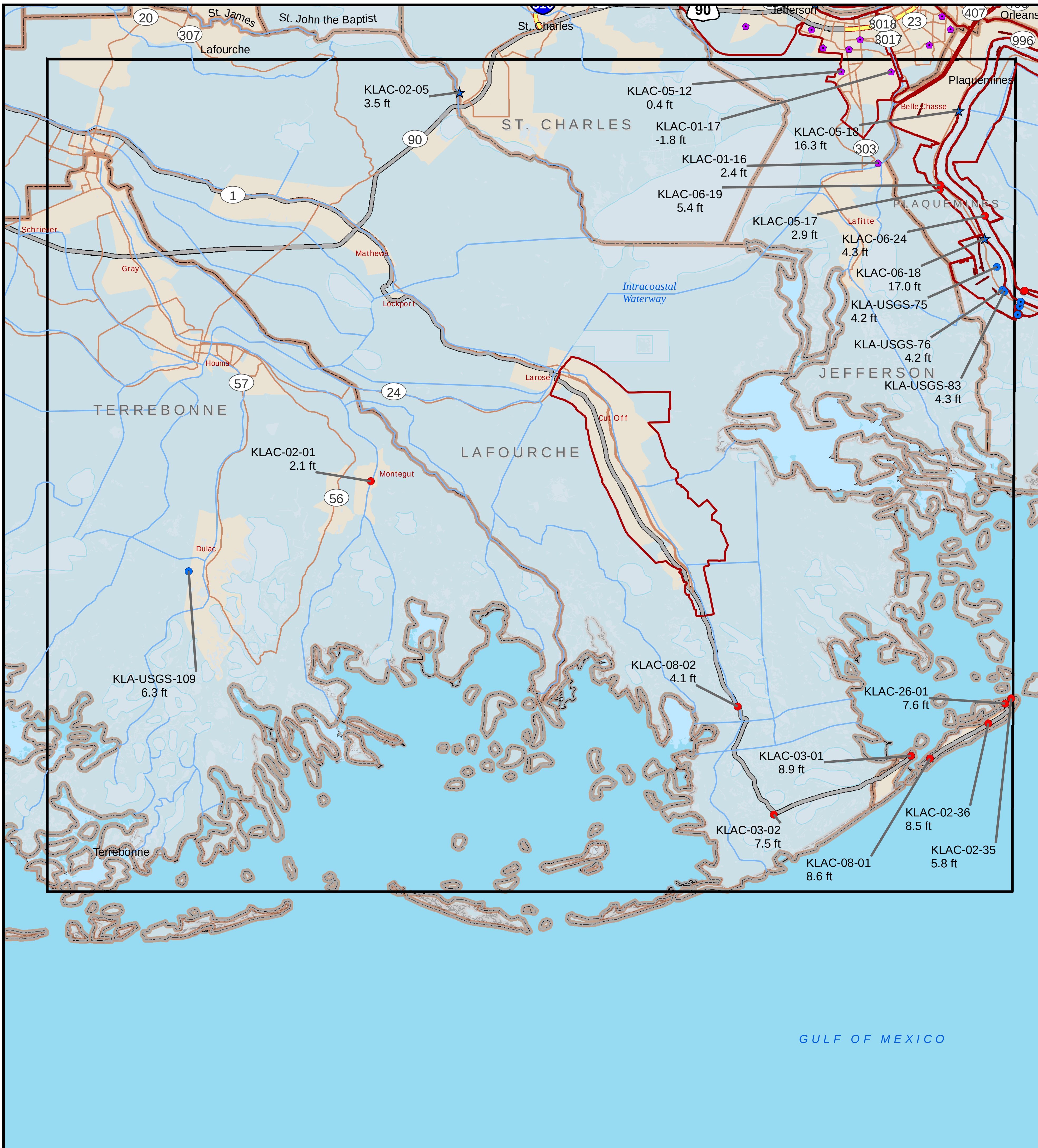


Figure B.5: Terrebonne & Lafourche Parishes
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, ft

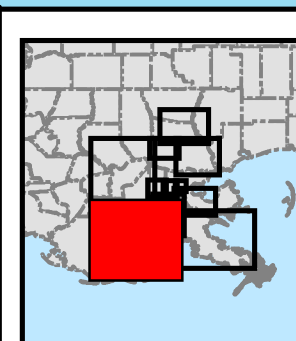
VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83

- ● Coastal- Surge Only
- ▲ Coastal- Wave Height
- ■ Coastal- Wave Runup
- ★ Riverine- Hurricane
- ● USGS HWM
- ⬟ Levee Issue

- Hydrology
- Levees
- Inset
- Municipalities
- Parish Boundaries
- Water Body
- Swamp or Marsh

Road Classification
- Highway
- Major Road

Map feature locations are approximate.



FEMA

N

Miles: 0 2 4 8
Kilometers: 0 3.5 7 14

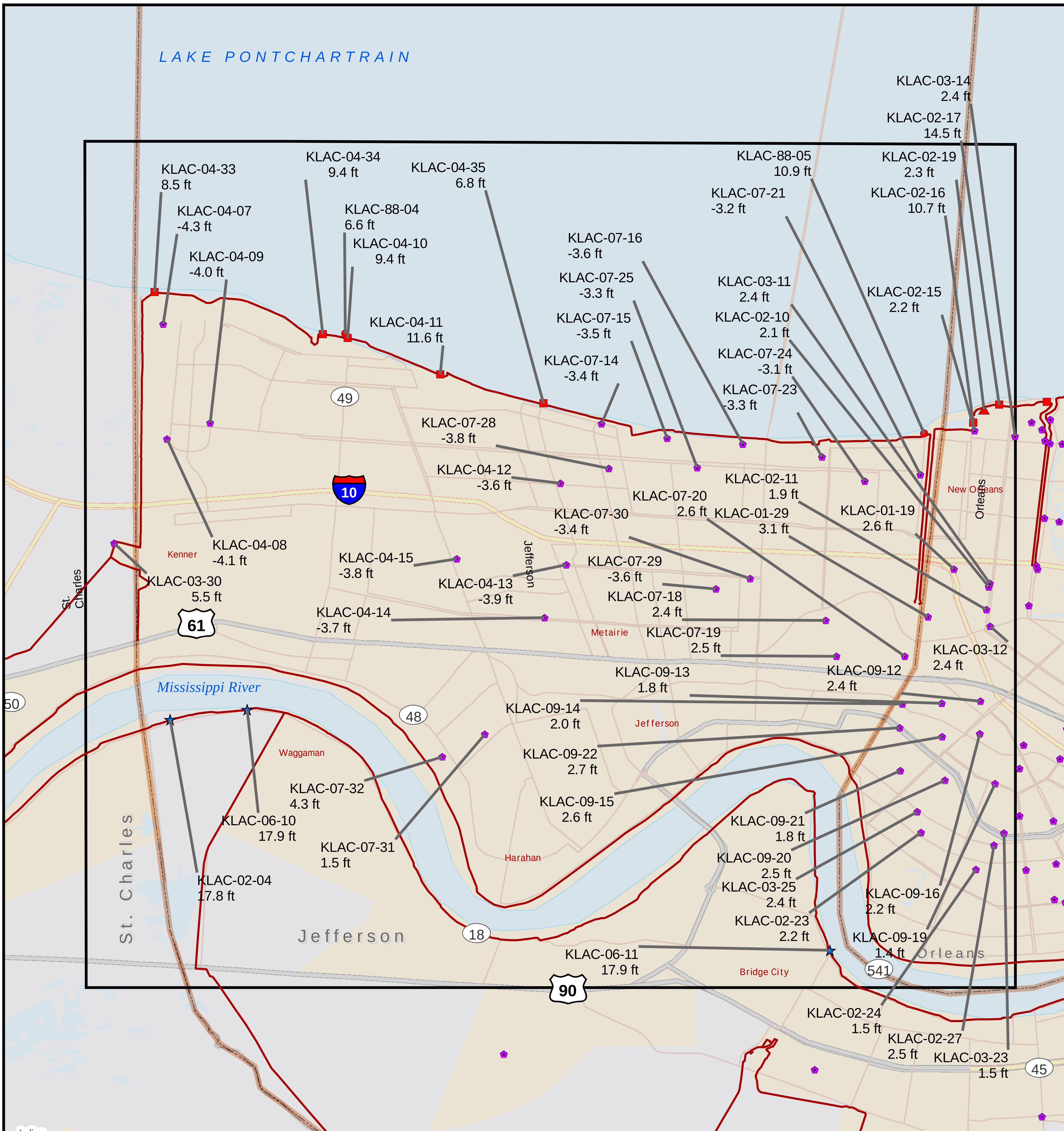
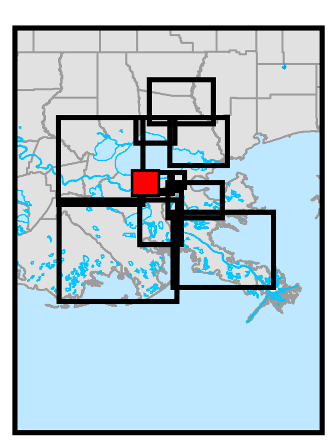


Figure B.6: St. Charles, Jefferson & Orleans Parishes
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations



FEMA

N

0 0.5 1 2
Kilometers

0 0.5 1 2
Miles

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, ft
- Coastal- Surge Only
- Coastal- Wave Height
- Coastal- Wave Runup

VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83
- Riverine- Hurricane
- USGS HWM
- Levee Issue

- Hydrology
- Levees
- Inset
- Municipalities
- Parish Boundaries
- Water Body
- Swamp or Marsh

Road Classification
- Highway
- Major Road

Map feature locations are approximate.

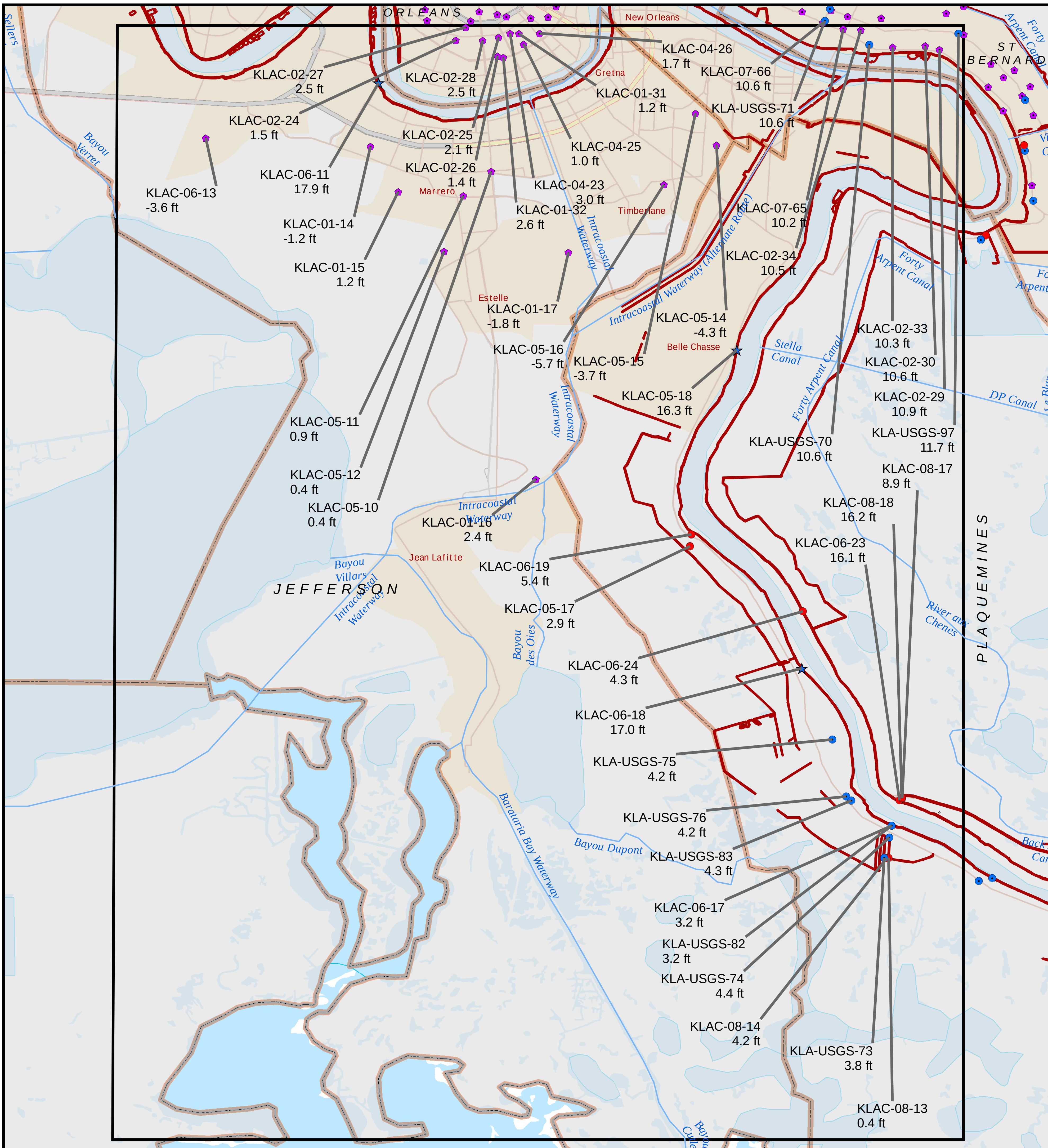
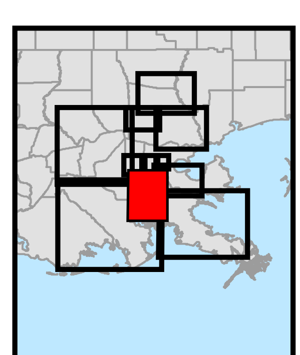


Figure B.7: Jefferson & Plaquemines Parishes
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations



FEMA

N

0 1.5 3 6
Kilometers
0 1 2 4
Miles

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, ft
Coastal- Surge Only
Coastal- Wave Height
Coastal- Wave Runup

VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83
Riverine- Hurricane
USGS HWM
Levee Issue

Hydrology
Levees
Inset
Municipalities
Parish Boundaries

Water Body
Swamp or Marsh
Road Classification
Highway
Major Road

Map feature locations are approximate.

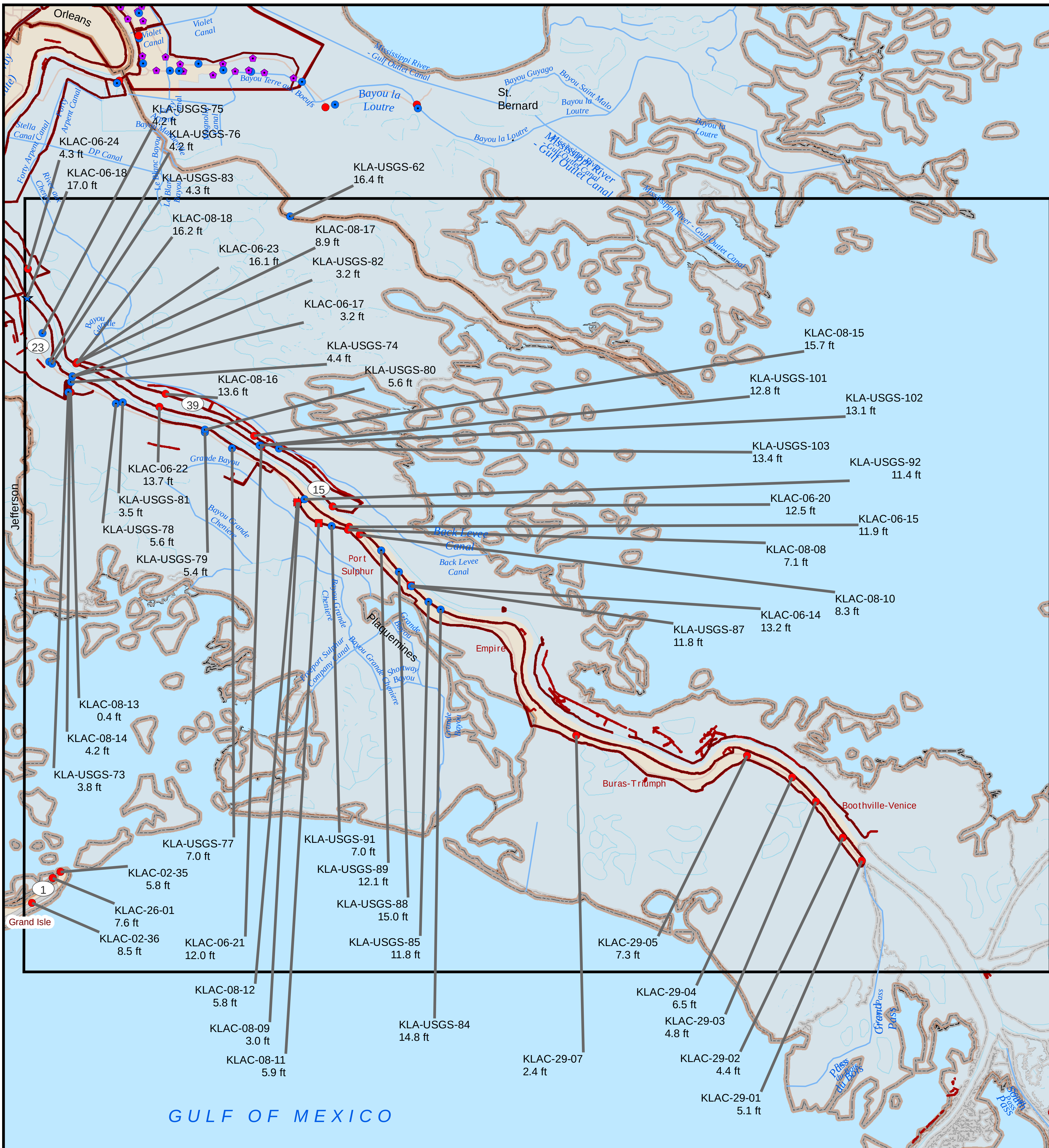


Figure B.8: Plaquemines Parish, Louisiana
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, ft

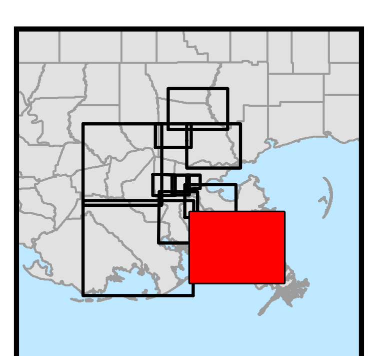
HORIZONTAL DATUM: NAD83
VERTICAL DATUM: NAVD88

- Coastal- Surge Only
- Coastal- Wave Height
- Coastal- Wave Runup
- Riverine- Hurricane
- USGS HWM
- Levee Issue

- Hydrology
- Levees
- Inset
- Municipalities
- Parish Boundaries
- Water Body
- Swamp or Marsh

Road Classification
- Highway
- Major Road

Map feature locations are approximate.



FEMA

N

0 1 2 4 Miles
0 2.5 5 10 Kilometers

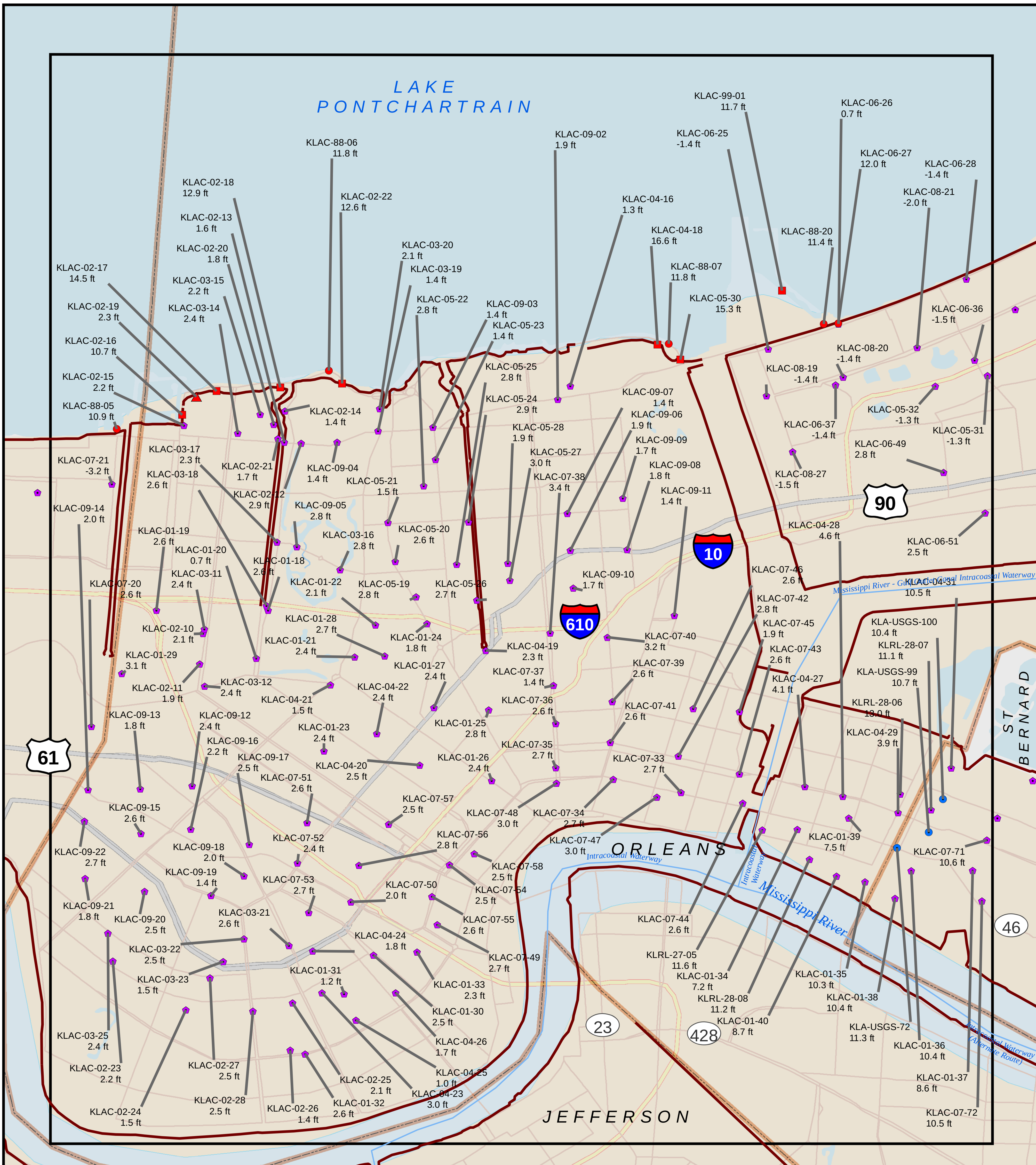


Figure B.9: Orleans, Jefferson, & St. Bernard Parishes
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, ft
Coastal- Surge Only
Coastal- Wave Height
Coastal- Wave Runup

VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83
Riverine- Hurricane
USGS HWM
Levee Issue

Levees
Hydrology
Inset
Municipalities
Parish Boundaries

Water Body
Swamp or Marsh
Road Classification
Highway
Major Road

Map feature locations are approximate.

FEMA
N
0 0.25 0.5 1 Miles
0 0.5 1 2 Kilometers

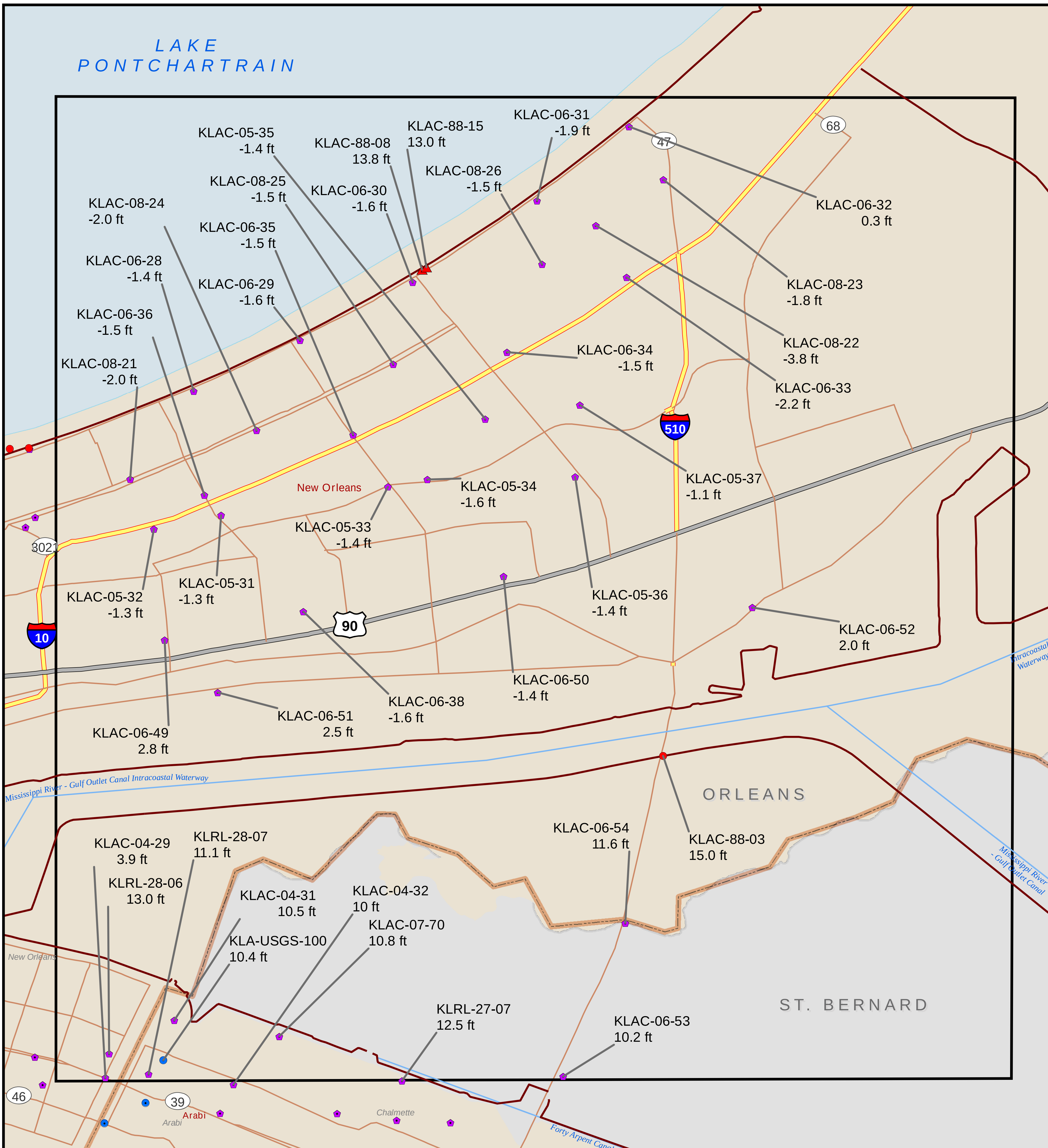
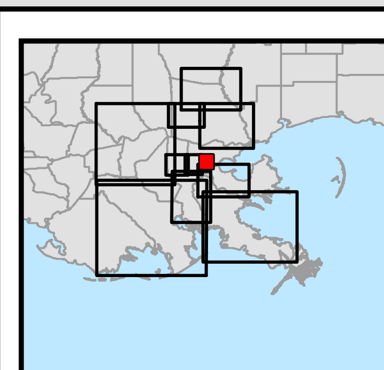


Figure B.10: Eastern Orleans & St. Bernard Parishes
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations



FEMA

N

0 0.25 0.5 1
Miles
0 0.5 1 2
Kilometers

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, ft
Coastal- Surge Only
Coastal- Wave Height
Coastal- Wave Runup

VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83
Riverine- Hurricane
USGS HWM
Levee Issue

Levees
Hydrology
Inset
Municipalities
Parish Boundaries

Water Body
Swamp or Marsh
Road Classification
Highway
Major Road

Map feature locations are approximate.

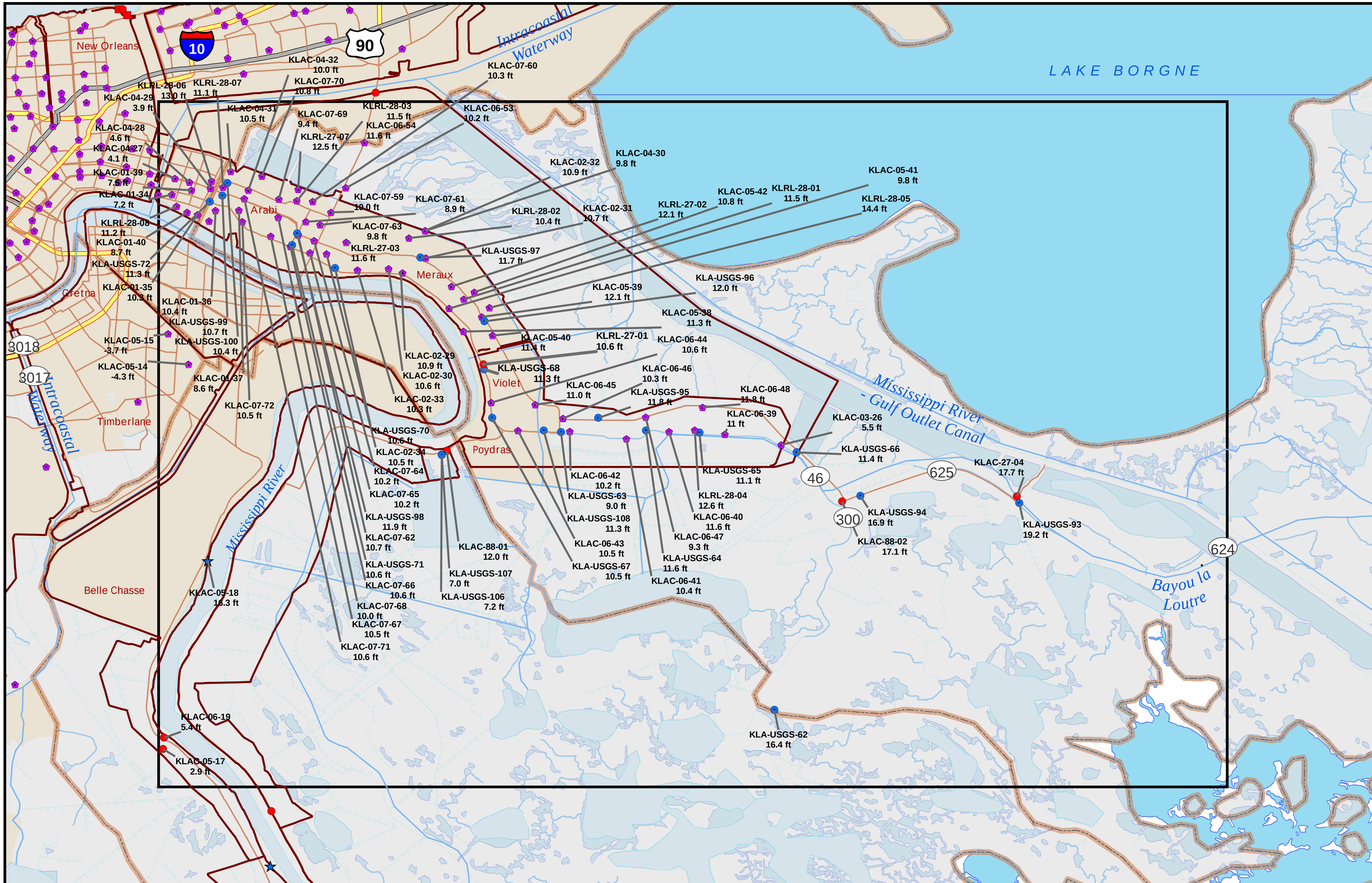


Figure B.11 : Plaquemines & St. Bernard Parishes
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations

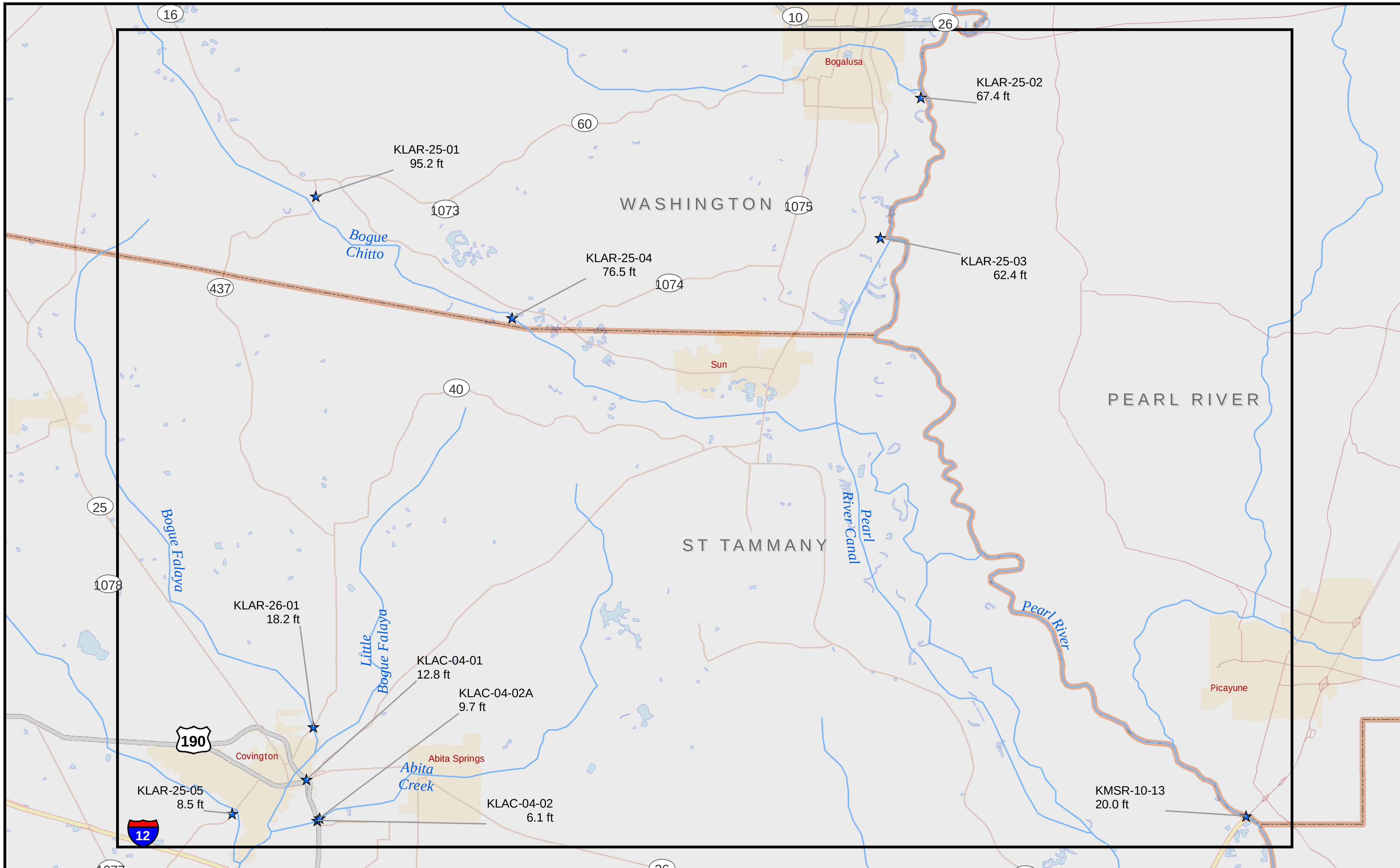


Figure B.12 : Northern St. Tammany & Washington Parishes
Hurricane Katrina, Louisiana
Surveyed High Water Mark (HWM) Elevations

Coastal- Surge Only
Coastal- Wave Height
Coastal- Wave Runup
Riverine- Hurricane
USGS HWM
Levee Issue

RLAR-15-13 HWM ID
6.2 Surveyed Elevation, Ft
VERTICAL DATUM: NAVD88
HORIZONTAL DATUM: NAD83

Inset
Municipalities
Parish Boundaries
Water Body
Hydrology
Swamp or Marsh
Levees
Road Classification
Highway
Major Road

Map feature locations are approximate.

FEMA

N

0 1 2 4
Miles
0 1.5 3 6
Kilometers

Table B.2 Hurricane Katrina Louisiana HWM Data Summary (same as Table 6, sorted by HWM-ID)[16]

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
URS Team Flagged Points						
KLAC-01-01	St. Tammany	Coastal - Surge Only	9.7	30.301813	-89.938861	St. Tam-1
KLAC-01-02	St. Tammany	Coastal - Surge Only	9.7	30.301163	-89.943654	St. Tam-2
KLAC-01-03	St. Tammany	Coastal - Wave Runup	7.6	30.309747	-89.939823	St. Tam-3
KLAC-01-05	St. Tammany	Coastal - Surge Only	10.5	30.328688	-89.987372	St. Tam-4
KLAC-01-06	St. Tammany	Riverine - Hurricane	27.9	30.394586	-89.893528	St. Tam-5
KLAC-01-07	St. Tammany	Coastal - Surge Only	9.7	30.299328	-89.934764	St. Tam-6
KLAC-01-09	St. Tammany	Coastal - Surge Only	9.7	30.293306	-89.935446	St. Tam-7
KLAC-01-10	St. Tammany	Coastal - Surge Only	9.8	30.314372	-89.927285	St. Tam-8
KLAC-01-11	St. Tammany	Coastal - Surge Only	9.6	30.331819	-89.945904	St. Tam-9
KLAC-01-12	St. Tammany	Coastal - Surge Only	9.8	30.315155	-89.954774	St. Tam-10
KLAC-01-13	St. Tammany	Coastal - Surge Only	10.8	30.326294	-89.984678	St. Tam-11
KLAC-01-14	Jefferson	Levee - Interior	-1.2	29.893883	-90.144871	Jeffers-1
KLAC-01-15	Jefferson	Levee - Interior	1.2	29.876847	-90.134363	Jeffers-2
KLAC-01-16	Jefferson	Levee - Interior	2.4	29.768640	-90.082523	Jeffers-3
KLAC-01-17	Jefferson	Levee - Interior	-1.8	29.854061	-90.070304	Jeffers-4
KLAC-01-18	Orleans	Levee - Break	2.6	29.993873	-90.100315	Orleans-1
KLAC-01-19	Orleans	Levee - Break	2.6	29.993859	-90.117045	Orleans-2
KLAC-01-20	Orleans	Levee - Break	0.7	29.986634	-90.102085	Orleans-3
KLAC-01-21	Orleans	Levee - Break	2.4	29.986863	-90.087302	Orleans-4
KLAC-01-22	Orleans	Levee - Break	2.1	29.991654	-90.084224	Orleans-5
KLAC-01-23	Orleans	Levee - Break	2.4	29.972796	-90.091926	Orleans-6
KLAC-01-24	Orleans	Levee - Break	1.8	29.991871	-90.076471	Orleans-7
KLAC-01-25	Orleans	Levee - Break	2.8	29.978922	-90.067231	Orleans-8
KLAC-01-26	Orleans	Levee - Break	2.4	29.968307	-90.066752	Orleans-9
KLAC-01-27	Orleans	Levee - Break	2.4	29.979253	-90.075412	Orleans-10
KLAC-01-28	Orleans	Levee - Break	2.7	29.987004	-90.082823	Orleans-11
KLAC-01-29	Orleans	Levee - Break	3.1	29.984352	-90.122208	Orleans-12
KLAC-01-30	Orleans	Levee - Break	2.5	29.942190	-90.084509	Orleans-13
KLAC-01-31	Orleans	Levee - Break	1.2	29.936390	-90.088888	Orleans-14
KLAC-01-32	Orleans	Levee - Break	2.6	29.927393	-90.094766	Orleans-15
KLAC-01-33	Orleans	Levee - Break	2.3	29.942651	-90.077960	Orleans-16
KLAC-01-34	Orleans	Levee - Break	7.2	29.960985	-90.020957	Orleans-17
KLAC-01-35	Orleans	Levee - Break	10.3	29.953198	-90.010822	Orleans-18
KLAC-01-36	St. Bernard	Levee - Break	10.4	29.954800	-90.003893	St. Ber-1
KLAC-01-37	St. Bernard	Levee - Break	8.6	29.954864	-89.994656	St. Ber-2
KLAC-01-38	St. Bernard	Levee - Break	10.4	29.950690	-90.006295	St. Ber-3
KLAC-01-39	Orleans	Levee - Break	7.5	29.962709	-90.013226	Orleans-19
KLAC-01-40	Orleans	Levee - Break	8.7	29.954032	-90.015063	Orleans-20
KLAC-02-01	Terrebonne	Coastal - Surge Only	2.1	29.469424	-90.559291	Terrebo-1
KLAC-02-02	St. Charles	Riverine - Hurricane	13.6	29.938693	-90.374965	St. Cha-1
KLAC-02-03	St. Charles	Riverine - Hurricane	15.7	29.935227	-90.363427	St. Cha-2
KLAC-02-04	St. Charles	Riverine - Hurricane	17.8	29.963860	-90.273558	St. Cha-3
KLAC-02-05	St. Charles	Riverine - Hurricane	3.5	29.834727	-90.475951	St. Cha-4
KLAC-02-06	Livingston	Coastal - Surge Only	3.1	30.262079	-90.646197	Livings-1
KLAC-02-07	Livingston	Coastal - Surge Only	2.8	30.261999	-90.647581	Livings-2
KLAC-02-08	Livingston	Coastal - Surge Only	3.3	30.263901	-90.623945	Livings-3
KLAC-02-09	Livingston	Coastal - Surge Only	5.4	30.310067	-90.602358	Livings-4
KLAC-02-10	Orleans	Levee - Break	2.1	29.990358	-90.110050	Orleans-21
KLAC-02-11	Orleans	Levee - Break	1.9	29.985831	-90.110528	Orleans-22
KLAC-02-12	Orleans	Levee - Break	2.9	30.018905	-90.095364	Orleans-23

[16] Note – For HWM data summary listing sorted by Parish and HWM sheet number, refer to Table 6

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-02-13	Orleans	Levee - Break	1.6	30.019020	-90.097882	Orleans-24
KLAC-02-14	Orleans	Levee - Break	1.4	30.023763	-90.097788	Orleans-25
KLAC-02-15	Orleans	Levee - Break	2.2	30.021567	-90.112928	Orleans-26
KLAC-02-16	Orleans	Coastal - Wave Runup	10.7	30.023155	-90.113175	Orleans-27
KLAC-02-17	Orleans	Coastal - Wave Runup	14.5	30.026717	-90.108023	Orleans-28
KLAC-02-18	Orleans	Coastal - Wave Runup	12.9	30.027252	-90.098456	Orleans-29
KLAC-02-19	Orleans	Levee - Break	2.3	30.025849	-90.111054	Orleans-30
KLAC-02-20	Orleans	Levee - Break	1.8	30.021737	-90.099432	Orleans-31
KLAC-02-21	Orleans	Levee - Break	1.7	30.019575	-90.098801	Orleans-32
KLAC-02-22	Orleans	Coastal - Wave Runup	12.6	30.027855	-90.089186	Orleans-33
KLAC-02-23	Orleans	Levee - Break	2.2	29.941290	-90.123572	Orleans-34
KLAC-02-24	Orleans	Levee - Break	1.5	29.933939	-90.112644	Orleans-35
KLAC-02-25	Orleans	Levee - Break	2.1	29.935016	-90.096632	Orleans-36
KLAC-02-26	Orleans	Levee - Break	1.4	29.927913	-90.096958	Orleans-37
KLAC-02-27	Orleans	Levee - Break	2.5	29.938780	-90.109033	Orleans-38
KLAC-02-28	Orleans	Levee - Break	2.5	29.933777	-90.102596	Orleans-39
KLAC-02-29	St. Bernard	Levee - Break	10.9	29.930352	-89.930483	St. Ber-4
KLAC-02-30	St. Bernard	Levee - Break	10.6	29.931828	-89.935829	St. Ber-5
KLAC-02-31	St. Bernard	Levee - Break	10.7	29.936127	-89.921286	St. Ber-6
KLAC-02-32	St. Bernard	Levee - Break	10.9	29.946932	-89.921561	St. Ber-7
KLAC-02-33	St. Bernard	Levee - Break	10.3	29.931295	-89.948093	St. Ber-8
KLAC-02-34	St. Bernard	Levee - Break	10.5	29.937716	-89.960173	St. Ber-9
KLAC-02-35	Jefferson	Coastal - Surge Only	5.8	29.265225	-89.957349	Jeffers-5
KLAC-02-36	Jefferson	Coastal - Surge Only	8.5	29.241738	-89.978814	Jeffers-6
KLAC-03-01	Lafourche	Coastal - Surge Only	8.9	29.211475	-90.051541	Lafourc-1
KLAC-03-02	Lafourche	Coastal - Surge Only	7.5	29.156245	-90.180386	Lafourc-2
KLAC-03-03	Tangipahoa	Coastal - Surge Only	6.0	30.404156	-90.323376	Tangipa-1
KLAC-03-04	Tangipahoa	Coastal - Surge Only	5.6	30.405803	-90.262036	Tangipa-2
KLAC-03-05	Tangipahoa	Coastal - Surge Only	3.5	30.290135	-90.401377	Tangipa-3
KLAC-03-06	St. John the Baptist	Coastal - Wave Height	6.0	30.281138	-90.399966	St. Joh-1
KLAC-03-07	St. John the Baptist	Coastal - Surge Only	2.8	30.194538	-90.435975	St. Joh-2
KLAC-03-09	St. John the Baptist	Coastal - Surge Only	3.9	30.101686	-90.425410	St. Joh-3
KLAC-03-10	St. John the Baptist	Coastal - Surge Only	5.7	30.101597	-90.424877	St. Joh-4
KLAC-03-11	Orleans	Levee - Break	2.4	29.991046	-90.109842	Orleans-40
KLAC-03-12	Orleans	Levee - Break	2.4	29.982494	-90.109802	Orleans-41
KLAC-03-14	Orleans	Levee - Break	2.4	30.020426	-90.104834	Orleans-42
KLAC-03-15	Orleans	Levee - Break	2.2	30.023225	-90.101497	Orleans-43
KLAC-03-16	Orleans	Levee - Break	2.8	29.999931	-90.089522	Orleans-44
KLAC-03-17	Orleans	Levee - Break	2.3	30.004097	-90.098971	Orleans-45
KLAC-03-18	Orleans	Levee - Break	2.6	29.994576	-90.100559	Orleans-46
KLAC-03-19	Orleans	Levee - Break	1.4	30.020791	-90.083810	Orleans-47
KLAC-03-20	Orleans	Levee - Break	2.1	30.024105	-90.083555	Orleans-48
KLAC-03-21	Orleans	Levee - Break	2.6	29.943609	-90.097165	Orleans-49
KLAC-03-22	Orleans	Levee - Break	2.5	29.944630	-90.103927	Orleans-50
KLAC-03-23	Orleans	Levee - Break	1.5	29.941178	-90.107024	Orleans-51
KLAC-03-25	Orleans	Levee - Break	2.4	29.945435	-90.124320	Orleans-52
KLAC-03-26	St. Bernard	Levee - Break	5.5	29.862818	-89.781835	St. Ber-10
KLAC-03-29	St. Charles	Coastal - Surge Only	6.4	30.055665	-90.371799	St. Cha-5
KLAC-03-30	Jefferson	Levee - Interior	5.5	29.999022	-90.284746	Jeffers-7
KLAC-03-31	St. Charles	Coastal - Surge Only	9.3	30.072671	-90.399370	St. Cha-6
KLAC-04-01	St. Tammany	Riverine - Hurricane	12.8	30.477691	-90.087241	St. Tam-12
KLAC-04-02	St. Tammany	Riverine - Hurricane	6.1	30.460596	-90.082856	St. Tam-14
KLAC-04-02A	St. Tammany	Riverine - Hurricane	9.7	30.461502	-90.081745	St. Tam-13
KLAC-04-03	St. Tammany	Riverine - Hurricane	7.7	30.438345	-90.115926	St. Tam-15
KLAC-04-04	St. Tammany	Riverine - Hurricane	8.1	30.437713	-90.116280	St. Tam-16
KLAC-04-05	St. Tammany	Coastal - Surge Only	6.9	30.398989	-90.155788	St. Tam-17

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-04-07	Jefferson	Levee - Interior	-4.3	30.042867	-90.274929	Jeffers-8
KLAC-04-08	Jefferson	Levee - Interior	-4.1	30.019869	-90.274156	Jeffers-9
KLAC-04-09	Jefferson	Levee - Interior	-4.0	30.023151	-90.265552	Jeffers-10
KLAC-04-10	Jefferson	Coastal - Wave Runup	9.4	30.040061	-90.238090	Jeffers-11
KLAC-04-11	Jefferson	Coastal - Wave Runup	11.6	30.032774	-90.219619	Jeffers-12
KLAC-04-12	Jefferson	Levee - Interior	-3.6	30.011045	-90.195617	Jeffers-13
KLAC-04-13	Jefferson	Levee - Interior	-3.9	29.994800	-90.194420	Jeffers-14
KLAC-04-14	Jefferson	Levee - Interior	-3.7	29.984246	-90.198763	Jeffers-15
KLAC-04-15	Jefferson	Levee - Interior	-3.8	29.995970	-90.216290	Jeffers-16
KLAC-04-16	Orleans	Levee - Break	1.3	30.027518	-90.054973	Orleans-53
KLAC-04-18	Orleans	Coastal - Wave Runup	16.6	30.033719	-90.041892	Orleans-54
KLAC-04-19	Orleans	Levee - Break	2.3	29.987848	-90.067639	Orleans-55
KLAC-04-20	Orleans	Levee - Break	2.5	29.970660	-90.077545	Orleans-56
KLAC-04-21	Orleans	Levee - Break	1.5	29.982684	-90.090947	Orleans-57
KLAC-04-22	Orleans	Levee - Break	2.4	29.975356	-90.083980	Orleans-58
KLAC-04-23	Orleans	Levee - Break	3.0	29.936543	-90.092225	Orleans-59
KLAC-04-24	Orleans	Levee - Break	1.8	29.942776	-90.093619	Orleans-60
KLAC-04-25	Orleans	Levee - Break	1.0	29.932419	-90.087119	Orleans-61
KLAC-04-26	Orleans	Levee - Break	1.7	29.936553	-90.081185	Orleans-62
KLAC-04-27	St. Bernard	Levee - Break	4.1	29.967424	-90.019830	St. Ber-11
KLAC-04-28	St. Bernard	Levee - Break	4.6	29.965940	-90.014121	St. Ber-12
KLAC-04-29	St. Bernard	Levee - Break	3.9	29.963503	-90.005880	St. Ber-13
KLAC-04-30	St. Bernard	Levee - Break	9.8	29.946767	-89.921476	St. Ber-14
KLAC-04-31	St. Bernard	Levee - Break	10.5	29.970211	-89.997887	St. Ber-15
KLAC-04-32	St. Bernard	Levee - Break	10.0	29.962731	-89.990968	St. Ber-16
KLAC-04-33	Jefferson	Coastal - Wave Runup	8.5	30.049191	-90.276670	Jeffers-17
KLAC-04-34	Jefferson	Coastal - Wave Runup	9.4	30.040810	-90.243065	Jeffers-18
KLAC-04-35	Jefferson	Coastal - Wave Runup	6.8	30.027021	-90.198977	Jeffers-19
KLAC-05-01	St. Tammany	Coastal - Surge Only	13.2	30.219233	-89.819947	St. Tam-18
KLAC-05-02	St. Tammany	Coastal - Surge Only	11.4	30.275539	-89.853008	St. Tam-19
KLAC-05-03	St. Tammany	Coastal - Surge Only	11.2	30.278714	-89.838555	St. Tam-20
KLAC-05-04	St. Tammany	Coastal - Surge Only	11.0	30.272160	-89.795137	St. Tam-21
KLAC-05-05	St. Tammany	Coastal - Surge Only	10.5	30.272963	-89.794737	St. Tam-22
KLAC-05-06	St. Tammany	Coastal - Surge Only	11.4	30.263776	-89.793520	St. Tam-23
KLAC-05-07	St. Tammany	Coastal - Surge Only	15.3	30.195716	-89.756186	St. Tam-24
KLAC-05-09	St. Tammany	Coastal - Surge Only	16.0	30.203851	-89.699580	St. Tam-25
KLAC-05-10	Jefferson	Levee - Interior	0.4	29.884566	-90.099468	Jeffers-20
KLAC-05-11	Jefferson	Levee - Interior	0.9	29.875315	-90.109900	Jeffers-21
KLAC-05-12	Jefferson	Levee - Interior	0.4	29.854456	-90.117160	Jeffers-22
KLAC-05-14	Jefferson	Levee - Interior	-4.3	29.894341	-90.014498	Jeffers-23
KLAC-05-15	Jefferson	Levee - Interior	-3.7	29.906414	-90.022410	Jeffers-24
KLAC-05-16	Jefferson	Levee - Interior	-5.7	29.879582	-90.034295	Jeffers-25
KLAC-05-17	Plaquemines	Coastal - Surge Only	2.9	29.743390	-90.024501	Plaquem-1
KLAC-05-18	Plaquemines	Riverine - Hurricane	16.3	29.817290	-90.006881	Plaquem-2
KLAC-05-19	Orleans	Levee - Break	2.8	29.995878	-90.078121	Orleans-63
KLAC-05-20	Orleans	Levee - Break	2.6	30.001183	-90.081248	Orleans-64
KLAC-05-21	Orleans	Levee - Break	1.5	30.007019	-90.082341	Orleans-65
KLAC-05-22	Orleans	Levee - Break	2.8	30.012504	-90.076960	Orleans-66
KLAC-05-23	Orleans	Levee - Break	1.4	30.016459	-90.075170	Orleans-67
KLAC-05-24	Orleans	Levee - Break	2.9	30.007128	-90.070245	Orleans-68
KLAC-05-25	Orleans	Levee - Break	2.8	30.000777	-90.072038	Orleans-69
KLAC-05-26	Orleans	Levee - Break	2.7	29.995359	-90.068977	Orleans-70
KLAC-05-27	Orleans	Levee - Break	3.0	29.998317	-90.064052	Orleans-71
KLAC-05-28	Orleans	Levee - Break	1.9	30.000915	-90.064341	Orleans-72
KLAC-05-30	Orleans	Coastal - Wave Runup	15.3	30.031421	-90.038513	Orleans-73
KLAC-05-31	Orleans	Levee - Break	-1.3	30.029053	-89.992436	Orleans-74

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-05-32	Orleans	Levee - Break	-1.3	30.027460	-90.000252	Orleans-75
KLAC-05-33	Orleans	Levee - Break	-1.4	30.032334	-89.973003	Orleans-76
KLAC-05-34	Orleans	Levee - Break	-1.6	30.033226	-89.968415	Orleans-77
KLAC-05-35	Orleans	Levee - Break	-1.4	30.040248	-89.961665	Orleans-78
KLAC-05-36	Orleans	Levee - Break	-1.4	30.033504	-89.951188	Orleans-79
KLAC-05-37	Orleans	Levee - Break	-1.1	30.041876	-89.950630	Orleans-80
KLAC-05-38	St. Bernard	Levee - Break	11.3	29.907335	-89.906557	St. Ber-17
KLAC-05-39	St. Bernard	Levee - Break	12.1	29.913047	-89.899305	St. Ber-18
KLAC-05-40	St. Bernard	Levee - Break	11.4	29.905706	-89.895124	St. Ber-19
KLAC-05-41	St. Bernard	Levee - Break	9.8	29.916301	-89.912116	St. Ber-20
KLAC-05-42	St. Bernard	Levee - Break	10.8	29.922763	-89.902248	St. Ber-21
KLAC-05-43	St. Tammany	Coastal - Surge Only	7.8	30.389975	-90.205244	St. Tam-26
KLAC-06-01	St. Tammany	Coastal - Surge Only	12.8	30.222620	-89.815969	St. Tam-27
KLAC-06-02	St. Tammany	Riverine - Hurricane	17.1	30.325798	-89.837902	St. Tam-28
KLAC-06-03	St. Tammany	Riverine - Hurricane	12.6	30.309997	-89.779832	St. Tam-29
KLAC-06-04	St. Tammany	Coastal - Surge Only	12.1	30.285462	-89.728436	St. Tam-30
KLAC-06-05	St. Tammany	Riverine - Hurricane	15.2	30.381480	-89.737359	St. Tam-31
KLAC-06-06	St. Tammany	Riverine - Hurricane	15.2	30.384245	-89.734828	St. Tam-32
KLAC-06-07	St. Tammany	Riverine - Hurricane	22.5	30.323686	-89.753897	St. Tam-33
KLAC-06-08	St. Tammany	Coastal - Surge Only	12.4	30.247756	-89.763806	St. Tam-34
KLAC-06-09	St. Tammany	Coastal - Surge Only	13.4	30.290653	-89.767705	St. Tam-35
KLAC-06-10	Jefferson	Riverine - Hurricane	17.9	29.965889	-90.258175	Jeffers-26
KLAC-06-11	Jefferson	Riverine - Hurricane	17.9	29.917806	-90.141784	Jeffers-27
KLAC-06-13	Jefferson	Levee - Interior	-3.6	29.897037	-90.206959	Jeffers-28
KLAC-06-14	Plaquemines	Coastal - Wave Runup	13.2	29.480648	-89.693675	Plaquem-3
KLAC-06-15	Plaquemines	Coastal - Surge Only	11.9	29.524854	-89.739953	Plaquem-4
KLAC-06-17	Plaquemines	Coastal - Surge Only	3.2	29.638149	-89.948467	Plaquem-5
KLAC-06-18	Plaquemines	Riverine - Hurricane	17.0	29.697418	-89.982336	Plaquem-6
KLAC-06-19	Plaquemines	Coastal - Surge Only	5.4	29.747804	-90.023973	Plaquem-7
KLAC-06-20	Plaquemines	Coastal - Surge Only	12.5	29.540295	-89.752529	Plaquem-8
KLAC-06-21	Plaquemines	Coastal - Surge Only	12.0	29.585034	-89.806325	Plaquem-9
KLAC-06-22	Plaquemines	Coastal - Surge Only	13.7	29.615051	-89.882991	Plaquem-10
KLAC-06-23	Plaquemines	Coastal - Surge Only	16.1	29.647733	-89.945611	Plaquem-11
KLAC-06-24	Plaquemines	Coastal - Surge Only	4.3	29.718877	-89.981940	Plaquem-12
KLAC-06-25	Orleans	Levee - Break	-1.4	30.033022	-90.025296	Orleans-81
KLAC-06-26	Orleans	Levee - Break	0.7	30.036767	-90.014753	Orleans-82
KLAC-06-27	Orleans	Coastal - Surge Only	12.0	30.036884	-90.014808	Orleans-83
KLAC-06-28	Orleans	Levee - Break	-1.4	30.043497	-89.995622	Orleans-84
KLAC-06-29	Orleans	Levee - Break	-1.6	30.049428	-89.983252	Orleans-85
KLAC-06-30	Orleans	Levee - Interior	-1.6	30.056162	-89.970125	Orleans-86
KLAC-06-31	Orleans	Levee - Break	-1.9	30.065669	-89.955639	Orleans-87
KLAC-06-32	Orleans	Levee - Break	0.3	30.074338	-89.944923	Orleans-88
KLAC-06-33	Orleans	Levee - Break	-2.2	30.056748	-89.945215	Orleans-89
KLAC-06-34	Orleans	Levee - Break	-1.5	30.048059	-89.959128	Orleans-90
KLAC-06-35	Orleans	Levee - Break	-1.5	30.038429	-89.977054	Orleans-91
KLAC-06-36	Orleans	Levee - Break	-1.5	30.031377	-89.994363	Orleans-92
KLAC-06-37	Orleans	Levee - Break	-1.4	30.027660	-90.015203	Orleans-93
KLAC-06-38	Orleans	Levee - Break	-1.6	30.017828	-89.982840	Orleans-94
KLAC-06-39	St. Bernard	Levee - Break	11.0	29.866900	-89.803919	St. Ber-22
KLAC-06-40	St. Bernard	Levee - Break	11.6	29.867923	-89.825791	St. Ber-23
KLAC-06-41	St. Bernard	Levee - Break	10.4	29.865145	-89.842511	St. Ber-24
KLAC-06-42	St. Bernard	Levee - Break	10.2	29.868054	-89.864807	St. Ber-25
KLAC-06-43	St. Bernard	Levee - Break	10.5	29.868316	-89.885116	St. Ber-26
KLAC-06-44	St. Bernard	Levee - Break	10.6	29.879348	-89.895626	St. Ber-27
KLAC-06-45	St. Bernard	Levee - Break	11.0	29.878557	-89.878265	St. Ber-28
KLAC-06-46	St. Bernard	Levee - Break	10.3	29.873169	-89.867391	St. Ber-29

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-06-47	St. Bernard	Levee - Break	9.3	29.873593	-89.835018	St. Ber-30
KLAC-06-48	St. Bernard	Levee - Break	11.8	29.877521	-89.812687	St. Ber-31
KLAC-06-49	Orleans	Levee - Break	2.8	30.014536	-89.999017	Orleans-95
KLAC-06-50	Orleans	Levee - Break	-1.4	30.021934	-89.959512	Orleans-96
KLAC-06-51	Orleans	Levee - Break	2.5	30.008423	-89.992803	Orleans-97
KLAC-06-52	Orleans	Levee - Break	2.0	30.018307	-89.930539	Orleans-98
KLAC-06-53	St. Bernard	Levee - Break	10.2	29.963679	-89.952610	St. Ber-32
KLAC-06-54	St. Bernard	Levee - Break	11.6	29.981529	-89.945356	St. Ber-33
KLAC-07-01	Livingston	Riverine - Hurricane	4.0	30.271941	-90.751523	Livings-5
KLAC-07-02	St. Tammany	Coastal - Surge Only	8.8	30.351446	-90.050334	St. Tam-36
KLAC-07-03	St. Tammany	Coastal - Surge Only	9.2	30.354669	-90.067620	St. Tam-37
KLAC-07-04	St. Tammany	Coastal - Surge Only	9.3	30.359690	-90.070840	St. Tam-38
KLAC-07-05	St. Tammany	Coastal - Surge Only	9.1	30.362328	-90.079797	St. Tam-39
KLAC-07-07	St. Tammany	Coastal - Wave Runup	6.6	30.364935	-90.091837	St. Tam-40
KLAC-07-08	St. Tammany	Coastal - Surge Only	9.2	30.363178	-90.077562	St. Tam-41
KLAC-07-09	St. Tammany	Coastal - Surge Only	10.3	30.357811	-90.065489	St. Tam-42
KLAC-07-10	St. Tammany	Coastal - Surge Only	8.4	30.371039	-90.104908	St. Tam-43
KLAC-07-11	St. Tammany	Coastal - Surge Only	7.8	30.396049	-90.121701	St. Tam-44
KLAC-07-12	St. Tammany	Coastal - Surge Only	7.8	30.419672	-90.104286	St. Tam-45
KLAC-07-13	St. Tammany	Coastal - Surge Only	9.0	30.425247	-90.081520	St. Tam-46
KLAC-07-14	Jefferson	Levee - Interior	-3.4	30.022910	-90.187433	Jeffers-29
KLAC-07-15	Jefferson	Levee - Interior	-3.5	30.020022	-90.174296	Jeffers-30
KLAC-07-16	Jefferson	Levee - Interior	-3.6	30.018831	-90.159174	Jeffers-31
KLAC-07-18	Jefferson	Levee - Break	2.4	29.983684	-90.142651	Jeffers-32
KLAC-07-19	Jefferson	Levee - Break	2.5	29.976499	-90.140491	Jeffers-33
KLAC-07-20	Jefferson	Levee - Break	2.6	29.976465	-90.126808	Jeffers-34
KLAC-07-21	Jefferson	Levee - Interior	-3.2	30.012813	-90.123723	Jeffers-35
KLAC-07-23	Jefferson	Levee - Interior	-3.3	30.016298	-90.143372	Jeffers-36
KLAC-07-24	Jefferson	Levee - Interior	-3.1	30.011497	-90.134864	Jeffers-37
KLAC-07-25	Jefferson	Levee - Interior	-3.3	30.014168	-90.168266	Jeffers-38
KLAC-07-28	Jefferson	Levee - Interior	-3.8	30.014035	-90.185925	Jeffers-39
KLAC-07-29	Jefferson	Levee - Interior	-3.6	29.989979	-90.164545	Jeffers-40
KLAC-07-30	Jefferson	Levee - Interior	-3.4	29.992000	-90.157755	Jeffers-41
KLAC-07-31	Jefferson	Levee - Interior	1.5	29.960933	-90.210735	Jeffers-42
KLAC-07-32	Jefferson	Levee - Interior	4.3	29.956418	-90.219183	Jeffers-43
KLAC-07-33	Orleans	Levee - Break	2.7	29.966548	-90.038379	Orleans-99
KLAC-07-34	Orleans	Levee - Break	2.7	29.968528	-90.048521	Orleans-100
KLAC-07-35	Orleans	Levee - Break	2.7	29.970246	-90.057182	Orleans-101
KLAC-07-36	Orleans	Levee - Break	2.6	29.976899	-90.057160	Orleans-102
KLAC-07-37	Orleans	Levee - Break	1.4	29.982597	-90.057495	Orleans-103
KLAC-07-38	Orleans	Levee - Break	3.4	29.990477	-90.057982	Orleans-104
KLAC-07-39	Orleans	Levee - Break	2.6	29.980149	-90.048693	Orleans-105
KLAC-07-40	Orleans	Levee - Break	3.2	29.989839	-90.049453	Orleans-106
KLAC-07-41	Orleans	Levee - Break	2.6	29.974059	-90.049001	Orleans-107
KLAC-07-42	Orleans	Levee - Break	2.8	29.971987	-90.038794	Orleans-108
KLAC-07-43	Orleans	Levee - Break	2.6	29.969304	-90.029645	Orleans-109
KLAC-07-44	Orleans	Levee - Break	2.6	29.964977	-90.029156	Orleans-110
KLAC-07-45	Orleans	Levee - Break	1.9	29.978703	-90.029617	Orleans-111
KLAC-07-46	Orleans	Levee - Break	2.6	29.979128	-90.036583	Orleans-112
KLAC-07-47	Orleans	Levee - Break	3.0	29.965862	-90.041988	Orleans-113
KLAC-07-48	Orleans	Levee - Break	3.0	29.967949	-90.057066	Orleans-114
KLAC-07-49	Orleans	Levee - Break	2.7	29.946740	-90.074960	Orleans-115
KLAC-07-50	Orleans	Levee - Break	2.0	29.950163	-90.087857	Orleans-116
KLAC-07-51	Orleans	Levee - Break	2.6	29.962029	-90.094450	Orleans-117
KLAC-07-52	Orleans	Levee - Break	2.4	29.955977	-90.095870	Orleans-118
KLAC-07-53	Orleans	Levee - Break	2.7	29.948563	-90.094213	Orleans-119

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-07-54	Orleans	Levee - Break	2.5	29.955683	-90.073097	Orleans-120
KLAC-07-55	Orleans	Levee - Break	2.6	29.950951	-90.075724	Orleans-121
KLAC-07-56	Orleans	Levee - Break	2.8	29.955626	-90.086697	Orleans-122
KLAC-07-57	Orleans	Levee - Break	2.5	29.961796	-90.082197	Orleans-123
KLAC-07-58	Orleans	Levee - Break	2.5	29.957368	-90.069406	Orleans-124
KLAC-07-59	St. Bernard	Levee - Break	10.0	29.954119	-89.958510	St. Ber-34
KLAC-07-60	St. Bernard	Levee - Break	10.3	29.958308	-89.965734	St. Ber-35
KLAC-07-61	St. Bernard	Levee - Break	8.9	29.950363	-89.968375	St. Ber-36
KLAC-07-62	St. Bernard	Levee - Break	10.7	29.945164	-89.971341	St. Ber-37
KLAC-07-63	St. Bernard	Levee - Break	9.8	29.949174	-89.962772	St. Ber-38
KLAC-07-64	St. Bernard	Levee - Break	10.2	29.942926	-89.965123	St. Ber-39
KLAC-07-65	St. Bernard	Levee - Break	10.2	29.938115	-89.966792	St. Ber-40
KLAC-07-66	St. Bernard	Levee - Break	10.6	29.940645	-89.974455	St. Ber-41
KLAC-07-67	St. Bernard	Levee - Break	10.5	29.944681	-89.982199	St. Ber-42
KLAC-07-68	St. Bernard	Levee - Break	10.0	29.952141	-89.979169	St. Ber-43
KLAC-07-69	St. Bernard	Levee - Break	9.4	29.959332	-89.978905	St. Ber-44
KLAC-07-70	St. Bernard	Levee - Break	10.8	29.968344	-89.985666	St. Ber-45
KLAC-07-71	St. Bernard	Levee - Break	10.6	29.959404	-89.992553	St. Ber-46
KLAC-07-72	St. Bernard	Levee - Break	10.5	29.950316	-89.993292	St. Ber-47
KLAC-08-01	Jefferson	Coastal - Surge Only	8.6	29.208757	-90.033853	Jeffers-44
KLAC-08-02	Lafourche	Coastal - Surge Only	4.1	29.257687	-90.214356	Lafourc-3
KLAC-08-08	Plaquemines	Coastal - Surge Only	7.1	29.522635	-89.740998	Plaquem-13
KLAC-08-09	Plaquemines	Riverine - Hurricane	3.0	29.543527	-89.778084	Plaquem-14
KLAC-08-10	Plaquemines	Coastal - Surge Only	8.3	29.518947	-89.732026	Plaquem-15
KLAC-08-11	Plaquemines	Coastal - Wave Runup	5.9	29.527769	-89.762985	Plaquem-16
KLAC-08-12	Plaquemines	Coastal - Wave Runup	5.8	29.543150	-89.779094	Plaquem-17
KLAC-08-13	Plaquemines	Coastal - Surge Only	0.4	29.625983	-89.949704	Plaquem-18
KLAC-08-14	Plaquemines	Coastal - Surge Only	4.2	29.625942	-89.950431	Plaquem-19
KLAC-08-15	Plaquemines	Coastal - Surge Only	15.7	29.593466	-89.811625	Plaquem-20
KLAC-08-16	Plaquemines	Coastal - Surge Only	13.6	29.624711	-89.878333	Plaquem-21
KLAC-08-17	Plaquemines	Coastal - Surge Only	8.9	29.648495	-89.944562	Plaquem-22
KLAC-08-18	Plaquemines	Coastal - Surge Only	16.2	29.648567	-89.944674	Plaquem-23
KLAC-08-19	Orleans	Levee - Break	-1.4	30.026014	-90.025569	Orleans-125
KLAC-08-20	Orleans	Levee - Break	-1.4	30.028813	-90.014087	Orleans-126
KLAC-08-21	Orleans	Levee - Break	-2.0	30.033235	-90.003006	Orleans-127
KLAC-08-22	Orleans	Levee - Break	-3.8	30.062793	-89.948767	Orleans-128
KLAC-08-23	Orleans	Levee - Break	-1.8	30.068128	-89.940925	Orleans-129
KLAC-08-24	Orleans	Levee - Break	-2.0	30.038939	-89.988281	Orleans-130
KLAC-08-25	Orleans	Levee - Break	-1.5	30.046632	-89.972388	Orleans-131
KLAC-08-26	Orleans	Levee - Break	-1.5	30.058282	-89.955038	Orleans-132
KLAC-08-27	Orleans	Levee - Break	-1.5	30.017604	-90.021657	Orleans-133
KLAC-09-02	Orleans	Levee - Break	1.9	30.025492	-90.056868	Orleans-134
KLAC-09-03	Orleans	Levee - Break	1.4	30.021333	-90.075571	Orleans-135
KLAC-09-04	Orleans	Levee - Break	1.4	30.019022	-90.089940	Orleans-136
KLAC-09-05	Orleans	Levee - Break	2.8	30.003373	-90.095982	Orleans-137
KLAC-09-06	Orleans	Levee - Break	1.9	30.002844	-90.054981	Orleans-138
KLAC-09-07	Orleans	Levee - Break	1.4	30.008381	-90.055428	Orleans-139
KLAC-09-08	Orleans	Levee - Break	1.8	30.002958	-90.046459	Orleans-140
KLAC-09-09	Orleans	Levee - Break	1.7	30.010685	-90.047117	Orleans-141
KLAC-09-10	Orleans	Levee - Break	1.7	29.997180	-90.054532	Orleans-142
KLAC-09-11	Orleans	Levee - Break	1.4	29.993101	-90.039379	Orleans-143
KLAC-09-12	Orleans	Levee - Break	2.4	29.967512	-90.111703	Orleans-144
KLAC-09-13	Orleans	Levee - Break	1.8	29.967078	-90.119451	Orleans-145
KLAC-09-14	Orleans	Levee - Break	2.0	29.966981	-90.127291	Orleans-146
KLAC-09-15	Orleans	Levee - Break	2.6	29.960412	-90.119374	Orleans-147
KLAC-09-16	Orleans	Levee - Break	2.2	29.961058	-90.111858	Orleans-148

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLAC-09-17	Orleans	Levee - Break	2.5	29.958750	-90.103130	Orleans-149
KLAC-09-18	Orleans	Levee - Break	2.0	29.954072	-90.103905	Orleans-150
KLAC-09-19	Orleans	Levee - Break	1.4	29.951070	-90.108852	Orleans-151
KLAC-09-20	Orleans	Levee - Break	2.5	29.951726	-90.118797	Orleans-152
KLAC-09-21	Orleans	Levee - Break	1.8	29.953681	-90.127727	Orleans-153
KLAC-09-22	Orleans	Levee - Break	2.7	29.962238	-90.127849	Orleans-154
KLAC-20-01	St. Charles	Riverine - Hurricane	13.5	29.979332	-90.402671	St. Cha-7
KLAC-20-02	St. John the Baptist	Riverine - Hurricane	12.9	30.044764	-90.549558	St. Joh-5
KLAC-20-03	St. James	Riverine - Hurricane	13.6	30.028047	-90.694202	St. Jam-1
KLAC-25-01	St. Tammany	Coastal - Surge Only	8.0	30.409188	-90.140448	St. Tam-47
KLAC-26-01	Jefferson	Coastal - Surge Only	7.6	29.260584	-89.963170	Jeffers-45
KLAC-27-04	St. Bernard	Coastal - Surge Only	17.7	29.842576	-89.689238	St. Ber-48
KLAC-29-01	Plaquemines	Coastal - Surge Only	5.1	29.273584	-89.354106	Plaquem-24
KLAC-29-02	Plaquemines	Coastal - Surge Only	4.4	29.290896	-89.368476	Plaquem-25
KLAC-29-03	Plaquemines	Coastal - Surge Only	4.8	29.318055	-89.388678	Plaquem-26
KLAC-29-04	Plaquemines	Coastal - Surge Only	6.5	29.336085	-89.406724	Plaquem-27
KLAC-29-05	Plaquemines	Coastal - Surge Only	7.3	29.352654	-89.440705	Plaquem-28
KLAC-29-07	Plaquemines	Coastal - Surge Only	2.4	29.367829	-89.569263	Plaquem-29
KLAC-88-01	St. Bernard	Coastal - Surge Only	12.0	29.860420	-89.913023	St. Ber-49
KLAC-88-02	St. Bernard	Coastal - Surge Only	17.1	29.840585	-89.757925	St. Ber-50
KLAC-88-03	Orleans	Coastal - Surge Only	15.0	30.000991	-89.940955	Orleans-155
KLAC-88-04	Jefferson	Coastal - Surge Only	6.6	30.040939	-90.238578	Jeffers-46
KLAC-88-05	Jefferson	Coastal - Surge Only	10.9	30.021010	-90.122967	Jeffers-47
KLAC-88-06	Orleans	Coastal - Surge Only	11.8	30.029783	-90.091199	Orleans-156
KLAC-88-07	Orleans	Coastal - Surge Only	11.8	30.033801	-90.040233	Orleans-157
KLAC-88-08	Orleans	Coastal - Wave Height	13.8	30.057677	-89.969006	Orleans-158
KLAC-88-15	Orleans	Coastal - Wave Height	13.0	30.057932	-89.968537	Orleans-159
KLAC-88-20	Orleans	Coastal - Surge Only	11.4	30.036790	-90.017013	Orleans-160
KLAC-99-01	Orleans	Coastal - Wave Runup	11.7	30.041787	-90.023215	Orleans-161
KLAR-25-01	Washington	Riverine - Hurricane	95.2	30.720711	-90.083432	Washing-1
KLAR-25-02	Washington	Riverine - Hurricane	67.4	30.761990	-89.831306	Washing-2
KLAR-25-03	Washington	Riverine - Hurricane	62.4	30.703549	-89.848047	Washing-3
KLAR-25-04	Washington	Riverine - Hurricane	76.5	30.670099	-90.001615	Washing-4
KLAR-25-05	St. Tammany	Riverine - Hurricane	8.5	30.463462	-90.118189	St. Tam-48
KLAR-26-01	St. Tammany	Riverine - Hurricane	18.2	30.499589	-90.084433	St. Tam-49
KLAR-31-01	St. Tammany	Riverine - Hurricane	7.2	30.303100	-89.706707	St. Tam-50
KLRL-27-01	St. Bernard	Coastal - Surge Only	10.6	29.894428	-89.898608	St. Ber-51
KLRL-27-02	St. Bernard	Levee - Break	12.1	29.924996	-89.911154	St. Ber-52
KLRL-27-03	St. Bernard	Levee - Break	11.6	29.942210	-89.952472	St. Ber-53
KLRL-27-05	Orleans	Levee - Break	11.6	29.960971	-90.026233	Orleans-162
KLRL-27-07	St. Bernard	Levee - Break	12.5	29.963170	-89.971364	St. Ber-54
KLRL-28-01	St. Bernard	Levee - Break	11.5	29.919897	-89.906412	St. Ber-55
KLRL-28-02	St. Bernard	Levee - Break	10.4	29.943974	-89.927901	St. Ber-56
KLRL-28-03	St. Bernard	Levee - Break	11.5	29.958577	-89.971980	St. Ber-57
KLRL-28-04	St. Bernard	Levee - Break	12.6	29.868570	-89.815673	St. Ber-58
KLRL-28-05	St. Bernard	Levee - Break	14.4	29.916635	-89.896237	St. Ber-59
KLRL-28-06	St. Bernard	Levee - Break	13.0	29.966306	-90.005487	St. Ber-60
KLRL-28-07	St. Bernard	Levee - Break	11.1	29.963951	-90.000883	St. Ber-61
KLRL-28-08	St. Bernard	Levee - Break	11.2	29.956537	-90.019127	St. Ber-62
USGS Flagged Points						
KLA-USGS-01	St. Tammany	N/A	7.9	30.399072	-90.157097	U-St. Tam-1
KLA-USGS-03	St. Tammany	N/A	7.5	30.404488	-90.158156	U-St. Tam-2
KLA-USGS-04	St. Tammany	N/A	7.6	30.410498	-90.168527	U-St. Tam-3
KLA-USGS-05	St. Tammany	N/A	7.5	30.409486	-90.162145	U-St. Tam-4
KLA-USGS-06	St. Tammany	N/A	7.6	30.413102	-90.159872	U-St. Tam-5
KLA-USGS-07	St. Tammany	N/A	7.7	30.406241	-90.155311	U-St. Tam-6

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLA-USGS-08	St. Tammany	N/A	7.9	30.400375	-90.152972	U-St. Tam-7
KLA-USGS-09	St. Tammany	N/A	12.8	30.408792	-90.140096	U-St. Tam-8
KLA-USGS-10	St. Tammany	N/A	8.6	30.367210	-90.09760	U-St. Tam-9
KLA-USGS-11	St. Tammany	N/A	7.9	30.415975	-90.135863	U-St. Tam-10
KLA-USGS-12	St. Tammany	N/A	8.1	30.402588	-90.130998	U-St. Tam-11
KLA-USGS-13	St. Tammany	N/A	8.8	30.369432	-90.107317	U-St. Tam-12
KLA-USGS-14	St. Tammany	N/A	8.8	30.366710	-90.110850	U-St. Tam-13
KLA-USGS-15	St. Tammany	N/A	8.7	30.364880	-90.083016	U-St. Tam-14
KLA-USGS-16	St. Tammany	N/A	9.3	30.358349	-90.078546	U-St. Tam-15
KLA-USGS-17	St. Tammany	N/A	9.1	30.361793	-90.076332	U-St. Tam-16
KLA-USGS-19	St. Tammany	N/A	9.4	30.350002	-90.060104	U-St. Tam-17
KLA-USGS-20	St. Tammany	N/A	10.0	30.339285	-90.039780	U-St. Tam-18
KLA-USGS-21	St. Tammany	N/A	8.4	30.335535	-90.044980	U-St. Tam-19
KLA-USGS-22	St. Tammany	N/A	9.5	30.329096	-90.004008	U-St. Tam-20
KLA-USGS-23	St. Tammany	N/A	9.6	30.300184	-89.957295	U-St. Tam-21
KLA-USGS-25	St. Tammany	N/A	6.4	30.284085	-89.916991	U-St. Tam-22
KLA-USGS-26	St. Tammany	N/A	11.7	30.273698	-89.859623	U-St. Tam-23
KLA-USGS-27	St. Tammany	N/A	10.2	30.280911	-89.860937	U-St. Tam-24
KLA-USGS-28	Livingston	N/A	3.9	30.307745	-90.608591	U-Livings-1
KLA-USGS-29	Livingston	N/A	5.7	30.372860	-90.551176	U-Livings-2
KLA-USGS-30	Livingston	N/A	6.8	30.431380	-90.547055	U-Livings-3
KLA-USGS-31	Tangipahoa	N/A	5.0	30.404156	-90.323376	U-Tangipa-1
KLA-USGS-32	St. Tammany	N/A	11.0	30.271359	-89.793486	U-St. Tam-25
KLA-USGS-33	St. Tammany	N/A	10.5	30.270442	-89.783787	U-St. Tam-26
KLA-USGS-34	St. Tammany	N/A	11.3	30.248595	-89.793939	U-St. Tam-27
KLA-USGS-35	St. Tammany	N/A	13.4	30.229114	-89.806735	U-St. Tam-28
KLA-USGS-36	St. Tammany	N/A	11.3	30.277091	-89.807319	U-St. Tam-29
KLA-USGS-37	St. Tammany	N/A	12.2	30.265562	-89.844152	U-St. Tam-30
KLA-USGS-38	St. Tammany	N/A	10.0	30.226541	-89.677548	U-St. Tam-31
KLA-USGS-39	St. Tammany	N/A	15.2	30.230726	-89.711506	U-St. Tam-32
KLA-USGS-40	St. Tammany	N/A	16.0	30.231136	-89.669291	U-St. Tam-33
KLA-USGS-41	St. Tammany	N/A	21.9	30.239215	-89.613944	U-St. Tam-34
KLA-USGS-42	St. John the Baptist	N/A	16.8	30.157315	-89.737728	U-St. Joh-1
KLA-USGS-43	Tangipahoa	N/A	3.8	30.289380	-90.402108	U-Tangipa-2
KLA-USGS-44	Tangipahoa	N/A	5.0	30.289241	-90.402013	U-Tangipa-3
KLA-USGS-45	Tangipahoa	N/A	2.9	30.289675	-90.401320	U-Tangipa-4
KLA-USGS-46	Tangipahoa	N/A	2.9	30.289679	-90.401347	U-Tangipa-5
KLA-USGS-47	Tangipahoa	N/A	4.0	30.293711	-90.404156	U-Tangipa-6
KLA-USGS-48	Tangipahoa	N/A	2.4	30.302949	-90.405055	U-Tangipa-7
KLA-USGS-49	Tangipahoa	N/A	2.3	30.308865	-90.404687	U-Tangipa-8
KLA-USGS-50	St. Tammany	N/A	6.4	30.396116	-90.157098	U-St. Tam-35
KLA-USGS-51	St. Tammany	N/A	7.8	30.397819	-90.156036	U-St. Tam-36
KLA-USGS-52	St. Tammany	N/A	7.7	30.400775	-90.156962	U-St. Tam-37
KLA-USGS-53	St. Tammany	N/A	6.8	30.401321	-90.158482	U-St. Tam-38
KLA-USGS-54	Tangipahoa	N/A	5.1	30.404078	-90.324010	U-Tangipa-9
KLA-USGS-56	St. Tammany	N/A	7.6	30.387738	-90.209318	U-St. Tam-39
KLA-USGS-57	St. Tammany	N/A	4.5	30.309137	-89.929698	U-St. Tam-40
KLA-USGS-59	St. Tammany	N/A	9.8	30.286559	-89.953497	U-St. Tam-41
KLA-USGS-60	St. Tammany	N/A	9.6	30.297754	-89.939846	U-St. Tam-42
KLA-USGS-61	St. Tammany	N/A	9.7	30.293306	-89.935446	U-St. Tam-43
KLA-USGS-62	St. Bernard	N/A	16.4	29.758632	-89.784467	U-St. Ber-1
KLA-USGS-63	St. Bernard	N/A	9.0	29.867845	-89.868162	U-St. Ber-2
KLA-USGS-64	St. Bernard	N/A	11.6	29.868332	-89.834880	U-St. Ber-3
KLA-USGS-65	St. Bernard	N/A	11.1	29.867531	-89.813785	U-St. Ber-4
KLA-USGS-66	St. Bernard	N/A	11.4	29.859845	-89.775653	U-St. Ber-5
KLA-USGS-67	St. Bernard	N/A	10.5	29.873446	-89.895142	U-St. Ber-6

HWM ID	Parish	Flood Type	HWM Flood Elevation - NAVD88	Survey Latitude	Survey Longitude	HWM Report Sheet No
KLA-USGS-68	St. Bernard	N/A	11.3	29.892341	-89.898341	U-St. Ber-7
KLA-USGS-70	St. Bernard	N/A	10.6	29.932132	-89.956962	U-St. Ber-8
KLA-USGS-71	St. Bernard	N/A	10.6	29.941266	-89.973720	U-St. Ber-9
KLA-USGS-72	St. Bernard	N/A	11.3	29.958216	-90.006024	U-St. Ber-10
KLA-USGS-73	Plaquemines	N/A	3.8	29.626077	-89.951343	U-Plaquem-1
KLA-USGS-74	Plaquemines	N/A	4.4	29.633632	-89.949389	U-Plaquem-2
KLA-USGS-75	Plaquemines	N/A	4.2	29.670619	-89.970904	U-Plaquem-3
KLA-USGS-76	Plaquemines	N/A	4.2	29.649179	-89.965662	U-Plaquem-4
KLA-USGS-77	Plaquemines	N/A	7.0	29.583893	-89.828095	U-Plaquem-5
KLA-USGS-78	Plaquemines	N/A	5.6	29.617380	-89.915642	U-Plaquem-6
KLA-USGS-79	Plaquemines	N/A	5.4	29.595853	-89.848673	U-Plaquem-7
KLA-USGS-80	Plaquemines	N/A	5.6	29.597849	-89.848681	U-Plaquem-8
KLA-USGS-81	Plaquemines	N/A	3.5	29.618379	-89.910538	U-Plaquem-9
KLA-USGS-82	Plaquemines	N/A	3.2	29.638149	-89.948467	U-Plaquem-10
KLA-USGS-83	Plaquemines	N/A	4.3	29.647637	-89.963690	U-Plaquem-11
KLA-USGS-84	Plaquemines	N/A	14.8	29.462508	-89.671123	U-Plaquem-12
KLA-USGS-85	Plaquemines	N/A	11.8	29.468431	-89.680300	U-Plaquem-13
KLA-USGS-87	Plaquemines	N/A	11.8	29.480121	-89.693192	U-Plaquem-14
KLA-USGS-88	Plaquemines	N/A	15.0	29.490806	-89.702664	U-Plaquem-15
KLA-USGS-89	Plaquemines	N/A	12.1	29.506911	-89.715938	U-Plaquem-16
KLA-USGS-91	Plaquemines	N/A	7.0	29.525419	-89.753345	U-Plaquem-17
KLA-USGS-92	Plaquemines	N/A	11.4	29.545586	-89.773668	U-Plaquem-18
KLA-USGS-93	St. Bernard	N/A	19.2	29.839902	-89.688303	U-St. Ber-11
KLA-USGS-94	St. Bernard	N/A	16.9	29.842661	-89.750731	U-St. Ber-12
KLA-USGS-95	St. Bernard	N/A	11.8	29.873418	-89.853565	U-St. Ber-13
KLA-USGS-96	St. Bernard	N/A	12.0	29.911314	-89.898268	U-St. Ber-14
KLA-USGS-97	St. Bernard	N/A	11.7	29.936323	-89.923365	U-St. Ber-15
KLA-USGS-98	St. Bernard	N/A	11.9	29.945682	-89.971762	U-St. Ber-16
KLA-USGS-99	St. Bernard	N/A	10.7	29.960582	-90.001226	U-St. Ber-17
KLA-USGS-100	St. Bernard	N/A	10.4	29.965577	-89.999144	U-St. Ber-18
KLA-USGS-101	Plaquemines	N/A	12.8	29.586328	-89.806839	U-Plaquem-19
KLA-USGS-102	Plaquemines	N/A	13.1	29.586142	-89.807530	U-Plaquem-20
KLA-USGS-103	Plaquemines	N/A	13.4	29.583721	-89.792962	U-Plaquem-21
KLA-USGS-106	Plaquemines	N/A	7.2	29.858856	-89.914975	U-Plaquem-22
KLA-USGS-107	Plaquemines	N/A	7.0	29.858770	-89.914978	U-Plaquem-23
KLA-USGS-108	St. Bernard	N/A	11.3	29.868294	-89.875042	U-St. Ber-19
KLA-USGS-109	Terrebonne	N/A	6.3	29.384750	-90.730364	U-Terrebo-1

Appendices

Appendices C through P are not included due to privacy issues.