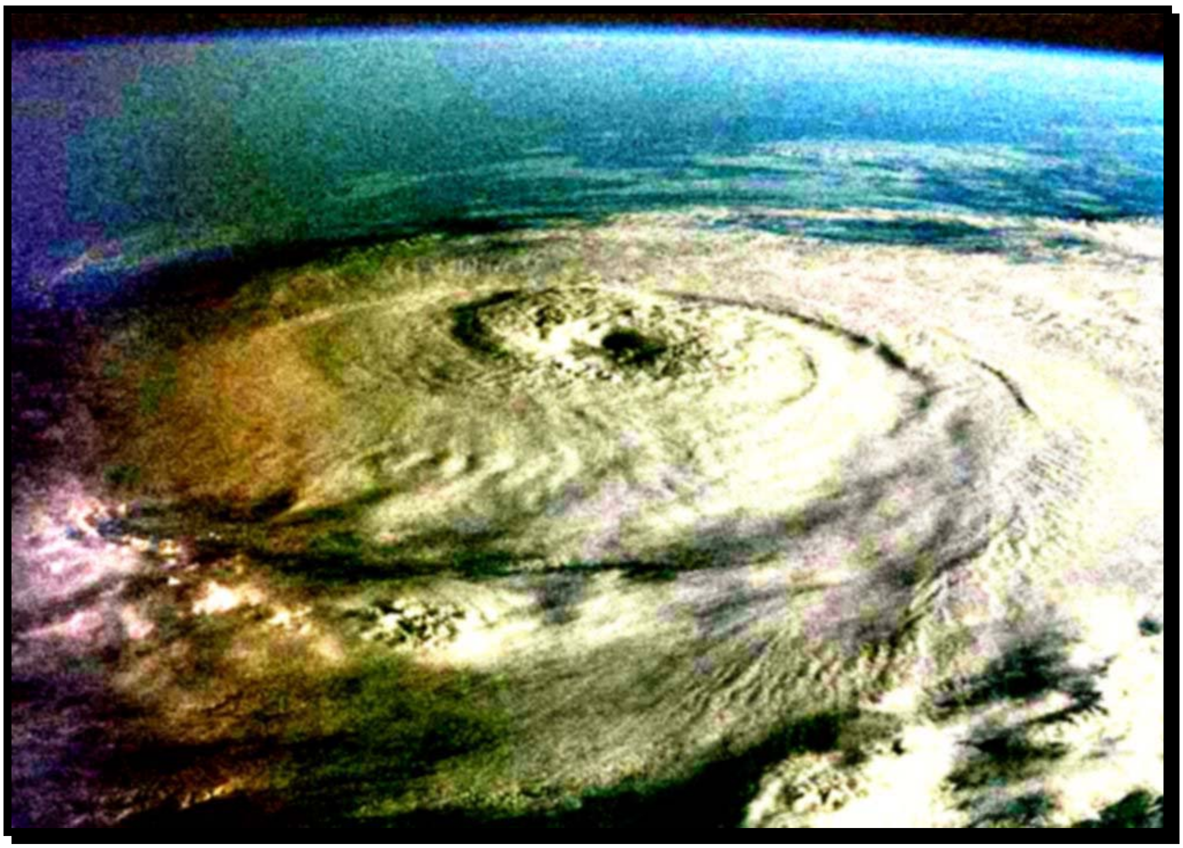
REPORT TO CONGRESS

For:

P.L. 109-234, Title II, Chapter 3, Flood Control and Coastal Emergencies, page 37 (120 STAT 454-455). Hurricane and Storm Damage Risk Reduction System Vertical Settlement, New Orleans, Louisiana



By:
U.S. Army Corps of Engineers

October 2007

US Army Corps
of Engineers®

VERTICAL SETTLEMENT

TABLE OF CONTENTS

VERTICAL SETTLEMENT

1. EXECUTIVE SUMMARY

This report is submitted in response to Public Law 109-234, Title II, Chapter 3, Flood Control and Coastal Emergencies, which states:

"*…the Secretary shall provide to the Congress a report, by not later than 90 days after the enactment of this Act, describing, for the period beginning on the date on which the individual system components for hurricane and storm damage reduction were constructed and ending on the date on which the report is prepared, the difference between the vertical settlement of the system that is attributable to the settling of levees and floodwalls or subsidence versus the vertical grade deficiencies that are attributable to new storm data that may require a higher level of vertical protection in order to comply with 100-year floodplain certification and standard project hurricane*."

For consistency of report presentation, the existing elevations were taken from the May 2006 levee assessment surveys which covered the entire Hurricane and Storm Damage Risk Reduction System (HSDRRS) in Metropolitan New Orleans. Example reaches were selected from project areas throughout the system. Two sets of calculations were performed for each of the example reaches: the elevation differences attributable to settlement or subsidence, and the elevation differences attributable to the new 100-year authorized elevations.

The calculation of elevation differences attributable to settlement/subsidence was derived using the May 2006 elevations versus the pre-Katrina authorized elevations. The elevation difference is influenced by regional subsidence, datum issues, sea level rise and consolidation of underlying soils. The influence of each of these factors is detailed in Section 2 of this report. For the example reaches, this elevation difference is as much as 2.5 feet.

To calculate the vertical differences attributable to the newly authorized level of protection, pre-Katrina design elevations were compared to the new 100-year elevations. The methods of analysis used to determine 100-year elevations have changed significantly over time. Factors that influenced this change are advances in tropical event forecasting, new hurricane surge and wave modeling techniques, and new design criteria for wave run-up and overtopping. A technical discussion of these factors is provided in Section 3 of this report. For the example reaches, this vertical difference is as much as 5.5 feet.

A summary of the elevation differences attributable to settlement/subsidence and to 100-year designs for the example reaches is tabulated in Section 4 of this report.

Plates 1 through 9 show the location of these reaches, and Plates 10 through 17 show the plan and profile views of these reaches with their May 2006, pre-Katrina authorized, and the currently authorized 100-year elevations.

In addition to the summary table, plates, and discussion of the factors influencing these elevations, this report provides our current policies and practices to assure elevations used during construction are accurate and in sync with design elevations generated by state-of-the-art storm surge and wave modeling.

2. VERTICAL SETTLEMENT

The factors that influence the vertical settlement of the levees and floodwalls in Metropolitan New Orleans are complex and interrelated. The following paragraphs give a description of these factors and the methods utilized in current designs to minimize their impact to the Hurricane and Storm Damage Risk Reduction System (HSDRRS).

2.1 REGIONAL SUBSIDENCE

Subsidence in south Louisiana is the result of numerous processes, both natural and man-made. Natural processes include compaction of Holocene, Pleistocene, and Tertiary age deposits, downwarping[1] of the Gulf Coast Geosyncline due to sediment loading, movement on the downthrown side of deep-seated faults, and oxidation of organic matter. Man-made processes include lowering of the groundwater table through forced drainage and production from oil and gas fields. Drainage of highly organic soils (marsh and swamp) with high water content causes significant shrinkage in the soil column resulting in subsidence. Withdrawal of oil, gas, and production water from deep reservoirs has led to compaction of overlying sediments resulting in localized subsidence.

Rates of subsidence vary widely across south Louisiana due to the complex nature of deltaic deposits, the underlying geologic structure, and human impact. Estimates of subsidence have been made by comparing benchmark leveling data, tide gage analysis, and radiometric dating of buried peat horizons.

Estimates of natural subsidence in the vicinity of the New Orleans area hurricane protection system range from 0.25 feet to 1.6 feet over a 50 year duration (Burkett, Zilkoski, and Hart 2003; Shinkle and Dokka 2004; unpublished Corps of Engineers (USACE) data). These estimates are based on historical subsidence data and may or may not be predictive of future conditions.

[1] Downwarping is a gradually subsiding trough in deep seated "basement" geologic formations driven by progressively thicker layers of fine sediments deposited above.

Subsidence rates within the HSDRRS are generally much higher than those outside the system due to man-made processes such as forced interior drainage. Subsidence rates of several feet over the past century have been documented for areas containing highly organic soils in both Orleans and Jefferson Parishes (Traughber, Snowden, and Simmons 1977; URS, 2006).

2.2 DATUM ISSUES

During design and construction, HSDRRS projects use benchmarks tied to a specific datum to control the vertical elevation. Over several decades, a variety of datums were used for these projects in Metropolitan New Orleans. These included datums such as Mean Tide Level (MTL), Mean Low Gulf (MLG), Mean Sea Level (MSL), Mississippi River Low Water Reference Planes (LWRP), National Geodetic Vertical Datum of 1929 (NGVD29), North American Vertical Datum of 1988 (NAVD88), and Cairo Datum. The use of each datum was technically acceptable at the time it was used. Although the datums and benchmarks were periodically updated over time, the effect of regional subsidence was not consistently incorporated into these changes. This resulted in some inconsistencies across the region, and was a contributing factor to the elevation differences between existing HSDRRS features and their associated design elevations.

2.3 SEA LEVEL RISE

Local Mean Sea Level (LMSL) is defined as the local height of the sea with respect to land, averaged over a period of time (such as a month or a year) long enough that fluctuations caused by waves and tides are smoothed out. Atmospheric pressure, ocean currents and local ocean temperature changes can also affect LMSL. “Eustatic” change (as opposed to local change) results from changes in global sea levels, such as changes in the volume of water in the world oceans or changes in the volume of an ocean basin. Sea Level Rise also changes the relationship of HSDRRS project elevations to the local mean sea level or water surface.

The critical relationship between local mean sea level and the geodetic datum used for design and construction must be accounted for in the design of hurricane protection projects. Benchmarks used for design and construction projects are often referenced to a geodetic datum, NGVD29 or NAVD88. Elevations from these benchmarks are not directly related to Local Mean Sea Level (LMSL) or local water levels. The true relationship between NAVD88 and LMSL varies with location and can only be determined by performing a site specific analysis.

2.4 CONSOLIDATION AND SETTLEMENT

Soil is a nonhomogeneous porous material consisting of solids, water, and air. Soil deformation may occur as the result of changes in loading, air or water content, soil mass, or temperature. During levee construction, increase in vertical stress occurs in all subsurface strata due to the addition of embankment fill. Vertical displacements and settlement caused by change in stress and air/water content can be depicted by three types of soil responses:

(1) Elastic deformation. Elastic or immediate deformation caused by static loads is usually small, and it occurs essentially at the same time these loads are applied.

(2) Primary Consolidation. Time delayed consolidation is the reduction in volume associated with a reduction in water content due to adjustment to a new overlying load such as new levee fill. Consolidation occurs quickly in coarse-grained soils such as sands and gravels. Consolidation in fine-grained soils such as clays and organic materials can be significant and usually takes considerable time to complete depending on the soil properties.

(3) Secondary compression and creep. Secondary compression and creep are associated with decomposition of organic soil and the compression and distortion at constant water content of compressible soils such as clays, silts, organic materials, and peat.

Settlement estimates can be made by theoretical analysis as set forth in US Army Corps of Engineers, Engineering Manual 1110-1-1904. Detailed settlement analyses are made when significant consolidation is expected, as under high embankment loads, embankments of highly compressible soil, embankments on compressible foundations, and beneath steel and concrete structures in levee systems founded on compressible soils. These conditions are prevalent throughout the project area.

2.4.1 Levee Construction

When constructing levees atop very soft cohesive soils like those found in southern Louisiana, settlement can be quite significant. Therefore, to ensure that the final "settled" levee crown is at its authorized elevation, the designer has two options. The first would be to construct the levee section with adequate overbuild such that the levee crown is ultimately at its authorized design elevation after primary consolidation is complete. This, however, would require significant overbuild in most cases, and could result in a much larger levee footprint and possibly require additional Rights-of-Way (ROW). The second option is to construct the levee utilizing lift construction where moderate overbuild is incorporated into the design. Prior to the levee crown settling below its required design height, a subsequent lift is constructed to a new overbuilt crown elevation. The advantage to this method is that the designer will take advantage of the notable gains in shear strength of the foundation strata as they consolidate. The latter option could also reduce construction costs, require a smaller levee footprint, potentially require little or no additional ROW, and could have fewer impacts on the environment. Lifts are scheduled based on estimated and observed settlement rates. Much of the Metropolitan New Orleans HSDRRS is in the process of scheduled lift construction, while some levee reaches have completed their final lift under the original project authorization.

2.4.2 Floodwalls

Settlement of floodwalls is generally restricted to movement resulting from regional subsidence of the area. Local consolidation and settlement are minimal, since the loading on these walls is supported by the foundation piling.

2.5 CURRENT PRACTICES TO ADDRESS VERTICAL SETTLEMENT

The discrepancies in elevation caused by the use of different datums and by not linking the design elevations to water levels have been corrected for all ongoing HSDRRS projects. A rigorous protocol was developed to include verification of permanent water level gages, tying all projects into Local Mean Sea Level, periodic monitoring to detect or verify the rate of subsidence, and calibrating all storm modeling elevations to the same datum used for construction. The vertical datum that is used for design and construction, NAVD88 (2004.65), is referenced to nationwide spatial reference systems used by other Federal and local agencies through the use of the Global Positioning System (GPS) which is independent of local benchmarks which may continue to be affected by local subsidence.

3. DESIGN ELEVATIONS

Design elevations are influenced by both storm surge and storm wave runup. Methods of determining these factors have changed over time. An explanation of the methods used for establishing the pre-Katrina authorized design elevations and the current 100-year elevations follows.

3.1 PRE-KATRINA AUTHORIZED SPH ELEVATIONS

The Lake Pontchartrain and Vicinity (LPV) and West Bank and Vicinity (WBV) hurricane protection systems were designed for heights to prevent overtopping from storm surge and its accompanying significant, and/or smaller, waves[2] produced by a particular hypothetical storm impacting the coast on a critical track. This hypothetical storm, called the Standard Project Hurricane (SPH), represented a particular set of characteristics, including radius to maximum winds, barometric pressure deficit, wind speeds, and forward speed. The SPH was derived by the National Weather Service (NWS) for USACE using studies of historic hurricanes over a selected period of time. The original 1959 SPH was developed using data from the 1880s through 1956. It was revised several times prior to hurricane Katrina: after Hurricane Betsy in 1965 (1966 NWS update); after Hurricane Camille in 1969; and in 1979 in Report NWS23. The SPH for LPV was the 1966 NWS update. The SPH for WBV was the 1979 NWS23 update.

---

[2] Significant wave height is approximately equal to the average of the highest one-third of the waves.

The SPH storm had a central pressure index with a frequency of occurrence of once in 100 years within Zone B, a reach of the gulf coast from Apalachicola, Florida, to the Sabine River at the Louisiana-Texas border. There was a 1% chance that there would be a SPH storm anywhere within that region. Several critical tracks were associated with the SPH; those generally mirrored the tracks of the Hurricanes of 1915 and 1947 and Hurricane Betsy, although tracks were somewhat shifted to provide maximum storm surge at a particular site. The frequency of surge elevation for a SPH storm at each location of interest varied, depending on the probability of track direction.

Additionally, the calculations and simulations used to support this older method were based on limited meteorological and topographic data; it also used simple models developed prior to the availability of computers.

Maximum hurricane surge heights were obtained from computations made for ranges extending through the project area out to the continental shelf by use of a general wind tide formula. Protective structures exposed to wave run up were constructed to an elevation sufficient to prevent overtopping from the significant wave accompanying the SPH. Waves larger than the significant wave were allowed to overtop structures; however, such overtopping was considered minor. Where waves were not expected to occur, freeboard was added to account for uncertainties.

3.2 NEW 100-YEAR DESIGN ELEVATIONS

For the current 100-year design for LPV and WBV, the hurricane protection system is designed to a sufficient height to limit the overtopping from the 1% chance annual occurrence surge, and associated waves, to 0.1 cubic feet per second per foot (cfs/ft) at the 90% assurance. This is a probabilistic analysis that takes into account the possibility of many different storm characteristics, tracks, forward speeds, etc.

The calculations and simulations used in this advanced analysis are based on updated meteorological data from NWS containing many more years of data and expanded research; updated coastline, topographic and hydrographic data (from Light Detection and Ranging (LIDAR) and other surveys); and, they are produced from more detailed models (Advanced Circulation (ADCIRC) Model, Steady Wave (STWAVE) Model and others). These complex modeling techniques are now possible with the advent of supercomputers. Evaluation of risk has been added to the newer analysis as a measure of sustainability of the system.

In 2006 and 2007, a team of subject matter experts from USACE, Federal Emergency Management Agency (FEMA), National Oceanic & Atmospheric Administration (NOAA), the private sector, and academia developed a new process for estimating hurricane inundation probabilities called the Joint Probability Method with Optimal Sampling (JPM-OS). This work is being applied to USACE work, the Interagency

Performance Evaluation Taskforce (IPET) risk analysis, and FEMA Base Flood Elevations for production of DFIRMs (Digital Flood Insurance Rate Maps) for coastal Mississippi, Louisiana, and Texas. Currently, USACE and FEMA work uses the same model grids, the same model software, the same model input, such as wind fields, and the same method for estimating hurricane inundation probabilities. Several thousand events are evaluated for a standard Joint Probability Method analysis. With the JPM-OS method, optimal sampling allows for a smaller number of events to be used.

USACE is following a step wise approach regarding the hydraulic design of the protection system for the 1% annual exceedence still water elevation (SWE)[3] and waves. The approach considers overtopping from waves, as the design elevation of levees and floodwalls is always set higher than the 1% still water elevation. The height of the protection system has been calculated so that the overtopping rate does not exceed the overtopping criteria. The overtopping criteria were selected after a technical review of available information, including the Technical Report Wave Run-Up and Overtopping at Dikes, by the Netherlands Technical Advisory Committee on Flood Defense, 2002. The criteria were reviewed and approved by members of the American Society of Civil Engineers (ASCE) External Review Panel for IPET. Collaboration between the Federal agencies, private sector and academia continues in the review process. Teams of USACE, FEMA, and ASCE external peer reviewers are continuing review of the modeling products to ensure the products satisfy current USACE and FEMA requirements.

3.3 FUTURE CONDITIONS (GLOBAL SUBSIDENCE AND SEA LEVEL RISE)

Two designs were determined for levees: existing conditions (2007) and conditions 50 years from now (2057). Only one design was determined for floodwalls: the 2057 condition. The 2007 existing condition elevations assume the current sea and land environment but with levee and floodwall repairs completed. Design elevations for 2057 conditions take into account regional subsidence and sea level rise. Relative subsidence rates were derived using the database of long-term rates maintained by the USACE. The predicted sea level rise was taken from the Intergovernmental Panel on Climate Change Third Assessment Report, published in 2001. More detailed explanations of subsidence and sea level rise are given in Section 2 of this report.

The Engineer Research and Development Center (ERDC) used the ADCIRC and STWAVE models to evaluate the effect of anticipated natural subsidence on still water elevations and waves to determine how surge and waves will change between now and 2057. Natural subsidence was modeled as apparent sea level rise. Five storms representing current conditions (2007) were selected from the suite of 152

[3] Still Water Elevation (SWE) is the elevation of the sea with motions such as wind waves averaged out—averaged over a period of time such that changes in sea level, e.g., due to the tides also get averaged out.

storm simulations. These five storms each were run with 1 ft, 2 ft, and 3 ft increases in water level. No other changes to input were made (same offshore waves, same friction, same model parameters, etc.). Model results showed that effects of apparent sea level rise are not uniform across the hurricane protection area - the effects depend on depth of water and topography of area.

4. CURRENT CONDITIONS

The existing Hurricane and Storm Damage Risk Reduction System (HSDRRS) is shown on Plates 1 to 9. Annotated areas show project reaches in which construction, including all lifts, had been completed prior to Hurricane Katrina. Plan and profile sheets (plates 10 to 17) show examples of the differences between the May 2006 elevations, the pre-Katrina authorized design elevations and the new 100-year elevations. The 100-year elevations for both earthen levees and floodwalls as shown on Plates 10 - 17 are based on coastal and landscape conditions projected for the 2057 timeframe. The following table shows the differences between May 2006 elevations, pre-Katrina authorized SPH design elevations and new 100-year elevations for selected points in the areas covered by the plan and profile sheets.

Vertical Differences - Comparison of May 2006, Pre-Katrina Authorized and New 100-year Design Elevations NAVD88 (2004.65)						
Location		May 2006 Elevation[1]	Pre-Katrina Authorized Design Elevation[2]	New 100-year Design Elevation[3]	Settlement/Subsidence Pre-Katrina Authorized Elevation Minus May 2006 Elevation[4]	New Storm Data New 100-year Design Elevation Minus Pre-Katrina Authorized Elevation[4]
Plate	Station					
10	150+00	12	14	17.5	2	3.5
10	270+00	13.3	15	17.5	1.7	2.5
11	350+00	16.9	16.5	17.5	-0.4	1
11	500+00	16.2	16.5	17.5	0.3	1
12	280+00	19.2	18.5	17.5	-0.7	-1
12	210+00	17.3	18	19	0.7	1
13	270+00	12.5	15	15.5	2.5	0.5
13	360+00	18.4	19	16.5	0.6	-2.5
14	550+00	9.3	11	14	1.7	3
14	590+00	8.7	10	14	1.3	4
15	70+00	8.5	10.5	16	2	5.5
15	240+00	9.2	11.5	14	2.3	2.5
16	780+00	8.8	10	14.5	1.2	4.5
16	860+00	8.7	10	14.5	1.3	4.5
17	110+00	8.8	9.5	11	0.7	1.5
17	280+00	8.6	10	14	1.4	4

NOTES:

1. USACE conducted a system-wide survey in May 2006 of existing hurricane levee and floodwall centerlines based on contemporary topographic surveys and benchmarks.
2. Authorized Design Elevations were calculated using the Standard Project Hurricane (SPH) and state-of-the-art methods in use at the time the respective design reports were completed.
3. New 100-year Design Elevations were calculated using a probabilistic analysis that takes into account the possibility of many different storm characteristics, tracks, forward speeds, etc. The 100-year event has a 1% chance of exceedence in any given year and a 26% chance of exceedence in any 30-year period.
4. Values that are shown as negative (-) represent locations where the existing elevation is above the pre-Katrina authorized elevation and where the new 100-year elevation is lower than the previously authorized elevation. These are not typical but illustrate the wide variety of conditions found in the system.

5. CONCLUSION

The differences in vertical elevations that exist in the Metropolitan New Orleans HSDRRS are the result of many different factors. These factors include new hurricane surge and wave modeling methods, new design criteria for wave run up and overtopping, advances in tropical event forecasting, settlement, regional subsidence, sea level rise and datum issues. As illustrated in this report, the factors are complex and interrelated.

List of Plates

Vertical Settlement Report, Plan & Profile Sheet Index

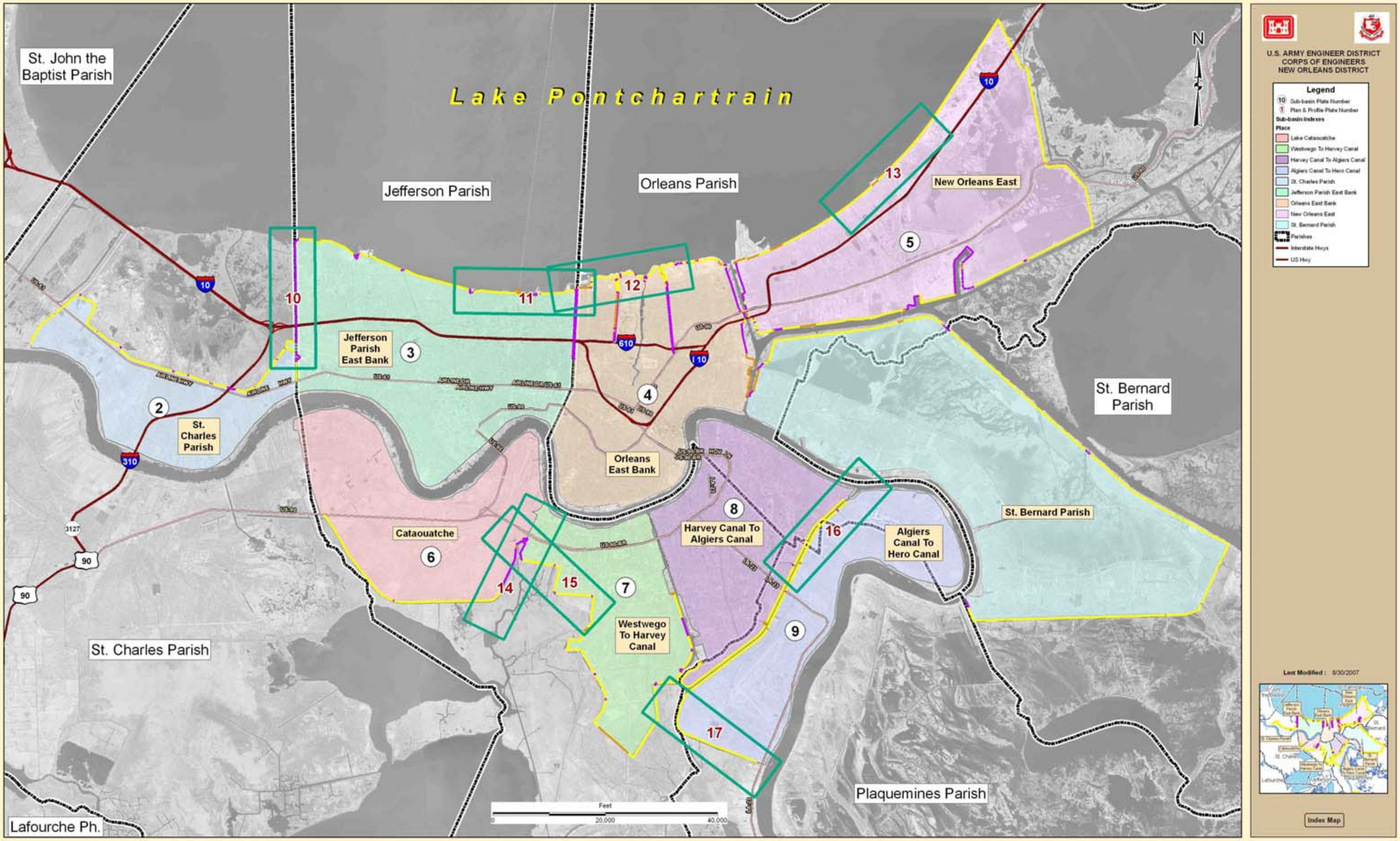
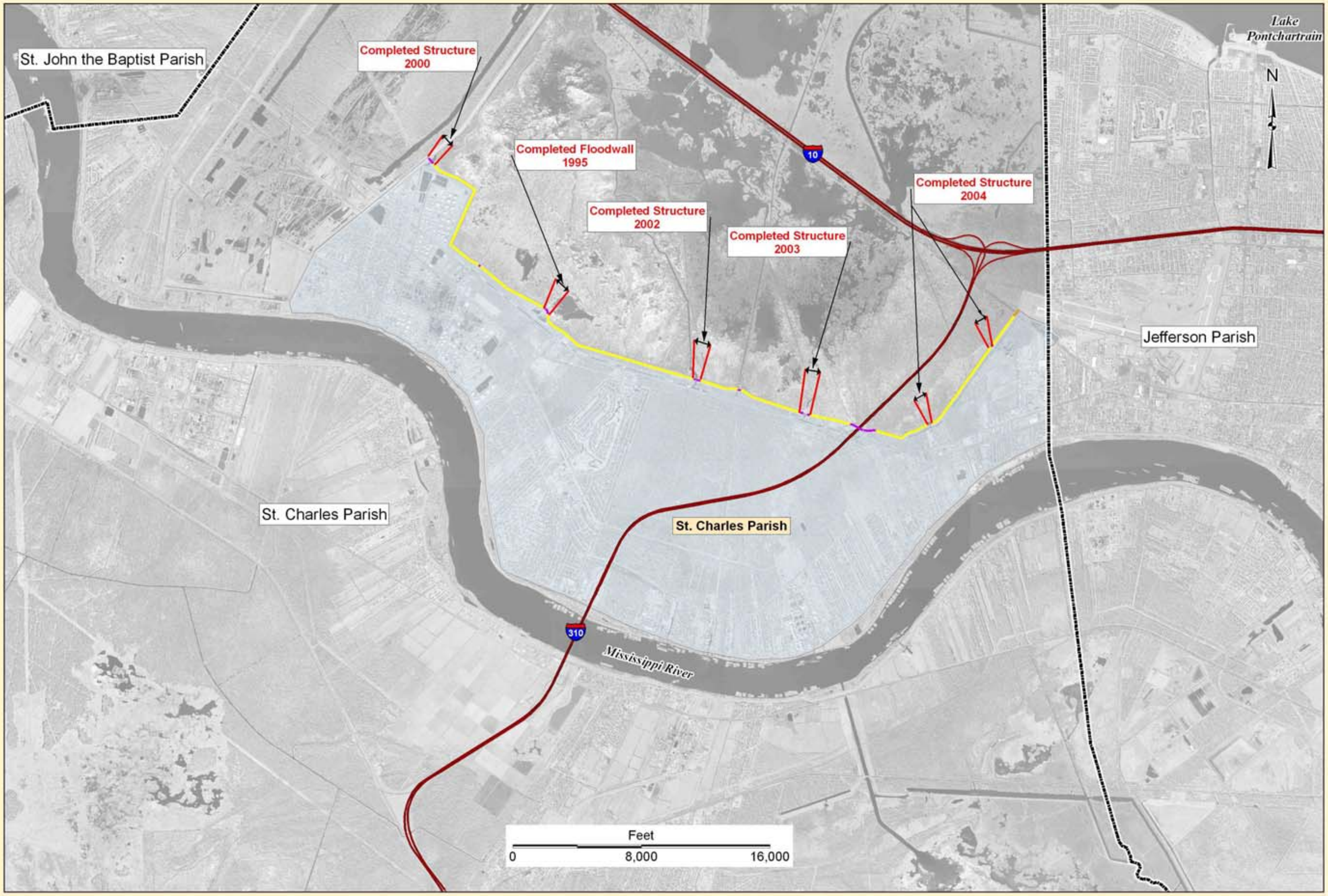


PLATE 1

Vertical Settlement Report, Plan & Profile Sheets, St. Charles Parish



U.S. ARMY CORPS
OF ENGINEERS
NEW ORLEANS DISTRICT

N

Legend

Sub-basin Indexes

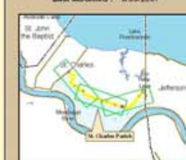
Place

- Lake Cataouatche
- Westwego To Harvey Canal
- Harvey Canal To Algiers Canal
- Algiers Canal To Hero Canal
- St. Charles Parish
- Jefferson Parish East Bank
- Orleans East Bank
- New Orleans East
- St. Bernard Parish

CENTERLINE CLASSIFICATION

- Federal Hurricane Floodwall
- Federal Hurricane Levee
- Federal Hurricane Levee and Floodwall
- Interstate Hwys
- US Hwy
- Parishes

Last Modified : 8/30/2007



IMAGERY
Projected coordinate system name:
NAD_1983_UTM_Zone_15N
Geographic coordinate system name:
GCS_North_American_1983
Resolution: 1.000000

PLATE 2

Vertical Settlement Report, Plan & Profile Sheets, Jefferson Parish East Bank

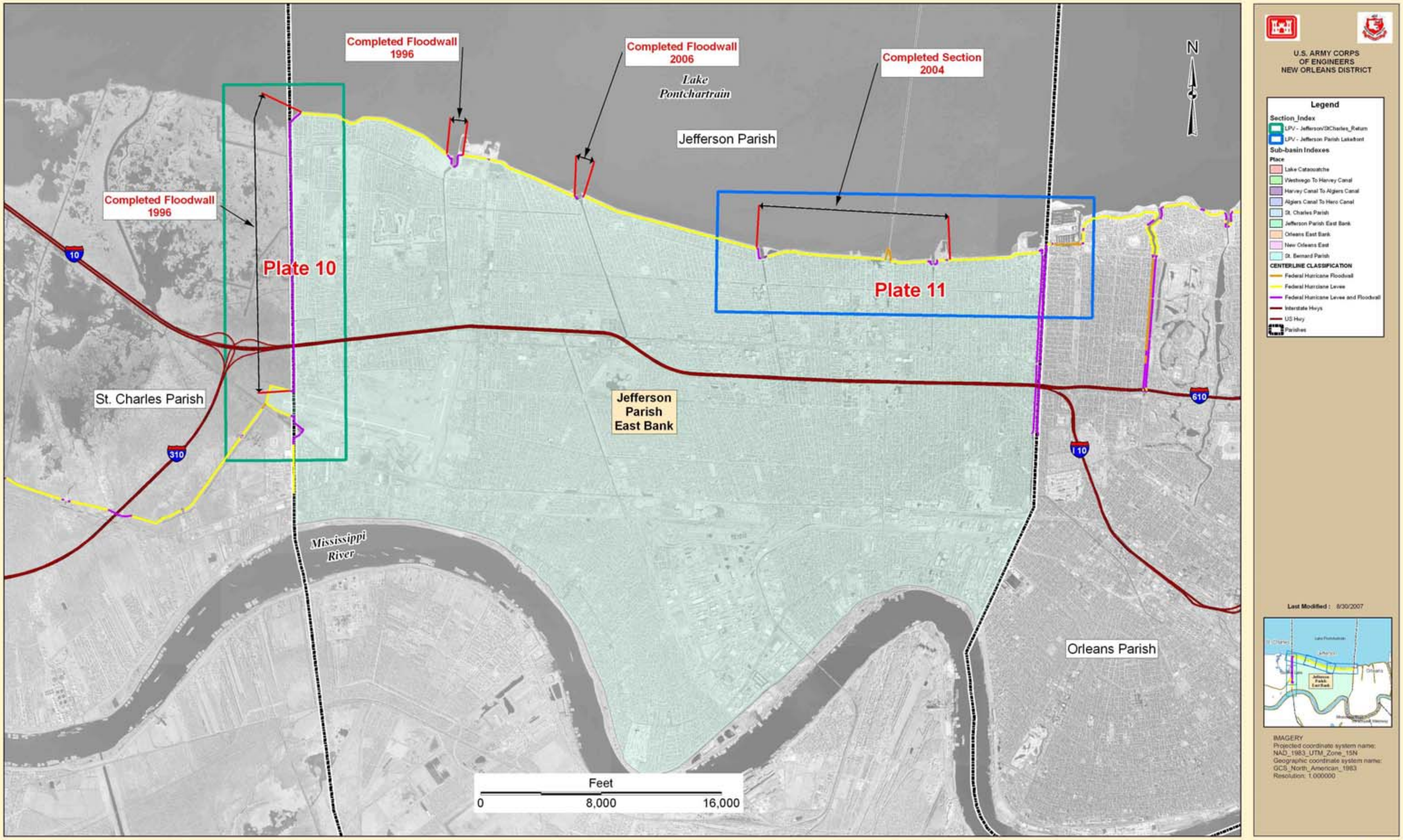
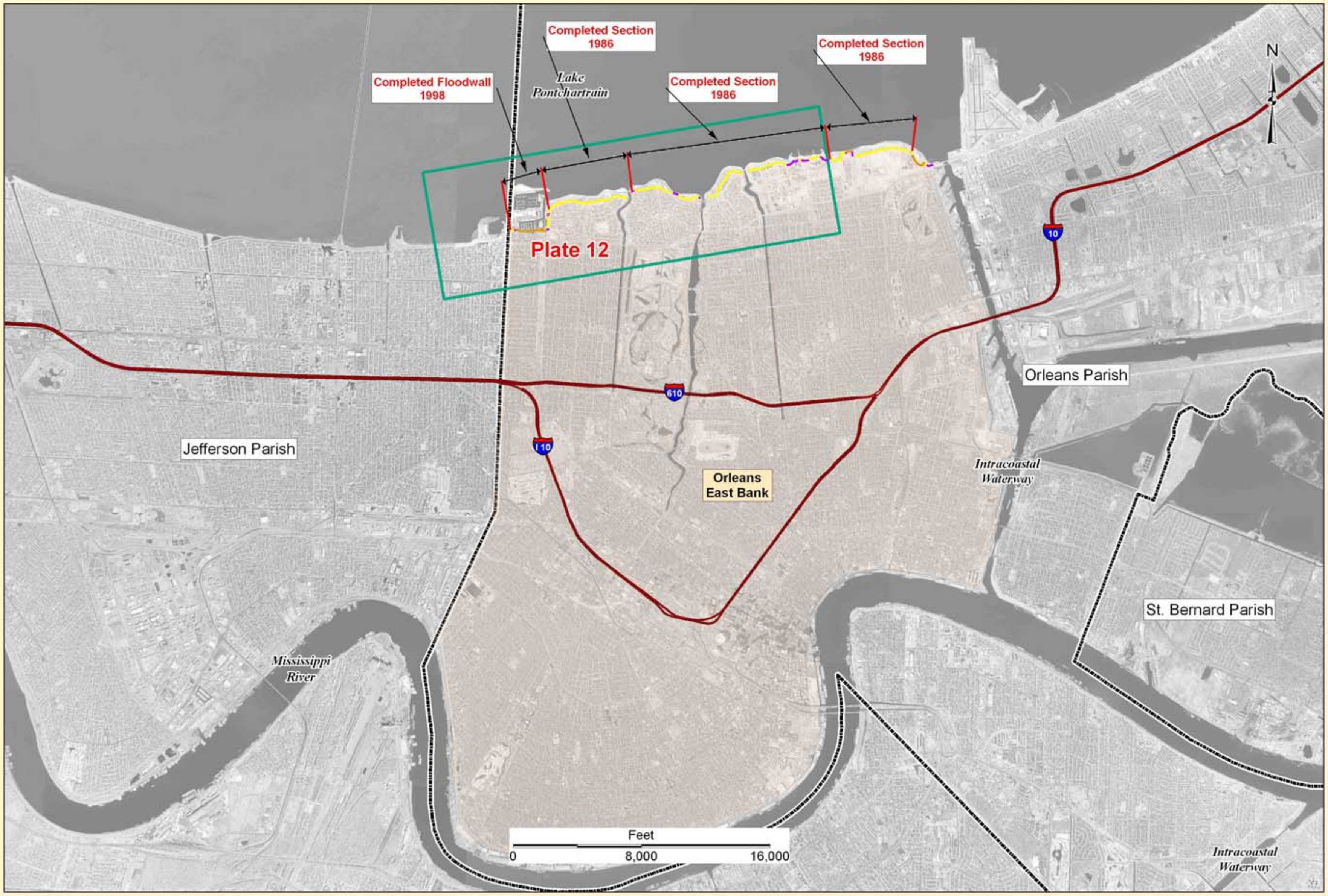
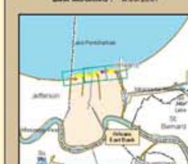


PLATE 3

Vertical Settlement Report, Plan & Profile Sheets, Orleans East Bank

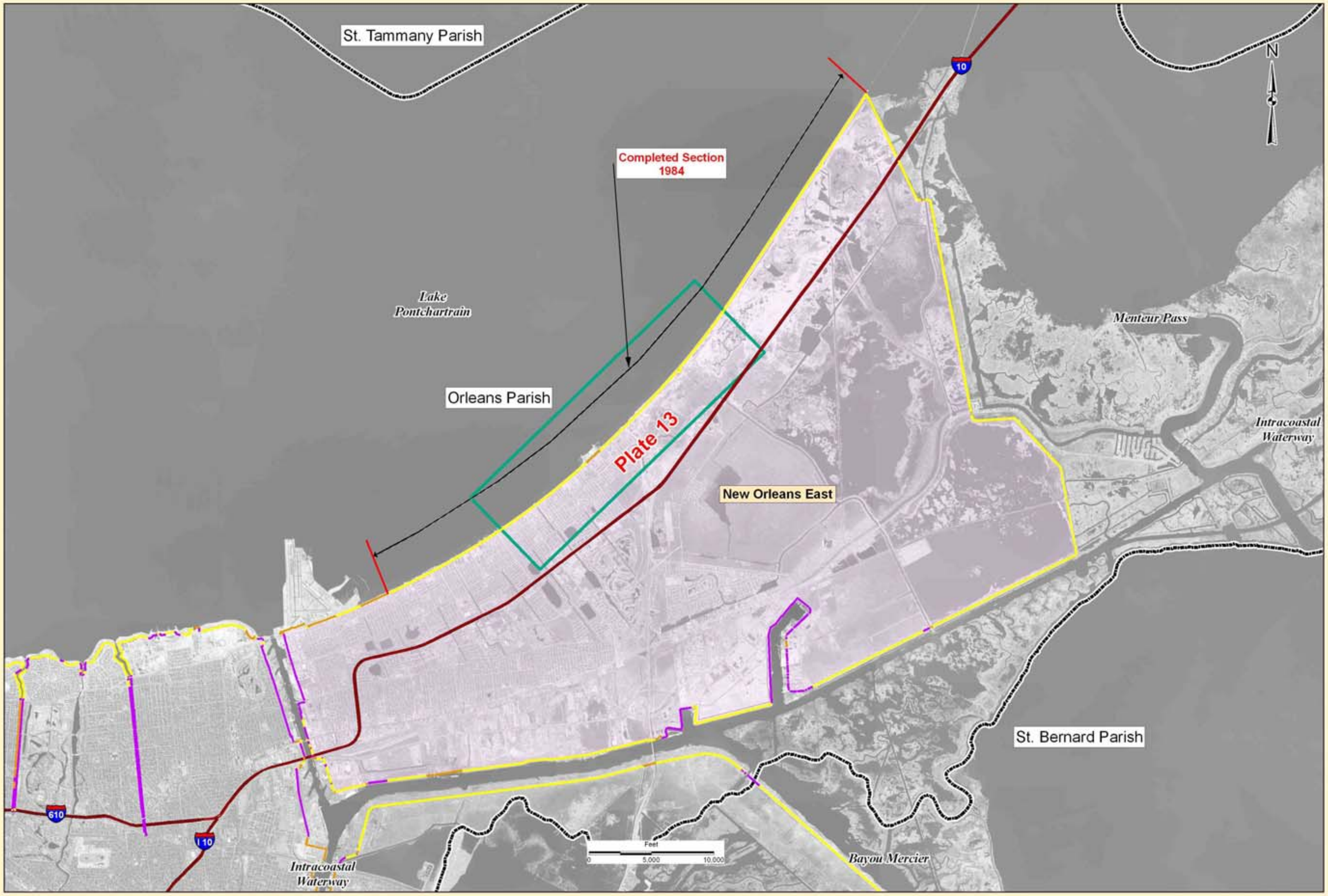




IMAGERY
Projected coordinate system name:
NAD_1983_UTM_Zone_15N
Geographic coordinate system name:
GCS_North_American_1983
Resolution: 1.000000

PLATE 4

Vertical Settlement Report, Plan & Profile Sheets, New Orleans East



U.S. ARMY CORPS
OF ENGINEERS
NEW ORLEANS DISTRICT

Legend

- LPV - New Orleans East Lakefront
- Sub Place
  - Lake Catasouatche
  - Westwego To Harvey Canal
  - Harvey Canal To Algiers Canal
  - Algiers Canal To Hero Canal
  - St. Charles Parish
  - Jefferson Parish East Bank
  - Orleans East Bank
  - New Orleans East
  - St. Bernard Parish
- CENTERLINE CLASSIFICATION
  - Federal Hurricane Floodwall
  - Federal Hurricane Levee
  - Federal Hurricane Levee and Floodwall
  - Interstate Hwys
  - US Hwy
- Parishes

Last Modified : 8/30/2007

IMAGERY
Projected coordinate system name:
NAD_1983_UTM_Zone_15N
Geographic coordinate system name:
GCS_North_American_1983
Resolution: 1.000000

PLATE 5

Vertical Settlement Report, Plan & Profile Sheets, Lake Cataouatche

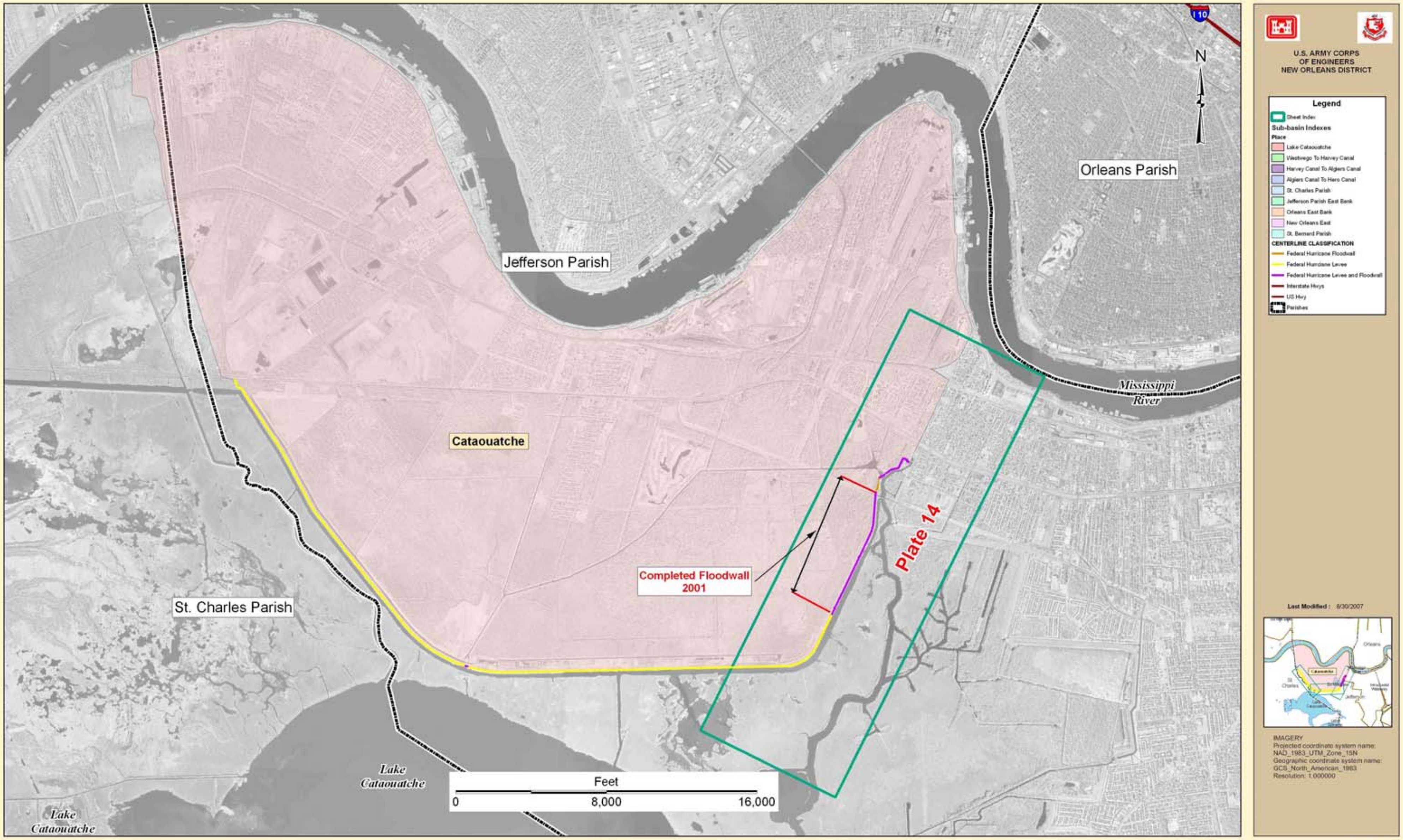
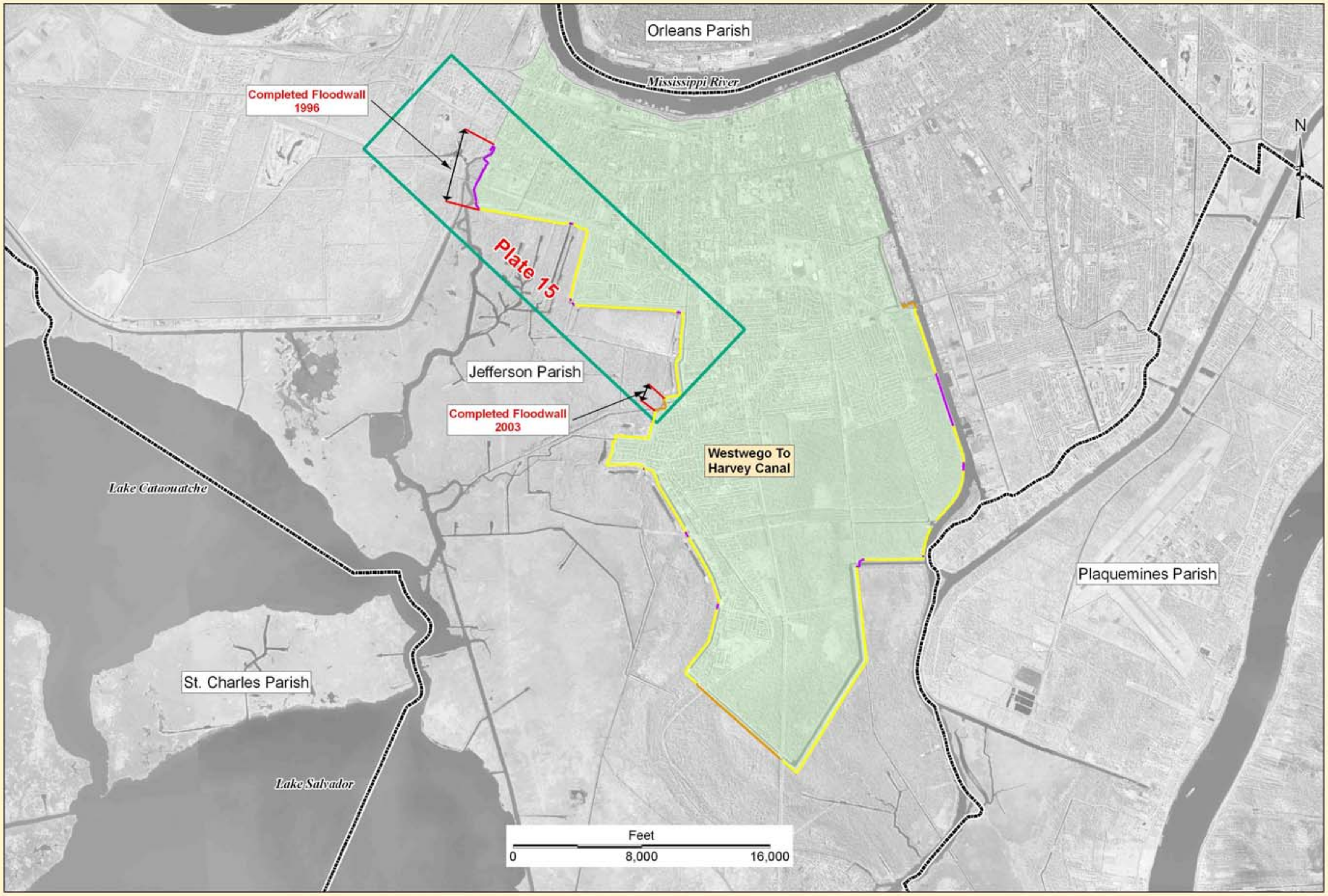


PLATE 6

Vertical Settlement Report, Plan & Profile Sheets, Westwego To Harvey Canal



U.S. ARMY CORPS
OF ENGINEERS
NEW ORLEANS DISTRICT

Legend

- Sheet Index

Sub-basin Indexes

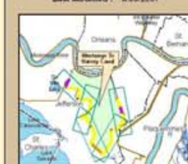
Place

- Lake Cataouatche
- Westwego To Harvey Canal
- Harvey Canal To Algiers Canal
- Algiers Canal To Hero Canal
- St. Charles Parish
- Jefferson Parish East Bank
- Orleans East Bank
- New Orleans East
- St. Bernard Parish

CENTERLINE CLASSIFICATION

- Federal Hurricane Floodwall
- Federal Hurricane Levee
- Federal Hurricane Levee and Floodwall
- Interstate Hwys
- US Hwy
- GIS.SecHwys
- Parishes

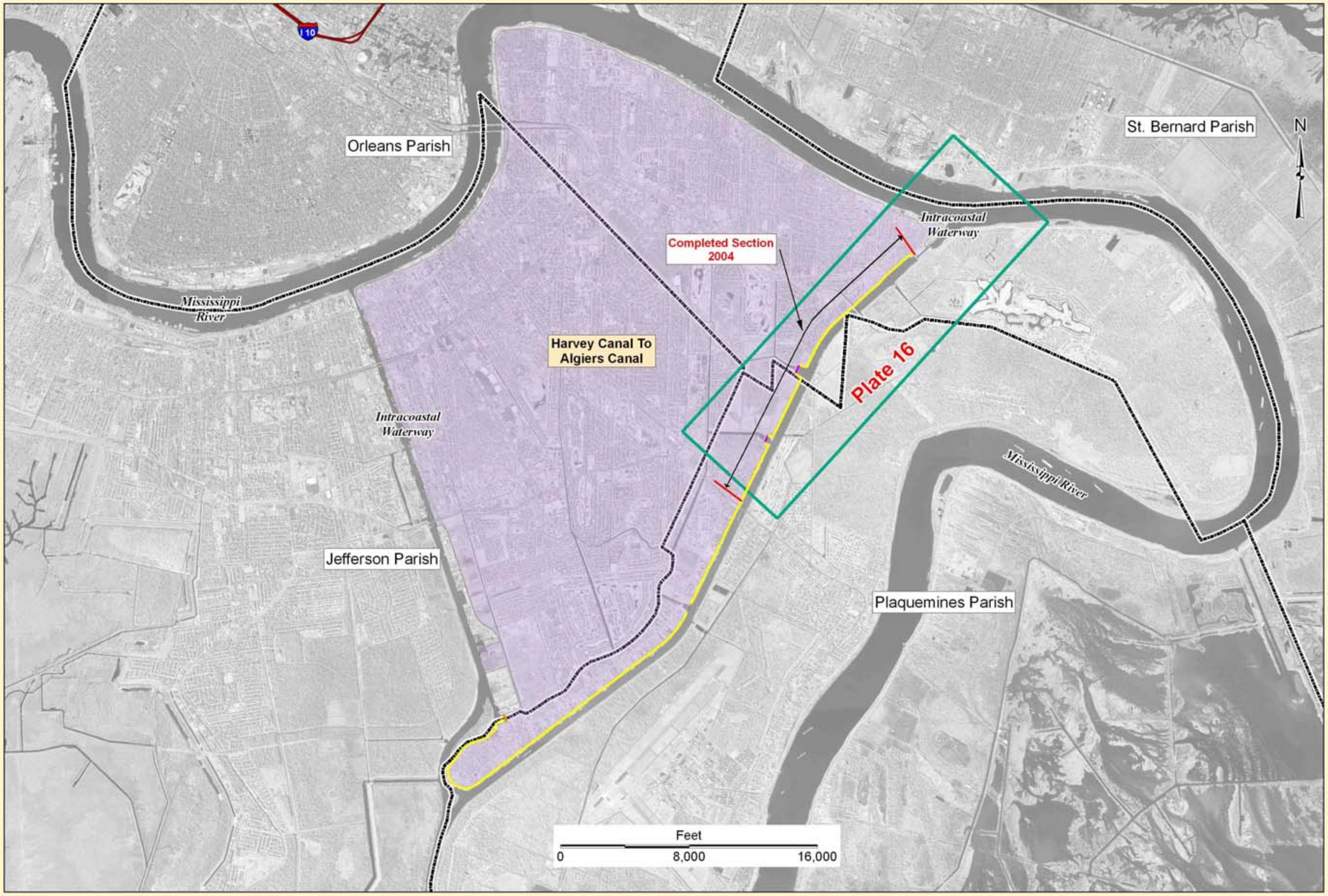
Last Modified : 8/30/2007



IMAGERY
Projected coordinate system name:
NAD_1983_UTM_Zone_15N
Geographic coordinate system name:
GCS_North_American_1983
Resolution: 1.000000

PLATE 7

Vertical Settlement Report, Plan & Profile Sheets, Harvey Canal To Algiers Canal



U.S. ARMY CORPS
OF ENGINEERS
NEW ORLEANS DISTRICT

Legend

- Sheet Index

Sub-basin Indexes

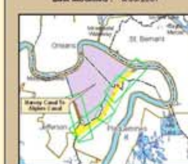
Place

- Lake Cataouatche
- Westwego To Harvey Canal
- Harvey Canal To Algiers Canal
- Algiers Canal To Hero Canal
- St. Charles Parish
- Jefferson Parish East Bank
- Orleans East Bank
- New Orleans East
- St. Bernard Parish

CENTERLINE CLASSIFICATION

- Federal Hurricane Floodwall
- Federal Hurriciane Levee
- Federal Hurricane Levee and Floodwall
- Interstate Hwys
- US Hwy
- Parishes

Last Modified : 8/30/2007



IMAGERY
Projected coordinate system name:
NAD_1983_UTM_Zone_15N
Geographic coordinate system name:
GCS_North_American_1983
Resolution: 1.000000

PLATE 8

Vertical Settlement Report, Plan & Profile Sheets, Algiers Canal To Hero Canal

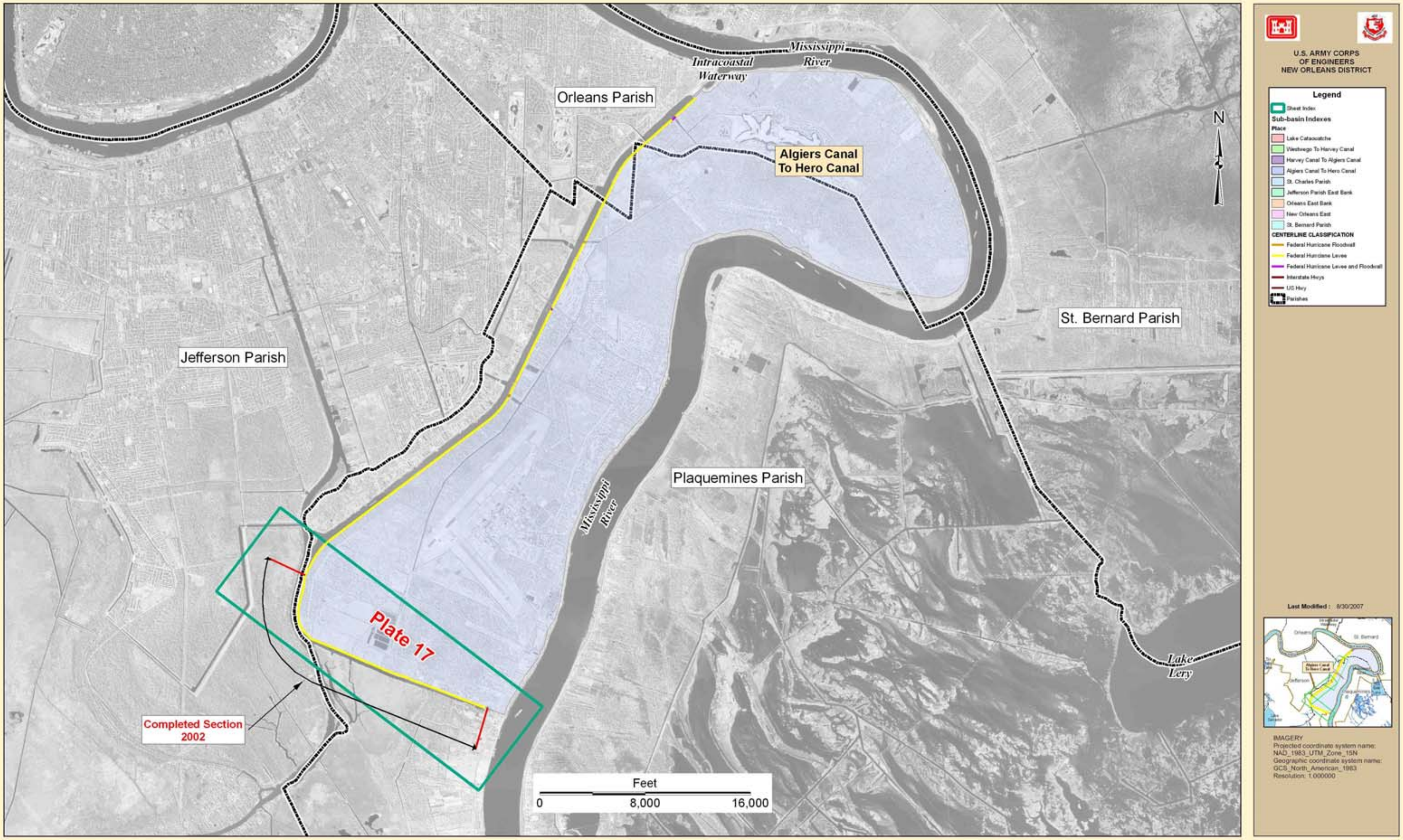
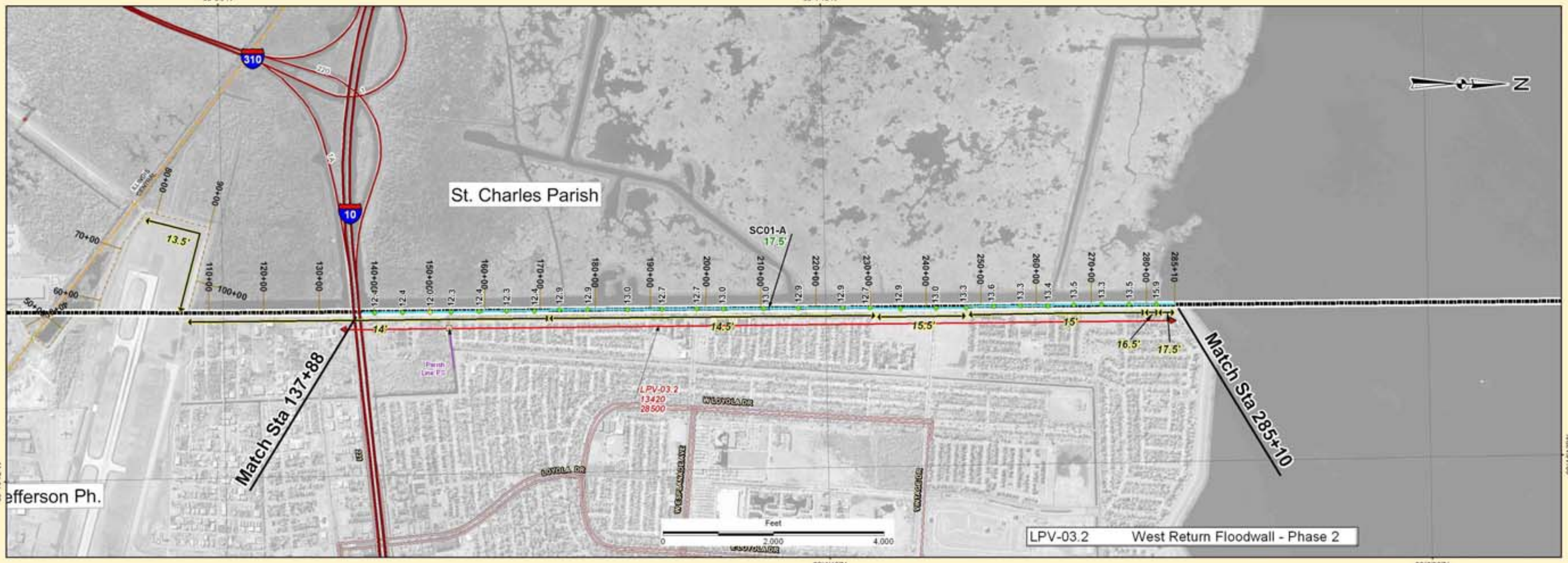
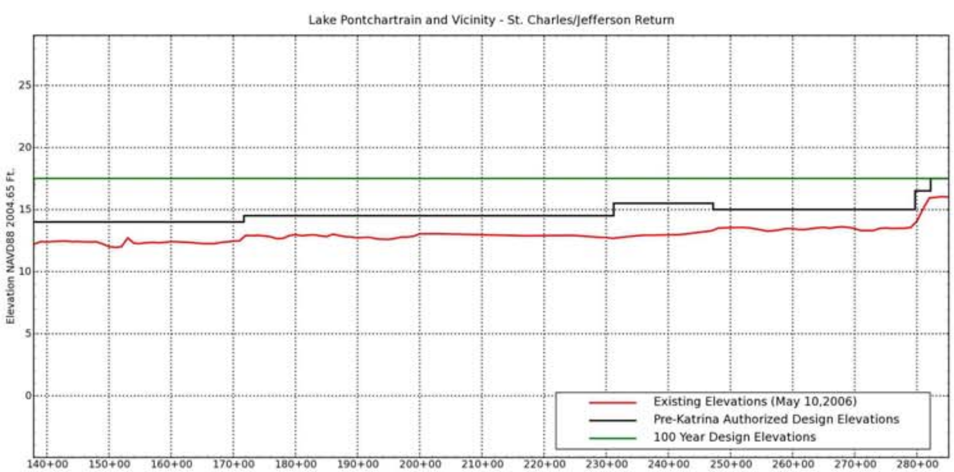


PLATE 9

Vertical Settlement Report, Plan & Profile Sheets, Lake Pontchartrain and Vicinity - St. Charles/Jefferson Return
Projects: LPV-03.2





SCALE IN FEET

0 1,000 2,000

U.S. ARMY CORPS
OF ENGINEERS
NEW ORELANS DISTRICT

Legend

100 Yr Design Reach Levee Centerline
- SC01-A
- Pre-Katrina Authorized Design Grade

Centerline Profile Elevations
- 0 - 11.79
- 11.80 - 12.00
- 12.01 - 18.00
- Contract Acquisition
- LEVEE CENTERLINE STATIONS
- Interstate Hwys
- US Hwy
- LA Hwys
- GIS.SecHwys
- Rail Roads
- Parish Boundary

Pre-Katrina Authorized Design Grades

Hydraulic Reach
100 Year Design Elevation (2057)

Note:
Pre-Katrina Authorized Design Grade & Contract Acquisition layers are offset from the 100 yr Design Reach (Levee Centerline) for display purposed only.

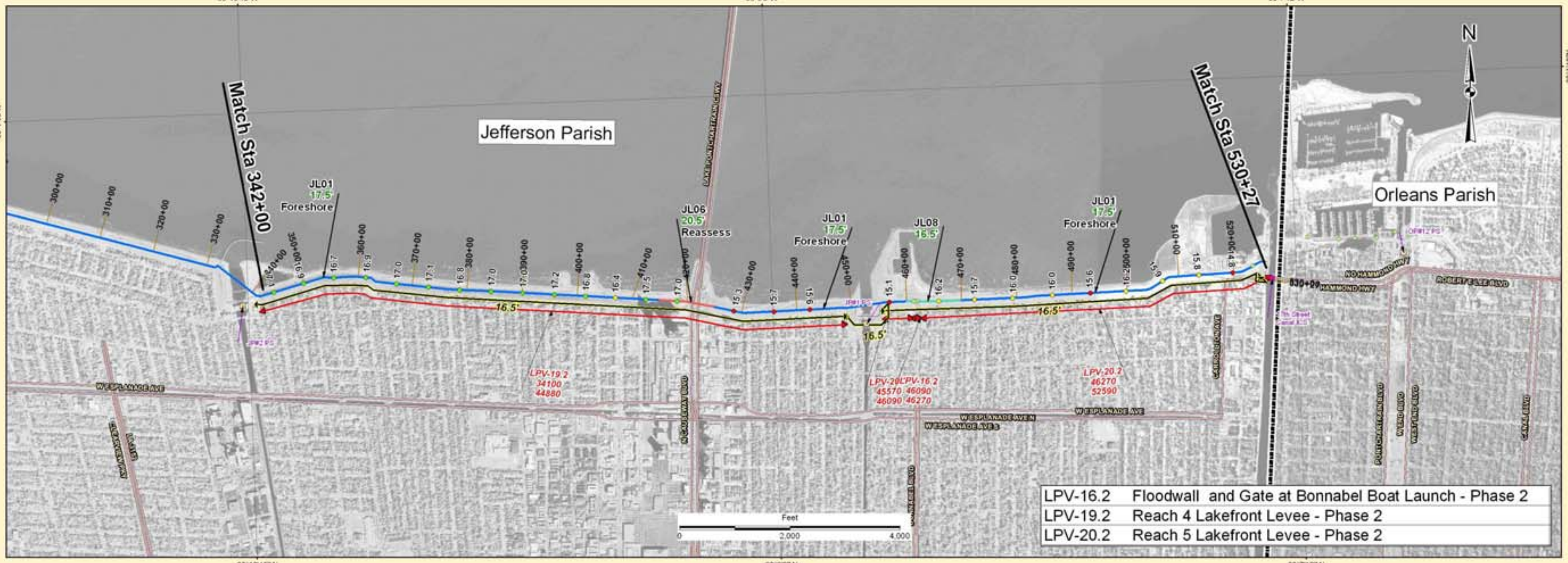
Note:
Abrupt changes in new 100-Year Design Elevations may occur at structures such as pump stations and walls. These changes may be attributable to structural superiority or the presence of features such as breakwater structures in front of walls or levees.

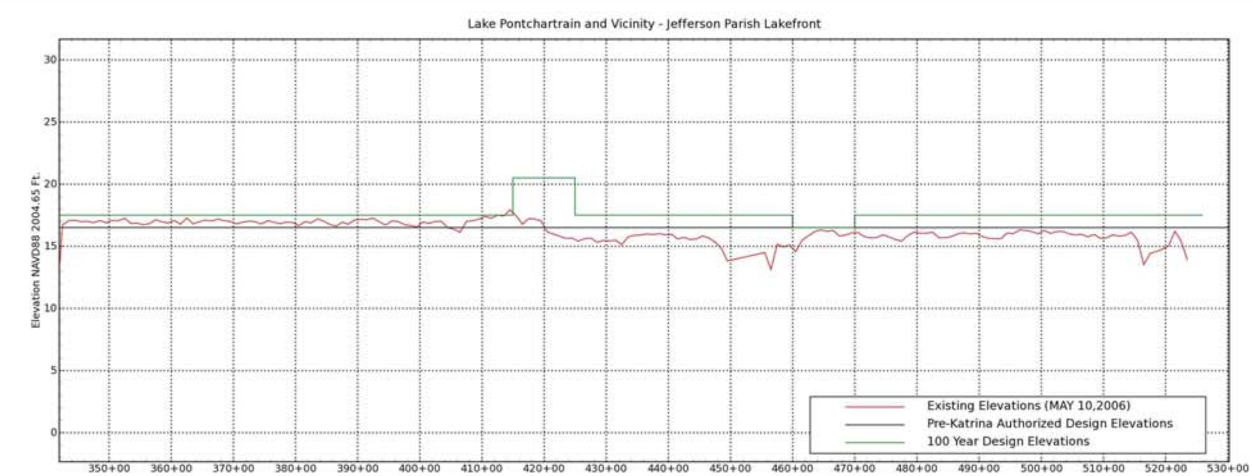
Last Modified : 10/26/2007

LPV - St Charles/Jefferson Return
Lake Pontchartrain and Vicinity
Section 2 of 2

PLATE 10

Vertical Settlement Report, Plan & Profile Sheets, Lake Pontchartrain and Vicinity - Jefferson Parish Lakefront
Projects: LPV-16.2, LPV-19.2, LPV-20.2





SCALE IN FEET

0 1,000 2,000

U.S. ARMY CORPS OF ENGINEERS NEW ORLEANS DISTRICT

Legend

100 Yr Design Reach Levee Centerline
- JL01
- JL06
- JL08
- Pre-Katrina Authorized Design Grade

CENTERLINE_POINTS_VIEW Events ELEVATION
- 14.81 - 15.70
- 15.71 - 16.59
- 16.60 - 17.48
- Contract Acquisition
- LEVEE CENTERLINE STATIONS
- Interstate Hwys
- US Hwy
- LA Hwys
- GIS.SecHwys
- Rail Roads
- Parish Boundary

Pre-Katrina Authorized Design Grades

Hydraulic Reach
100 Year Design Elevation (2057)

Note:
Pre-Katrina Authorized Design Grade & Contract Acquisition layers are offset from the 100 yr Design Reach (Levee Centerline) for display purposed only.

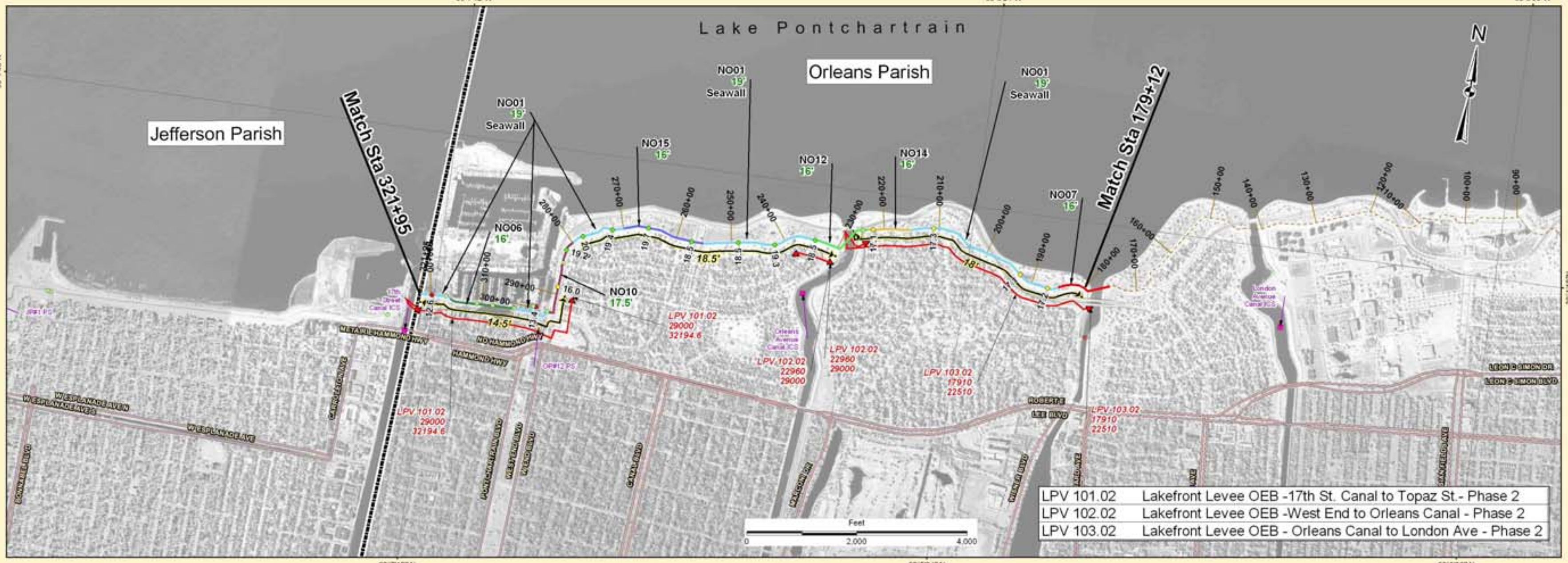
Note:
Abrupt changes in new 100-Year Design Elevations may occur at structures such as pump stations and walls. These changes may be attributable to structural superiority or the presence of features such as breakwater structures in front of walls or levees.

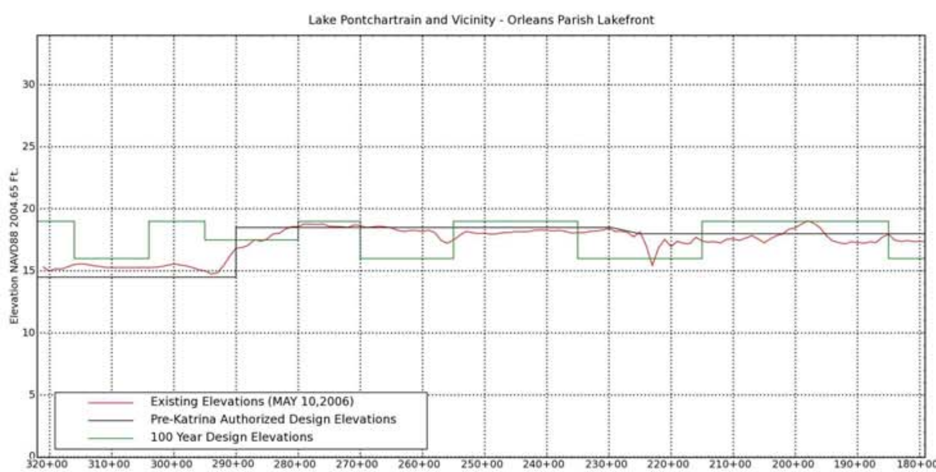
Last Modified: 10/16/2007

LPV - Jefferson Parish Lakefront
Lake Pontchartrain and Vicinity
Section 3 of 3

PLATE 11

Vertical Settlement Report, Plan & Profile Sheets, Lake Pontchartrain and Vicinity - Orleans Parish Lakefront
Projects: LPV 101.02, LPV 102.02, LPV 103.02





U.S. ARMY CORPS OF ENGINEERS NEW ORELANS DISTRICT

Legend

100 Yr Design Reach Levee Centerline: NO01, NO06, NO07, NO10, NO12, NO14, NO15

Pre-Katrina Authorized Design Grade

CENTERLINE_POINTS_VIEW Events ELEVATION: 12.62 - 15.08; 15.09 - 17.53; 17.54 - 19.98

Contract Acquisition

LEVEE CENTERLINE STATIONS

Interstate Hwys; US Hwy; LA Hwys; GIS.SecHwys; Rail Roads; Parish Boundary

Pre-Katrina Authorized Design Grades

Hydraulic Reach
100 Year Design Elevation (2057)

Note:
Pre-Katrina Authorized Design Grade & Contract Acquisition layers are offset from the 100 yr Design Reach (Levee Centerline) for display purposed only.

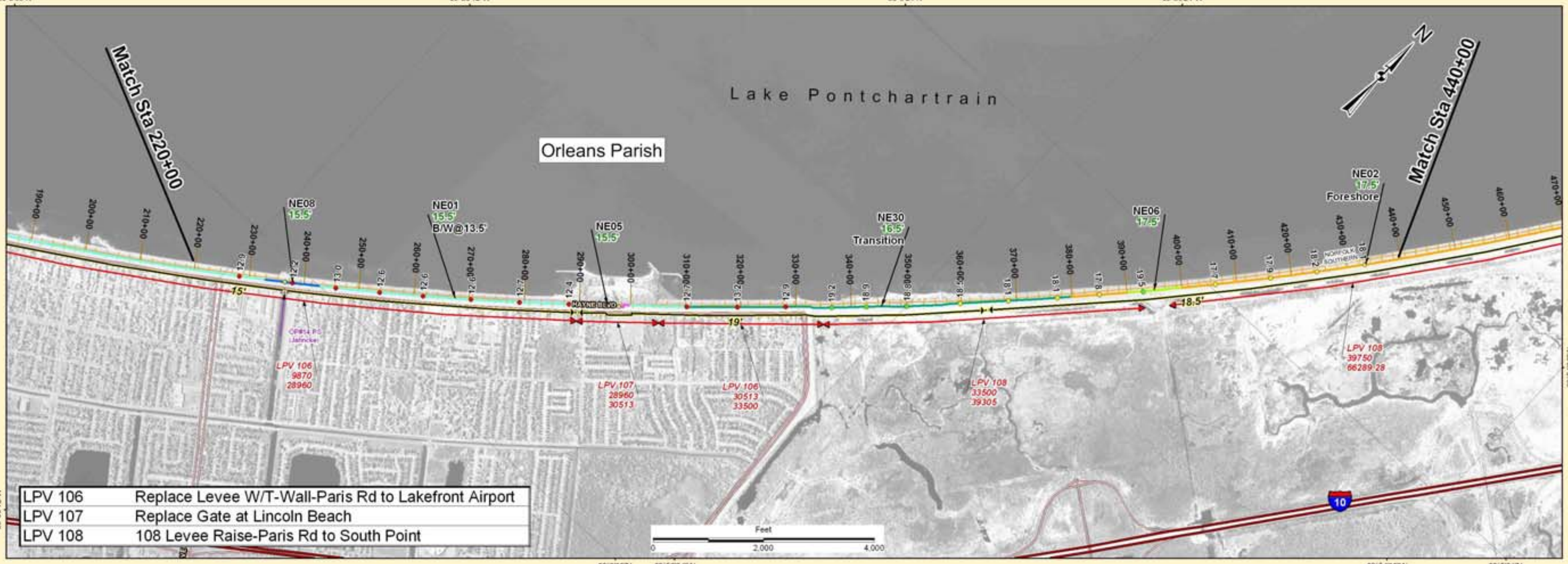
Note:
Abrupt changes in new 100-Year Design Elevations may occur at structures such as pump stations and walls. These changes may be attributable to structural superiority or the presence of features such as breakwater structures in front of walls or levees.

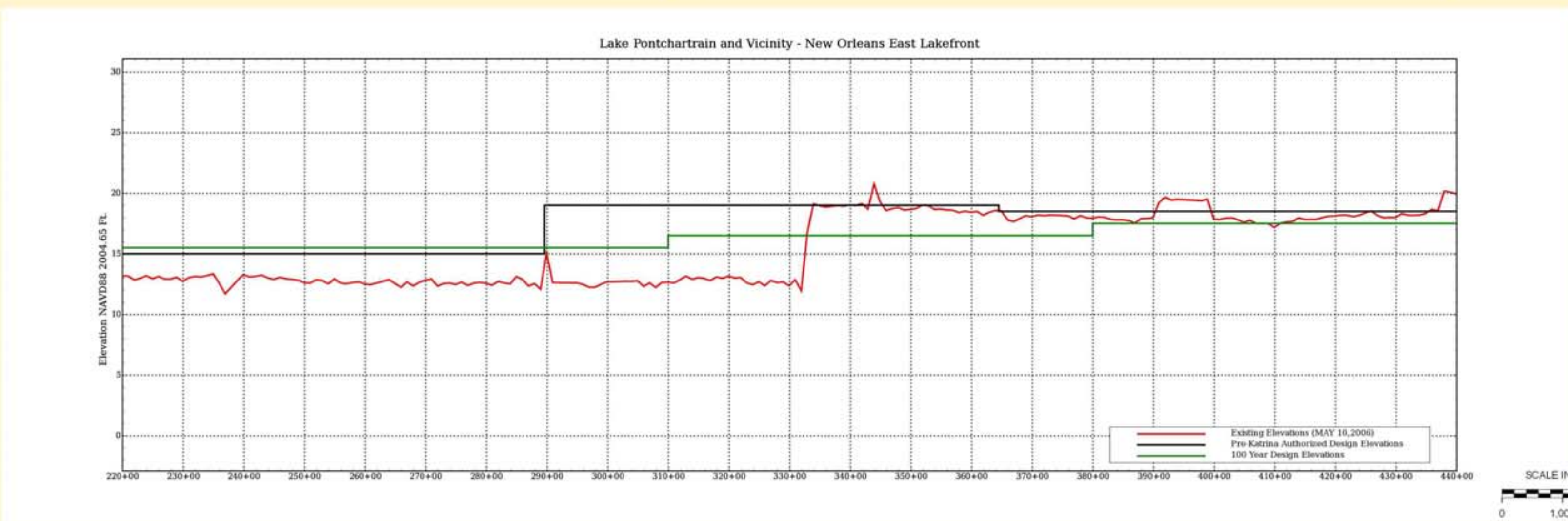
Last Modified: 10/19/2007

LPV - Orleans Parish Lakefront
Lake Pontchartrain and Vicinity
Section 2 of 2

PLATE 12

Vertical Settlement Report, Plan & Profile Sheets, Lake Pontchartrain and Vicinity - New Orleans East Lakefront
Projects: LPV 106, LPV 107, LPV 108





SCALE IN FEET
0 1,000 2,000

U.S. ARMY CORPS OF ENGINEERS
NEW ORELANS DISTRICT

Legend

100 Yr Design Reach Levee Centerline
CONTRACT_ID
- NE01
- NE02
- NE05
- NE06
- NE08
- NE30

Pre-Katrina Authorized Design Grade
CENTERLINE_POINTS_VIEW Events
ELEVATION
- 5.07 - 14.38
- 14.39 - 18.63
- 18.64 - 20.82

Contract Acquisition
LEVEE CENTERLINE STATIONS
Interstate Hwys
US Hwy
LA Hwys
GIS.SecHwys
Rail Roads
Parish Boundary

Pre-Katrina Authorized Design Grades

Hydraulic Reach
100 Year Design Elevation (2057)

Note:
Pre-Katrina Authorized Design Grade & Contract Acquisition layers are offset from the 100 yr Design Reach (Levee Centerline) for display purposed only.

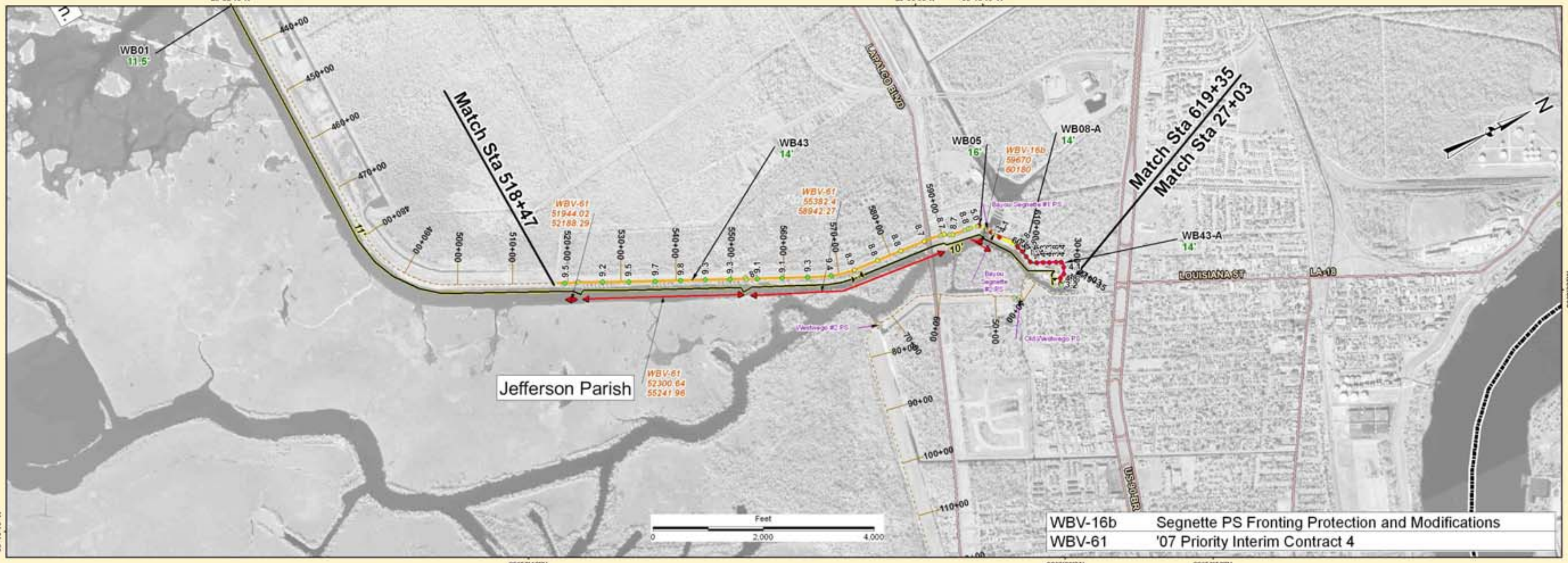
Note:
Abrupt changes in new 100-Year Design Elevations may occur at structures such as pump stations and walls. These changes may be attributable to structural superiority or the presence of features such as breakwater structures in front of walls or levees.

Last Modified : 9/5/2007

LPV - New Orleans East Lakefront
Lake Pontchartrain and Vicinity
Section 2 of 3

PLATE 13

Vertical Settlement Report, Plan & Profile Sheets, Westbank and Vicinity - Lake Cataouatche
Projects: WBV-16b, WBV-61



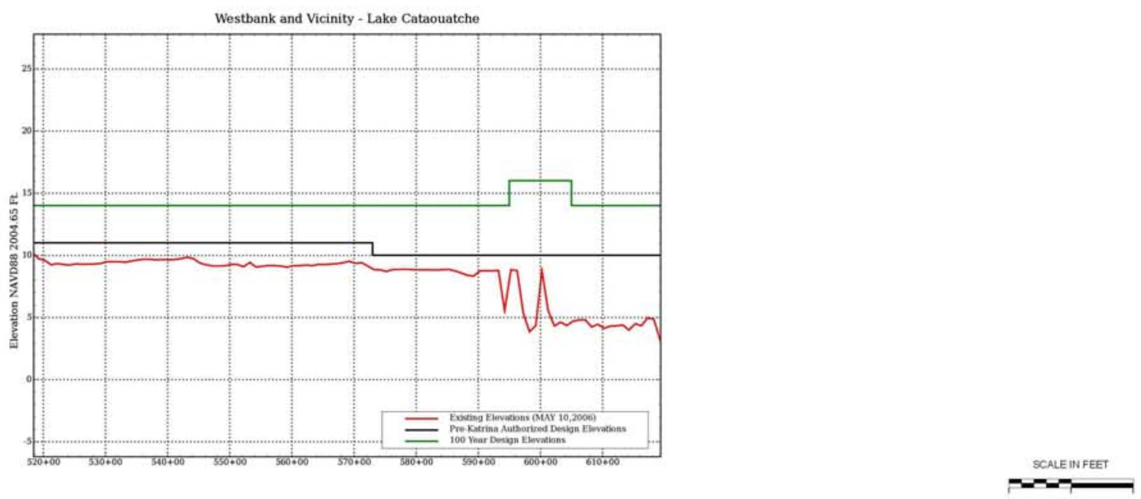
Pre-Katrina Authorized Design Grades

Hydraulic Reach

100 Year Design Elevation (2057)

Note:
Pre-Katrina Authorized Design Grade & Contract Acquisition layers are offset from the 100 yr Design Reach (Levee Centerline) for display purposed only.

Note:
Abrupt changes in new 100-Year Design Elevations may occur at structures such as pump stations and walls. These changes may be attributable to structural superiority or the presence of features such as breakwater structures in front of walls or levees.



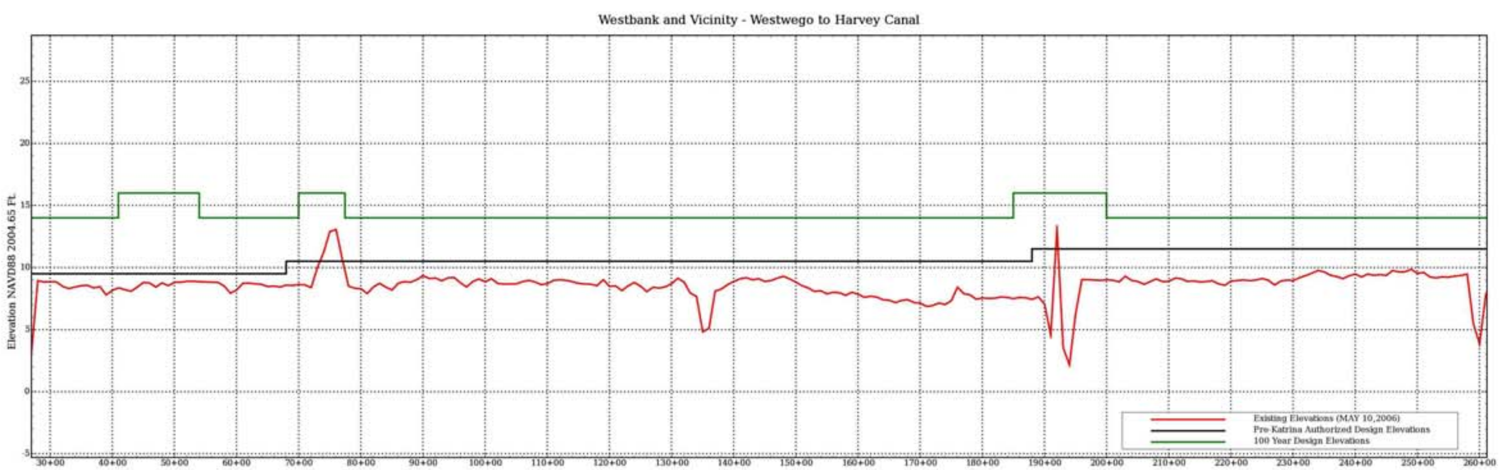
Last Modified : 9/5/2007

Cataouatche Canal
Westbank and Vicinity Index
Section 3 of 3

PLATE 14

Vertical Settlement Report, Plan & Profile Sheets, Westbank and Vicinity - Westwego to Harvey Canal
Projects: WBV-14c.2, WBV-19, WBV-20, WBV-21, WBV-22, WBV-30, WBV-53, WBV-55, WBV-56, WBV-60

WBV-14c.2	New Westwego PS to Vicinity Orleans Village - Phase 2
WBV-19	Segnette PS to New Westwego PS Floodwall - Phase 2
WBV-20	New Westwego PS Fronting Protection and Modifications
WBV-21	Old Westwego PS Fronting Protection and Modifications
WBV-22	Segnette PS to New Westwego PS Floodwall - Phase 2
WBV-30	Westminister PS Fronting Protection and Modiifications
WBV-53	Priority Interim Contract 2
WBV-55	Priority Interim Contract 4
WBV-56	Priority Interim Contract 5
WBV-60	'07 Priority Interim Contract 3



SCALE IN FEET
0 1,000 2,000

U.S. ARMY ENGINEER DISTRICT
NEW ORLEANS DISTRICT

Legend

100 Yr Design Reach Levee Centerline
- WB07
- WB08-B
- WB10
- WB31
- WB43
- WB43-B
- WB43-C
- Pre-Katrina Authorized Design Grade

CENTERLINE_POINTS_VIEW Events
ELEVATION
- 5.02 - 7.99
- 8.00 - 10.95
- 10.96 - 13.92
- Contract Acqusitions
- LEVEE CENTERLINE STATIONS
- Interstate Hwys
- US Hwy
- LA Hwys
- GIS.SecHwys
- Rail Roads
- Parish Boundary

Pre-Katrina Authorized Design Grades

Hydraulic Reach
100 Year Design Elevation (2057)

Note:
Pre-Katrina Authorized Design Grade & Contract Acquisition layers are offset from the 100 yr Design Reach (Levee Centerline) for display purposed only.

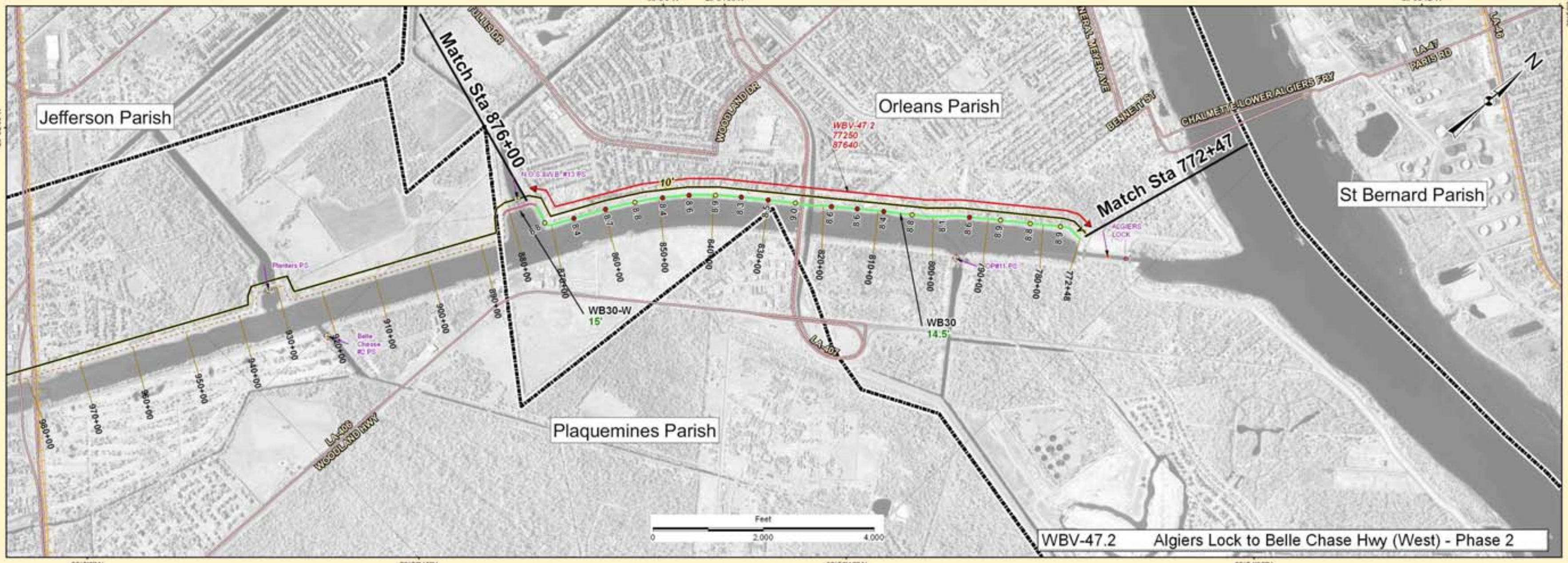
Note:
Abrupt changes in new 100-Year Design Elevations may occur at structures such as pump stations and walls. These changes may be attributable to structural superiority or the presence of features such as breakwater structures in front of walls or levees.

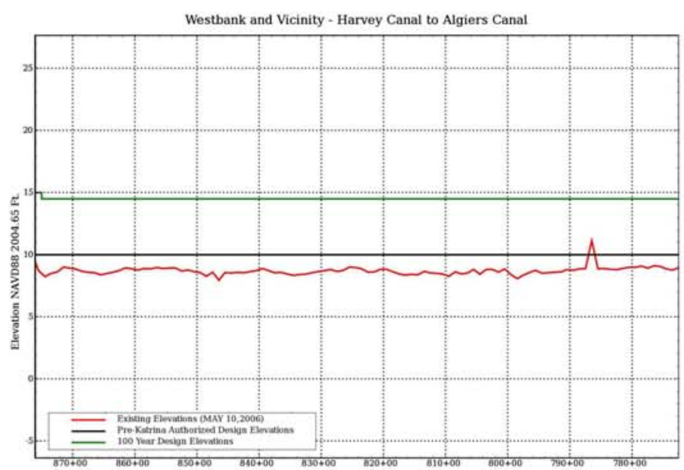
Last Modified : 9/5/2007

Westwego to Harvey Canal Levee
Westbank and Vicinity Index
Section 1 of 5

PLATE 15

Vertical Settlement Report, Plan & Profile Sheets, Westbank and Vicinity - Harvey Canal to Algiers Canal
Projects: WBV-47.2





SCALE IN FEET

0 1,000 2,000

U.S. ARMY CORPS
OF ENGINEERS
NEW ORLEANS DISTRICT

Legend

100 Yr Design Reach Levee Centerline

- WB30
- WB30-W
- Pre-Katrina Authorized Design Grade

CENTERLINE_POINTS_VIEW Events

ELEVATION

- 8.28 - 8.75
- 8.76 - 9.21
- 9.22 - 9.68
- Contract Acquisitions
- LEVEE CENTERLINE STATIONS
- Interstate Hwys
- US Hwy
- LA Hwys
- GIS SecHwys
- Rail Roads
- Parish Boundary

Pre-Katrina Authorized Design Grades

Hydraulic Reach

100 Year Design Elevation (2057)

Note:
Pre-Katrina Authorized Design Grade & Contract Acquisition layers are offset from the 100 yr Design Reach (Levee Centerline) for display purposed only.

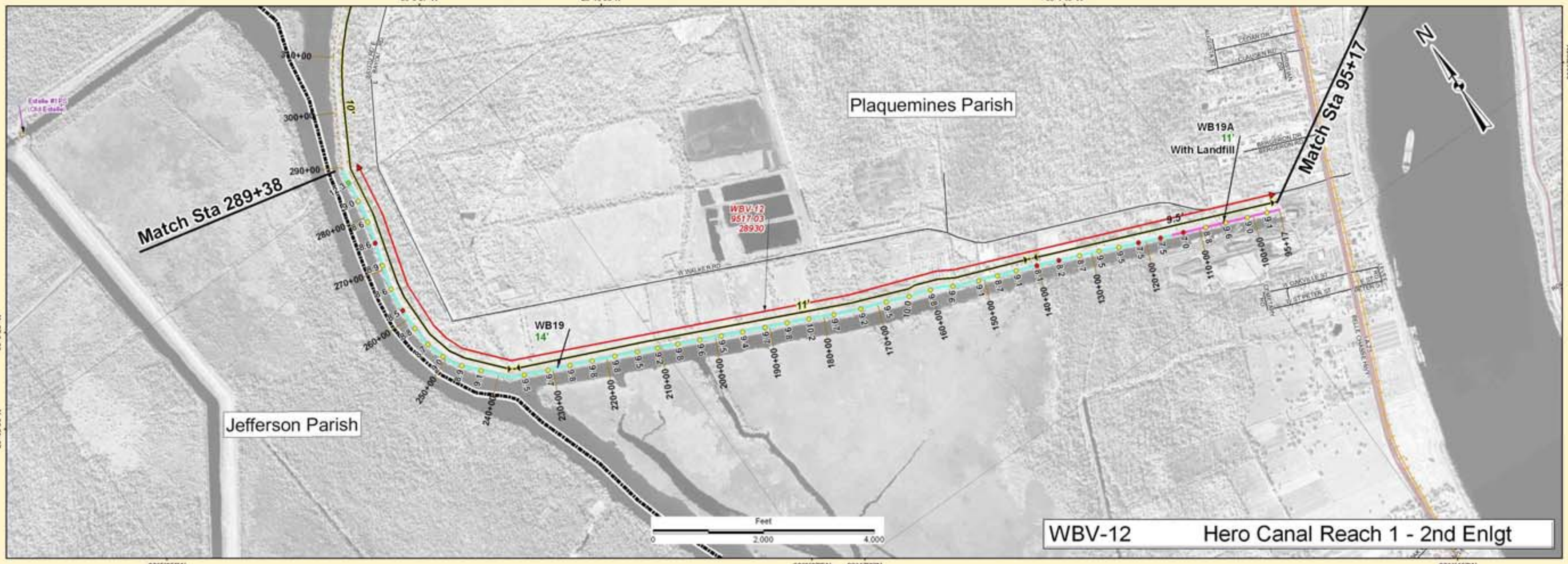
Note:
Abrupt changes in new 100-Year Design Elevations may occur at structures such as pump stations and walls. These changes may be attributable to structural superiority or the presence of features such as breakwater structures in front of walls or levees.

Last Modified : 9/5/2007

Harvey to Algiers Canal Levee
Westbank and Vicinity
Section 1 of 4

PLATE 16

Vertical Settlement Report, Plan & Profile Sheets, Westbank and Vicinity - East of Algiers Canal
Projects: WBV-12



U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT

Legend

100 Yr Design Reach Levee Centerline
- WB19
- WB19A
- Pre-Katrina Authorized Design Grade
- Contract Acquisitions

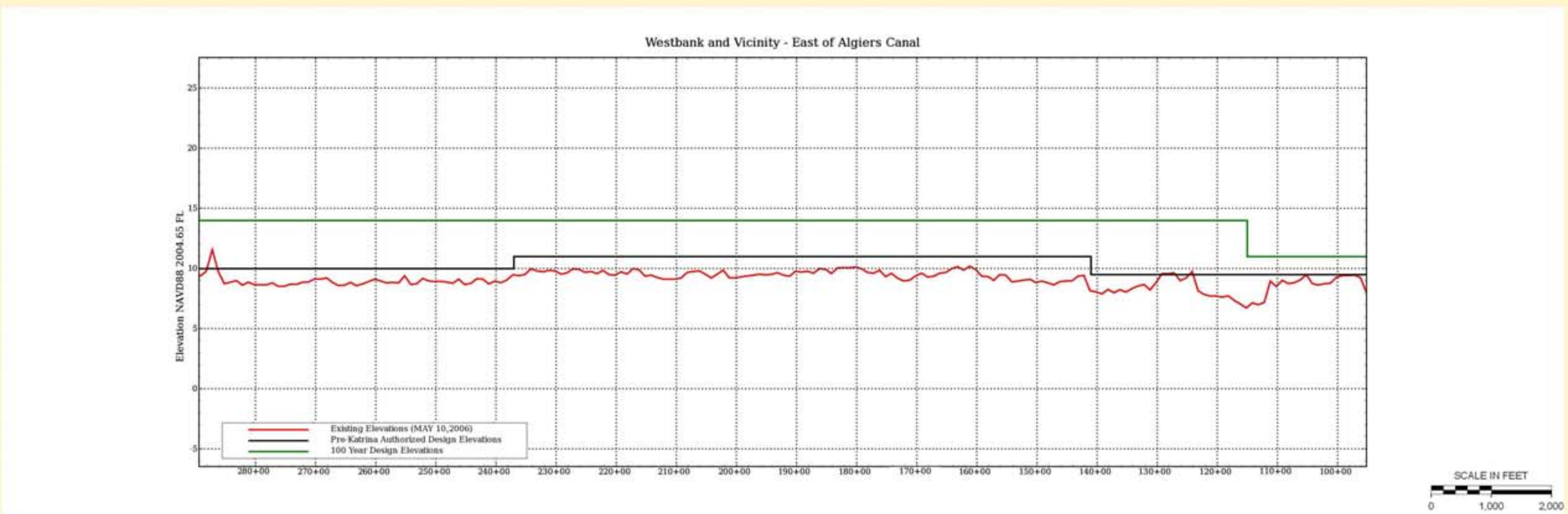
CENTERLINE_POINTS_VIEW Events ELEVATION
- 6.69 - 8.57
- 8.58 - 10.44
- 10.45 - 12.32
- LEVEE CENTERLINE STATIONS
- Interstate Hwys
- US Hwy
- LA Hwys
- GIS.SecHwys
- Rail Roads
- Parish Boundary

Pre-Katrina Authorized Design Grades

Hydraulic Reach
100 Year Design Elevation (2057)

Note:
Pre-Katrina Authorized Design Grade & Contract Acquisition layers are offset from the 100 yr Design Reach (Levee Centerline) for display purposed only.

Note:
Abrupt changes in new 100-Year Design Elevations may occur at structures such as pump stations and walls. These changes may be attributable to structural superiority or the presence of features such as breakwater structures in front of walls or levees.



Last Modified : 9/5/2007

East of Algiers Canal
Westbank and Vicinity Index
Section 1 of 4

PLATE 17