CAUTION: Analysis for this report was completed prior to the issuance of Engineer Technical Letter (ETL) 1110-2-575, EVALUATION OF I-WALLS, dated 1 September 2011.

http://publications.usace.army.mil/publications/eng-tech-ltrs/ETL_1110-2-575/ETL_1110-2-575.pdf

The Corps is performing additional evaluation of the I-walls along the 17th, Orleans and London outfall canals to address the 2011 ETL.

As of June 11, 2013, the new evaluation reports have not been finalized.

Any reference to this report should include this notice.

U. S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT

USACE CONTRACT No. W912P8-09-D0014
Task Order 0025

for the

New Orleans Hurricane Protection Office

Remediation of Canal Walls for the Orleans Avenue Canal OFC-06

Design Documentation Report (DDR)

Final Submittal

October 2010

URS PROJECT No. 10004026

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DESIGN DOCUMENTATION REPORT (DDR)

TABLE OF CONTENTS

Figures

Tables

Appendices

1. Project Information

A. Project Number

A/E Contract No. W912P8-09-D0014, Task Order No. 0025, Remediation of Canal Walls for the Orleans Avenue Canal OFC-06, Orleans Parish, Louisiana issued August 2, 2010.

B. Project Name and Location

The project name is "Remediation of Canal Walls for the Orleans Avenue Canal OFC-06".

The project is located between Sewerage and Water Board of New Orleans (SWBNO) Drainage Pump Station (DPS) #7 and the Harrison Avenue Bridge on the west side of the Orleans Avenue Canal (approximate Sta. 0+00 to 14+20 and Sta. 14+20 to 21+75 and 24+85 to 28+85) and between the Harrison Avenue Bridge and the Filmore Avenue Bridge on the east side of the Orleans Avenue Canal (approximate Sta. 50+00 to 64+00). The project begins at Latitude 29°59'39.85", Longitude 90° 6'4.83" and ends at Latitude 30° 0'40.89", Longitude 90° 5'55.90".

C. Project Description

The project consists of the remediation of the existing flood protection (concrete capped I-walls and levees) along the Orleans Avenue Canal. Remediation of the canal is necessary to ensure that the canal walls and the levees can support the requirements of the Sewerage and Water Board of New Orleans in removing rain water from the city unimpeded.

The project has 3 reaches (10A, 10B and 4) as defined by USACE in the original B&V report for this canal. A subsequent B&V report, 2009-2010, identified 4 reaches (10A, 10B, 18A and 18B).

In all the reaches, the flood protection consists of concrete capped I-wall embedded in an earthen embankment. For all reaches compacted material will be used. All embankment material shall meet or exceed USACE requirements for compacted fill material.

For Reaches 10A and 10B, the remediation consists of raising the protected side embankment to a minimum of El. 4.0.

For Reaches18A and 18B, the remediation consists of improving the stability of the flood protection by placing more material on an existing stability berm and placing riprap in the canal. The canal side remediation will be done under a separate construction contract. The remediation of the canal walls for Reach 18A starts at Sta. 50+00 B/L (OLD/

USACE B/L) and ends at Sta. 61+00 B/L (OLD/USACE B/L). The remediation of the canal walls for Reach 18B starts at Sta. 61+00 B/L (OLD/ USACE B/L) and ends at Sta. 63+57.58 B/L (OLD/USACE B/L).

Refer to paragraph 1.E for baseline information for this project.

D. Background information

The Orleans Avenue Canal is one of three drainage outfall canals in New Orleans, Louisiana. The west bank of the canal is generally adjacent to residential neighborhoods whereas the east bank of the canal is adjacent to New Orleans City Park. It is part of the system used to pump rain water out of the streets of the city into Lake Pontchartrain.

The Canal has also been known as the Orleans Outfall Canal, the Orleans Tail Race, and early on, the Girod Canal.

The earliest version of the Orleans Avenue Canal did not include any of the current route. It was a drainage ditch dug alongside Orleans Avenue in the 1830s, running from the Treme neighborhood into Bayou St. John. It was part of a city drainage plan by state engineer George T. Dunbar.

The canal was expanded during the developments and civic improvements in New Orleans in the 1870s. In 1871, drainage improvements rerouted and extended the canal, changing its terminus from Bayou St. John to Lake Pontchartrain. While some 19th century city maps show a grid of streets in this area, in reality these streets were not extended into this area, and it remained a swamp with little development until the 20th century. At the time, the main intention of the canal was to remove water from the developed area on the lake side of the original drainage system stations, not from the swampy ground along the canal closer to the lake along most of the canal's length.

In the first decade of the 20th century, a second pumping station was added closer to the lake at Florida Boulevard (bounded by Kenilworth Street and Florida Avenue to the north and south, respectively, and by Orleans Avenue and Marconi Drive, west and east, respectively). In the early 20th century a greatly improved drainage pumping system was developed as designed by A. Baldwin Wood.

Starting in the late 1920s, the Lake Pontchartrain shore line was extended and lake side levees were constructed. The levees along the canal were raised. As the former swamp was developed after World War II, the area on the east side of the canal became an extension of City Park. The west side of the canal became the Lakeview residential neighborhood. Frequently the level of the water in the canal was higher than the surrounding streets.

As part of hurricane protection projects following Hurricane Betsy in 1965 (see Orleans Avenue Canal, Phases IA, IIB, IIC, IIA and Phase IID.), the Orleans Avenue Canal levees were degraded and a system of concrete capped I-walls and pile founded T-walls were constructed on top of the canal levees.

During Hurricane Katrina in 2005, the Orleans Avenue Canal levees and floodwalls did not fail. Post-Katrina forensic engineering reports speculated that the Orleans Canal did not fail because a section of its floodwalls at City Park were unfinished and much lower than the rest of the canal; thus the surge waters were able to flow out into the city through this low spot, relieving the pressure along the rest of the canal.

The existing Orleans Avenue Canal is approximately 2.4 miles long and extends from SWBNO DPS No. 7 (located near Interstate 610) to Lake Pontchartrain. The flood protection on the east and west banks of the canal were designed to provide parallel protection from tidal influence of Lake Pontchartrain via the lake-canal connection. The existing I-walls and T-walls were constructed at the crests of the levees to provide additional protection from higher water elevations during storm events. The Orleans Canal ranges in width from 100 to 160 feet and the invert ranges in depth from El. -6 to El. -10 feet, with the deepest section located near Lake Pontchartrain.

E. Alignment and Survey

The alignment used for this project was provided by the USACE and based the survey described below. This project is located along several segments of the existing Orleans Avenue Canal floodwall. The most recent survey was completed in June 2010 conducted by Chustz Surveying, Inc. under ECM/GEC JV Contract No. W912P8-07-D-0031. The survey included Reaches 10A and 10B on the west side and 18A and 18B on the east side. The survey did not include Right-of-Way data.

On the east side, the new alignment has differing beginning stationing which results in differing stationing relative to the Orleans Avenue Phase IIA baseline stationing.

F. Limits of Right-of-Way

The Right-of-Way for the Orleans Avenue Canal project is based on information provided by the USACE through the As-built drawings. URS had not received any viable information or drawings to accurately determine the exact location of Right-of-Way points. The Right-of-Way used in the plan set is a Right-of-Way based on the As-Builts for Orleans Avenue Canal, Phase IID and Orleans Avenue Canal, Phase IIA. These As-Built drawing sets can be downloaded from the USACE website. From these projects, the right-of-way line was assumed to be correct. The Right-of-Way for the project appears to fall along the protected side toe of the levee on the east side. More information is required to accurately determine the Right-of-Way for this project.

2. Pertinent Data (source: USACE)

A. Material and Unit Weights

Table 2-1 Material Unit Weights

Material	Unit Wt (lb/ft3)
Water	64
Concrete	150
Steel	490
Riprap	132
Semi-Compacted Granular Fill	110
Fully-Compacted Granular Fill, Wet	122
Fully-Compacted Granular Fill, Effective	58
Fully-Compacted Clay Fill, Wet	115
Fully-Compacted Clay Fill, Effective	51

B. Project Purpose and Objectives

The primary purpose of the project is to eliminate or reduce the risk of a flood control failure due to excessive horizontal movement and or global failure of the I-walls during a storm event condition in the canal. For the purpose of this project, the projected high water elevation used in this project is the highest elevation of the canal water to maintain the stability of the flood control system

For all reaches, the existing flood protection is a concrete capped I-wall embedded in an earthen embankment and an earthen stability berm. A geotechnical analysis was conducted to determine the existing stability of the I-wall and embankment in order to prevent a flood protection failure in this reach.

C. Project Cost

Project Cost The project cost was determined using the parameters shown below and in Appendix F.

D. Cost Estimates

1. Quantities

Quantities were determined by the A/E's designers of each individual discipline. Submitted quantities were reviewed by the A/E's project manager for completeness and project integration.

Assumptions for quantity computations include:

a) Civil quantities for earthwork were determined using software from Bentley. The Average End Method was used to compute estimated volumes of material required for each reach. When using Bentley software the existing surfaces were subtracted from proposed surfaces.

b) Embankment fill quantities were computed based upon volumes of embankment fill in place. Embankment quantities do not account for the increased quantity of borrow required by compaction but does include an estimate for increased volume due to foundation settlement and/or larger term consolidation.

c) Miscellaneous civil quantities were generally determined from direct measurement in Microstation model files and were compiled using Microsoft Excel spreadsheets.

The detailed quantity computations can be found in Appendix E.

2. MCACES

The cost estimate is prepared in MCACES MII version 3.01. The MCACES cost estimate is prepared within the HPO Template provided by the New Orleans District (MVN) of the U.S. Army Corps of Engineers (USACE), New Orleans.

The detailed cost estimate including explanation, details, methodology, and assumptions of the HPO Template can be found in Appendix F.

3. Construction Schedule

The schedule was developed using Microsoft Project software and is presented in bar chart (Gantt) format using the critical path method of scheduling. The full construction schedule is provided in Appendix F.

Many options and methods are available in the planning and execution of a construction schedule covering multiple tasks in multiple locations. The schedule included with this report is not represented as the only way of accomplishing the work.

For the purposes of this report, the schedule is presented as a way in which the project can be accomplished in an efficient manner with a midsize contractor able to mobilize in two locations at the same time.

a) Weather Restraints

Hurricane season is from 1 June to 30 November.

Because the existing flood protection (I-walls) will not be breached or disturbed, the schedule does not include any time necessary to accommodate the requirements of the Hurricane Plan or the Emergency Gap Closure Plan as noted in the General Provisions of the Construction Specifications

b) Construction and Scheduling Sequence

The construction schedule provides time for mobilization as well as demobilization for the contractor and staging of the project from the protected side of the Orleans Avenue Canal.

c) Project Close Out

The projected project completion is June 2011. This assumes that the site is cleaned up, trailers and equipment removed, the staging area and access roads are re-graded, seeded and mulched, and the project is closed out. The estimated project duration is approximately 4 months.

E. Controlling Elevations

All the elevations hereafter in this report are referenced to NAVD88 (2004.65). The as-built drawings for the existing wall indicate the top elevation is 14.9 ft, NGVD29. The approximate conversion equation (including settlement) for this area is

El 0.0 Ft, NAVD88 = El. 0.0 Ft, NGVD29 – 0.5.

1. Topographic Surveys and Survey Control

a) Vertical Datums. The establishment and use of vertical datums in the design work follows the guidance provided in "USACE New Orleans District Guide for Minimum Survey Standards", Edition 2.1, dated September 2009 and the "Hurricane Storm and Damage Reduction System Design Guidelines", Oct 07 with changes in May 08 and Jun 08.

b) Horizontal and Vertical control. Horizontal data shall be tied to the State Plane Coordinate System using North American Datum of 1983 (NAD83, LA Southern 702). Distances are in feet by horizontal measurement. Coordinates are Louisiana Lambert South Zone. Vertical data is tied to the North American Vertical Datum of 1988, Epoch 2004.65 (NAVD88-2004.65). Elevations are in feet. Horizontal and vertical accuracies are of third order.

2. Benchmarks

Figure 1 shows the locations of the benchmarks used on the project. The benchmarks used on the project have been successfully recovered, verified and recorded by the National Geodetic Survey.

PHOTO SOURCE: USACE (2006)

Figure 1 Bench Mark Locations

a) Project Benchmark, A 148

Station recovery by Woolpert Consultants 2009 (JPD). Recovered in good condition. To reach the station from the intersection of St. Bernard Ave. and Desaix Blvd., travel west on Desaix Blvd. for 0.8 miles to the station on the left. The station is on the east bound lane at the end of a sidewalk that is on a bridge over Bayou St. John. The station is located in New Orleans, LA, 3.9 miles east of Metairie, LA, 5.5 miles north-northwest of Gretna, LA and 8.1 miles northwest of Chalmette, LA. The monument is a bench mark disk found in good condition, stamped “A 148 1951”. The station is 15.9 feet south of the centerline of the east bound lane of Desaix Blvd., 37.0 feet west of the a light pole on the south side of Desaix Blvd., 0.3 feet north of a concrete pier and 3.4 feet south of the north edge of the sidewalk on the bridge.

Northing 543,696.11, Easting 3,675,283.42, Elevation 5.81

b) Verification Benchmark, BLOUNT

Station recovery (2005) recovery by LADH.

The station is located in New Orleans, LA, at the intersection of north Broad Street and A P Tureaud Ave., in a concrete apron at the southwest corner of a canal clean out ramp at Pump Station number 3, 58.1 ft. Northwest of the center of the southwest bound lanes of the street, 42.0 ft. North of a traffic light, 10 8 ft. Southeast of a chain-link fence, 6.6 ft. Northeast of a chain-link fence, 2.0 ft. above the level of the street, and on the extended center of the northbound lanes of the avenue, the mark is on property owned by the City of New Orleans, to gain access to the mark contact—Ray Fabre, 2800 Peoples Avenue, New Orleans, LA 70119, telephone number (504)585-2420. The station is a triangulation disk set in pavement stamped BLOUNT 1972.

Northing 543352.65, Easting 3,681, 458.34, Elevation -1.35'

c) Verification Benchmark, ALCO

Station recovery (2003) recovery note by 3001, inc. 2003 (kd)

The station is located in New Orleans on a sea wall beside Joe's Restaurant at the lake shore. It is next to a green and white light house. The station is 3.8 miles from Metairie, 8.0 miles from Kenner, and 10.7 miles from Chalmette. To reach the station from the intersection of I-10 and I-610 drive north on West End Blvd. for 1.7 miles. The road becomes Lake Front Drive. Keep going for 0.4 miles to a curve in the road. Turn into Joe's Restaurant parking lot on the left side of the road. The station is located north of the parking area in the seawall. The station is a triangulation station disk set flush in a seawall. It is located 68.7 ft. east from the corner of the seawall, 23.5 ft. Northeast from a light pole, and 54 ft. Northwest of a storm drain.

Northing 557,299.70, easting 3,667,048.43, Elevation 6.1

3. References

The EM web link is: http://140.194.76.129/publications

A. General References.

1. Hurricane and Storm Damage Reduction System Design Guidelines, New Orleans District Engineering Division, Interim. October 2007, with revisions dated June 2008.
2. Hurricane and Storm Damage Reduction System Design Guidelines, Quality Management System, dated 30 October 2009.

B. Civil Engineering References.

1. ER 1110-1-8156, Policies, Guidance, and Requirements for Geospatial Data and Systems, dated 30 Sep 2005.
2. ERDC/ITL Technical Report, TR-06-X, A/E/C CADD Standards, Release 3.0, September 2006.
3. American Association of State Highway Transportation Officials (AASHTO), "A Policy on Geometric Design of Highways and Streets" 2004, 5th edition.
4. Manual on Traffic Uniform Control Devices for Streets and Highways (MUTCD), Washington D.C., 2009 edition.
5. Louisiana Department of Transportation and Development, Roadway Design Procedures and details, July 2006 edition.

C. Geotechnical References.

1. Division, Interim. October 2007 with revisions up to June 2008.
2. Stability Modeling with SLOPE/W, GeoStudio 2007 V7.1, GEO-SLOPE/W International Ltd.
3. U.S. Army Corps of Engineers, New Orleans District Engineering Division, Stability with Uplift (MVD Method of Planes).
4. U.S. Army Corps of Engineers, Engineer Manual 1110-2-1901, Seepage U.S. Army Corps of Engineers, Engineer Manual 1110-2-1902 Slope Stability, 31 October 2003.
5. U.S. Army Corps of Engineers, Engineer Manual 1110-2-1913 Design and Construction of Levees, 30 April 2000.
6. U.S. Army Corps of Engineers, Engineer Manual 1110-2-2502, Retaining and Flood Walls, 29 September 1989.
7. U.S. Army Corps of Engineers, Engineer Manual 1110-2-2504, Design of Sheet Pile Walls, 31 March 1994.
8. U.S. Army Corps of Engineers, Engineer Manual 1110-2-2906 Design of Pile

Foundations, 15 January 1991.

9. U.S. Army Corps of Engineers, ETL 1110-2-569, Design Guidance for Levee Underseepage, 2005.
10. U.S. Army Corps of Engineers, Engineer Manual 1110-2-1904 Settlement, 30 September 1990.
11. U.S. Army Corps of Engineers, Engineer Manual 1110-2-1905 Bearing Capacity of Soils, 30 October 1992.
12. U.S. Army Corps of Engineers, Engineer Manual 1110-2-1906 Laboratory Soils Testing, 20 August 1986.
13. Harr, M.E., "Groundwater and Seepage" McGraw Hill Book Company, New York, 1962.
14. US Army Corps of Engineers, New Orleans District, Elevations for the Initial Design of Hurricane Protection Levees and Structures within the New Orleans District – Draft Report Version 1.2, 26 September 2006.
15. US Army Corps of Engineers, Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System, Draft Final Report of the Interagency Performance Evaluation Task Force, Volume I – Executive Summary and Overview, 1 June 2006.
16. US Army Corps of Engineers, Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System, Draft Final Report of the Interagency Performance Evaluation Task Force, Volume V – The Performance – Levees and Floodwalls, 1 June 2006.
17. US Army Corps of Engineers (GCAT), "Stability Analysis of I-Walls Containing Gaps between the I-wall and Backfill Soils" with additional examples by GCAT, (adapted from paper by Brandon, Thomas L., Stephen G. Wright, and J. Michael Duncan (2008)), Version 6.0, 14 Sep 09

D. Project Design Reports

1. (Draft) 95% Safe Water Elevation, Evaluation, Orleans Canal, United States Army Corps of Engineers, Hurricane Protection Office, New Orleans District, June 2009.
2. (Draft) 95% Safe Water Elevation, Evaluation, Orleans Canal, United States Army Corps of Engineers, Hurricane Protection Office, New Orleans District, August 2010.

E. Project-Specific Criteria

Elevations for Design of Hurricane Protection Levees and Structures, Lake Pontchartrain, Louisiana and Vicinity, Hurricane Protection Project, West Bank and Vicinity, Hurricane Project, U.S. Army Corps of Engineers, New Orleans District (09 October 2007).

F. Other Design Criteria and Information

1. EM 385-1-1, General Safety Requirements, September 2008.
2. ER 415-1-11, Biddability, Constructability, Operability, and Environmental Review.
3. ER 1110-2-1302, Civil Works Cost Engineering. 31 Mar 94.
4. Design Memorandum 19, General Design, Orleans Avenue Outfall Canal, Volumes I, II and II, U.S. Army Corps of Engineers, New Orleans District, August 1989

G. Computer Program Manuals

1. Stability With Uplift program (Method of Planes), U.S. Army Corps of Engineers, New Orleans District, P.O. Box 60267, New Orleans, LA 70160.
2. Stability Modeling with SLOPE/W 2007, Engineering Methodology, GEOSLOPE/W International, Ltd, 2007.
3. US Army Corps of Engineers, Engineer Research and Development Center, Design/Analysis of Sheet-Pile Walls by Classical Methods (CWALSHT), April 2006.

H. Right-of-Way

The right-of-ways shown in the As-Built Orleans Avenue Canal, Phase IID and IIA drawings were used for the right-of-way

The temporary easement used for Reaches 10A and 10B is within the apparent Rights-of-Way limits shown in the As-Built drawings. On the west side the easement is 13-feet from the Orleans Avenue retaining wall (centerline of Orleans Avenue) and on the east side is the protected side of the existing I-wall.

The temporary work area easement used for Reach 4(new 18A and 18B) is within the rights-of-way limits of Phase IIA. The temporary work area easement varies from the west of the floodwall to the rights-of-way limits of Phase IIA. In addition, temporary work area easements for access are at the north of the work near Filmore Avenue.

I. Utilities and Relocations - Reaches 18A and 18B

For Reaches 10A and 10B, there are two electrical lines that cross the flood protection. Neither the lines or the poles are expected to impact the project and are designated to be not disturbed.

For Reach 4, (new 18A and 18B) there are 5 drain inlets, 5-6 light poles and about 12 trees within the project limits. None of the utilities are expected to impact the project and are designated not to be disturbed.

There are approximately 17 trees. The trees are not to be disturbed. If the remediation (berms) will impact the tree(s), remediation will be changed. The use of tree wells will be evaluated on a case by case basis.

See Construction Drawing C-09 for a complete list of utilities.

4. Design Related Documents

A. Geotechnical Design Criteria

1. Seepage Analysis

Seepage analyses were performed using the finite element modeling program SEEP/W (Version 7.17) to define the pore water pressures and piezometric lines for use in the slope stability calculations. Refer to Tab 6 for the SEEP/W output sheets.

2. Gap Analysis

New guidelines for conducting gap analysis, which no longer use the CWALSHT program, are outlined in "Stability Analysis of I-Walls Containing Gaps between the I-wall and Backfill Soils", GCAT Version 6.0, 14 SEP 09. Further, the new method employs finite element seepage analysis as part of the procedure.

3. Slope Stability Analysis

Slope stability analyses were performed for the I-Wall structures in accordance with the recently revised "Stability Analysis of I-Walls Containing Gaps between the I-Wall and Backfill Soils" version 4 and HSDRRS Design Guidelines, using The Method of Planes (MOP) computer program (1994) and SLOPE/W (Version 7.17). Required factors of safety were taken from the HSDRRS Design Guidelines and are listed in Table 4-1.

Table 4-1 Minimum Factors of Safety for Slope Stability Analyses

Analysis Condition	Required Minimum FS	
	Spencer	MOP
Extreme Hurricane –Safe Water Elevation (SWE)	1.4	1.3
Low Water (Hurricane Condition) – Q-Case [1]	1.4	1.3
Low Water (Non-Hurricane Condition) – Walls – S-Case [2]	1.4	1.3

Note 1: Flood side of walls only.
Note 2: Flood and protected side of walls.

For I-wall analyses, the Method of Planes is intended as a design check only; it does not control the analysis.

B. Civil Design

1. Traffic Control Design

The traffic control plan for the Orleans Avenue Canal project consists of the partial closing of Orleans Avenue from Harrison Avenue to Kenilworth Street, the west side of the Orleans Avenue Canal, and the partial closing of Marconi Drive from Filmore Avenue to Harrison Avenue, on the East side of the Orleans Avenue Canal

C. Task Order Schedule

Table 4-2 Task Order Schedule
Remediation to Raise MOL for Orleans Avenue Canal OFC 06

	Work Item	Time Interval for Work Item	Time from NTP	Expected Schedule	Actual Schedule
1	NTP	0	0	**2-Aug-10**	**2-Aug-10**
2	Pre-Design Conference	3	3	**6-Aug-10**	**6-Aug-10**
3	DQCP	5	8	**11-Aug-10**	**6-Aug-10**
4	Draft ROW Drawings	12	20	**23-Aug-10**	**23-Aug-10**
5	35% P&S, 100% ROW Drawings With Utility Relocations, Draft Geotechnical Report And Draft DDR	10	30	**2-Sep-10**	**2-Sep-10**
6	60% P&S, 100% Geotechnical Report And 100% DDR	15	45	**16-Sep-10**	**16-Sep-10**
7	60% Cost Estimate	5	50	20-Sep-10	**20-Sep-10**
8	95% P&S, Responses Complete To 60% Review Comments, Completed A-E Contractor Statement Of Technical Review	10	60	30-Sep-10	**30-Sep-10**
9	95% Cost Estimate	5	65	7-Oct-10	**7-Oct-10**
10	100% P&S (Ready To Advertise), Responses Complete To 95% BCOE Review	5	70	14-Oct-10	**14-Oct-10**
11	100% Cost Estimate	5	75	18-Oct-10	
12	Engineering During Advertisement	20	95	8-Nov-10	

5. Engineering Studies, Investigations and Design

A. Project Features

This section includes basic descriptions of the project features as well as basic plans for construction of these features based on analysis. For further description of the project features as well as full analyses narratives and computations, please refer to the appropriate appendix following this report.

B. Geotechnical Investigation and Analysis

1. See Appendix C for analysis results and conclusions.
2. Field investigations: test borings and cone penetration tests

The soils underlying the Orleans Avenue Canal were evaluated by a number of borings obtained from past investigations. Twenty borings were drilled along the alignment of the canal, on both the west and east sides between 1970 - 1973 and 1984 - 1985. They have various designations including OUW-#, OUE-#, and OUG-#. Sixteen of the borings were obtained using a 5-inch diameter, undisturbed sample. Four of the borings utilized a 1 7/8-inch ID core barrel or 1 3/8-inch split spoon sampler. Selected samples from these borings were tested in a geotechnical laboratory to estimate their mechanical properties and classified mainly by USACE personnel. Additionally, 52 borings and associated laboratory tests completed by a contractor in 1985 as part of work commissioned by the Orleans Levee Board, were used as part of the original effort to design the I-Wall and T-Wall designs. All of these borings are provided in DM 19A. They are designated B-1 through B-52. Tables taken from DM 19A, detailing boring names, locations and dates, are provided in Tab 5 of the geotechnical report for reference

In May 2010, 45 CPTs were completed along Orleans Avenue Canal. See Appendix C for the CPT logs.

Only borings and CPTs in the vicinity of Reaches 10A, 10B and 4(new18A and 18B) were utilized in the analyses for this project, and they are noted on the strengthlines. See Appendix C for the strengthline figures.

3. Stratigraphy and Strengthlines

In developing the stratigraphy and strengthlines for the Reaches, URS plotted available laboratory test results as well as shear strength data from recent CPTs. Only data from borings and CPTs in the vicinity of Reaches 10A, 10B and 4(new18A and 18B) were considered for the plots. The geological profile from DM 19A, which considered a wider range of test data, was also referenced to assist in the interpretation of stratigraphy trends. Shear strength and unit weights versus elevation were plotted separately for toe and crest, to account for differences in overburden pressure.

Strength and unit weight parameters for design were developed per HSDRRS guidelines. Shear strength gain in the clays due to consolidation was estimated based on a c/p' ratio of 0.22. The strengthlines were generally drawn such that approximately one-third of the shear test result points fall below the strengthline and two-thirds above. Where laboratory shear strength tests were unavailable, more attention was given to the shear strength plots from the CPTs and the c/p' ratio. In accordance with the Clarifications to the Scope of Work document, the undrained shear strength of existing artificial levee fill was limited to a maximum of 600 psf, even though test data may indicate higher values.

The corresponding wet unit weight specified was 115 pcf. The strengthlines developed by URS for this project were compared to those developed as part of DM 19A for general consistency, and are shown in the Geotechnical Report.

4. Geotechnical Analysis Sections

I-Wall cross-sections for the project were cut every 50 ft. from surveyed topographical data along the alignment on the east and west sides of the canal. After review, critical cross sections for each reach were chosen for the geotechnical analyses. These cross-sections are shown in the Geotechnical Report.

The bottom of sheetpile elevation was determined based on a recent survey of the top of I-wall elevations. The sheetpile depths shown on as-built plans were subtracted from top of wall elevations to estimate the current sheet pile tip elevations The calculated elevations were all very close, so the most conservative elevation, -27.5 ft, was used for the geotechnical analyses of all Reaches.

5. Seepage analysis and Gap Calculation

A seepage analysis and gap calculation was performed for each reach in accordance with the guidelines provided in "Stability Analysis of I-Walls Containing Gaps between the I-Wall and Backfill Soils". A SEEP/W finite element model was used to calculate hydrostatic pressures on the existing sheet pile wall and pore pressures in the sand. Although the sheet pile itself was assumed to be 100% effective, or impervious, the sheet pile does not cutoff the sand layer Permeability values used are summarized on Table 5.1. The sheet pile wall was modeled as 0 5 feet thick element with a very low permeability. Boundary conditions consisted of "no drainage" on the flood side and bottom perimeter while a piezometric "curb" elevation of 2-ft below the ground surface was used as the boundary condition on the protected side.

Table 5.1 – Material Properties used in the Seep/W Analyses

Material	k_h (cm/s)	k_h (ft/s)	k_v/k_h
Embankment Fill	1.0×10^{-6}	3.28×10^{-8}	1
Marsh	1.0×10^{-5}	3.28×10^{-7}	1
Beach Sand	1.0×10^{-3}	3.28×10^{-5}	1
Bay Sound Clay	1.0×10^{-6}	3.28×10^{-8}	1

Assuming a Safe Water Elevation of +8 ft, hydrostatic water pressures along the sheet pile wall were obtained from the SEEP/W run. The calculated pressure points were entered into an Excel spreadsheet, which was created to calculate gap depth as well as the

magnitude and elevation of horizontal resultant forces to be used in the global stability analysis. The spreadsheet was verified by checking with hand calculations. Soil properties used for the gap analyses are the same properties as those used for the global stability analyses. The analysis is similar to GCAT Case 3, in which the I-wall penetrates sand below a clay levee and foundation stratum.

It is evident that a gap along the sheet pile will propagate to the top of the sand layer at El.-12 and hydrostatic water pressure would be applied to the sheet pile between the canal water elevation and the bottom of the gap. Based on the guidelines, it was assumed that the sand layer would not sustain the gap. Effective active earth pressures were calculated in sand between the bottom of the gap and the tip of sheet pile using pore pressures calculated from SEEP/W finite element analyses. The equivalent forces due to the effective active earth pressures below the gap were calculated and used in the stability analyses as described in the GCAT procedure.

6. Stability analysis

Global stability analyses were performed on each of the Design Cross Sections. SLOPE/W (Version 7.17) was used as the main design tool for a Spencer's method analysis, and Method of Planes (MOP) computer program was used as a design check, in accordance with standard procedures. The stability analyses were performed according to the current HSDRRS Design Guidelines.

A safe water level of EL +8 ft was analyzed, as well as a low water condition of EL -3 ft, and S-Case conditions. Piezometric lines used for both SLOPE/W and MOP stability analyses were produced from the SEEP/W runs. It was assumed that no failures would occur through the sheet pile. For the purpose of stability analysis, the no-failure zone was conse vatively assumed to begin at an elevation 5 ft above the calculated sheet pile tip elevation, which is -22.5 ft for this project.

In addition to the other global stability analyses, a gap analysis was also performed on the I-wall per the guidelines provided by the Hurricane Protection Office (HPO) with USACE. For this analysis, the water and all soil material on the flood side of the sheet pile is removed from the surface to the tip of the sheet pile. The hydrostatic pressure and active earth pressures are replaced by resultant forces acting on along the sheet pile. The resultant forces utilized were obtained through the gap calculation procedure described in Section 4.3 of Appendix C.

A summary of the safety factors for the I-wall analyses is presented in Tables 4.1 through 4.4. Graphical presentations of the results are presented by the Slope Stability Analysis Results in the Geotechnical Report. Details of the analyses are attached to this report in the stability ITR packages in TAB-3 of the Geotechnical Report.

The critical cross-sections were also checked for possible local failure; however, the

objective of this project is the immediate need to remediate the existing I-wall structures to meet the HSDRRS Design Guidelines for the Q-cases at Safe Water Elevation of +8.0, not stability of the embankment slopes which have historically performed adequately under long term and fluctuating tide conditions. Inadequate safety factors were indicated for local failures for protected side of Reach 4 (Q-Case) and for all of the drained S-case analyses. It was decided that the inadequate safety factors for S-cases were unrealistic and should not be reported due to the following factors:

1. The drained case parameters ($\phi = 23°$) may be a conservative assumption

2. The performance of the retaining wall on the existing the protected side for Reaches 10A, 10B and 4(new18A and 18B) was not considered in the model. It is beyond this scope of work to consider the stability of the protected side retaining wall.

C. Civil Design

1. Traffic Control and Detour Design

The road closures and detours will be coordinated with the City of New Orleans. The contractor is required to inform local emergency services prior to the roadway closures. The roadway closures and detours were designed in accordance with MUTCD, AASHTO and LADOTD criteria

D. Water Control Plan

The existing I wall will remain in place throughout construction, and there are no excavations or work on the flood side of the I-wall. Therefore no water control plan is included in the project.

E. Relocations

No utility relocations are expected on the project.

F. Water Quality

The contractor is responsible for the development and implementation of the Storm Water Pollution Prevention Plan (SWPPP) as required by the Louisiana Department of Environmental Quality and as listed in the specifications.

G. Disposal Areas

The contractor is responsible for the disposal of debris, trash, and excess excavated material per the specifications.

H. Government Furnished Property

No government furnished property is anticipated for this project.

I. Vibration

For Reach 10A and 10B, the work is adjacent to residential buildings. Haul trucks should be observe all traffic speed signage in order to reduce the possibility of vibrations. Pre-construction video survey should be conducted (see specifications). For Reaches 18A and 18B, the expected construction equipment and the nature of the work should not cause excessive vibrations to occur.

J. Borrow Material

All Embankment material is supplied by the government in accordance with the specifications.