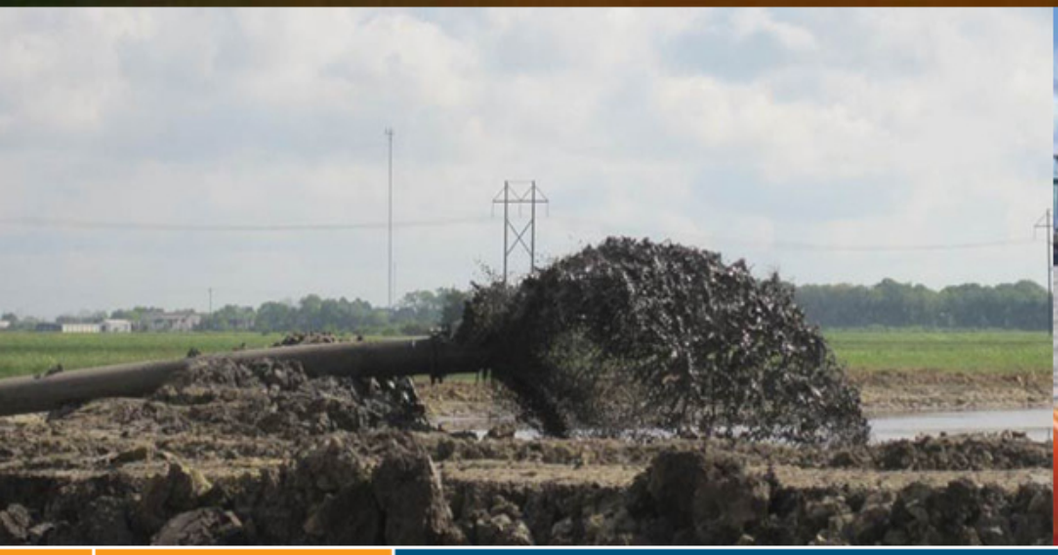
Atchafalaya River Long Distance Sediment Pipeline Feasibility Study (Phase I)

Prepared for the
Terrebonne Parish Consolidated Government
July 2014



Submitted by CBI

Atchafalaya River Long Distance Sediment Pipeline Feasibility Study-Phase I

Terrebonne Parish, Louisiana

July 2014

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1.0 General

1.1 Introduction

CB&I Coastal, Inc. was retained by Terrebonne Parish Consolidated Government (TPCG) to provide engineering services for the Atchafalaya Long Distance Sediment Pipeline project, Contract B, including design criteria of a sediment pipeline conveyance system and cost comparison development.

The TPCG, Department of Coastal Restoration & Preservation has received Federal Coastal Impact Assistance Program (CIAP) funds to develop the feasibility study (project). The project involves a feasibility level analysis of a long distance sediment pipeline for moving dredged sediments from available sources within the Atchafalaya Basin eastward into the sediment deficient marshes of central and eastern Terrebonne Parish. If implemented, this project will replenish sediment in the sediment-starved areas of the Barataria-Terrebonne basin.

TPCG has selected four endpoint target areas for sediment transport: Bay Raccourci, the open area south of Falgout Canal, west of Bayou Dularge and east of the Houma Navigational Canal, areas near Lake Tambour and areas in the vicinity of Wonder Lake (Figure 2-1). This feasibility study is the initial step required in designing a long distance sediment pipeline to help restore these critical marshes. The overarching project goals are to:

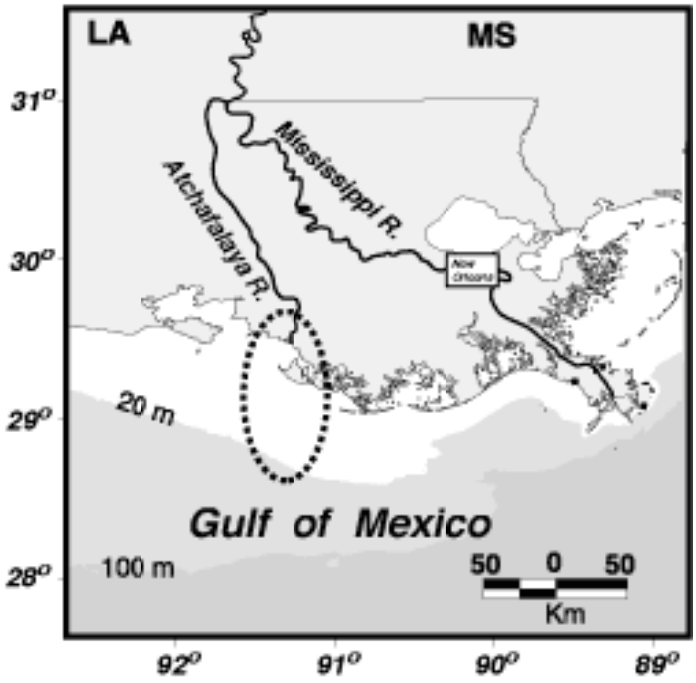
- Develop a feasibility study to install and operate a sediment delivery system
- Develop a feasibility study to restore marsh habitat in the central Terrebonne Hydrologic Basin

Other factors and assumptions considered in this feasibility study are:

- Minimization of execution risks
- Incorporation of construction industry's highest standards
- Innovative approaches towards cost savings
- Consistency with the Louisiana State Master Plan and other initiatives
- Consideration of engineering, economics, and environmental principles (EEE Principles)

The Atchafalaya River is a distributary of the Mississippi and Red Rivers. The Atchafalaya River is approximately 137 miles long and flows south, west of the Mississippi River. The

Atchafalaya River navigation channel is used extensively by various industries. USACE maintains this channel to an authorized depth of -20 feet N.A.V.D. 88 through their dredging program.



Source: http://en.wikipedia.org/wiki/Atchafalaya_River

Figure 1-1 Atchafalaya River and Delta Region

The Atchafalaya originates at the confluence of the Red and Mississippi Rivers and receives 30 percent of the Mississippi River's discharge as well as 100% of the Red River's. The volume of water allowed from the Mississippi River into the Atchafalaya is controlled by the Old River control structure. The Old River forms a seven-mile long channelized connection between the Red and Mississippi Rivers.

The Atchafalaya River has an abundance of sediment. A significant amount of sediment, suspended and bed is transported through this river, which results in a growing delta near the Gulf of Mexico. However, the abundance of sediment also clogs connecting waterways, resulting in the need for continuous maintenance dredging and significant funding expenditures dedicated to this activity on an annual basis. Unfortunately, there is less interaction between the Atchafalaya River and the eastern portion of the Barataria-Terrebonne Basin. The 2007 Louisiana's Comprehensive Master Plan for a Sustainable Coast recognizes the importance of restoring wetlands and provides measures for its sustainability.

The 2012 Master Plan's goal for the Central Coast states "Maintain the land building capacity of the Atchafalaya region, while increasing the use of Atchafalaya River sediment and water east to Terrebonne Parish to sustain the coastal ecosystem. Rebuild marshes, barrier islands, and ridges." Therefore, the proposed project scope is consistent with the master plan.

1.2 Project Components

1.2.1 Borrow Area Evaluation

A desktop evaluation of potential borrow locations and available volumes was performed as part of the study by Moffat and Nichol (M&N). Dredging history, sediment quantities, and average sediment refill rates in the Atchafalaya River and nearby areas were used to identify potential borrow sites. This information was also used to select the point(s) of sediment intake for the proposed long distance sediment pipeline. CB&I performed analysis of pipeline routes and transport methods for each of the four proposed fill areas.

1.2.2 Pipeline Corridor Evaluation

Terrebonne Parish had preliminarily identified the Tennessee Gas Pipeline (TGP) and Columbia Gulf Pipeline (CGP) corridors as potential sediment pipeline routes. The final proposed sediment delivery corridor (to include trunk line and laterals) was evaluated to accommodate equipment required for pipeline construction. The proposed corridor was also evaluated for accessibility during construction and maintenance, as well as other considerations such as infrastructure crossings, length, elevation change, number and extent of bends, and general constructability. CB&I assisted the Parish with engaging stakeholders and adjacent and intersecting infrastructure owners.

CB&I also developed a conceptual design for the proposed pipeline system based on the following criteria:

- Pipeline diameter and wall thickness
- Wear rates depending on type of borrow material and type of pipeline material
- Flow rates and head losses to assist in the location of booster pumps
- Slurry ratios
- Flow rates vs. head loss vs. booster energy
- Cost per additional segment for a scalable system
- Location of booster stations.

1.2.3 Placement Area Evaluation

Discharge area development was conducted through the examination of several factors based on the effectiveness, benefits, acreage, constructability, land ownership and existing oil and gas infrastructure. The proposed discharge locations are chosen to optimize sediment availability, cost and the project timeline. CB&I evaluated the feasibility of confined and unconfined discharge approaches. Nearby existing channels and navigable waterways were also evaluated regarding the feasibility of access for on-site construction equipment as well as maintenance. CB&I contacted and coordinated with adjacent landowners about facilitating the construction and continued maintenance of the sediment delivery system.

1.3 Methodology

1.3.1 Surveying

CB&I and its team conducted a reconnaissance-level field survey that evaluated the feasibility of utilizing the existing gas pipeline corridors for the sediment delivery system. This survey consisted of photographs, GPS coordinates of pipeline crossings, obstructions, etc., and collecting spot water depths within the channels of the potential routes. This preliminary data was used as the basis for the field work in the second phase of this project.

1.3.2 Geotechnical Analysis

CB&I and its team conducted a desktop geotechnical investigation of the proposed pipeline route to determine if soil conditions along the route could support the weight of a pipeline and how the soil conditions may affect the constructability of the project. The team researched available geotechnical, topographic, and geologic information as well as examined the existing database of borings in the region. All data were collected and developed into geologic and stratigraphic profiles. Possible uncertainties and inconsistencies that may affect the project were identified. The team assessed the constructability of the pipeline, including the stability of open cuts, potential settlement of pipelines placed in open water or buried in trenches, and support for booster stations. This is achieved by summarizing preliminary engineering calculations and preliminary estimates of settlement of dredged materials placed in the proposed placement areas. Recommendations are made for final investigations along the selected pipeline route and placement areas to be used. These will the basis for the field work in the second phase of this project.

1.3.3 Cultural Resources Survey

In order to ascertain the long distance sediment pipeline project's potential impacts on cultural resources along the proposed pipeline routes and areas where sediment will be deposited, CB&I and its team conducted research focused on historical, literature and site file investigations for the Terrebonne project area. Research was initiated by contacting the

Louisiana State Archaeologist and State Historic Preservation Officer, followed by a survey of the state maintained archaeological site files to collect specific information on previously identified and investigated cultural resources in the immediate vicinity of pipelines and restoration areas.

2.0 Project Area

2.1 General

The Atchafalaya River has deposited nutrient rich sediment that has helped build coastal Louisiana and continues to rebuild areas that have been subjected to subsidence and erosion. The river influence is mostly concentrated in the western portions of the Terrebonne Basin. Most of the Terrebonne basin is starved of sediment as the Atchafalaya and Mississippi Rivers do not contribute to its sediment, freshwater, or nutrient budget.

The Terrebonne Basin is an abandoned delta complex, characterized by a thick section of unconsolidated sediments that are undergoing dewatering and compaction. This process contributes to high subsidence rates and a network of old distributary ridges extending southward from Houma. The southern end of the basin is defined by a series of narrow, low lying barrier islands (the Isle Derniers and Timbalier chains) separated from the mainland marshes by a series of wide, shallow lakes and bays (eg. Lake Pelto, Terrebonne Bay, Timbalier Bay). (LCA, 2005)

Terrebonne Basin consists of four sub-basins including Timbalier, Penchant, Verret, and Field. The placement areas considered for this study are located in the Penchant and Timbalier sub-basins. Bay Raccourci is located in the Penchant sub-basin and Flagout Canal, Lake Tambour, and Wonder Lake are in the Timbalier sub-basin.

2.2 Sub-Basin Description and Habitat Conditions

2.2.1 Penchant Sub-Basin

The Penchant sub-basin is located south of Bayous Boeuf and Black, east of the Atchafalaya River and Atchafalaya Bay, west of Bayou Dularge, and includes Point Au Fer Island. Major habitats of this sub-basin include large areas of highly organic fresh floating marsh and mineral brackish marsh. Freshwater from the Atchafalaya River, Bay, and the Gulf Intracoastal Waterway (GIWW) flows into the system through a number of bayous and canals.

Eastern reaches of this sub-basin suffer from salt water intrusion and subsidence. These problems are aggravated by landscape modifications such as the Houma Navigation Canal (HNC), GIWW, and oil and gas activities, which have caused substantial hydrologic changes to the basin. Impediments to the natural distribution and retention of sediment and freshwater have caused significant problems and severely reduced freshwater movement to the eastern Terrebonne marshes. In addition, the increasing influence of the Atchafalaya River has

introduced higher velocity turbid water into fresh marshes with fragile organic soils, including floatant marshes, in the western reaches of this subdivision.

2.2.2 Timbalier Sub-Basin

Habitats in the Timbalier sub-basin range from organic freshwater and organic fresh marsh to saline marsh. This sub-basin receives freshwater from rainfall events as well as from the Atchafalaya River inflow to the GIWW by the way of the HNC and Grand Bayou Canal. There are 71,000 and 153,000 acres of brackish and saline marshes, respectively, which exist in Timbalier sub-basin.

The Timablier sub-basin loses more acreage of wetlands per year than any other sub-basin within Terrebonne Basin due to its isolation from freshwater and sediment input and its substantial rate of subsidence. Natural deterioration of barrier islands contributes to the increased influence of the marine tidal process (including erosion, scour, and saltwater intrusion).

2.3 Borrow Areas

Using readily available information, Moffatt & Nichol identified and delineated potential borrow areas for the sediment pipeline as well as estimated sediment volumes and refill rates of the potential sites. The first step in identifying the potential borrow sites was to locate shallow sections along the river that contained large volumes of sediment that could be reached by conventional dredges and also have naturally high rates of sediment deposition. Once identified, the potential sites were further analyzed to refine and identify certain areas of concern or challenges during dredging operations.

The potential borrow sites for the long distance sediment pipeline are located within the Atchafalaya River sediment balance boundaries, in the vicinities of the Atchafalaya River, Bayou Boeuf, Bayou Black, Bayou Chene and Bayou Shaffer (Figure 2-1). These areas are discussed in detail in Section 3.0.

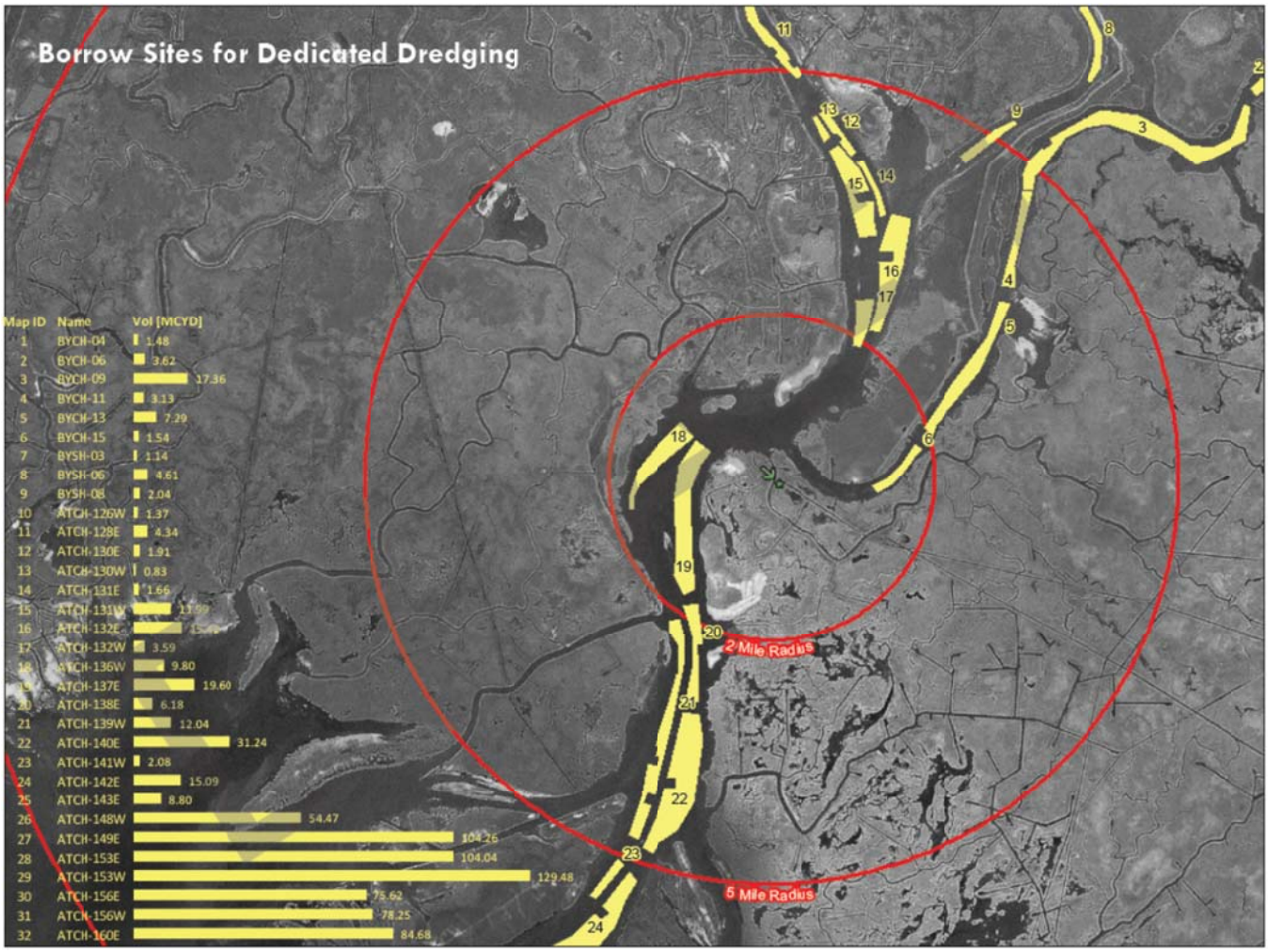


Figure 2-1 Potential borrow sites for the long distance sediment pipeline project (from M&N 2013 & 2014)

2.4 Pipeline Corridor

The pipeline corridors considered are located in the coastal zone and consist of fresh and intermediate marsh inland and salt marsh near the bays and Gulf. The topography is mostly flat marsh with drainage channels and water body crossings. The corridors are located within distributary lobes of the Mississippi River, and therefore, the area consists of abandoned distributaries, ridges, and inter-distributary deposits. These corridors serve as pipeline/utility corridors. There is no predominant land use along the corridors. Minor developments are observed along some segments of the corridor as it traverses populated areas.

2.5 Placement Areas

The pipeline will deposit sediment to the east, to areas selected by Terrebonne Parish in the vicinities of Bay Raccourci, Falgout Canal, Lake Tambour and Wonder Lake. Having little interaction with the Atchafalaya River, these fill areas are located outside of the Atchafalaya River sediment balance boundaries; therefore, they are not naturally replenished with sediment deposits. The principal remaining formative process in the development and maintenance of these swamp and marsh areas is the accumulation of peat from plant deposits. The capacity of marsh plants to replenish soils through the formation of peat is insufficient to counteract subsidence and erosion, which have become the dominant processes in the marshes of the study area. The location of the placement areas are shown in the Figure 2-2.

The four locations for sediment placement are part of the Terrebonne Basin. Terrebonne Basin (which includes all of Terrebonne Parish and parts of Lafourche, Assumption, and St. Martin Parishes) is bordered by Bayou Lafourche on the east, the Atchafalaya Basin floodway on the west, the Gulf of Mexico on the south, and the Mississippi River to the north. Bay Raccourci is located approximately 22 miles east of the mouth the Atchafalaya River, Falgout Canal is approximately 30 miles east of the river's mouth, and Lake Tambour and Wonder Lake are located approximately 40 miles east of the mouth of the Atchafalaya River. Further examination of the placement areas is discussed in Section 6.0.

3.0 Borrow Area Evaluation & Dredging Considerations

3.1 Design Criteria and Assumptions

The information provided here is a synopsis of the reports that M&N submitted to Terrebonne Parish tilted "Atchafalaya River Long Distance Sediment Pipeline-Preliminary Borrow Site Identification Report" and "Atchafalaya River Long Distance Sediment Pipeline: Final Borrow Site Identification Report, Final Report May, 2014".

One of the assumptions coordinated between CB&I and M&N pertains to the approximate point of sediment intake. The distances discussed in the M&N report between borrow locations and the point of sediment intake is based on this assumption. The potential sediment intake location (Figure 3-1) is assumed to be in close vicinity of Crewboat Cut and is validated by the general consensus that was reached by the stakeholders. This assumption is valid since the potential location has proximity to the two pipeline corridors that were considered as potential sediment pipeline routes for this project.

Figure 3-1. Potential Location for Intake Structure

M&N's approach to borrow area evaluation was comprised of two phases:

- Phase 1: Preliminary borrow sites identification and estimation of associated borrow volumes as well as an initial desktop estimation of refill rates for the borrow sites.

- Phase II: Detailed assessment of refill rates through numerical modeling for selected set of borrow sites.

The identification and estimation of potential borrow areas and volumes are based on availability of sustainable sources of large quantities of sediment. To achieve this objective, M&N utilized USACE data primarily and other available data on the Atchafalaya River and associated bayou systems. In addition, factors such as proximity to Atchafalaya River levees and revetments, potential conflicts with oil and gas infrastructure in the vicinity, navigational concerns, and other factors were considered. As a study approach for sediment availability, M&N considered two concepts for evaluating potential borrow sites, utilizing beneficial use of dredged material from USACE's maintenance dredging program and potential dedicated borrow sites.

The details regarding factors considered for sediment source identification is described in detail in the M&N Reports (M&N, 2014 a & b).

The following paragraphs detail the major findings of potential borrow locations and available sediment quantities for the proposed project. The analysis was focused on the following:

- The availability of dredge material based on USACE's annual navigational channel maintenance of the Atchafalaya River systems (beneficial use of dredge material)

- Dedicated dredging locations for the proposed project

3.1.1 USACE Channel Maintenance -Beneficial Use of Dredged Material

The annual maintenance dredging performed by USACE in the Lower Atchafalaya River produces approximately 3.9 million cubic yards of dredged sediments that are potentially available for beneficial use. These areas include Horseshow Bend/ Crewboat Cut, Bayou Chene, the Upper and Lower Bay Channels and a small portion of the Bar Channel (Table 3-1). These locations have already been permitted by USACE and most of them fall within a 10 miles radius from the point of intake.

Table 3-1 Historical Annual Average Dredged Volumes (USACE 2012)

Dredging Reach	Annual Average Dredged Volume 2001-2012 (CY)
Bayou Black	207,709
Bayou Chene and Avoca Island Cutoff	732,263
Horseshoe Bend	593,075
Atchafalaya Bay Channel	949,909
Atchafalaya Bar Channel	12,256,305
Historical Annual Total Average Dredged Volume	**14,700,000**

However, all of the dredge locations listed in Table 3.1 are not listed by USACE for maintenance dredging/disposal from 2014 to 2030. Other risks involved are the unreliable predictions of availabilities of sediment volume through 2030 and federal funding, which determine the frequency of dredging.

An overview of the potential beneficial use of dredge material is provided in Table 3-2, which lists the USACE dredge reaches and the project volumes of dredge material based on USACE's DMMP (USACE 2012) and qualitative characteristics of the dredge volumes.

Table 3-2 USACE Projected Dredge Volumes and Cost (including mobilization and demobilization and 25% contingency) through 2030 (USACE 2012)

	Bar Channel		Bay Channel		Horseshoe/Crewboat		Bayou Chene		Bayou Black	
Year	Vol (M CYD)	Cost	Vol (M CYD)	Cost	Vol (M CYD)	Cost	Vol (M CYD)	Cost	Vol (M CYD)	Cost
2011	12,300,000	$ 20,807,947.05	1,500,000	$11,302,021.36	1,100,000	$ 7,414,400.60	-	$ -	-	$ -
2012	12,300,000	$ 20,807,947.05	500,000	$ 5,244,187.68	1,100,000	$ 7,414,400.60	4,400,000	$26,318,325.29	-	$ -
2013	12,300,000	$ 20,807,947.05	1,500,000	$10,560,702.55	1,100,000	$ 10,581,890.99	-	$ -	-	$ -
2014	12,300,000	$ 18,183,345.13	500,000	$ 3,827,402.61	400,000	$ 3,988,009.18	-	$ -	-	$ -
2015	12,300,000	$ 18,183,345.13	1,500,000	$10,497,285.55	-	$ -	-	$ -	-	$ -
2016	12,300,000	$ 18,183,345.13	500,000	$ 5,041,511.98	-	$ -	4,400,000	$21,638,020.59	-	$ -
2017	12,300,000	$ 18,183,345.13	1,500,000	$10,796,629.08	750,000	$ 9,964,042.70	-	$ -	-	$ -
2018	12,300,000	$ 18,183,345.13	500,000	$ 4,652,203.68	-	$ -	-	$ -	-	$ -
2019	12,300,000	$ 18,183,345.13	1,500,000	$11,290,227.35	-	$ -	-	$ -	-	$ -
2020	12,300,000	$ 18,183,345.13	500,000	$ 5,145,531.93	750,000	$ 9,964,042.70	4,400,000	$23,187,512.06	2,000,000	$ 10,090,173.76
2021	12,300,000	$ 18,183,345.13	1,500,000	$10,243,160.58	-	$ -	-	$ -	-	$ -
2022	12,300,000	$ 18,183,345.13	500,000	$ 4,815,798.73	-	$ -	-	$ -	-	$ -
2023	12,300,000	$ 18,183,345.13	1,500,000	$13,147,717.29	750,000	$ 9,964,042.70	-	$ -	-	$ -
2024	12,300,000	$ 18,183,345.13	500,000	$ 5,864,873.29	-	$ -	4,400,000	$23,187,512.06	-	$ -
2025	12,300,000	$ 18,183,345.13	1,500,000	$11,164,534.26	-	$ -	-	$ -	-	$ -
2026	12,300,000	$ 18,183,345.13	500,000	$ 4,806,434.08	750,000	$ 9,964,042.70	-	$ -	-	$ -
2027	12,300,000	$ 18,183,345.13	1,500,000	$10,315,840.39	-	$ -	-	$ -	-	$ -
2028	12,300,000	$ 18,183,345.13	500,000	$ 4,999,628.59	-	$ -	4,400,000	$23,187,512.06	-	$ -
2029	12,300,000	$ 18,183,345.13	1,500,000	$10,974,989.69	750,000	$ 9,964,042.70	-	$ -	-	$ -
2030	12,300,000	$ 18,183,345.13	500,000	$ 4,861,114.46	-	$ -	-	$ -	-	$ -
Avg/Year	**12,300,000**	**$ 18,183,345.13**	**970,588**	**$ 7,790,875.50**	**244,118**	**$ 3,165,189.57**	**1,035,294**	**$ 5,364,738.63**	**117,647**	**$ 593,539.63**

(Note: Averages are taken from 2014 through 2030)

One way to alleviate the federal funding concerns and the maintenance dredging uncertainty is to consider the Horseshoe Crew boat Cut Disposal Area as a potential "sump". This sump could provide a storage location for the disposed sediment from various events of maintenance dredging to be mined for this project, thereby making sediment availability independent or less dependent on federal funding.

Recently, an approval was granted to the U.S. Army Corps of Engineers, New Orleans District to re-align the federally-authorized navigation channel to Crewboat Cut instead of the Horseshoe Bend reach. (KATC.com; October 21, 2011).

In conclusion, the beneficial use of dredge material cannot be considered as a sustainable source of sediments for this project since significant sources are not listed in USACE's maintenance program scheduled from 2014 through 2030. In addition, unreliable predictions of sediment volume availability through 2030 and the uncertainty of federal funding, which determine the frequency of dredging, add uncertainty and risk to the proposed project implementation.

3.1.2 Dedicated Borrow Sites

M&N analyzed the dedicated borrow sites identified within a two-mile radius and sites between two and five miles from the point of intake. The study determined that there is a substantial amount of borrow material available if a cut depth of -70 feet is assumed as a vertical limit for the sites within the River. Based on these preliminary borrow areas, M&N estimates that there is an approximate volume of 146 M cubic yards (CY) of sediment available within the Atchafalaya River, including Bay Channel (34 M CY) and 8 M CY potentially available within Bayou Chene and Shaffer. The borrow sites delineated in the Bar Channel area hold a potential of 360 M CY. However, there are two disadvantages to Bar Channel borrow sites that must be taken into account. The distance between the Bar Channel sites and the potential intake structure is more than 10 miles, and the material characteristics of the Bar Channel are of poor quality for marsh restoration.

The analyses at this stage narrow down the possibility to three potential borrow sites less than two miles away from the point of intake. The two larger sites (ATCH-136 W and ATCH-137E) (Figure 3-2) contain substantially more sediment than the smaller site (in Bayou Chene), which is in closer proximity to the point of intake. The sediment in these areas is of good quality, and the refill rates based on preliminary analyses for these sites are estimated to be in order of 6 to 20 years.

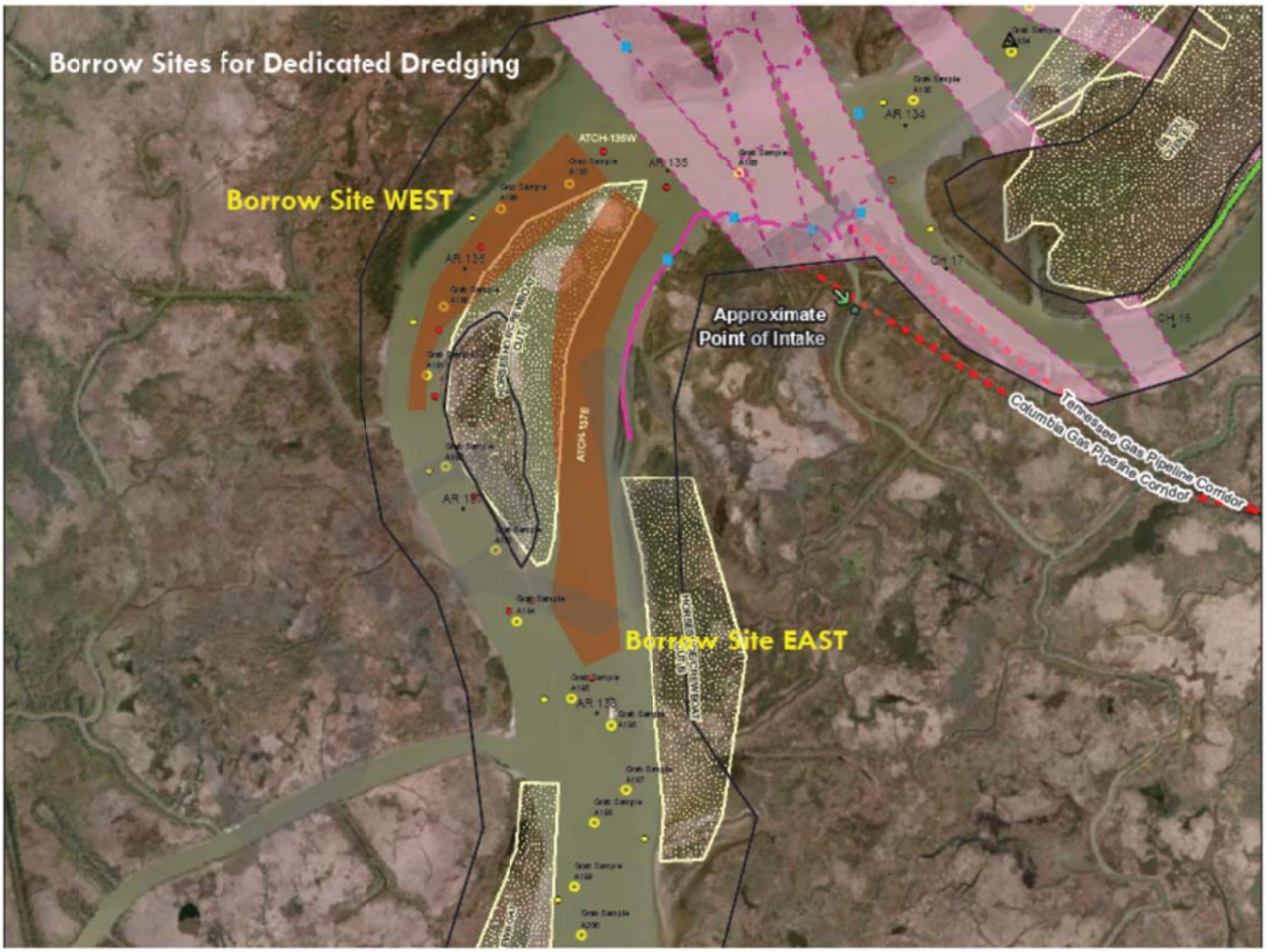


Figure 3-2. Borrow Sites for Dedicated Dredging, ATCH136 W (Borrow Site West) and ATCH 137 East (Borrow Site East), from M&N, 2013 & 2014)

The borrow sites delineated within a 2 to 5 mile radius of the point of intake was analyzed and large amounts of available sediments that are of good quality were found. However, these sites are located further from the point of intake and are preliminarily selected as Tier 2 sites. Site ATCH-140E is selected because its estimated capacity is the largest of all sites within the Atchafalaya River (excluding Bar Channel) and it is located less than 5 miles away from the point of intake. For the sites beyond the 5 mile radius, it was found that the bed material is uncertain and the distance from the point of intake could make the transport to the LDSP intake cost-prohibitive (The details are in the M&N reports (M&N 2013 & 2014).

In summary, M&N concludes that borrow sites ATCH-136W and ATCH-137E have potential availability of approximately 50 million cubic yards of borrow material in close proximity to the point of intake. It is possible that this borrow material can be dredged at the rate of 5 million cubic yards per year.

Further, M&N concludes from their annual refill volume analysis that the dredging rate of 5 million cubic yards per year can be sustained by the ATCH-137E borrow site to satisfy the 50 million cubic yards requirement.

ATCH-137E characteristics are as follows:

- Has an initial volume of 19.5 CY
- The site is estimated to have an annual average infill volume of 5.6 million CY
- The borrow site is expected to exceed the assumed demand of approximately 5 million CY/year
- 50 million CY demand for this project could be met in 6.5 years
- The slurry pipeline for transport from ATCH-137E to the point of intake will not affect navigation and has a shorter length compared to other borrow sites.

The details can be seen in M&N's report, "Atchafalaya River Long Distance Sediment Pipeline: Final Borrow Site Identification Report, Final Report May, 2014".

3.2 Dredging- Conceptual Considerations

Based on M&N's analysis of borrow locations, CB&I assumes that the intake structure can be located in the vicinity of the pipeline corridor. The structure will be positioned in the Atchafalaya River near Horseshoe Bend and will be designed to accommodate both hopper and cutter head dredges, if necessary. The intake structure will include a raw water intake pump to be used to flush the pipeline. The discharge from a cutter head operating in the River will connect directly to the intake structure. Hopper dredges will mine the borrow area and then dock in a mooring area adjacent to the intake structure. They will re-slurry their load and discharge directly into the intake structure using a pump and discharge piping.

4.0 Pipeline Corridor Evaluation

4.1 General

This section describes the process of identifying feasible corridor alternatives for the study to select the preferred route and includes an in-depth field assessment of the preferred corridor route.

The evaluation is to eliminate corridors that do not appear technically feasible, economically reasonable and consistent with the Louisiana State Master Plan or do not meet Terrebonne Parish's goals. In addition, the proposed pipeline corridor requires compatibility with other restoration and protection projects, system hydraulics, environmental constraints, permitting requirements, right-of-way requirements and constructability. The route assessment recognizes project goals and remains consistent with the objectives of the long distance sediment pipeline (LDSP).

The proposed corridor traverses through Terrebonne Parish easterly, beginning at the Atchafalaya River, which has been identified as the sediment source. This study defines the most logical corridor for delivery of sediment from the sediment source to the areas identified by the Parish.

CB&I performed a desktop evaluation of three pipeline corridors that were considered as possible corridors for the LDSP. The pipeline corridors identified were the Tennessee Gas Pipeline (TGP), the Columbia Gulf Pipeline (CGP), and Bar Channel – Southern Pipeline Corridor (BCS). The BCS alternative was discussed early on due to the importance of utilizing sediments from the Bar Channel. BCS begins near the Bar Channel and proceeds east towards Central Terrebonne Parish. It is conceived to traverse north on Bayou Dularge Ridge (Master Plan 2012 project list). This alternative was eliminated in the preliminary analysis after careful considerations of economical, engineering, and environmental parameters such as environmental permitting constraints, hurricane impacts to pipeline infrastructure due to exposure, construability constrains, and cost constraints.

Only TGP and CGP corridors are considered for further analysis. Figure 4-1 shows the TGP, the CGP and the BCS. TGP and CGP were chosen because they made use of existing pipeline right-of-ways and are supported by the pipeline companies and adjacent land owners. The approach and results of the corridor evaluation will be discussed in this section. The centerline of each corridor was then analyzed in GIS for environmental impact, land use, engineering design, constructability and operational integrity. Based on the comparison of

the alternatives coupled with reconnaissance observations, a preferred corridor was selected. Further analysis on the preferred corridor will be completed in later phases of study.

4.2 Desktop Review of Corridor Alternatives

CB&I developed maps of the potential corridors by gathering existing pipeline data from the State of Louisiana and other agencies and public GIS databases.

The desktop evaluation was conducted utilizing GIS data, USGS Quadrangle Maps, and current aerial imagery to characterize, evaluate, and refine each corridor. The evaluation was used to select the preferred corridor and to identify areas that should be further evaluated in detail by field and aerial reconnaissance study for the preferred alternative. Corridor options were then reviewed by a multi-disciplinary team (engineering, construction, environmental, regulatory, and land) using aerial imagery and the GIS data to identify potential issues with both proposed corridors. This analysis resulted in more realistic corridor options for subsequent comparison of the data using GIS. Every effort was undertaken to avoid cities and towns, federally or state protected lands, and limit the number of crossings to the extent practicable in the development of a route within the preferred corridor.

4.2.1 Corridor Analysis

The approximate locations, exclusion areas, and opportunities for marsh creation were mapped by CB&I for a desktop evaluation and the general description of each corridor is given below.

4.2.1.1 Tennessee Gas Pipeline (TGP)

The existing TGP pipeline corridor runs approximately 42 miles southeasterly beginning at the Atchafalaya River and ending at the Houma Navigational Canal. The existing right-of-way is forty (40) feet in width and contains a 24” high pressure gas pipeline owned and operated by Kinder Morgan Energy Company. Access channels were dredged for the construction of the gas pipeline and those access channels are still in use today. However, in order for the proposed sediment pipeline to reach Lake Tambour and Wonder Lake, the sediment pipeline corridor must be extended another 15 miles out of the TGP corridor. This extension brings the proposed long distance sediment pipeline to 57 miles in length. The TGP pipeline right-of-way is shown in the attached Figure 4-2.

4.2.1.2 Columbia Gulf Pipeline (CGP)

The CGP begins at the Atchafalaya River and also runs southeasterly in Terrebonne Parish. The pipeline runs north of Bayou Decade and appears to terminate near Chauvin, Louisiana. CB&I was unable to obtain the dimensions for CGP’s existing right-of-way for this study. The CGP pipeline right-of-way is shown in the attached Figure 4-3.

4.2.2 Pipeline Corridor Criteria

In the course of identifying potential corridors within the study area, sediment availability, right-of-way availability, and areas of greatest sediment needs were established for comparison of corridor alternatives.

The following aspects related to the design, construction and maintenance of long distance sediment pipelines were considered in the evaluation and determination of the pipeline corridor. As stated in USACE ERDC TR-11-2 (USACE 2011), certain factors included but were not limited to the following:

- Location(s) of sediment source
- Locations of dredged material placement
- Lands, easements and ROWs
- Environmental resources (e.g., wildlife habitats)
- Topography and bathymetry
- Presence of access channels
- Presence of oil and gas pipelines
- Physical obstructions (levee protection, railroads, etc.)
- Duration of pipeline life
- Use of existing infrastructure
- Synergy with other wetland restoration projects
- Utilization of existing rights of ways or co-location opportunities with other existing pipelines and other utilities to the extent practical
- Minimizing the length of the pipeline and impact to adjacent landowners
- Regulatory restrictions (permitting constraints)

4.2.3 Construction and Safety Issues

The two corridors were examined for the following construction and safety issues:

- Potential construction and operational problems
- Challenges that would affect the safety of the project's workers and operational employees or public at large
- Unduly increase potential environmental impact(s)

- Increase project footprint
- Impair construction quality
- Cause schedule delays
- Have significant effects on project cost
- Road crossings and major water body crossings

Additional factors considered were access and permitting, erosion control and restoration limitations presented by construction in such areas. CB&I anticipates the constructability for both options will be equal and require the same combination of the various types of pipeline construction that will be discussed in Section 5

4.2.4 Regulatory

The regulatory permitting process can influence routing considerations. Difficulty in obtaining permits as well as the time it takes for permits to be granted is key determinants in choosing a corridor. The use of existing right-of-ways should minimize the permitting process. CB&I projects that the use of either corridor should limit the amount of permitting required.

4.2.5 Access

There appears to be sufficient access for each of the existing routes due to the fact that both existing pipelines are currently being maintained by their respective owners. The selected pipeline route should enable year-round, 24-hour, unhindered and adequate access to the pipeline, and associated above-ground installations. Access should be available from the public highways and waterways for the equipment and materials necessary for inspections, maintenance and repairs.

4.2.6 Adjacent Property Owners

Major adjacent property owners along each of the existing right-of-ways were identified and listed in the following tables.

Table 4-1 Adjacent Property Owners: Tennessee Gas Pipeline

Land Owners:
Continental Land and Fur Co, Inc.
Henican Terrebonne Property, LLC
Apache Louisiana Materials, Inc
The Louisiana Land and Exploration Co, LLC
Buckley Terrebonne Land Development Corp

Table 4-2 Adjacent Property Owners: Columbia Gulf Pipeline

Land Owners:
Continental Land and Fur Co, Inc
Terrebonne Parish School Board
The Louisiana Land and Exploration Co, LLC
Apache Louisiana Materials, Inc
Jon L. Steinberg

CB&I met with adjacent property owners, and the majority have indicated support for the project. Previous efforts by the adjacent property owners were incorporated into this report. Although the same major landowners are along both pipeline alignments, the majority land owners are in support of using the TGP right-of-way. A map showing the adjacent property owners along the TGP right-of-way is shown in the attached Figure 4-4.

4.3 Selection of Preferred Corridor

At the conclusion of the desktop analysis, the CGP corridor was eliminated from further evaluation due to a number of reasons, including the location's lack of access to the sediment starved areas of the Barataria-Terrebonne Basin, which is not consistent with the parish's objectives for this project. The CGP's location within the Louisiana Coastal Master Plan's proposed protection levees makes this alternative inconsistent with the Master Plan objectives as well as the design constraints that would be encountered to negotiate the physical obstructions. In addition, additional R-O-W would be required for CGP and would result in significant impact to the marshes in the area. The selection criteria described in Section 4.2 were used to aid in the selection of the preferred corridor and the evaluation is summarized in the Table 4-3.

Table 4-3 Selection Criteria

Criteria	TPG	CGP
Proximity to Sediment Source/Borrow Areas	X	X
Right-of-Way	X	X
Favorable Topography	X	X
Access to Placement Areas	X	
Lack of Physical Obstructions	X	
Permitting Constraints	X	X
Additional R-O-W Required and Marsh Impacts		X
Constructability	X	X
Meeting Parish Objectives	X	
Consistency with Louisiana State Master Plan	X	

The TGP corridor was selected and carried forward for field reconnaissance. After evaluating both routes, the TGP corridor is more efficient for sediment transport because it provides immediate access to the areas in need of sediment and avoids conflicts with future coastal restoration and protection projects.

4.4 Field Reconnaissance of Preferred Corridor

Subsequent to the desktop analysis, field reconnaissance was conducted to allow for further assessment of the TGP corridor and to confirm data used during the desktop analysis and refine the corridor to reflect observations made in the field.

CB&I conducted ground reconnaissance of the TGP corridor and observed many access points in terms of constructability and identified physical features and potential crossings of the corridor. Features observed include potential pump station sites, pipeline crossings, and water body crossings. The goal of the field reconnaissance was to document obstructions in the proposed alignment, identify new or abandoned structures, observe constructability challenges and issues, observe drainage patterns and crossings, and confirm existing GIS data to improve the feasibility analysis. Photographs and locations of the existing features from the desktop route study are contained in Appendix A.

4.4.1 Topography

The preferred corridor is located in the coastal zone and consists of fresh and intermediate marsh inland and salt marsh near the bays and gulf. Field reconnaissance of the TGP corridor determined that the topography is mostly flat marsh with drainage channels and water body crossings.

A topographic/bathymetric and magnetometer survey was performed of the preferred corridor by CB&I. Twenty (20) cross sections were taken of the existing right-of-way to determine the locations of the existing pipeline, pipeline size, width of existing access channel, etc. The depth of the existing 24” gas pipeline varied from 8 to 12 feet in depth of cover. The width of the existing access waterway varied from approximately 60 to 100 feet with a water depth that varied from 2 feet to 6 feet. Water surface elevations ranged from -1 – 0 ft. NAVD 88 and ground elevations ranged from -3 to 0 feet NAVD 88. Results of the magnetometer survey are contained in Appendix B.

4.4.2 Geology and Geomorphology

The preferred corridor is located within one of the many distributary lobes of the Mississippi River as part of the deltaic system. As a result of the many bifurcations of the various distributaries, the entire area consists of abandoned distributaries, ridges, and inter-distributary deposits. These deposits are all part of the recent Holocene Age. The inter-

distributary deposits are underlain by substratum sand deposits of the Holocene/Pleistocene Age followed by Prairie Pleistocene deposits.

4.4.3 Land Use

Land use of the existing corridor is restricted and serves as a pipeline/utility corridor for the TGP and owned by Kinder Morgan Energy. Use of the existing corridor is limited to routine maintenance and inspection by Kinder Morgan. Field reconnaissance along the proposed corridor showed that there is no predominant land use along the corridor outside of the existing pipeline right-of-way. The surrounding areas predominantly consist of fresh and intermediate marsh inland and salt marsh. There is some minor development along some of the corridor segments as it reaches populated areas.

4.4.4 Environmental and Regulatory

The pipeline route and its impacts on the environment are required to be considered, justified, and approved by state and federal agencies, the general public and land owners. The surrounding areas predominantly consist of fresh, intermediate, and salt marshes. A detailed assessment should be undertaken to ascertain the impact of the pipeline on environmentally sensitive areas. Care should be taken to identify and minimize any possible effects on the following:

- Wetlands
- Sites of special scientific interest
- National parks and state parks
- Nature reserves
- Flora and fauna
- Forests/tree preservation orders
- Heritage sites/coasts
- Special areas of conservation
- Special protection areas
- Areas of outstanding natural beauty
- Ancient monuments, archaeological and ornamental sites
- Natural resources, such as catchment areas and forests
- Mineral resources

- Indigenous population sites
- Groundwater protection areas

Relevant planning and approval authorities should be contacted at an early stage to determine the requirements and the extent/coverage of an environmental impact assessment (EIA), required for a pipeline and its associated above-ground installations.

The regulatory permitting process can influence routing considerations. Due to factors relating to impacts and time delay issues associated with receiving permits, permits are a key determinant in choosing a corridor. The use of existing right-of-ways should minimize the permitting process time.

4.4.5 Sediment Pipeline Crossings

Potential crossings identified during field reconnaissance were photographed and documented by CB&I. Crossings consisted of navigable waterways, pipelines and utilities. A list of known and unknown crossings is listed below:

Table 4-4 Sediment Pipeline Crossings

1	Big Horn Bayou
2	Texas Gas PL Crossing
3	Location Canal #1
4	Palmetto Bayou
5	Location Canal #2
6	Superior Canal
7	Apache Location Canal (A-27 Well)
8	Apache Location Canal (A-29 Well)
9	Apache Location Canal (#1 Well)
10	Creole Bayou
11	Apache Location Canal (#3 Well)
12	Carencro Bayou
13	Bayou DeCade
14	Raccourci Bayou/Bay
15	Bayou Chevreau
16	Fred Bayou
17	Little Bayou Chevreau
18	Bayou Dufrene
19	Bayou Dularge
20	Bay Long

21	Bayou Sauver
22	Bayou du Nord
23	Unknown Waterway
24	Four Island Bayou
25	Unknown Waterways
26	Unknown Waterways
27	Deer Bayou
28	Unknown Waterway
29	Unknown Waterway

Crossings shall be further identified during the next phase of the study. Appropriate means and methods to construct the dredge pipeline crossings that will protect and maintain existing river and flood protection levees, canals, roads, drives, etc. will be identified. Methods of crossing the potential pipeline conflicts will be discussed in Section 5. Photographs of crossing identified during the field reconnaissance phase are contained in Appendix A.

4.4.6 Conclusion

Field reconnaissance of the right-of-way found that the location of the existing 24” gas pipeline varied within the limits of the existing 40’ right-of-way and in some cases was located outside of the platted right-of-way. In addition, the access channel varied significantly in depth and width throughout the 57 mile corridor. CB&I has developed multiple cross sections to address and account for these varying conditions.

CB&I contacted and met with TGP (Kinder Morgan) to discuss previous efforts by the adjacent landowners in regards to the use of the TGP corridor. Kinder Morgan is receptive to the idea of using the existing pipeline corridor and efforts were made previously to develop a typical section for the long distance sediment pipeline, but unfortunately CB&I was not able to obtain this information. Kinder Morgan requires a minimum of twenty-five (25) feet separation between their 24” gas pipeline and the proposed long distance sediment pipeline. In addition, temporary placement of barges and other equipment during construction over the existing pipeline will be an issue that will have to be addressed with Kinder Morgan.

5.0 Sediment Pipeline Design

5.1 General

This section discusses the design of the long distance sediment pipeline and describes the design criteria and assumptions made by CB&I. The proposed long distance sediment pipeline alignment shall utilize the existing pipeline canal and existing right-of-way to the extent possible while optimizing design, operation, and maintenance to achieve strategic restoration goals in the most efficient, cost-effective, and environmentally acceptable manner as possible.

5.2 Pipe Alignment

The proposed sediment pipeline will utilize approximately 42 miles of the existing TGP corridor and approximately 15 miles of additional right-of-way outside and beyond the TGP corridor at final build out. The proposed sediment pipeline is divided into four (4) segments determined by the required marsh creation/placement areas as shown in Figure 5-1. Laterals to deliver sediment from the trunk line to the marsh creation sites are also shown in Figure 5-1.

5.2.1 Pipeline Segments

CB&I proposes that the pipeline construction be phased in segments as shown in Figure 5-1 for a number reasons including construction funding, sediment availability, sediment replenishment and Terrebonne Parish's marsh creation goals. Since R-O-W conditions vary throughout the length of the proposed sediment pipeline, CB&I realizes that each segment of the proposed sediment pipeline may require a combination of proposed typical section alternatives. Only the proposed segment 1 and segment 2 will fully utilize the TGP right-of-way and Segments 3 and 4 will require additional R-O-W.

5.2.1.1 Segment 1 Bay Raccourci

Segment 1 will be the initial phase of construction of the sediment pipeline and will begin at the Atchafalaya River and run southeasterly along the TGP right-of-way to the Bay Raccourci placement area. The trunk line length, lateral length and number of booster stations for Segment 1 are shown in Table 5-1 below.

Table 5-1 Segment 1 Length and Booster Stations

	Miles	No. of Stations
Segment 1		
Trunk Line (TPG)	19	
Lateral	5	
Booster Stations		3

5.2.1.2 Segment 2 Falgout Canal

Segment 2 will be the second phase of construction of the long distance sediment pipeline and will continue southeasterly along the TGP right-of-way from the Bay Raccourci placement area and continue to the Falgout Canal area and serve the open area south of Falgout Canal, west of Bayou Dularge and east of the Houma Navigational Canal. The trunk line length, lateral length and number of booster stations for Segment 2 are shown in Table 5-2 below.

Table 5-2 Segment 2 Length and Booster Stations

	Miles	No. of Stations
Segment 2		
Trunk Line (TPG)	14	
Lateral	9	
Booster Stations		3

5.2.1.3 Segment 3 Lake Tambour

Segment 3 will be the third phase of construction of the long distance sediment pipeline and will continue southeasterly along the TGP right-of-way from the Falgout Canal area and continue east until it reaches the Houma Navigation Canal and then turn north towards the Lake Tambour area. After crossing the Houma Navigation Canal, Segment 3 will require acquisition of right-of-way for construction. The trunk line length, lateral length and number of booster stations for Segment 3 are shown in Table 5-3 below.

Table 5-3 Segment 3 Length and Booster Stations

	Miles	No. of Stations
Segment 3		
Trunk Line (TPG)	9	
Trunk Line (Non-TPG)	8	
Lateral	10	
Booster Stations		3

5.2.1.4 Segment 4 Wonder Lake

Segment 4 will be the final phase of construction of the long distance sediment pipeline and will continue north towards the Wonder Lake area. Segment 4 will require complete acquisition of right-of-way for construction. The trunk line length, lateral length and number of booster stations for Segment are shown in Table 5-4 below.

Table 5-4 Segment 4 Length and Booster Stations

	Miles	No. of Stations
Segment 4		
Trunk Line (Non-TPG)	7	
Lateral	6	
Booster Stations		1

Table 5-4 below shows the total TGP trunk line length, non-TGP trunk line length and number of booster stations for Segments 1-4.

Table 5-4 Total Segment Lengths and Booster Stations

	Miles	No. of Stations
Totals		
Trunk Line (TPG)	42	
Trunk Line (Non-TPG)	15	
Booster Stations		10

5.2.2 Pipeline Typical Section Alternatives

CB&I and its team developed four alternatives for the placement of the proposed long distance sediment pipeline. Those alternatives are described in detail below. The existing TGP is 40 feet in width, and Kinder Morgan requires a 25 feet minimum separation from the existing 24 inch gas pipeline and the proposed sediment pipeline. These alternatives take the existing right-of-way width and construction requirements as well as the variations in existing conditions along the TGP corridor into consideration. A combination of the proposed corridor alternatives will be required along each segment.

5.2.2.1 Submerged Placement

CB&I has developed two options for submerged placement of the pipeline. Submerged placement shall consist of placing the submerged pipeline along the natural ground along the proposed corridor, submerged beneath the existing water surface with timber piles spaced to anchor the pipeline in place. Two options were developed due to the varying width of the access channel waterway and the variation of placement of the existing 24” gas pipeline within the TGP right-of way.

The first option for submerged placement consists of placing the pipeline within the TGP right-of-way as shown in Figure 5-2 below.

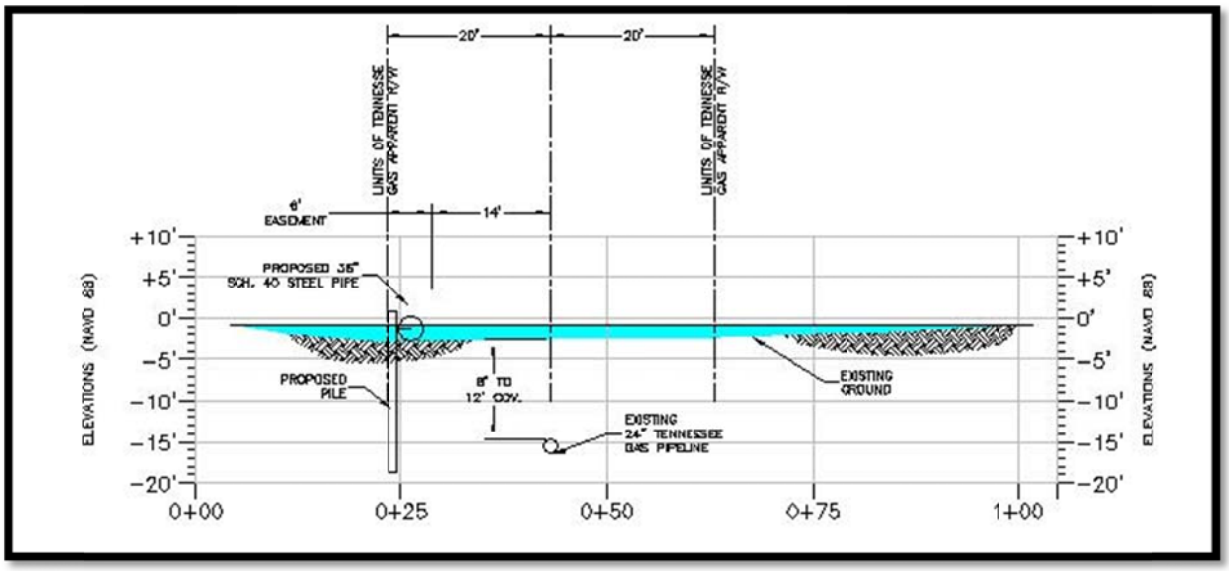


Figure 5-2 Proposed Submerged Pipe Typical Section

The second option for submerged placement consists of the acquisition of a right-of-way or easement from the adjoining property owners and submerging the pipeline outside of the TGP right-of-way as shown in Figure 5-3 below.

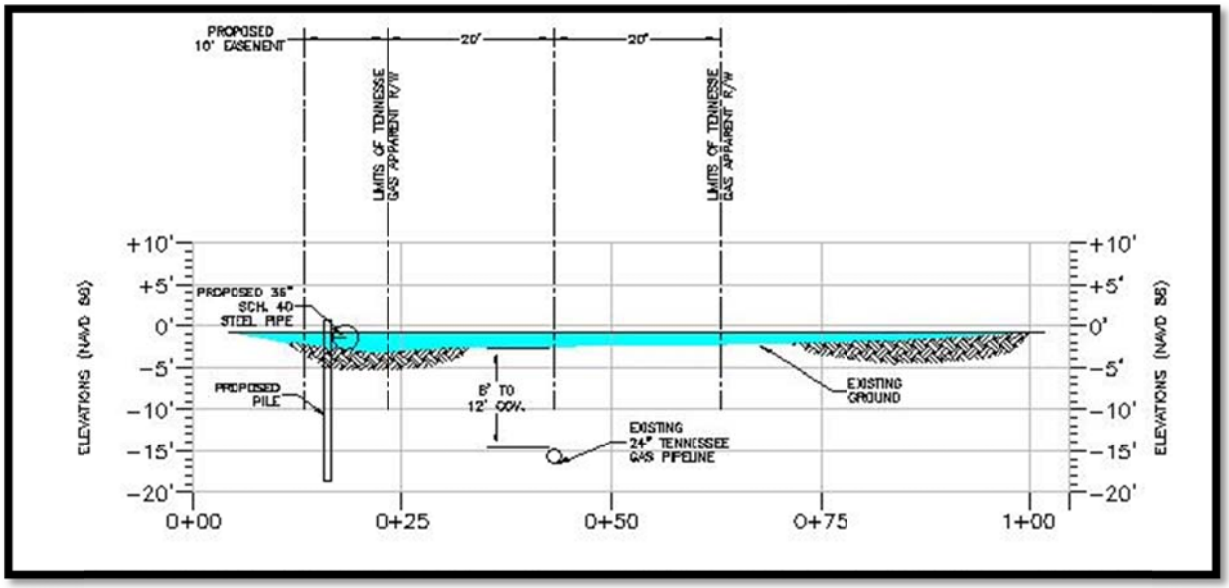


Figure 5-3 Proposed Submerged Pipe W/ ROW or Easement Typical Section

5.2.2.2 At Grade Placement

CB&I has developed two options for at grade placement of the proposed long distance sediment pipeline. At grade placement shall consist of placing the sediment pipeline along the natural ground along the south spoil bank of the corridor with timber piles spaced to anchor the pipeline in place. Two options were developed due to the varying width of the access channel waterway and the variation of placement of the existing 24" gas pipeline within the TGP right-of way.

The first option for at grade placement consists of placing the pipeline within the TGP right-of-way as shown in Figure 5-4 below.

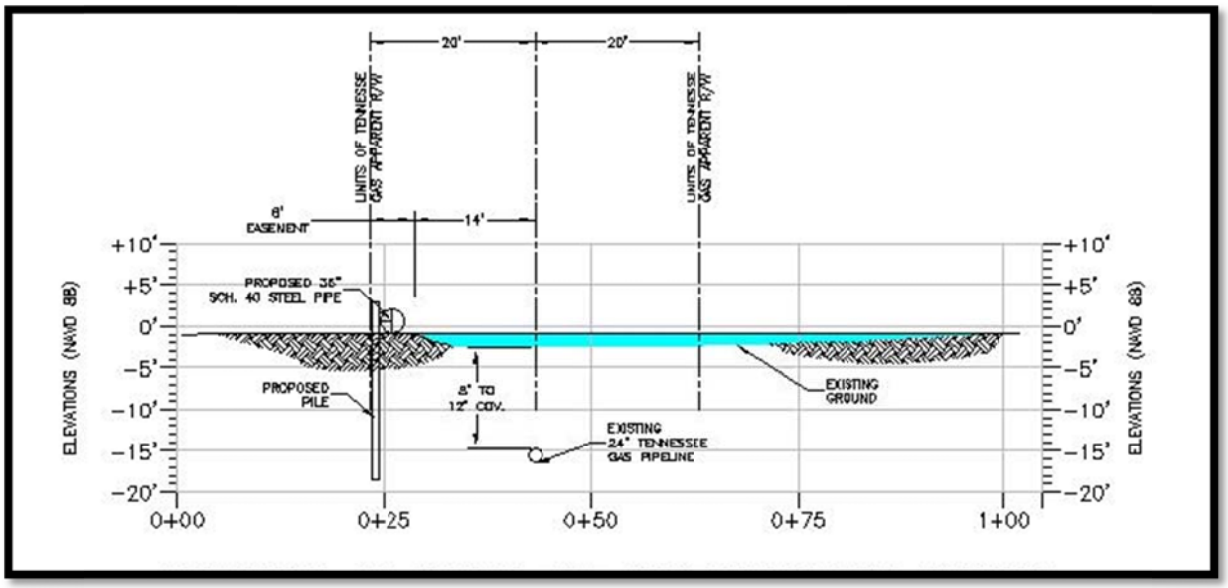


Figure 5-4 Proposed At-Grade Pipe Typical Section

The second option for at grade placement consists of the acquisition of right-of-way or easement from the adjoining property owners and placing the pipeline along the south spoil bank of the access waterway adjacent to the TGP right-of-way as shown in Figure 5-5 below.

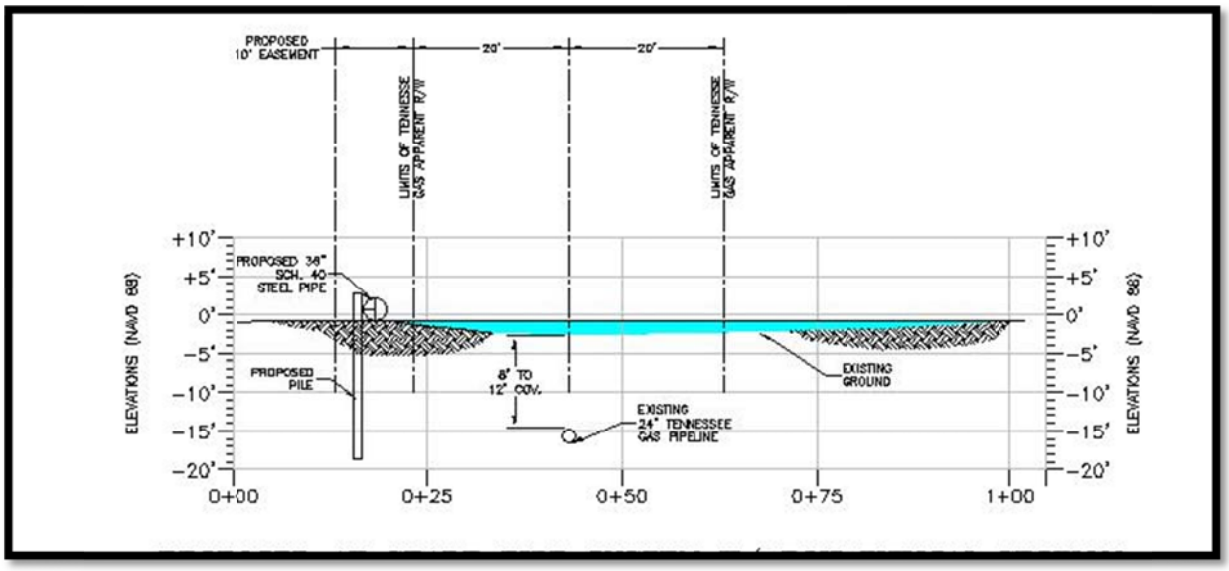


Figure 5-5 Proposed At-Grade Pipe W/ ROW or Easement Typical Section

5.2.2.3 Fill Placement Pipeline Corridor

CB&I has developed one option for the fill placement pipeline. Fill placement shall consist of creating a corridor for the long distance sediment pipeline south of the spoil bank of the existing water access and TGP right-of way. Right-of-way or easements will be required to construct a crowned raised land ridge for placement of the proposed long distance sediment pipeline. This option will require extensive permitting and coordination and is shown in Figure 5-6 below.

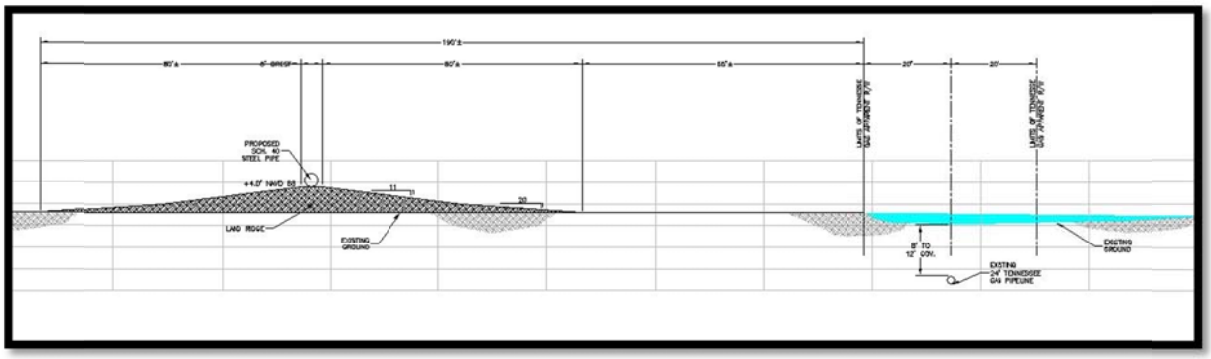


Figure 5-6 Proposed Ridge Pipe W/ ROW Typical Section

5.2.2.4 Floating Steel Pipe

CB&I has developed two options for floating steel pipe placement of the proposed sediment pipeline. Floating steel pipe shall consist of placing the pipeline along the south bank of the

existing access channel with timber piles spaced to anchor the pipeline in place. Two options were developed due to the varying width of the access channel and the variation of placement of the existing 24” gas pipeline within the TGP right-of way.

The first option for floating steel pipe consists of placing the pipeline within the TGP right-of-way as shown in Figure 5-7 below.

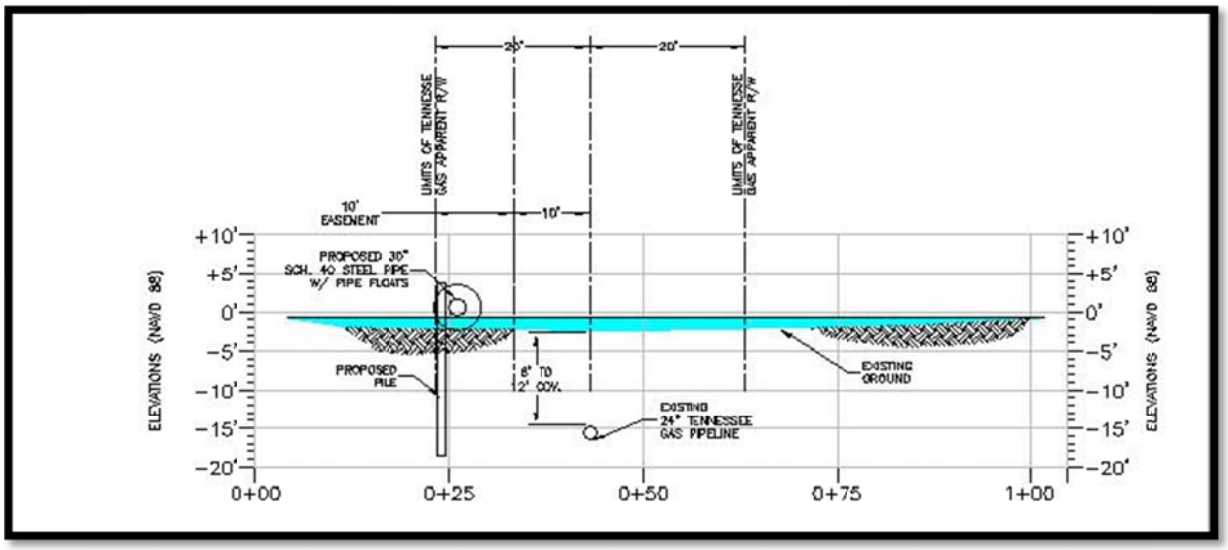


Figure 5-7 Proposed Floating Pipe W/ ROW Typical Section

The second option for floating steel pipe consists of the acquisition of a right-of-way or easement from the adjoining property owners and placing the pipeline along the south bank of the access channel adjacent to the TGP right-of-way as shown in Figure 5-8 below.

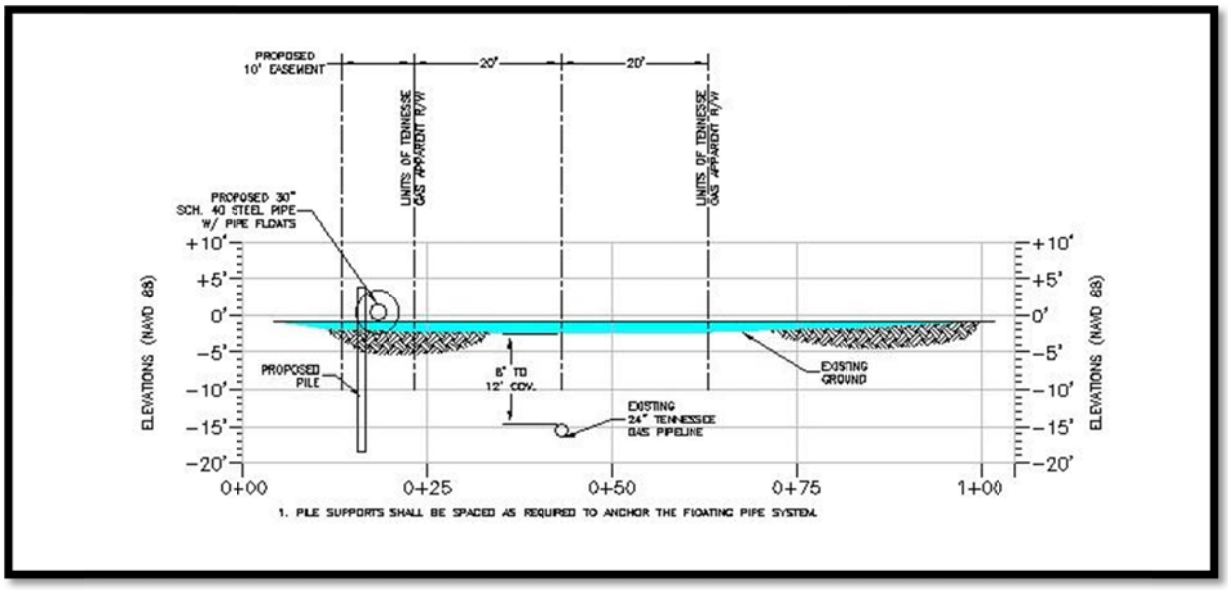


Figure 5-8 Proposed Floating Pipe W/ ROW or Easement Typical Section

5.3 Hydraulic Design

CB&I has prepared conceptual level recommendations for the size and material for the long distance sediment pipeline. Size and material depend upon a number of factors such as the volume and characteristics of the dredged sediment, required velocity to maximize transport efficiency and prevent sediment accumulation in the pipe, and/or required project elevation. For the purposes of this study, the following assumptions were made for dredge production rates, pipeline size and pipeline material and are discussed in the sections below.

- Dredge Production Rate: 40,000 to 50,000 cubic yards per day
- Pipeline Size: 30” to 36” Diameter Pipe; optimal size to be determined
- Pipeline Material: Steel Pipe with approximately ¾” Wall Thickness; optimal size to be determined
- Pipeline Longevity: 50 Million Cubic Yards

5.3.1 Dredge Production Rate and Material

Dredge production rates and dredge material are critical components when designing and sizing a long distance sediment pipeline. Sediment characteristics, discharge length, booster pump horsepower and terminal elevation affect the rate of production. As per the desktop analysis performed in Section 5, the following assumptions have been made for determining

dredge production rates. A production rate of 40,000 to 50,000 CY per day has been assumed and will be used as a design parameter for material and size of the pipeline.

5.3.2 Pipeline Size

Pipeline diameter will be determined by optimizing the flow with the necessary velocity for the sediment being transported. Velocity plays a key role in the design because velocity head loss increases at a rate of the square of the velocity. Consequently, minimizing and optimizing the velocity and concentration of the slurry maximizes the transport efficiency and the wear life of the pipeline. The required flow for the pipeline should ensure no blockage from sediment accumulation, therefore flow should be steady. This is the behavior of a flow when it has reached critical velocity. The optimum velocity is approximately 10% above critical velocity, which will result in a shallow, sliding bed-load along the bottom of the pipeline. For the purposes of this study, it is assumed that a 30-36 in pipe will maintain optimum velocity during sediment transport.

5.3.3 Pipeline Material

For the purpose of this study, a steel pipe has been chosen as the recommended material for the long distance sediment pipeline. For the submerged pipe corridor alternative, the pipeline will need to be raised to the water surface for rotating, transporting, and routine maintenance. This is accomplished by evacuating the water by pumping air into the pipe and allowing the pipe to float to the surface. If wall thickness and the corresponding weight of the pipe exceed the displacement value of the pipeline, the pipeline will not float; therefore the handling of the pipeline becomes more difficult and more expensive. Therefore wall thickness for the sediment pipeline shall be the maximum wall thickness to which the pipe will maintain positive buoyancy in water. For the purposes of this study, a ¾ inch wall thickness will be assumed.

5.3.4 Pipeline Longevity

Longevity of the pipeline is crucial to minimize maintenance and replacement costs of the pipeline. A steel pipeline transporting the sediment located in the borrow area vicinity has an estimated wear life of 50 million cubic yards and will require approximately 2 rotations after initial placement. However, pipeline material alternatives, anchoring, support requirements, and joints recommended by the contractor will be considered in the construction phase of this project.

5.3.5 Pipeline Crossings

Crossings for the LDSP were identified in Section 3 and include pipelines, navigable and non-navigable waterways and access channels. CB&I has prepared a conceptual section for

required crossing of potential conflicts along the long distance sediment pipeline, shown in Figure 5-9 below.

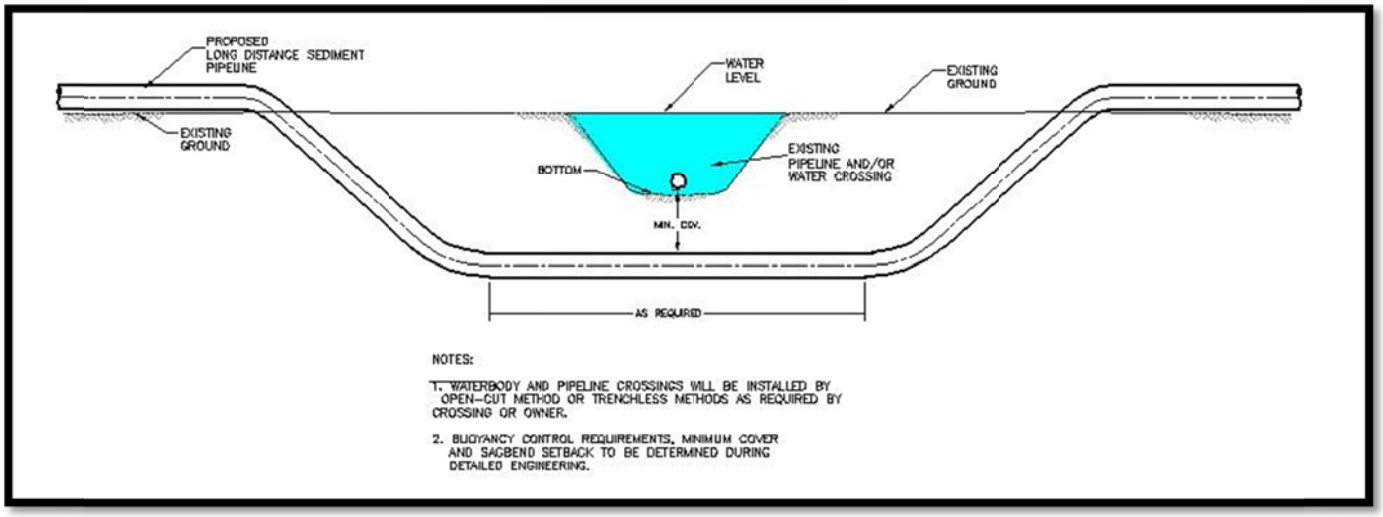


Figure 5-9 Long Distance Sediment Pipeline Crossing Detail

The long distance sediment pipeline will be required to cross beneath existing features including existing pipelines and water bodies to prevent damage to the existing pipelines and maintain access and navigation. Depths of cover will vary and means of construction shall also vary and depend on the needs at the particular crossing. Some crossings may be by conventional means while others may require boring technologies, but these options will be identified in detail in the next phase of the study. Navigable waterways will require minimum coverage of approximately 12 to 13 ft. from the existing bank line while pipeline conflicts will maintain the minimum clearances required by the pipeline owner.

5.3.6 Pipeline Construction

Pipeline will be fabricated in 120-foot lengths. The 120-foot sections will be delivered by barges to the site adjacent to the pipeline corridor. The 120-foot lengths of pipe will then be fusion welded into a seamless pipeline with breaks at booster stations.

5.4 Pumping Design Criteria and Guidelines

Due to the length of the pipeline it is necessary to place booster pumps in strategic locations to transport the dredge material to the placement locations along the pipeline corridor. The initial dredge should have the capability to pump approximately 4 to 5 miles, but booster pump stations will be required thereafter. The primary design criteria for booster pump placement are pressure, water depth, and geographic limitations. Incoming and outgoing pressures must be predicted and adjusted to reduce the risk of operating outside the design

pressure parameters. In addition, each booster station location will need adequate water depth to facilitate water cooled equipment of the pumps.

5.4.1 Booster Pumps

Booster pumps should always operate at a positive suction pressure. The dredge pump must be capable of providing the slurry at a positive pressure to the booster pump inlet. The number, sizes, and types of required booster station pumps will be determined after finalization of material requirements, and pumps shall be sized and placed to maintain a minimum velocity in the pipeline to keep the slurry mixture suspended.

Pumps will require access for fuel, supplies, maintenance and initial setup. Options for the booster stations include barge mounted and permanent pile supported systems. Horsepower limits on typical stations average 10,000 hp with an average spacing of approximately 7 miles between booster stations, although a combination of less booster locations and higher pressure is more cost effective. For this study, a booster pump spacing distance of approximately 5 miles has been used, and these proposed booster pump locations are shown in Figure 5-10.

5.4.2 Equipment Access

Geographic locations where the long distance sediment pipeline can be accessed by water will be the most practical locations for the placement of booster stations and also construction staging. For the purposes of this study, access channels with depths of 6-8 feet will be required at the booster station locations. Crossing water bodies and channels were identified in Section 3 and are also considered the most practical access routes. Pumps will require the most maintenance; therefore it is important to have sufficient draft for barge access. Natural gas fuel will be considered as a possible fuel source, and pump station locations will be determined to allow the possibility of connections to existing natural gas pipelines in the vicinity.

5.4.3 Utilization of Natural Gas Power

Past marsh creation projects and current planning for future marsh creation projects assumes a status quo of the dredging industry's use of diesel engines for their pumps. The Louisiana State Master Plan 2012 envisages approximately $17 billion for marsh creation over the next 50 years. A significant cost of creating marsh substrate can be attributed to the fuel. Conversion of diesel engines to natural gas for hydraulic pumping of sediment may create a significant savings in cost.

Use of natural gas would require cost to convert the conventional diesel engine to natural gas use. Diesel combustion engines would likely need to be replaced with possibly larger natural

gas engines. The natural gas engines may need to be supplemented with transmissions to develop adequate torque to drive large pumps. The supply of natural gas for dredging would be different than diesel.

Due to the current infrastructure of natural gas lines across south Louisiana, access to natural gas is generally available. Nevertheless, there would be front-end conversion costs. There are a number of natural gas pipelines in the project vicinity. A detailed analysis to include economics and other marker condition feasibility of utilization of natural gas for this project will be addressed in the Phase II of this project.

The current dredging industry is based on diesel use primarily because of its availability and the traditional need for portability and flexibility. This need may be greatly diminished by long- term planning of sediment delivery systems such as this project. Long-term contracts or other incentives could be devised.

Energy Prices per Million BTUs

The price of energy has a significant influence on the choices. The price and convenience of energy sources are the keys to market acceptance of a specific energy source. Below is a compilation of a list of prices for some of the more common energy options on an energy equivalent basis – the British Thermal Unit (BTU). Everything has been converted into U.S. dollars / million BTUs (MBTU).

- Coal – Powder River Basin – $0.56
- Coal – Northern Appalachian - $2.08
- Natural gas - $5.69
- Ethanol tax credit – $5.92
- Propane - $13.28
- Petroleum – $13.43
- #2 Heating oil - $14.74
- Jet fuel - $15.48
- Diesel - $15.59
- Gasoline - $17.81

Simple calculations suggest that the cost of an equivalent (BTU) of natural gas is about 1/5th the cost of unrefined crude oil. The natural gas cost compared to retail cost of diesel is about 1/6th.

Long-term contracts with fixed-pricing is common for natural gas but not for diesel. Using the leverage of the state and incentives for a long-term contract with the oil and gas industry could induce favorable pricing for natural gas for 10 years or more. Environmental benefits

for using natural gas are two-fold. Using natural gas is less polluting to the environment since it is cleaner-burning than diesel and emissions will be much lesser, resulting in lower carbon foot print. Secondly, since the cost savings are on the order of 3-6 times, the created wetland acreage may be 3-6 times that typically constructed within the available funding.

In summary, utilizing natural gas is a step forward in improving efficiency and cost savings. In the context of this type of project, long term application for transporting sediment, using existing dredging equipment and converting boosters is not an issue. Ultimately, it comes down to making the investment into the equipment for the long term and realizing the payback period. At this time it is the opinion of the dredging community that it may take a couple of years. Since this project is projected to be implemented for more than two years, conversion to natural gas is feasible. Natural gas piping from adjacent natural gas pipelines for booster stations will require detailed analysis and will be done in the Phase II of this project.

6.0 Placement Area Evaluation - Marsh Creation

According to the Office of Coastal Preservation and Restoration's "Terrebonne Parish Comprehensive Plan for Coastal Restoration", between 1956 and 2004, Terrebonne Basin lost 321 square miles of land and an additional 17 square miles of coastal land was lost in 2005 due to the effects of Hurricanes Katrina and Rita. Compounding this extreme and continuing rate of land loss, the Parish is without a functional hurricane protection system. Because of this rate of land loss, Terrebonne Parish must seek to optimize the influence of all available freshwater resources, rebuild critical landscape features which help to maintain an estuarine gradient, and lay the ground work for restoration activities beyond the scale at which they are currently practiced (Coastal Restoration Comprehensive Plan-verbatim).

The project objective is to create marsh by pumping sediment from the Atchafalaya River into the proposed marsh creation areas shown in Figure 2-1. The proposed marsh creation areas were evaluated using several different factors, and the decision methodology is explained below.

6.1 Placement Area Design Criteria and Assumptions

TPCG has predetermined potential sites for marsh creation within Terrebonne Parish. The pipeline is to have four phased endpoints that must be located in the following areas:

1. Existing and planned restoration projects in the vicinity of Bay Raccourci
2. Open water area south of Falgout Canal (and future Morganza to the Gulf Levee alignment), west of Bayou Dularge, and east of the Houma Navigational Canal (HNC)
3. Existing, planned and proposed restoration projects in the vicinity of Lake Tambour
4. Open water area in the vicinity of Wonder Lake

6.2 Placement Areas

Using the placement area criteria provided by TPCG, CB&I delineated the following four placement areas: Bay Raccourci, Falgout Canal, Wonder Lake and Lake Tambour areas. The delineated placement sites are shown in Figures 6-1 through 6-4.

Bay Raccourci has a total surface area of approximately 20,000-25,000 acres, Falgout Canal has a total surface area of approximately 25,000-30,000 acres, Wonder Lake has a total surface area of approximately 15,000-20,000 acres and Lake Tambour has a total surface area of approximately 30,000-35,000 acres. The total surface area delineated for marsh creation is approximately 90,000-110,000 acres. The breakdown of the areas is listed in Table 6.1.

For each major placement area, CB&I has contacted the landowners, discussed with them the proposed project's scope and plans and coordinated the further preliminary delineation of proposed marsh creation areas. All major landowners have been supportive of this preliminary design effort and have expressed their support of the project.

The placement areas have been carefully selected to be complimentary to all the existing coastal restoration projects in the areas and to support the proposed projects in the 2007 State Master Plan shown in Figure 6-5 and the Louisiana 2012 Coastal Master Plan shown in Figure 6-6.

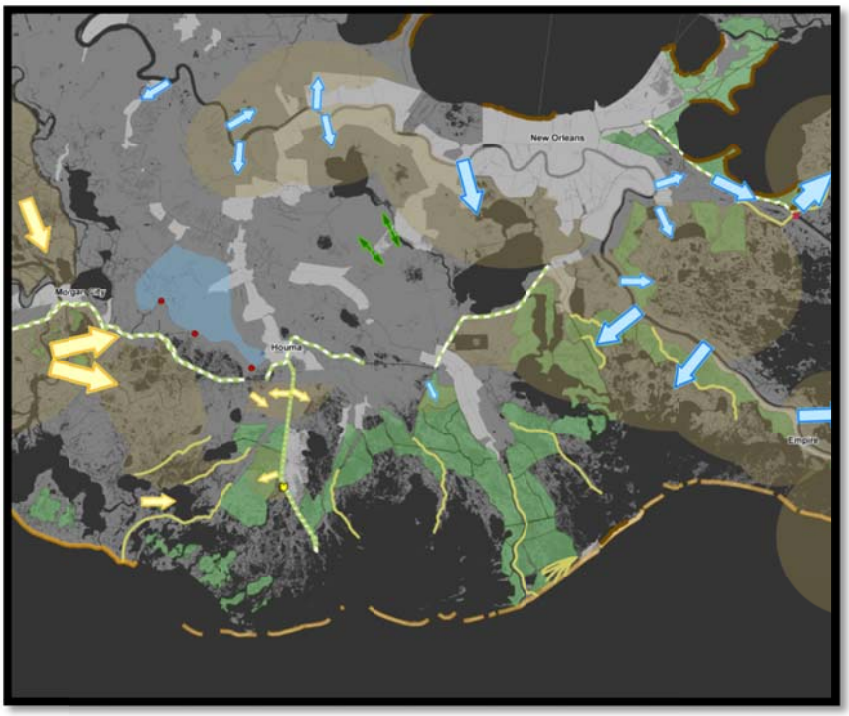


Figure 6-5 State Master Plan (2007) Projects Map

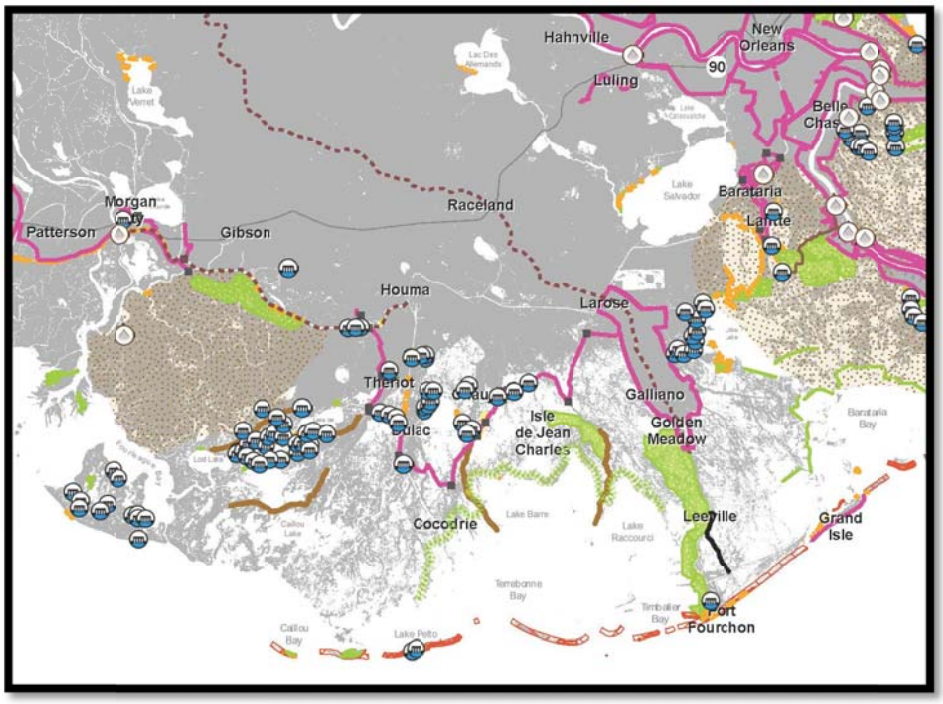


Figure 6-6 State Master Plan (2012) Projects Map

6.3 Marsh Creation Fill Design

Eustis Engineering was contracted to perform a desktop study of the project area and provided a geotechnical report that is included as Appendix C. The geotechnical report was required to describe the likely geological and geotechnical conditions at the site on the basis of existing data. The study concentrated on the constructability of the sediment pipeline routes, containment dikes, marsh fill, and booster stations. Preliminary general construction recommendations regarding site preparation, drainage, dredged fill, and compaction were provided.

The marsh creation sediment placement can be performed by several different methods, and each restoration site should employ the appropriate method. The method selected is dependent on the restoration project's objectives, site specific conditions, and sediment type being placed.

a) Traditional hydraulic method places dredged material by pumping it directly onsite with the goal to create marsh from open water at the lowest possible cost by maximizing the concentration of sediment in the slurry. The amount of sediment required to be transported and placed depends on the site specific conditions (open

water vs broken marsh, and confined vs unconfined) and sediment characteristics. A coarser sediment will allow for unconfined placement while fine sediment may require containment dikes. In future design, the sediment properties and existing conditions should be carefully evaluated to determine if confined, semi-confined, or unconfined placement is the best alternative for each area.

b) Thin Layer Placement is another hydraulic dredging option. Thin layer placement artificially supplies existing marshes with sediment to offset subsidence. This option consists of placing thin layers of sediment onto existing marshes through spraying of the sediment over the existing marsh surface. The slurry has high water content and may also be fine grained sediment to be more easily sprayed. This method should be considered as an option to re-nourish existing marsh in the placement areas.

c) Slurry placement is an additional hydraulic sediment placement technique. This newer alternative approach uses hydraulically pumped sediment with a very high water content to sheet flow over existing marsh areas. The sediment is transported long distances via suspension by the high water content.

The three sediment placement techniques – traditional method, thin layer placement, and slurry placement – should all be considered in the future detailed design and engineering of the marsh creation sites for the four placement areas. The best technique selected to be performed should provide the highest benefit to cost ratio.

6.3.1 Marsh Target Elevation

One major design component of marsh creation involves calculation of the fill volumes. Before this could be accomplished, a desired, long term marsh elevation had to be determined. To achieve the desired marsh elevation, constructed marsh elevation is required to be computed. The constructed marsh elevation is the marsh fill elevation at the end of construction reached by the placement of hydraulically dredged material to achieve healthy marsh for a twenty year design life. Constructed marsh elevation depends on the factors such as:

- Healthy marsh elevation
- Tidal datum
- The physical properties of the borrow material and the estimated self-weight consolidation
- The estimated settlement of the underlying soils

The detailed analysis of existing marsh conditions is an important activity in the final design and is beyond the scope of this report. The verification of fill area tidal datum as well as existing marsh elevation must be studied. Mean High Water (MHW) and Mean Low Water (MLH) will be utilized to compute the target marsh elevation. To achieve a sustainable marsh elevation throughout the life of the project in this basin, the marsh elevation needs to be higher than MWH at the end of construction. Consequently, the marsh surface settles into the intertidal zone over time.

The geotechnical report provided an initial recommended elevation of marsh fill at +3.0 to +3.5 ft. NAVD for all of the placement sites. The assumed average existing ground elevation of -2 ft. NAVD or higher was evaluated for the proposed placement areas.

The preliminary geotechnical report was developed using existing soil boring data from each approximate area and looked at the available subsurface soil information and a dredge material soil analysis to create long term settlement curves for each area. The report recommends an initial marsh fill elevation of +3.0 to +3.5 ft. NAVD to achieve a long term target elevation of +0 ft. NAVD for all marsh creation areas after 10 to 15 years. It is likely that a resulting elevation of +0 ft. NAVD will not meet the objective of attaining intertidal marsh throughout the project life. Multiple lifts may need to be constructed to achieve intertidal marsh elevation throughout the life of the project.

Future engineering design efforts should be aware that the Bay Raccourci placement area has the most difficult pre-existing soil conditions of the four proposed placement areas and special consideration should be taken in future marsh creation design. The Bay Raccourci areas achieve at most a +0 ft. (NAVD) target elevation (see Figure 6-7) by target year 15.

The Falgout Canal, Wonder Lake, and Lake Tambour placement areas have better underlying soil conditions and are estimated to surpass the target elevation of +0 ft. NAVD over a 15-20 year projected time period (see Figure 6-8 and Figure 6-9).

Based on the settlement curves of marsh creation projects in the region, it appears that the majority of the settlement will occur approximately two (2) years after construction. However, the marsh will continue to settle throughout the project life.

The projected long term settlement curves referenced above can be found below for the Bay Raccourci, Falgout Canal, and Lake Tambour/Wonder Lake areas:

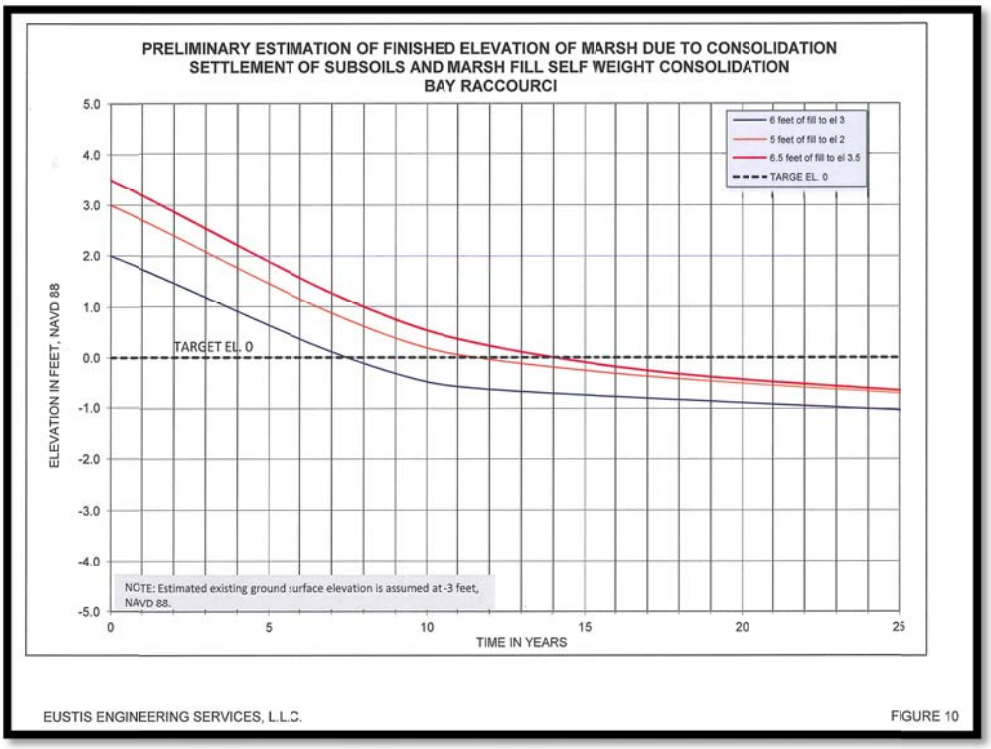


Figure 6-7: Bay Raccourci Estimated Marsh Elevation due to Long Term Consolidation

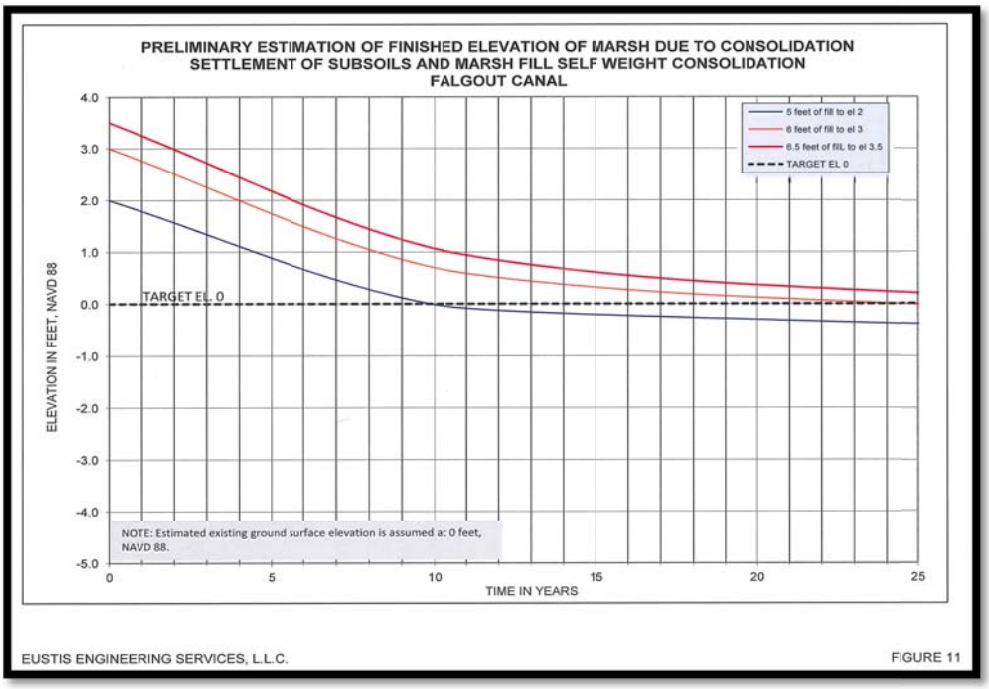


Figure 6-8 Falgout Canal Estimated Marsh Elevation due to Long Term Consolidation

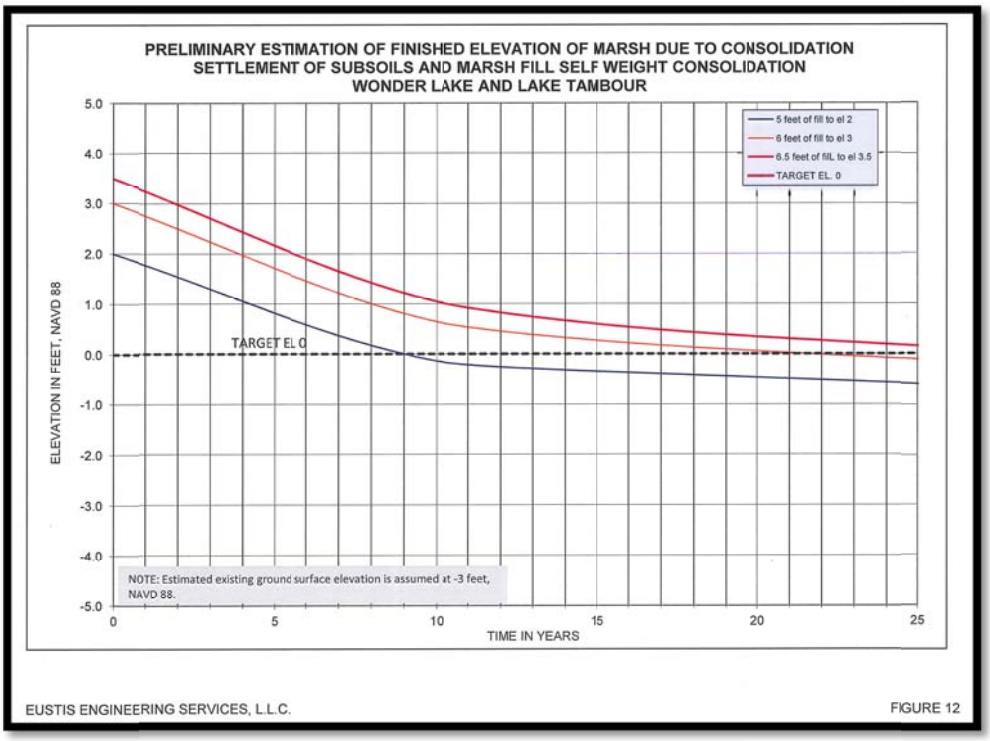


Figure 6-9Lake Tambour and Wonder Lake Estimated Marsh Elevation due to Long Term Consolidation

6.3.2 Marsh Fill Volumes

The preliminary estimated marsh fill volumes required to meet the target elevation were calculated using the assumed average existing elevation and the target fill elevation of +3.0 to a +3.5 ft. NAVD. A more thorough design and existing site conditions survey would be required to generate more accurate quantities.

The estimated marsh fill volume ranges were calculated using a 30% minimum and 65% maximum coverage over the entire selected placement site areas and the results are listed in Table 6-1 below:

Table 6-1 Marsh Fill Volumes

	Area	Estimated Placement Area	Initial Fill Elevation	Existing Average Mudline Elev.	Borrow Material Needed
Bay Raccourci		(Acres)	(NAVD Ft.)	(NAVD Ft.)	(CY)
	All	7500 - 16250	+3.5	0	42,500,000 – 92,000,000
	Area	**Estimated Placement Area**	**Initial Fill Elevation**	**Existing Average Mudline Elev.**	**Borrow Material Needed**
Falgout Canal		(Acres)	(NAVD Ft.)	(NAVD Ft.)	(CY)
	Central	2400 - 5200	+3.0	0	11,750,000 – 25,250,000
	South	6600 - 14300	+3.0	-1	42,750,000 – 92,500,000
	Area	**Estimated Placement Area**	**Initial Fill Elevation**	**Existing Average Mudline Elev.**	**Borrow Material Needed**
Wonder Lake		(Acres)	(NAVD Ft.)	(NAVD Ft.)	(CY)
	East	2100 - 4550	+3.0	0	10,250,000 – 22,250,000
	Central	2100 - 4550	+3.0	0	10,250,000 – 22,250,000
	West	3300 - 7150	+3.0	0	16,000,000 – 34,750,000
	Area	**Estimated Placement Area**	**Initial Fill Elevation**	**Existing Average Mudline Elev.**	**Borrow Material Needed**
Lake Tambour		(Acres)	(NAVD Ft.)	(NAVD Ft.)	(CY)
	All	12000 - 26000	+3.0	-2	97,000,000 – 209,750,000
	Total Area	**36,000 – 78,000**		**Total Borrow**	**230,500,000 – 498,750,000**

6.3.3 Construction Access Channels and Navigable Waters

The proposed placement areas have several major access channels running through them or adjacent to them including the Gulf Intracoastal Water Way and Houma Navigation Canal. There are also numerous smaller access channels located within each proposed marsh creation area including but not limited to Falgout Canal, Bayou Petit Caillou, Bayou Grand Caillou, Bayou Terrebonne, and Humble Canal and the areas are also interspersed with several navigable lakes. Every opportunity should be taken to utilize the existing routes to access and construct the project.

The construction access to the four major placement areas should not be a major issue since there are numerous navigable waterways accessing the project areas. There will be some required access dredging, but the existing oilfield canals and waterways should provide an easily accessible blueprint to be used with minimal costs for access dredging.

Overall, the marsh creation areas selected should allow ease of access for the construction and maintenance required for the project. In future design and planning the construction access should be more thoroughly evaluated and surveyed to provide an accurate cost analysis.

6.3.4 Access for Ancillary Equipment

The ancillary equipment access will use the same existing channels and waterways as the main construction equipment. This equipment may be able to access areas without performing maintenance access dredging and routes should be used as much as possible.

6.4 Containment Dike Analysis

A marsh creation area containment dike analysis was also performed in the geotechnical report for each of the placement areas. A uniform cross section of a containment dike is shown in Figure 6-10 and was used for the evaluation with a 5ft crown width and 1 (V):3 (H) side slopes. The estimated slope stability and short term and long term settlement were calculated for each area. The proposed typical containment dike cross section shown below in Figure 6-10 also shows the containment dike fill source located inside the marsh creation placement area. Additionally, typical construction recommendations dictate that the containment dike be built slowly in multiple lifts to allow for consolidation and stability of the foundation and to overcome poor in situ material working properties. The containment dike construction may be a long and continual process for the proposed marsh creation project and will require continued maintenance during sediment placement operations.

A more detailed map of the preliminary proposed marsh creation areas is given in Figure 6-11. Each major placement area was further separated into smaller preliminary containment areas. These smaller preliminary containment areas were created by following existing waterways, canals and bayous, existing lake and bay shorelines, existing oil and gas canals, and existing marsh creation project boundaries. The preliminary containment areas were used to determine the containment dike linear footage estimate used to calculate the costs.

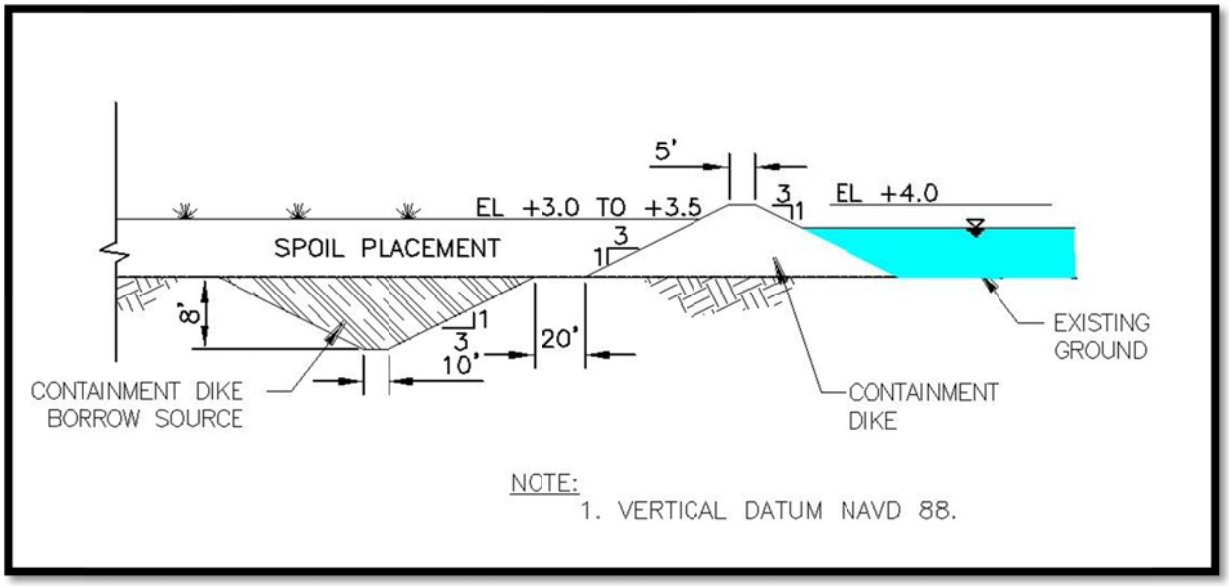


Figure 6-10 Typical Cross Section of Proposed Containment Dike

7.0 Cost Analysis

7.1 Dredging

Development of dredging costs for a project of this magnitude an early feasibility level is not an easy exercise. CB&I has developed a preliminary cost estimate for dredging and associated components using available information and reasonable assumptions.

Cost estimates presented here have been categorized into components such as dredging and placement, intake structure, pipeline and associated components construction, and dike construction.

7.1.1 Dredging and Placement

The cost incurred during a dredging event is a function of many factors. As Figure 7-1 describes, pipeline length is a significant factor. Slurry density and flow velocity also influence production rates and therefore the cost of dredging (Figure 7-2).

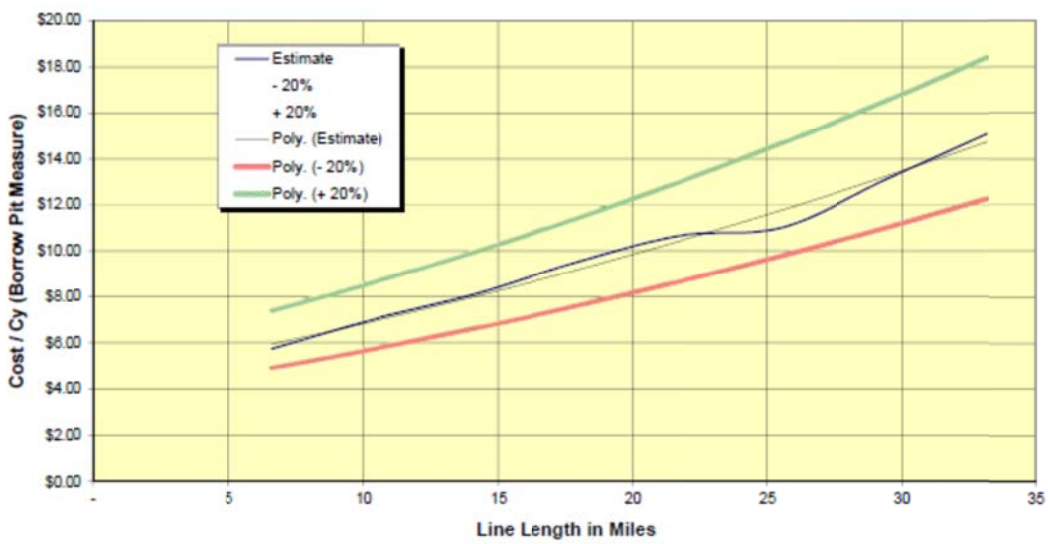


Figure 7-1 Transportation Cost as a function of pipeline length. (Appendix F)

CB&I reviewed available information such as restoration projects by CPRA and maintenance dredging events by USACE. There are no cost estimates available for a project comparable to the Atchafalaya Long Distance Pipeline project. Many of the available project information only describe dredging with pipeline distance ranging from 10 to 15 miles.

USACE's maintenance dredging usually places material on nearby disposal sites and rarely transports a maximum of 5 miles for beneficial use of dredge material (Appendix F).

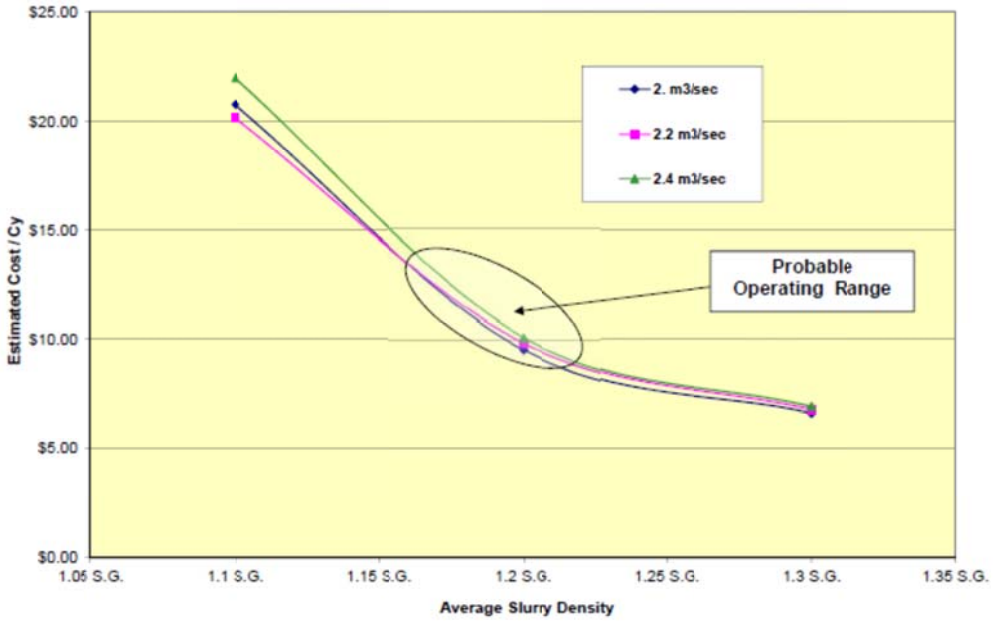


Figure 7-2 Relationship among cost/CY, slurry density (SG), and flow velocity (m3/sec)

By assuming that the dredge has to mine the sediment and deliver at the intake structure (distance varying between 2 to 5 miles), the cost is assumed as $5/cubic yard.. There are additional costs to be considered such as operation of the intake structure and boosters. An additional $5/cy was included as operational cost for a distance ranging 25 miles to 30 miles. Therefore, $10/cubic yards are assumed to be the cost of dredging and operation. This cost does not include cost for pipeline, booster pumps, and R-O-W acquisition. To dredge 50 million cubic yards, it is estimated to cost approximately $500 million.

The above cost estimate is very conceptual in nature. During the phase 2 of this project, detailed estimates will be provided.

7.1.2 Intake Structure

CB&I has evaluated the major components of the intake structure and determined that it will cost approximately $6M. The detailed estimate will be undertaken during the Phase 2 of this project.

7.2 Pipeline Construction Cost Estimate

CB&I developed conceptual level cost estimates for the construction of each segment of the long distance sediment pipeline based on the assumptions and design criteria discussed in previous sections of this report. Pipeline cost estimates do not include dredging cost, initial piping or pumping from the dredge to the long distance sediment pipeline. In addition, no cost for any required wetland or permitting cost is included in these construction cost estimates. Detailed cost estimates for the segments and corridor alternatives are contained in Appendix E.

7.2.1 Segment 1 Bay Raccourci

Construction alternatives for Segment 1 were discussed in Section 5 and the total cost of construction for each of those alternatives is summarized in Table 7-1 below. Segment 1 will provide sediment to the Bay Raccourci placement area and costs for the segment include the 19 mile trunk line, 5 miles of laterals, 3 booster stations and right-of-way or easement acquisition.

Table 7-1 Segment 1 Cost Summary

Pipeline Alternatives	Segment 1
Submerged Pipeline Within TGP ROW	$85,683,000
Submerged Pipeline Outside TGP ROW	$85,976,000
At Grade Pipeline Within TGP ROW	$98,203,000
At Grade Pipeline Outside TGP ROW	$98,496,000
Land Ridge Pipeline	$99,991,000
Floating Pipeline Within TGP ROW	$134,075,000
Floating Pipeline Outside TGP ROW	$134,367,000

Costs for constructing the segment utilizing the floating pipe alternative appear to be cost prohibitive and will not be considered as a feasible option for trunk line construction.

7.2.2 Segment 2 Falgout Canal

Construction alternatives for Segment 2 were discussed in Section 5, and the total cost of construction for each of those alternatives is summarized in Table 7-2 below. Segment 2 will provide sediment to the Falgout Canal placement area, and costs for the segment include the 15 mile trunk line, 9 miles of laterals, 3 booster stations and right-of-way or easement acquisition.

Table 7-2 Segment 2 Cost Summary

Pipeline Alternatives	Segment 2
Submerged Pipeline Within TGP ROW	$83,004,000
Submerged Pipeline Outside TGP ROW	$83,134,000
At Grade Pipeline Within TGP ROW	$92,458,000
At Grade Pipeline Outside TGP ROW	$92,750,000
Land Ridge Pipeline	$93,729,000
Floating Pipeline Within TGP ROW	$103,055,000
Floating Pipeline Outside TGP ROW	$119,982,000

Costs for constructing the segment utilizing the floating pipe alternative appear to be cost prohibitive and will not be considered as a feasible option for trunk line construction.

7.2.3 Segment 3 Lake Tambour

Construction alternatives for Segment 3 were discussed in Section 5, and the total cost of construction for each of those alternatives is summarized in Table 7-3 below. Segment 3 will provide sediment to the Lake Tambour placement area, and costs for the segment include the 17 mile trunk line, 10 miles of laterals, 3 booster stations and right-of-way or easement acquisition. Approximately 8 of the 17 miles are beyond the limits of existing TGP right-of-way and will require the acquisition of right-of-way or easement for approximately 8 miles of trunk line segment of the pipeline.

Table 7-3 Segment 3 Cost Summary

Pipeline Alternatives	Segment 3
Submerged Pipeline Within TGP ROW	$86,532,000
Submerged Pipeline Outside TGP ROW	$86,629,000
At Grade Pipeline Within TGP ROW	$97,036,000
At Grade Pipeline Outside TGP ROW	$97,133,000
Land Ridge Pipeline	$97,132,000
Floating Pipeline Within TGP ROW	$108,634,000
Floating Pipeline Outside TGP ROW	$127,232,000

Costs for constructing the segment utilizing the floating pipe alternative appear to be cost prohibitive and will not be considered as a feasible option for trunk line construction.

7.2.4 Segment 4 Wonder Lake

Construction alternatives for Segment 4 were discussed in Section 5, and the total cost of construction for each of those alternatives is summarized in Table 7-4 below. Segment 4 will provide sediment to the Wonder Lake placement area, and costs for the segment include the 7 mile trunk line, 6 miles of laterals, 1 booster station and right-of-way or easement acquisition. Segment 4 is beyond the limits of existing TGP right-of-way and will require the acquisition of right-of-way or easement for the trunk line segment of the pipeline.

Table 7-4 Segment 4 Cost Summary

Pipeline Alternatives	Segment 4
Submerged Pipeline Outside TGP ROW	$43,233,000
At Grade Pipeline Outside TGP ROW	$47,901,000
Land Ridge Pipeline	$48,232,000
Floating Pipeline Outside TGP ROW	$61,295,000

Costs for constructing the segment utilizing the floating pipe alternative appear to be cost prohibitive and will not be considered as a feasible option for trunk line construction.

7.2.5 Summary

As stated previously, conditions vary and a combination of the proposed construction alternatives will be required for the construction of each pipeline segment. The variables include but are not limited to:

- Existing TGP location within the existing 40 ft. right-of-way
- Existing Access Channel Width
- Soil Conditions

Based on these varying conditions, CB&I has summarized the cost by range with submerged placement being the least expensive and land ridge creation being the most expensive. As stated previously, floating pipe cost will not be included in the cost range due to the material cost. The range of cost for each section is summarized in Table 7-5 below.

Table 7-5 Long Distance Sediment Pipeline Cost Summary

	Minimum	Maximum
Segment 1	$85,683,000	$99,991,000
Segment 2	$83,004,000	$93,730,000
Segment 3	$86,532,000	$97,132,000
Segment 4	$43,233,000	$48,232,000
TOTAL PIPELINE CONSTRUCTION COST	**$298,452,000**	**$339,085,000**

7.3 Placement Area Construction Cost Estimate

CB&I and its team developed conceptual level cost estimates for the marsh creation placement area construction of each major region the long distance sediment pipeline will connect to. The preliminary cost estimate is based on the assumptions and design criteria discussed in previous sections of this report. The placement area cost estimates do not include dredging cost, initial piping or pumping from the dredge to the long distance sediment pipeline, or construction of the pipeline itself. In addition, cost for any required wetland mitigation or permitting cost is not included in these construction cost estimates. Detailed cost estimates for the placement areas are contained in Appendix E. Each major placement area was further separated into smaller preliminary containment areas. The smaller estimated placement areas were used to calculate the containment dike cost estimates. See Figure 6-11 for the preliminary placement areas. Bay Raccourci Placement Area (Containment Dike)

The Bay Raccourci placement area construction cost estimate was prepared by estimating the different placement areas within the Bay Raccourci region and a unit cost of $35 per linear foot was used. A unit rate of either $30 or $35 per linear foot of containment dike construction cost was used for all the placement areas. The unit rates were taken from recent CPRA project bids (BA-48).

The preliminary design placement areas containment dike construction costs are estimated in Table 7-5.

Table 7-5 Bay Raccourci Containment Dike Cost Summary

Alternatives		Bay Raccourci
MIN	LF of Containment Dike	$8,225,000
MAX	LF of Containment Dike	$27,400,000

7.3.1 Falgout Canal Placement Area (Containment Dike)

The Falgout Canal placement area construction cost estimate was prepared by estimating the different placement areas within the Falgout Canal region and a unit cost of $30 per linear foot was used. The preliminary design placement areas containment dike construction costs are estimated in Table 7-6.

Table 7-6 Falgout Canal Containment Dike Cost Estimate

Alternatives		Falgout Canal
MIN	LF of Containment Dike	$3,405,000
MAX	LF of Containment Dike	$11,335,000

7.3.2 Lake Tambour Placement Area (Containment Dike)

The Lake Tambour placement area construction cost estimate was prepared by estimating the different placement areas within the Lake Tambour region and a unit cost of $35 per linear foot was used. The preliminary design placement areas containment dike construction costs are estimated in Table 7-7.

Table 7-7 Lake Tambour Containment Dike Cost Summary

Alternatives		Lake Tambour
MIN	LF of Containment Dike	$7,560,000
MAX	LF of Containment Dike	$25,200,000

7.3.3 Wonder Lake Placement Area (Containment Dike)

The Wonder Lake placement area construction cost estimate was prepared by estimating the different placement areas within the Wonder Lake region and a unit cost of $30 per linear foot was used. The preliminary design placement areas containment dike construction costs are estimated in Table 7-8.

Table 7-8 Wonder Lake Containment Dike Cost Summary

Alternatives		Wonder Lake
MIN	LF of Containment Dike	$3,675,000
MAX	LF of Containment Dike	$12,220,000

7.3.4 Summary

As stated previously, the estimated construction costs for each area vary greatly and dependent on varying conditions in each area. The variables include but are not limited to:

- Existing marsh creation projects, containment dikes, and natural ridges in each area
- Existing access channels, pipelines, major bayous, and recreational residences
- Existing / historical bay and lake rims
- Soil conditions

Based on these varying conditions, CB&I has estimated the placement area construction cost by each area. As stated previously, the preliminary marsh creation containment cells were estimated for each placement area. The range of cost for each placement area is summarized in Table 7-9 below and a detailed cost estimate is provided in Appendix E.

Table 7-9 Long Distance Sediment Pipeline Containment Dike Cost Summary

Placement Area	Minimum	Maximum
Bay Raccourci	$8,225,000	$27,400,000
Falgout Canal	$3,405,000	$11,335,000
Lake Tambour	$7,560,000	$25,200,000
Wonder Lake	$3,675,000	$12,220,000
TOTAL CONSTRUCTION COST	$22,865,000	$76,155,000

Table 7-10 illustrates the cost summary of the entire project, which consists of all four segments. Each segment consists of cost for dredging and operations. It is assumed that it ranges from $10/cy to $17/cy for segment 1 to segment 4. This cost includes sediment dredging and subsequent discharge to the intake structure and operation costs of intake structures and booster pumps. The pipeline cost ranges from $100 million to $339 million for segments 1 to segment 4 along with a cost range of $3 million to $28 million for dike construction.

It is assumed that there is a need for a new set of pipeline for every segment to transport 50 million cubic yards to the placement sites. The intake structure is assumed to be replaced every two segments. If the project construction is considered in its entirety, it estimated to cost at $3.614 billion.

Table 7-10. Project Cost Summary

	Dredging & Intake Structure ($ Millions)						Pipeline Corridor And Placement Area Dike Construction ($ Millions)									
	Dredging*, 50 M CY				Intake Structure**	Sub-Total	Segment 1		Segment 2		Segment 3		Segment 4		Sub-Total	Total
	Segment 1	Segment 2	Segment 3	Segment 4			Pipeline	Dike	Pipeline	Dike	Pipeline	Dike	Pipeline	Dike		
	$10/cy	$12/cy	$13/cy	$17/cy												
Segment 1	$500				$6	$506	$100	$28							$128	$634
Segment 2		$600				$600			$193	$12					$205	$805
Segment 3			$650		$6	$656					$291	$26			$317	$973
Segment4				$850		$850							$339	$13	$352	$1,202
Total	$500	$600	$650	$850	$12	$2,612	$100	$28	$193	$12	$291	$26	$339	$3	$1,002	$3,614

* Operational Costs Included in the Dredging Cost

** Two replacements

Marsh Creation Cost

Unit marsh creation costs have been estimated. Table 7-11 shows cost per acre for Bay Raccourci. The cost for creating an acre of marsh for Bay Raccourci placement area is estimated at $102,285 and $127,857 for fill depths of 4 ft. and 5 ft., respectively. Cut to fill ratio was assumed to be 1:1.25. The unit price includes the cost for dredging, placement, pipeline, boosters, R-O-W acquisition, and operations.

Table 7-11. Cost per Acre for marsh creation- Bay Raccourci

MINIMUM COST PER ACRE		
DESCRIPTION	**QUANITIY**	**UNIT**
CUT VOLUME	50,000,000	C.Y.
FILL VOLUME	40,000,000	C.Y.
FILL VOLUME	1,080,000,000	C.F.
AVERAGE FILL HEIGHT	4.0	F.T.
AREA OF FILL	270,000,000	S.F.
AREA OF FILL	6,198	ACRE
TOTAL COST OF SEGMENT 1	$ 634,000,000	$
COST OF SEGMENT 1 PER ACRE	$ 102,285	$

TOTAL CONSTRUCTION COST PER ACRE	**$102,285**

MAXIMUM COST PER ACRE		
DESCRIPTION	**QUANITIY**	**UNIT**
CUT VOLUME	50,000,000	C.Y.
FILL VOLUME	40,000,000	C.Y.
FILL VOLUME	1,080,000,000	C.F.
AVERAGE FILL HEIGHT	5.0	F.T.
AREA OF FILL	216,000,000	S.F.
AREA OF FILL	4,959	ACRE
TOTAL COST OF SEGMENT 1	$ 634,000,000	$
COST OF SEGMENT 1 PER ACRE	$ 127,857	$

TOTAL CONSTRUCTION COST PER ACRE	**$127,857**

NOTE: ASSUME CUT TO FILL RATIO OF 1.25 FOR REPRESENTATIVE COST

Table 7.12 summarizes the unit cost for marsh creation for Falgout Canal area. The cost for creating an acre of marsh for Falgout Canal placement area is estimated at $97,405 and $129,873 for fill depths of 3 ft. and 4 ft., respectively.

Table 7.12 Cost per Acre for marsh creation- Falgout Canal

MINIMUM COST PER ACRE		
DESCRIPTION	**QUANITIY**	**UNIT**
CUT VOLUME	50,000,000	C.Y.
FILL VOLUME	40,000,000	C.Y.
FILL VOLUME	1,080,000,000	C.F.
AVERAGE FILL HEIGHT	3.0	F.T.
AREA OF FILL	360,000,000	S.F.
AREA OF FILL	8,264	ACRE
TOTAL COST OF SEGMENT 2	$ 805,000,000	$
COST OF SEGMENT 2 PER ACRE	$ 97,405	$

TOTAL CONSTRUCTION COST PER ACRE	**$97,405**

MAXIMUM COST PER ACRE		
DESCRIPTION	**QUANITIY**	**UNIT**
CUT VOLUME	50,000,000	C.Y.
FILL VOLUME	40,000,000	C.Y.
FILL VOLUME	1,080,000,000	C.F.
AVERAGE FILL HEIGHT	4.0	F.T.
AREA OF FILL	270,000,000	S.F.
AREA OF FILL	6,198	ACRE
TOTAL COST OF SEGMENT 2	$ 805,000,000	$
COST OF SEGMENT 2 PER ACRE	$ 129,873	$

TOTAL CONSTRUCTION COST PER ACRE	**$129,873**

NOTE: ASSUME CUT TO FILL RATIO OF 1.25 FOR REPRESENTATIVE COST

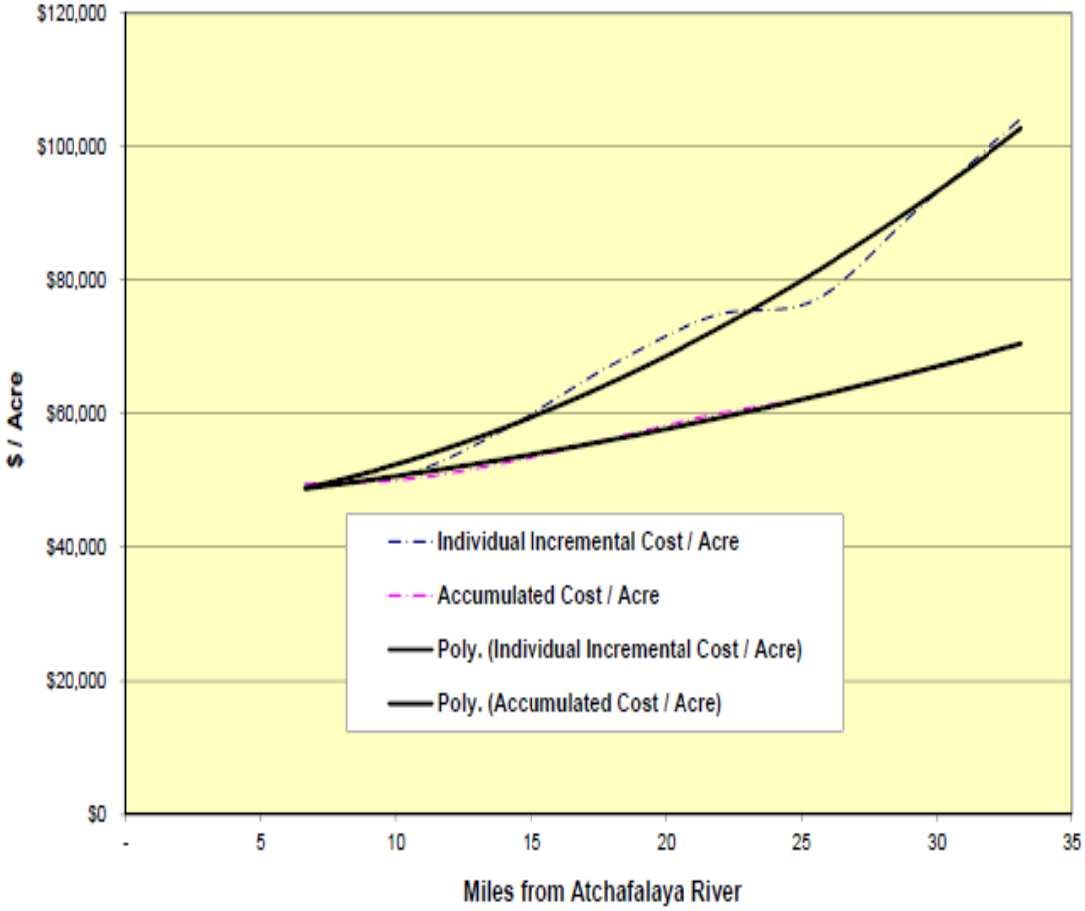


Figure 7.4 Marsh Creation cost/ acre as a function of distance from Atchafalaya River

Project cost per cubic yard

Table 7.13 summarizes the cost estimated per cubic yard for four segments and the entire project. The cost ranges from $12.68 to $24.04 for segment 1 through segment 4. An average of $18.07/cy is estimated for the entire project to transport approximately 200 million cubic yards.

Table 7.13. Cost/cubic yard for four segments and the entire project

Long Distance Sediment Pipeline Cost per CY			
COST PER CUBIC YARD			
DESCRIPTION	**COST**	**CUBIC YARDS**	**COST/CY**
Segment 1	$ 634,000,000	50,000,000	$12.68
Segment 2	$ 805,000,000	50,000,000	$16.10
Segment 3	$ 973,000,000	50,000,000	$19.46
Segment 4	$ 1,202,000,000	50,000,000	$24.04
TOTAL	**$3,614,000,000**	**$200,000,000**	**$18.07**

8.0 Cultural Resources, Stakeholder Coordination, and Public Meeting

8.1 Cultural Resources

In order to ascertain the subject project's potential impacts on cultural resources located along the proposed pipeline routes and in areas where sediment will be deposited, the team carried out a program of historical, literature, cartographic and site file research to identify areas previously surveyed for cultural resources and archaeological sites within the footprint of proposed project activities. Those sites were digitized and included in a project specific geographic information system (GIS). GIS shapefiles illustrating surveyed areas are identified by the corresponding Louisiana Division of Archaeology (LDA) site file reference number. Shapefiles associated with archaeological sites are identified by the LDA site number. Four 1:100,000 Topographic Maps make up the background for the GIS project. For each survey an abstract for the report has been included. A series of maps exported from the GIS are used to graphically illustrate report specific terrestrial and/or submerged cultural resource survey coverage that corresponds with the project footprint.

8.1.1 Research Methodology

Project research was initiated by contacting the Louisiana State Archaeologist Dr. Charles McGimsey and Section 106 Review and Compliance officer Rachel Watson. Based on that contact, the team initiated a program of historical and literature research designed to support development of historical and prehistoric backgrounds for the Terrebonne Project area.

With access to LDA site files established and data sources identified, a project specific GIS using ESRI ArcMap 10.1 was developed. The background for the Terrebonne GIS consists of four 1:100,000 Topographic maps downloaded from ChartTiff at Image Peak Systems in Berthound, Colorado. The Morgan City, Atchafalaya, Terrebonne and New Orleans Topographic maps were installed in the GIS using the Louisiana South NAD 83, US Survey foot State Plane coordinate system. With the background in place, shape files illustrating the existing pipeline canals, new pipeline corridors, dredging areas in the Atchafalaya and along the Intra-Coastal Waterway and locations for marsh and ridge habitat restoration in the vicinity of Bay Raccourci, south of Falgout Canal, the vicinity of Lake Tambour, and the vicinity of Wonder Lake.

Using data from the LDA site files, each survey area that extended into or was contained within the project footprint was digitized. Each digitized survey area was converted to a shapefile and identified according to the corresponding LDA alpha-numeric report

designation. An abstract of each survey report is included in the pending draft document with an accompanying map exported from the GIS. Known archaeological sites that extend into or are included within the project footprint have also been digitized, converted to point shapefiles and identified according to the corresponding LDA alpha-numeric site designation.

8.1.2 Surveyed Areas Extending Into or Included in the Project Footprint

A total of 22 surveys that extend into, or are contained within, the project footprint were identified, digitized and included in the project GIS. Seven remote-sensing surveys were carried out in the Atchafalaya where plans call for sediment associated with channel dredging to be recovered for transport through temporary pipelines laid in gas pipeline canals that transect the Terrebonne Hydrologic Basin. Six more surveys correlated with the location of extant pipeline canals or with proposed pipeline canals designed to transport material to the four marsh and ridge habitat restoration areas. The remaining nine surveys extend into or are included within the restoration areas. Five of those are within or extend into the Bay Raccourci area. Two surveys are within or extend into the Falgout Canal area. Two surveys are within or extend into the Lake Tambour area and five surveys are within or extend into the Wonder Lake area. Several surveys extend into more than one of the marsh and ridge habitat restoration areas.

While survey work has been carried out in each of the marsh and ridge habitat restoration areas, the Falgout Canal site has the highest survey density. The Lake Tambour site has been the site of the least cultural resource survey activity. Surveys in the Bay Raccourci ridge habitat restoration area have focused on small specific areas and along canal, bayou and lake levees. The Falgout Canal marsh and ridge habitat restoration area has the highest density of previous survey activity. Most of the northern third of the area has been surveyed along with several smaller areas in the south. The majority of cultural resource surveys in the Wonder Lake marsh and ridge habitat restoration area have been carried out along the rivers that border the area, and along the bayous and canals. Only two surveys extend into the Lake Tambour marsh and ridge habitat restoration area. Both are along the northern perimeter.

8.1.3 Conclusions

In light of the rich prehistoric and historical traditions associated with the Atchafalaya and the Central Terrebonne Hydrologic Basin, the project area is considered to be a high probability location for cultural resource sites. Previous research confirms that historical and archaeological resources in the project area can include prehistoric habitation sites, historic period habitation sites, historic agricultural, commercial and maritime structures and the

entire spectrum of vessels employed in transportation, fishing, agriculture and other activities on the rivers, lakes, canals and bayous of the Central Terrebonne Hydrologic Basin.

Clearly cultural resource surveys will be required in uninvestigated areas where dredging will occur and transects for the new pipeline canals will be excavated. Where marsh and ridge habitat restoration activity will alter the extant terrestrial and underwater environment, surveys will also be required to ensure that cultural resources meeting the eligibility requirements for nomination to the National Register of Historic Places are identified, avoided or preserved *in situ*. Where avoidance is not possible, archaeological investigation may be necessary to mitigate the loss of both physical remains and data through excavation and documentation.

As the proposed project activities will impact un-surveyed areas, plans for conducting underwater and terrestrial cultural resource surveys should be formulated as soon as specific impact areas can be identified. Plans for survey, resource avoidance and, where necessary, mitigation activities should be coordinated with the LDA as soon as project development and scheduling permits. That will ensure that any cultural resource related issues are identified and resolved prior to conflicting with construction activity.

Given the scope of the proposed project, cultural resource survey, investigation and mitigation will traditionally represent a relatively small portion of the necessary funding. However, as state and Federal legislation and regulations require established procedures for identifying, protecting, preserving and/or mitigating adverse impacts to cultural resources are required, that aspect of project planning, coordination and scheduling are imperative. The detailed report is included in Appendix D.

8.2 Stakeholder Coordination and Public Meeting

CB&I in coordination with TPCG conducted a stakeholder meeting on November 11, 2013 to discuss and obtain landowners' input to this project. Representatives from Apache Corporation, Conoco Phillips, Continental Land & Fur, and other stakeholders participated in the discussion.

The meeting discussed the borrow area, the pipeline corridor, and the placement areas. Landowners described their needs with regard to pipeline placement and water body crossings. Valuable information on the bayou crossings and closure dams was provided by Apache Corporation. Apache Corporation emphasized the need for maintaining the integrity

of current oil and gas activities and related infrastructures, while considering this project. Apache Corporation also provided their restoration plan for Bay Raccourci placement areas and stated that this project is consistent with their vision. All the participants were in agreement with this project and promised their support.

9.0 Conclusions and Recommendations

This report is a feasibility level analysis. Defendable and justifiable assumptions were made by analyzing existing information and were incorporated into this study. CB&I conducted feasibility analysis on pipeline corridor and placement area evaluation, while M&N carried out the borrow area evaluation.

9.1 Borrow Area Evaluation

Borrow area evaluation was based on the availability of sediment from beneficial use of dredge material and dedicated dredging. Beneficial use of dredge material seemed to be not sustainable due to the uncertainty with respect to USACE's funding as well as maintenance dredging schedule. Therefore, dedicated dredging is recommended for this project.

Based on the available information and analysis, borrow location ATCH-137E is recommended to be used to satisfy the project demand of 50 million cubic yards. This borrow location has an initial volume of 19.5 cubic yards. It is estimated that 5 million cubic yards of sediments can be dredged every year from this location. Approximately 5.6 million cubic yards of sediment is estimated to be refilled annually. In an optimum situation, 50 million cubic yards of material can be dredged in 6.5 years.

9.2 Pipeline Corridor Evaluation

Among the three pipeline corridors evaluated, Tennessee Gas Pipeline corridor owned and operated by Kinder Morgan is recommended for the proposed long distance pipeline. R-O-W dimensions with respect to the natural gas pipeline alignment vary along the corridor. The requirement by Kinder Morgan of 25 feet separation between the existing natural gas pipeline and the proposed pipeline made it necessary to consider various options for the sediment pipeline placement for the entire corridor.

9.3 Pipeline placement and Design

Approximately 42 miles of pipeline corridor and an additional 15 miles of right-of-way beyond the TGP corridor will be required for the trunk lines and laterals to deliver sediments to the placement areas. The entire proposed sediment pipeline is divided into four segments that reach four placement areas. There are 10 booster stations recommended for the entire pipeline system.

Four alternative pipeline placements with two options for each with the exception of one alternative are recommended for the entire pipeline corridor. This approach is necessary to accommodate large cross sectional variations that are observed along the TGP corridor. It is recommended that a combination of these alternatives be utilized to place the proposed sediment pipeline. The four placement alternatives recommended are submerged, at-grade, fill placement (ridge), and floating steel pipe. Two options for these four alternatives include one placement within and outside the R-O-W.

The pipeline and booster pump design elements assumptions are given below:

- ✓ Dredge Production Rate: 40,000 to 50,000 cubic yards/day
- ✓ Pipeline Diameter: 30” to 36”
- ✓ Pipeline Material: Steel Pipe with ¾” wall thickness
- ✓ Pipeline Longevity: 50 million Cubic yards
- ✓ Booster Pumps: 10,000 hp with an average spacing distance of 5 miles per booster stations

9.4 Marsh Creation/Dredge Placement Evaluation

TPCG has predetermined four potential placement areas which include Bay Raccourci (25,000 acres), the open waters south of Falgout Canal (30,000 acres), the vicinity of Lake Tambour (25,000 acres), and the vicinity of Wonder Lake (40,000).

Three methods of placement are recommended based on restoration type and objective, site specific conditions, and sediment type with or without containment dikes. These are traditional hydraulic placement, thin layer application, and slurry placement.

Construction target elevation is recommended as +3.0 ft. to +3.5 ft. NAVD based on geotechnical conditions of the four placement areas. It is estimated that the long term target elevation of 0to +1.5 ft. NAVD will be achieved in 10 to 15 years. It is recommended that detailed engineering analysis be carried out for all four placement areas, especially Bay Raccourci due to its poor soil conditions.

The marsh fill volume for each placement area has been estimated using the construction target elevation ranging from +3.0 ft. to +3.5 ft. NAVD using a minimum coverage percentage of 30% and a maximum coverage of 60%. It is not recommended to fill in the entire placement area so that marshes can be created that are ecologically sustainable.

Containment dike is recommended in multiple lifts under specific conditions and will be decided during the design stages of this project.

9.5 Cost Analysis

The cost analysis presented here is conceptual and based on justifiable assumptions. There are many variables unknown at this time. However, cost estimates described here for a feasibility level analysis are adequate.

Based on the assumptions described in this report, the cost elements are described below for Segment 1 Pipeline project:

- ✓ Dredging Cost: $500M
- ✓ Intake Structure: $6M
- ✓ Containment Dikes : $28M
- ✓ Pipeline: $100M
- ✓ Total Cost for Segment 1: **$634M**

Table 9-1 summarizes the cost for all segments. The cost includes dredging, intake structure, pipelines and containment dike construction.

Table 9-1 Cost Summary

	Dredging & Intake Structure ($ Millions)						Pipeline Corridor And Placement Area Dike Construction ($ Millions)									
	Dredging*, 50 M CY				Intake Structure**	Sub-Total	Segment 1		Segment 2		Segment 3		Segment 4		Sub-Total	Total
	Segment 1	Segment 2	Segment 3	Segment 4			Pipeline	Dike	Pipeline	Dike	Pipeline	Dike	Pipeline	Dike		
	$10/cy	$12/cy	$13/cy	$17/cy												
Segment 1	$500				$6	$506	$100	$28							$128	$634
Segment 2		$600				$600			$193	$12					$205	$805
Segment 3			$650		$6	$656					$291	$26			$317	$973
Segment4				$850		$850							$339	$13	$352	$1,202
Total	$500	$600	$650	$850	$12	$2,612	$100	$28	$193	$12	$291	$26	$339	$3	$1,002	$3,614

* Operational Costs Included in the Dredging Cost
** Two replacements

9.6 Recommendations

- ➢ Based on the dredge material demand of 50 M cubic yards, borrow location ATCH-137E is recommended
- ➢ Cutter head dredge operation is preferable
- ➢ Intake structure to be located in the Horseshoe Bend vicinity
- ➢ Tennessee Gas Pipeline (TGP) corridor is recommended as the LDSP corridor
- ➢ 42 miles of trunk line,15 miles of laterals, 10 booster pumps are required for the entire project, which consists of four segments

- Four alternative pipeline placement methods are suggested. A combination of these four alternatives are recommended to negotiate varying conditions of existing TGP R-O-W, submerged being the cheapest and ridge placement being the most expensive alternative
- Traditional hydraulic placement with a combination of confined and unconfined placement is recommended for marsh creation
- The entire project as conceived to include all four segments is estimated to cost more than $3.6 B, whereas a project with Segments 1 and 2 are estimated at $634M and $805M, respectively
- Detailed cost analysis is required and a Phase 2 of this feasibility study is recommended

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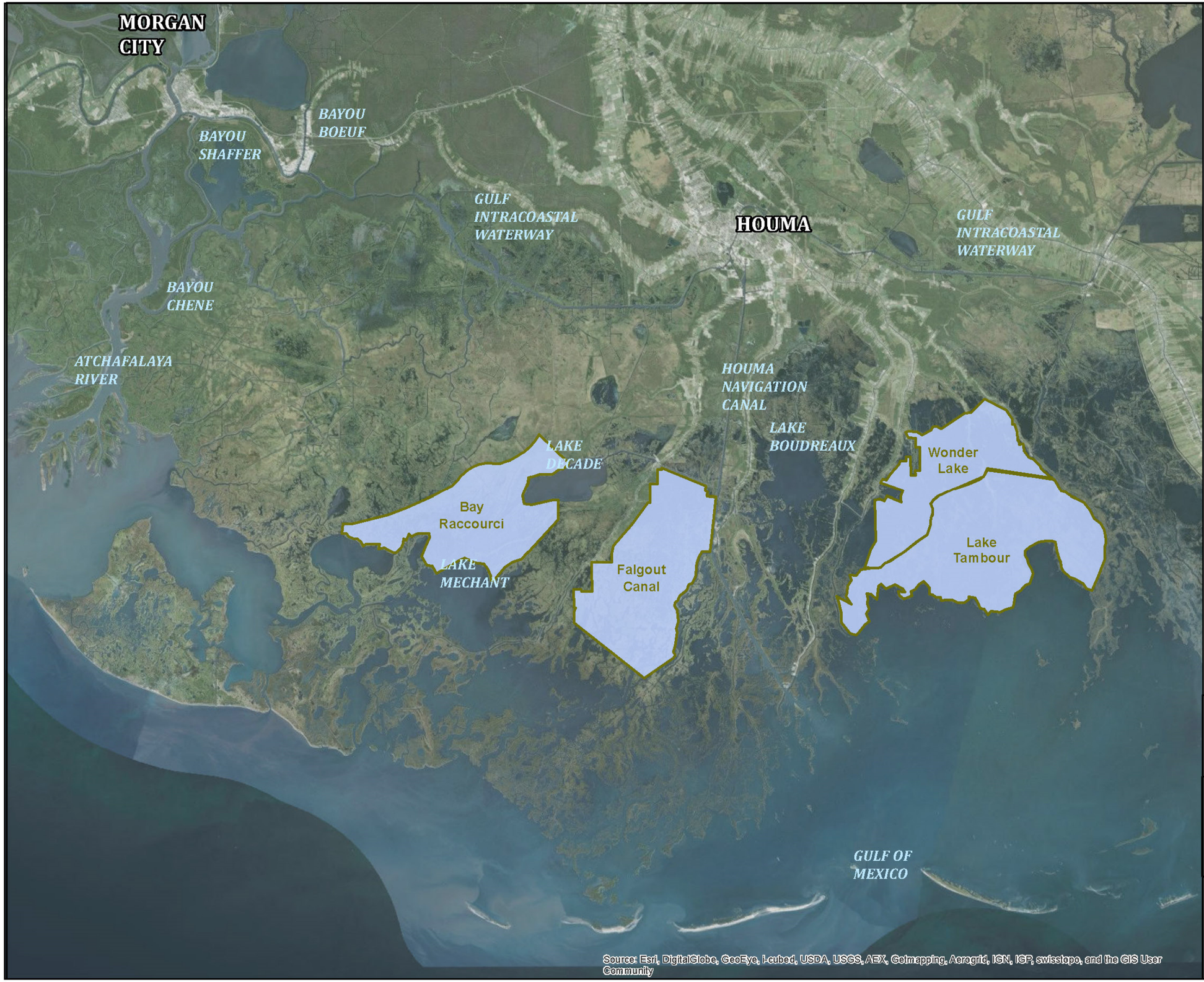
Figures



Legend

Placement Area

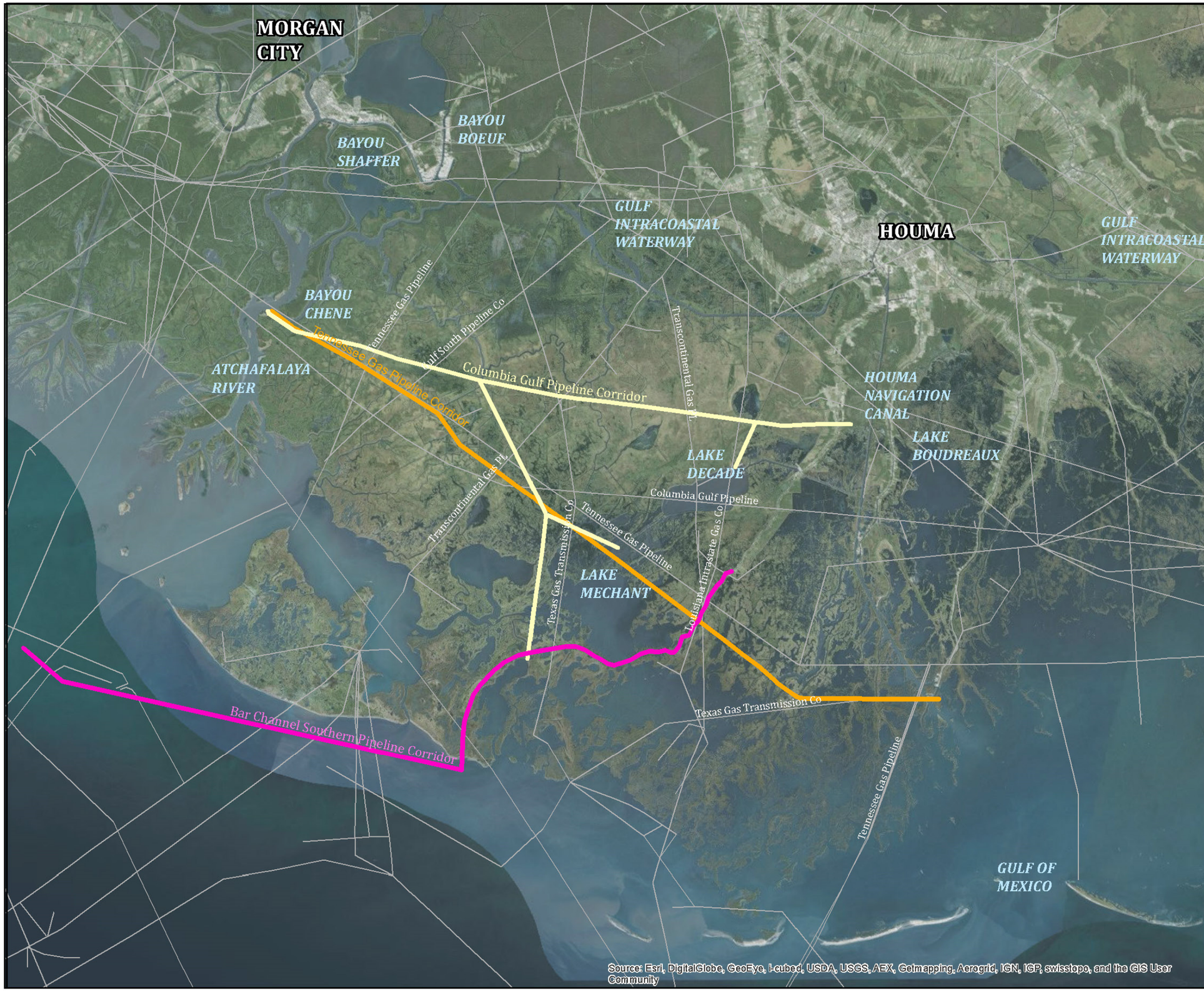
N

0 5 10 Miles

TERREBONNE PARISH GOVERNMENT
TERREBONNE PARISH, LA

FIGURE NUMBER	TERREBONNE PARISH Placement Areas
2-1	

CBI
4171 Essen Lane
Baton Rouge, Louisiana 70809
www.CBI.com



Legend

- Bar Channel Southern Pipeline Corridor
- Columbia Gulf Pipeline Corridor
- Tennessee Gas Pipeline Corridor
- U.S. Natural Gas Pipelines

N

0 5 10 Miles

TERREBONNE PARISH GOVERNMENT
TERREBONNE PARISH, LA

FIGURE NUMBER	TERREBONNE PARISH Proposed Long Distance Sediment Pipeline Corridors
4-1	

CBI
4171 Essen Lane
Baton Rouge, Louisiana 70809
www.CBI.com

Legend

Tennessee Gas Pipeline Corridor

U.S. Natural Gas Pipelines

N

0 5 10 Miles

TERREBONNE PARISH GOVERNMENT
TERREBONNE PARISH, LA

FIGURE NUMBER	TERREBONNE PARISH Existing Tennessee Gas Pipeline Corridor
4-2	

CBI
4171 Essen Lane
Baton Rouge, Louisiana 70809
www.CBI.com

Legend

Columbia Gulf Pipeline Corridor

U.S. Natural Gas Pipelines

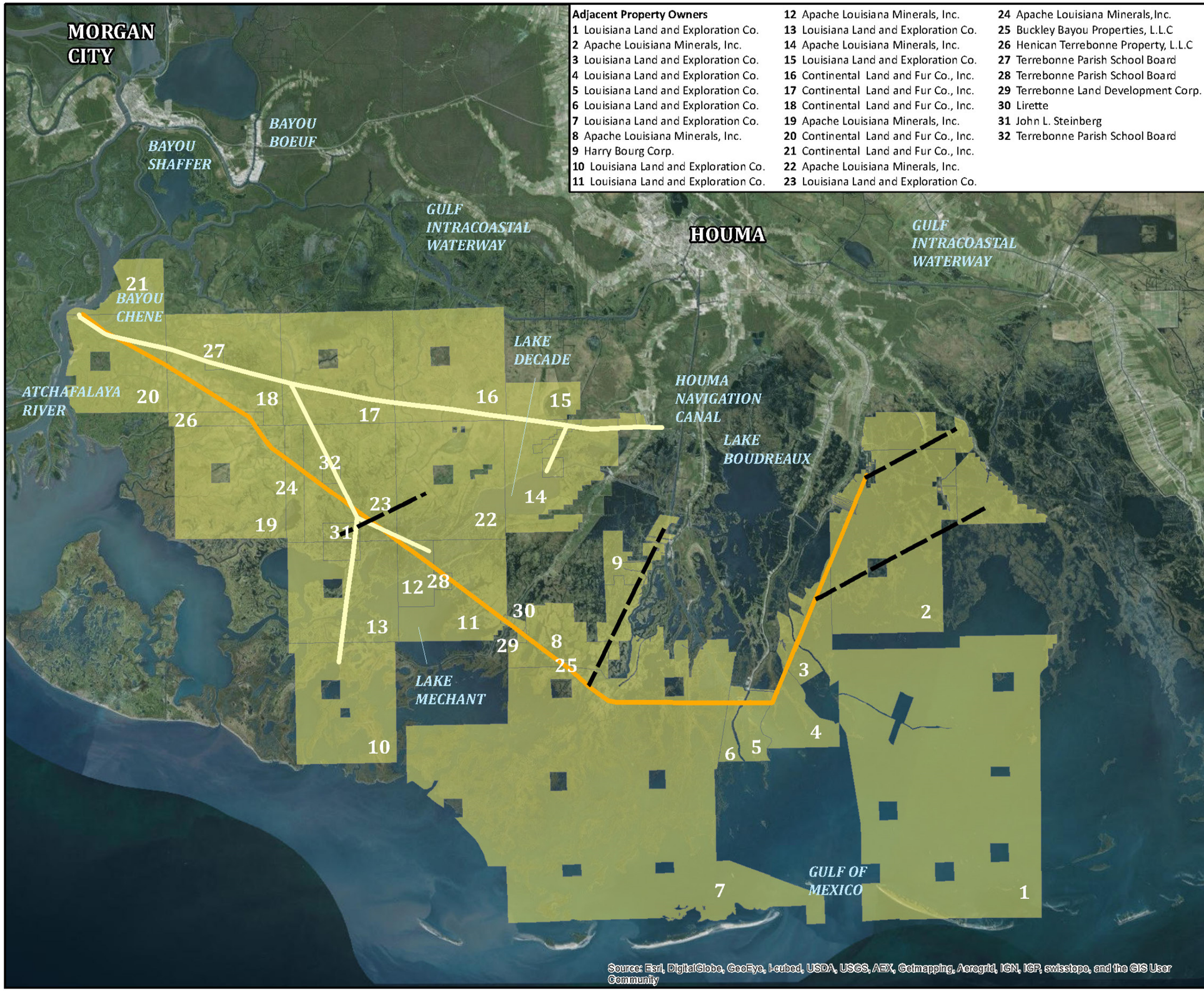
N

0 5 10 Miles

TERREBONNE PARISH GOVERNMENT
TERREBONNE PARISH, LA

FIGURE NUMBER	TERREBONNE PARISH Existing Columbia Gulf Pipeline Corridor
4-3	

CBI
4171 Essen Lane
Baton Rouge, Louisiana 70809
www.CBI.com



Adjacent Property Owners

1 Louisiana Land and Exploration Co.
2 Apache Louisiana Minerals, Inc.
3 Louisiana Land and Exploration Co.
4 Louisiana Land and Exploration Co.
5 Louisiana Land and Exploration Co.
6 Louisiana Land and Exploration Co.
7 Louisiana Land and Exploration Co.
8 Apache Louisiana Minerals, Inc.
9 Harry Bourg Corp.
10 Louisiana Land and Exploration Co.
11 Louisiana Land and Exploration Co.
12 Apache Louisiana Minerals, Inc.
13 Louisiana Land and Exploration Co.
14 Apache Louisiana Minerals, Inc.
15 Louisiana Land and Exploration Co.
16 Continental Land and Fur Co., Inc.
17 Continental Land and Fur Co., Inc.
18 Continental Land and Fur Co., Inc.
19 Apache Louisiana Minerals, Inc.
20 Continental Land and Fur Co., Inc.
21 Continental Land and Fur Co., Inc.
22 Apache Louisiana Minerals, Inc.
23 Louisiana Land and Exploration Co.
24 Apache Louisiana Minerals,Inc.
25 Buckley Bayou Properties, L.L.C
26 Henican Terrebonne Property, L.L.C
27 Terrebonne Parish School Board
28 Terrebonne Parish School Board
29 Terrebonne Land Development Corp.
30 Lirette
31 John L. Steinberg
32 Terrebonne Parish School Board

Legend

- Parcel
- Lateral
- Columbia Gulf Pipeline Corridor
- Tennessee Gas Pipeline Corridor

N

0 5 10 Miles

** Only parcels with readily available ownership information are numbered,*

TERREBONNE PARISH GOVERNMENT
TERREBONNE PARISH, LA

FIGURE NUMBER	TERREBONNE PARISH Existing Gas Pipeline Corridors - Adjacent Property Owners
4-4	

CBI
4171 Essen Lane
Baton Rouge, Louisiana 70809
www.CBI.com

Legend

- Placement Area
- Booster Station
- Five Mile Marker
- Lateral
- U.S. Natural Gas Pipelines

Tennessee Gas Pipeline Corridor

- Segment 1
- Segment 2
- Segment 3
- Segment 4

N

0 5 10 Miles

TERREBONNE PARISH GOVERNMENT
TERREBONNE PARISH, LA

FIGURE NUMBER	TERREBONNE PARISH Booster Station Location Map
5-10	

CBI
4171 Essen Lane
Baton Rouge, Louisiana 70809
www.CBI.com

Legend

Tennessee Gas Pipeline Corridor

Placement Area and Subarea

0

0 5 10 Miles

TERREBONNE PARISH GOVERNMENT
TERREBONNE PARISH, LA

FIGURE NUMBER	TERREBONNE PARISH Placement Areas and Subareas
6-11	

CBI
4171 Essen Lane
Baton Rouge, Louisiana 70809
www.CBI.com

Appendices

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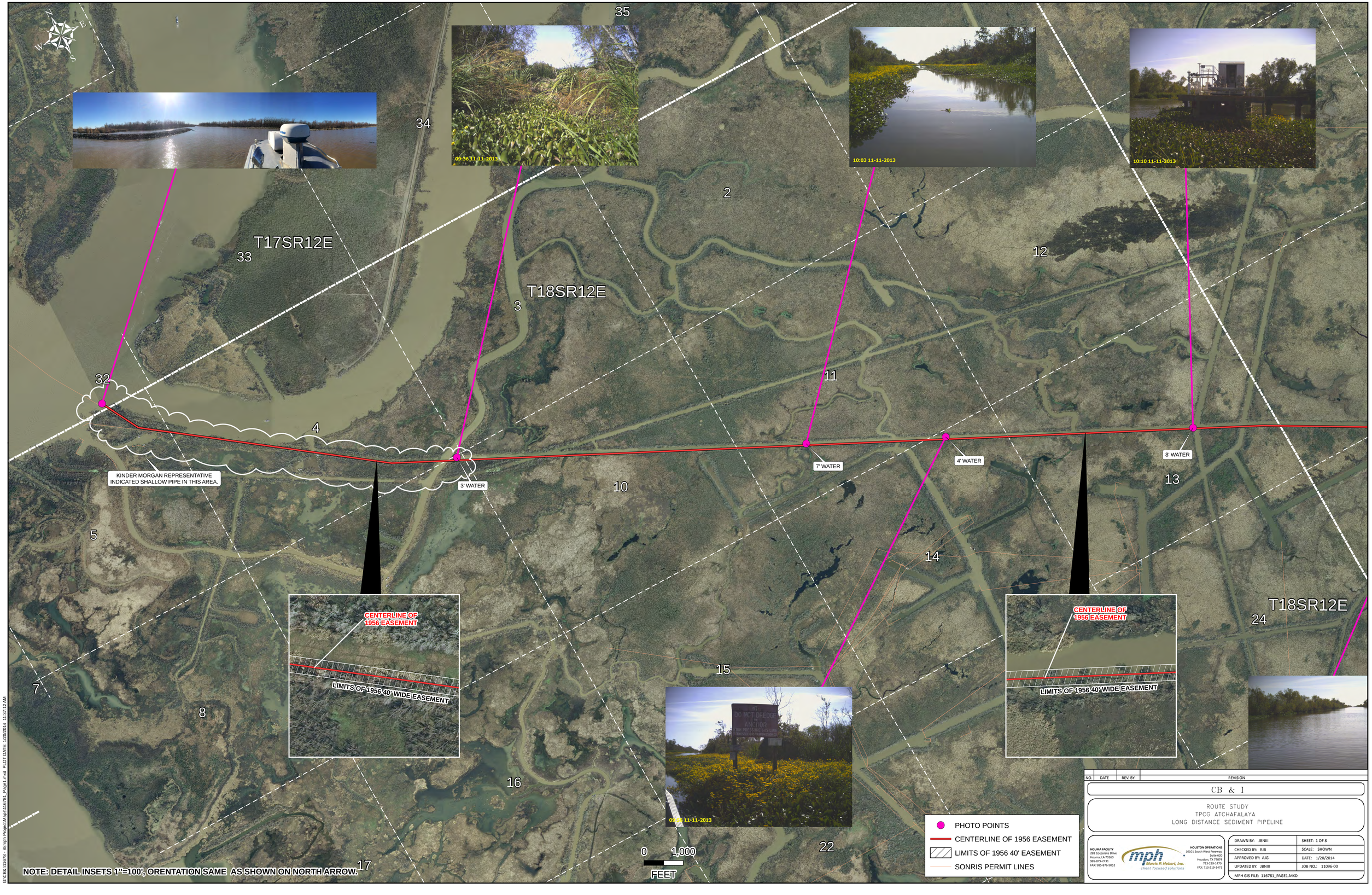
Appendix A

Route Study, TPCG Atchafalaya Long Distance Sediment Pipeline



NOTE: DETAIL INSETS 1"=100', ORENTATION SAME AS SHOWN ON NORTH ARROW.

NO.	DATE	REV. BY:	REVISION

CB & I

ROUTE STUDY
TPCG ATCHAFALAYA
LONG DISTANCE SEDIMENT PIPELINE

HOUMA FACILITY
285 Corporate Drive
Houma, LA 70360
985-879-2731
FAX: 985-876-9052

mph Morris P. Hebert, Inc. client focused solutions

HOUSTON OPERATIONS
10101 South West Freeway
Suite 620
Houston, TX 77074
713-219-1470
FAX: 713-219-1471

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CHECKED BY: RJB	SCALE: SHOWN
APPROVED BY: AJG	DATE: 1/20/2014
UPDATED BY: JBNIII	JOB NO.: 11096-00
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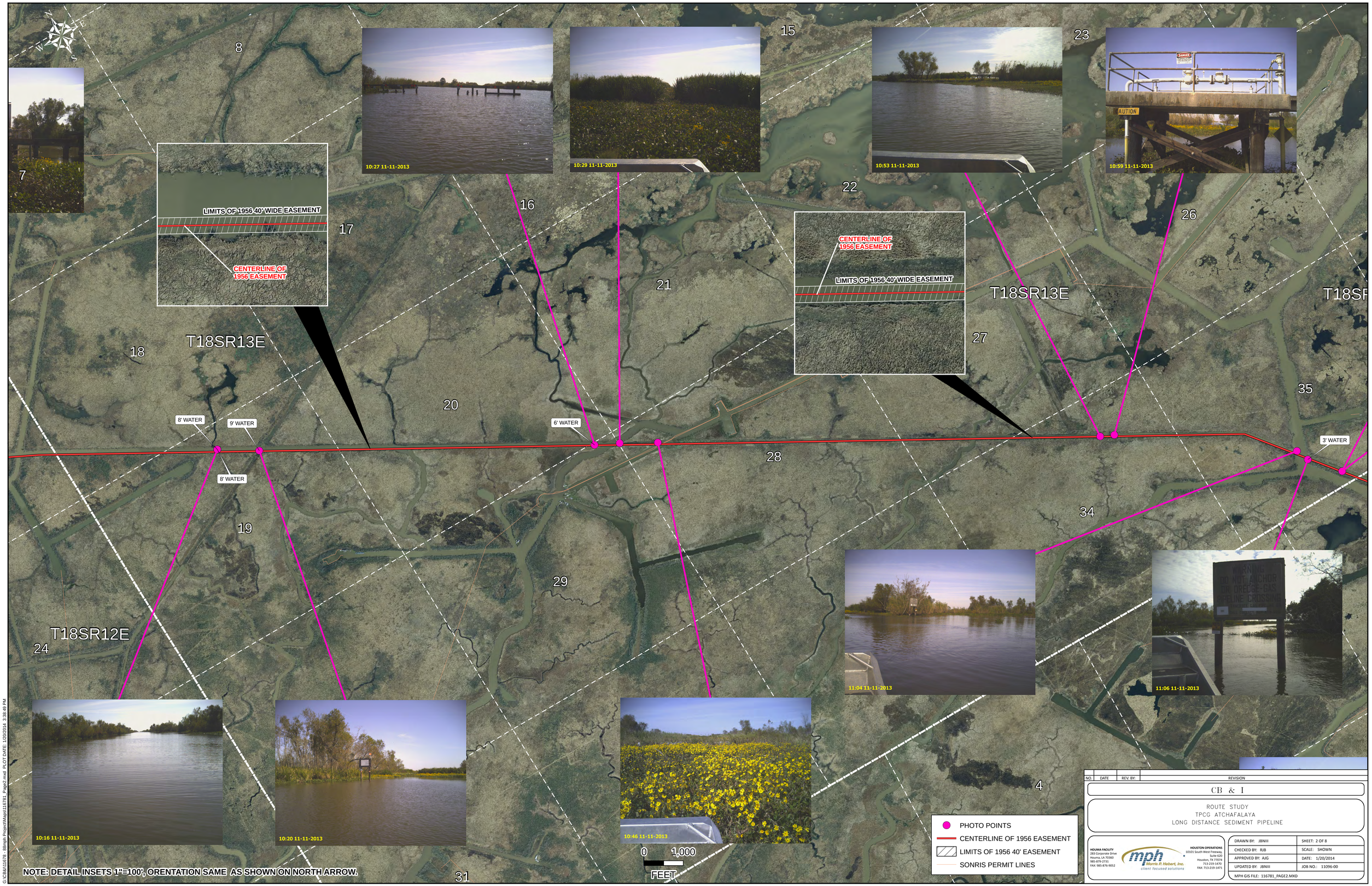

NOTE: DETAIL INSETS 1"=100', ORENTATION SAME AS SHOWN ON NORTH ARROW.

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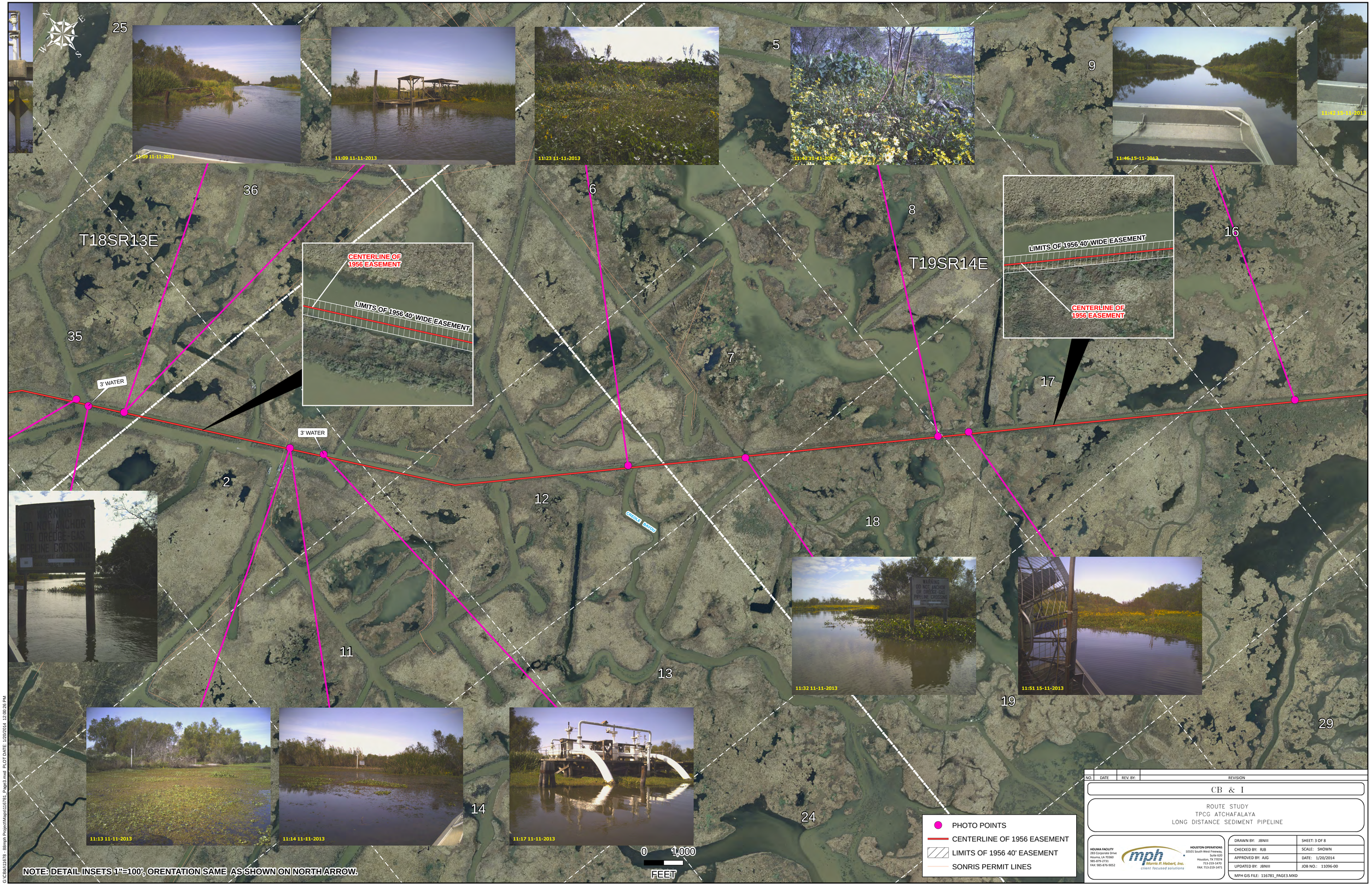

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mph Morris P. Hebert, Inc. client focused solutions

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713-219-1470
FAX: 713-219-1471

DRAWN BY: JBNIII	SHEET: 3 OF 8
CHECKED BY: RJB	SCALE: SHOWN
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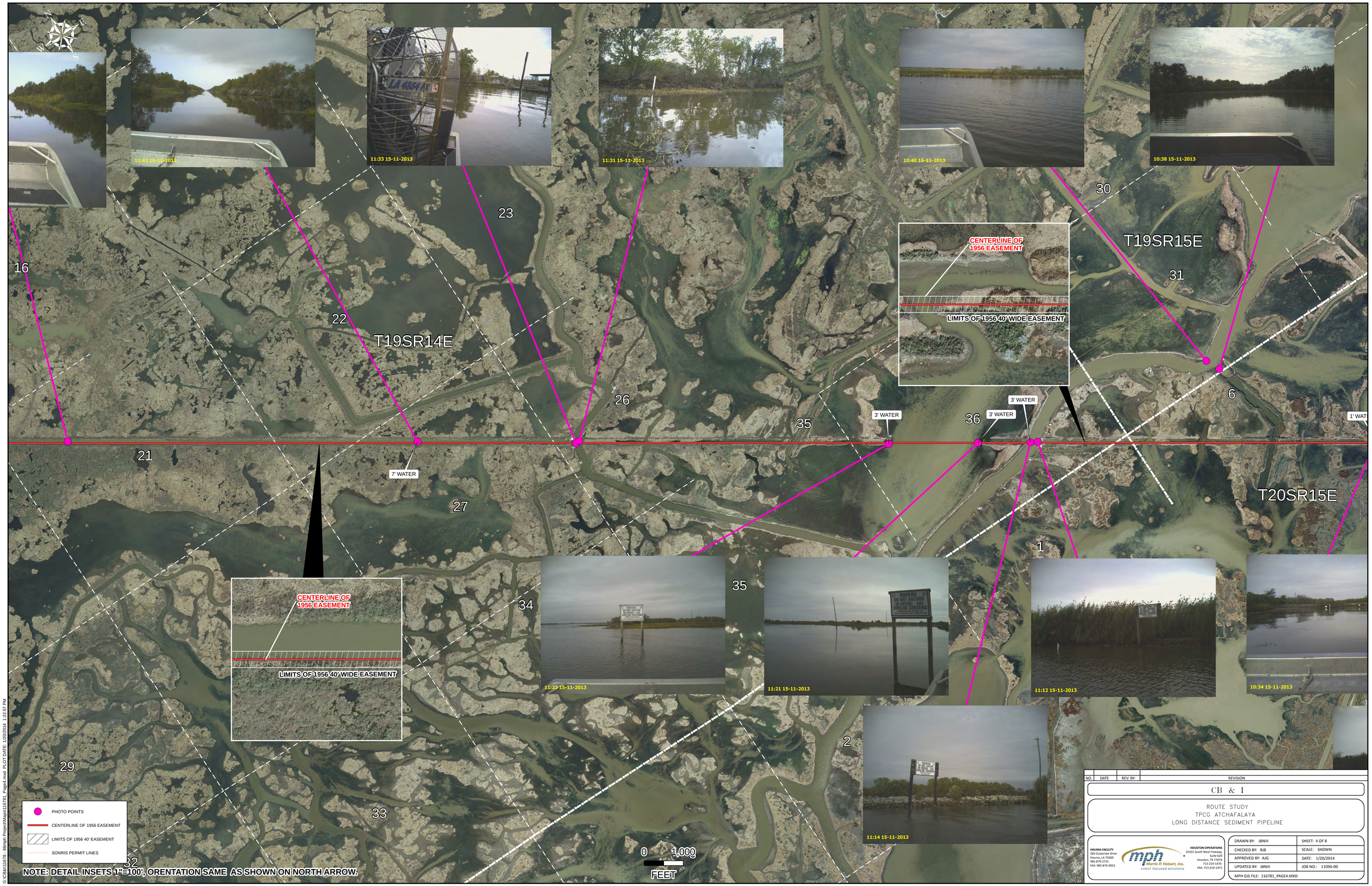

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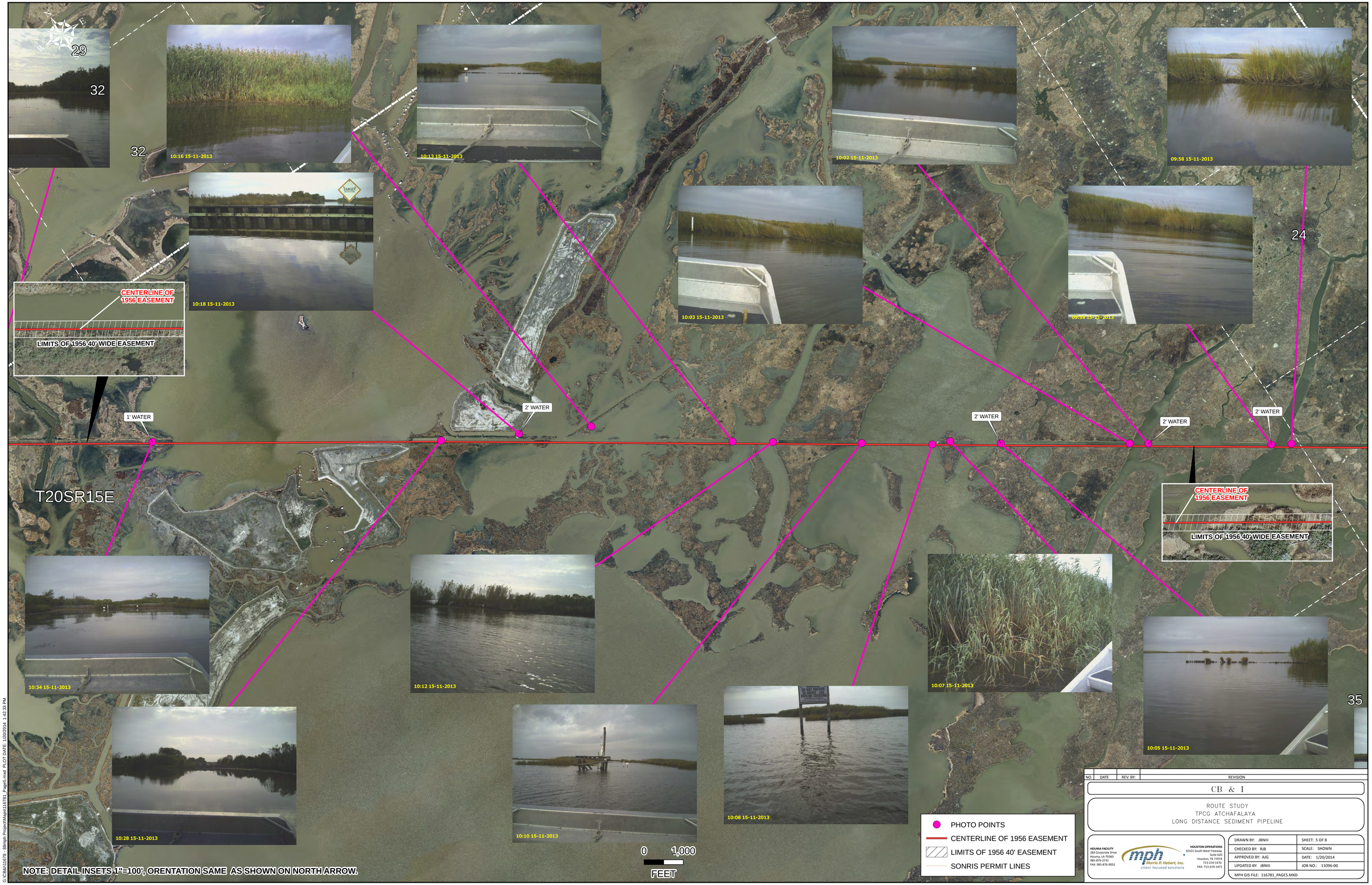

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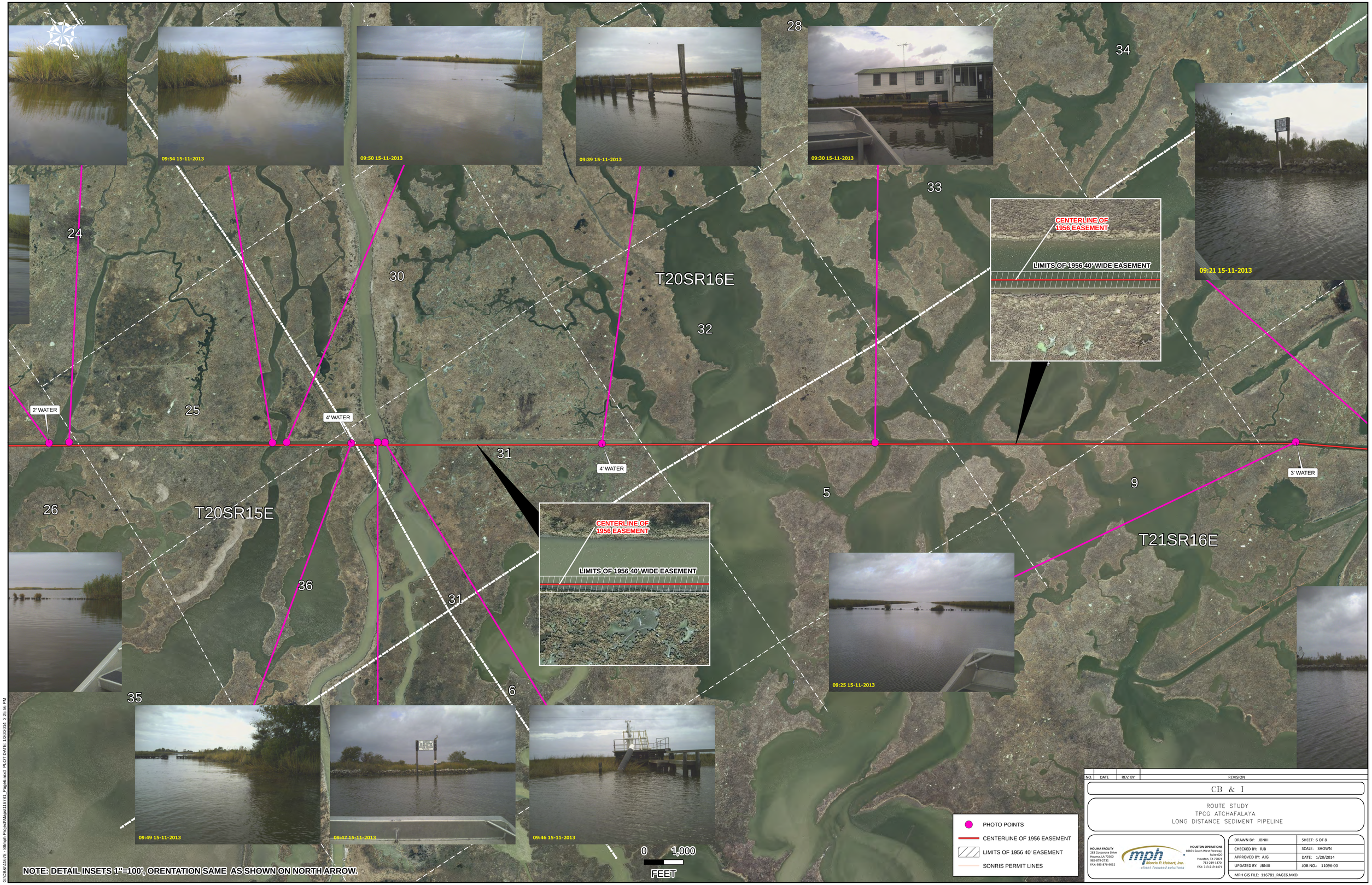

NOTE: DETAIL INSETS 1"=100', ORENTATION SAME AS SHOWN ON NORTH ARROW.

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FAX: 713-219-1471

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Houma, LA 70360
985-879-2731
FAX: 985-876-9052

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Houston, TX 77074
713-219-1470
FAX: 713-219-1471

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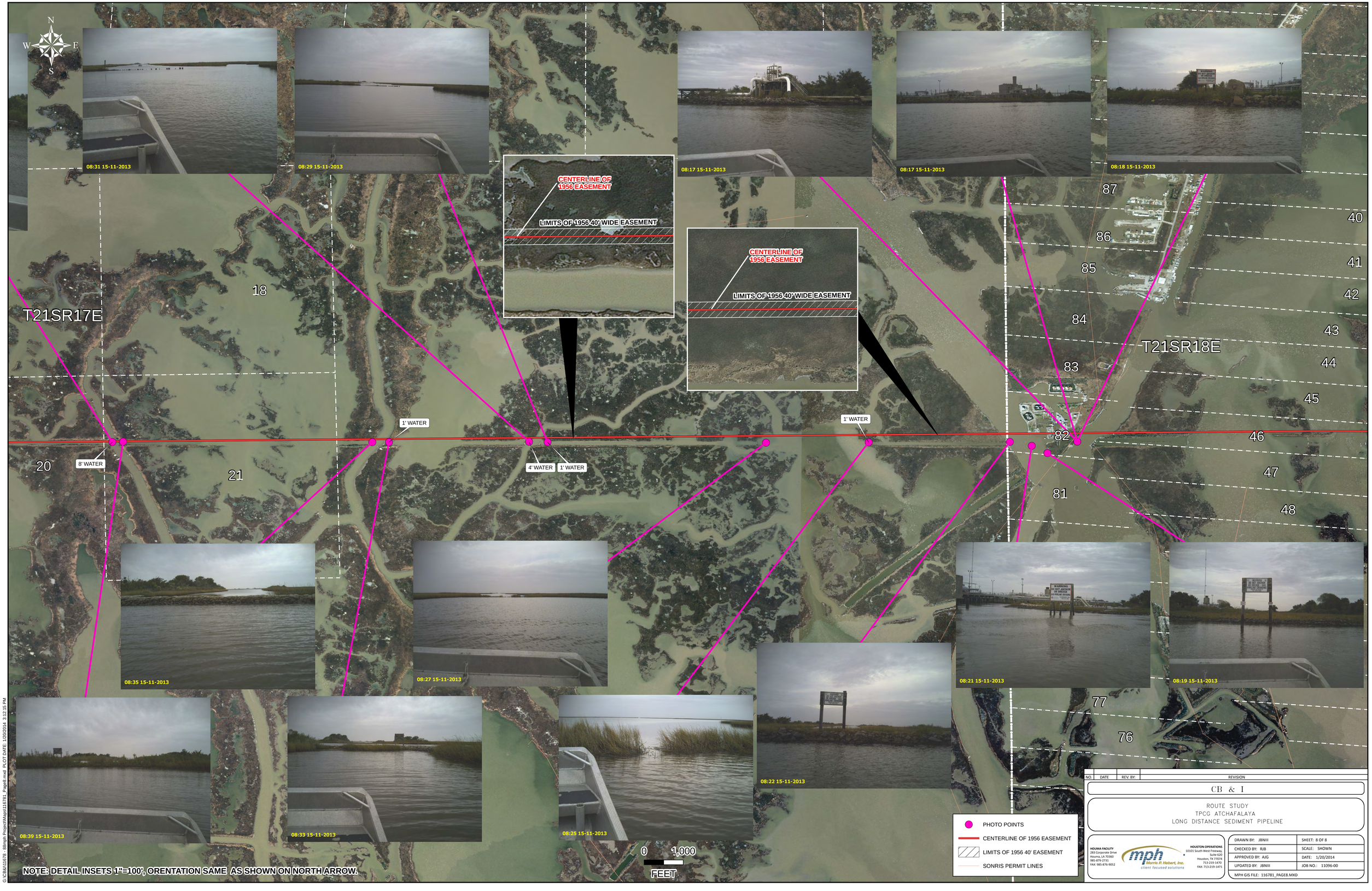
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S
E
W
08:31 15-11-2013
08:29 15-11-2013
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08:17 15-11-2013
08:18 15-11-2013
CENTERLINE OF 1956 EASEMENT
LIMITS OF 1956 40' WIDE EASEMENT
CENTERLINE OF 1956 EASEMENT
LIMITS OF 1956 40' WIDE EASEMENT
T21SR17E
T21SR18E
18
20
21
87
86
85
84
83
82
81
40
41
42
43
44
45
46
47
48
77
76
8' WATER
1' WATER
4' WATER
1' WATER
1' WATER
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08:19 15-11-2013
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08:33 15-11-2013
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08:22 15-11-2013
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FEET
PHOTO POINTS
CENTERLINE OF 1956 EASEMENT
LIMITS OF 1956 40' EASEMENT
SONRIS PERMIT LINES
NOTE: DETAIL INSETS 1"=100', ORENTATION SAME AS SHOWN ON NORTH ARROW.
NO. | DATE | REV. BY: | REVISION
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ROUTE STUDY
TPCG ATCHAFALAYA
LONG DISTANCE SEDIMENT PIPELINE
HOUMA FACILITY
283 Corporate Drive
Houma, LA 70360
985-879-2731
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FAX: 713-219-1471
DRAWN BY: JBNIII
SHEET: 8 OF 8
CHECKED BY: RJB
SCALE: SHOWN
APPROVED BY: AJG
DATE: 1/20/2014
UPDATED BY: JBNIII
JOB NO.: 11096-00
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Appendix B

Existing 24” Tennessee Pipeline Survey

THE PIPELINE RIGHT-OF-WAY SHOWN HEREON WAS PLOTTED FROM THE NAD 27 STATE PLANE COORDINATES PROVIDED IN INSTRUMENT NO. 150683 UNTIL THE POINT MARKED "X" ON SHEET 1 OF 2. THE COORDINATES PROVIDED FOR THE FOLLOWING POINT WERE FOUND TO BE ERRONEOUSLY RECORDED BASED ON THE PROPOSED ALIGNMENT SHEETS (T0-T2-500-1-50 & T0-T2-500-1-51) DATED 01/11/1971, AS WELL AS 2013 NAIP AERIAL PHOTOGRAPHY. THEREFORE THE PORTION OF THE RIGHT-OF-WAY EAST OF THE POINT MARKED "X" WAS PLOTTED USING THE BEARING AND DISTANCE RECORDED IN THE REFERENCED INSTRUMENT. AFTER THIS CENTERLINE WAS CONSTRUCTED IN NAD 27 COORDINATES, THE ENTIRELY OF SAID CENTERLINE WAS TRANSLATED FROM NAD 27 TO NAD 83 USING MODERN COMPUTATION TECHNIQUES.

NO ON-THE-GROUND EFFORT HAS BEEN MADE TO LOCATE AND INDICATE ALL BELOW GROUND FERROUS METAL CABLES, PIPELINES, UTILITIES, ETC. CROSSED BY THE PROPOSED PROJECT; HOWEVER, DUE TO THE INHERENT LIMITATIONS OF ELECTRONIC MAGNETIC LOCATING EQUIPMENT, MORRIS P. HEBERT, INC. IS NOT RESPONSIBLE FOR ANY CABLES, PIPELINES, UTILITIES OR ANY OTHER BELOW GROUND STRUCTURES (INCLUDING PVC) NOT LOCATED DURING THE COURSE OF THE SURVEY.

GRAPHIC SCALE

0 3,000' 6,000' 12,000' 18,000'

NOTES:

1.) SEE SHEET 2 FOR CROSS SECTIONS

2.) SURVEYED BY MORRIS P. HEBERT, INC. ON FEB. 27, 2014 BK. 1899, PG. 16-19, FEB. 28, 2014 BK. 1899, PG. 20-23, MAR. 03, 2014 BK. 1835, PG. 19-23.

NO.	DATE	REV. BY:	REVISION

CB&I

PLAN
EXISTING 24" TENNESSEE PIPELINE
SURVEY
LOCATED IN
TERREBONNE PARISH, LOUISIANA

Morris P. Hebert, Inc.
SURVEYING • ENGINEERING • ENVIRONMENTAL SERVICES • FIELD SERVICES • GIS
P.O. BOX 3106 • 283 CORPORATE DRIVE • HOUMA, LOUISIANA 70361 • (985) 879-2731
HOUMA, LA. • BATON ROUGE, LA. • HOUSTON, TX. • SAN ANTONIO, TX. • CLINTON, NJ.
TEXAS SURVEY FIRM REGISTRATION NUMBER: 10193786 (HOUMA OFFICE)

DRAWN BY: NPB	SHEET: 1 OF 2		
CHKD./APPD. BY: AJG	SCALE: 1" = 6000'		
UPDATED BY:	DATE: 3/13/2014		
DATA BASE: 11678	JOB NO. 11678		
MPH CAD FILE: MAG BASEMAP.DWG			

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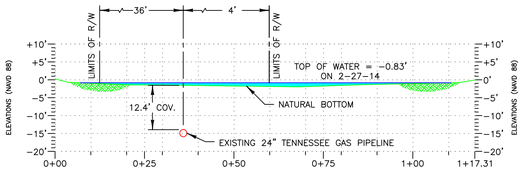

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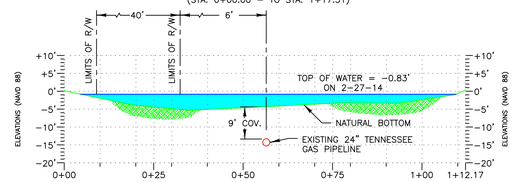

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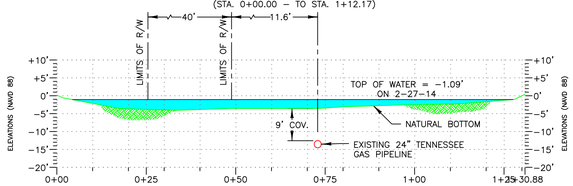

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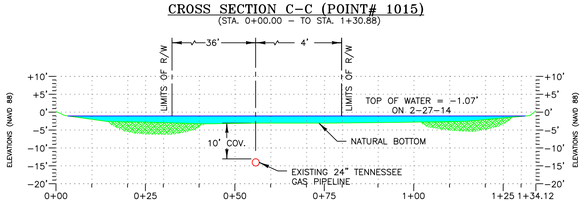

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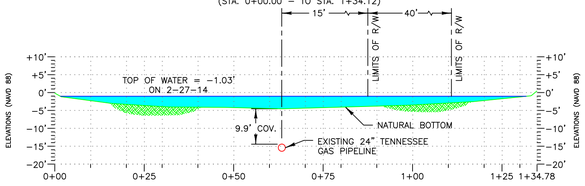

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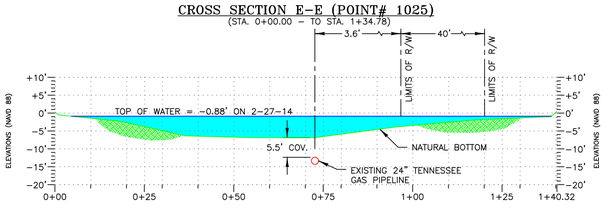

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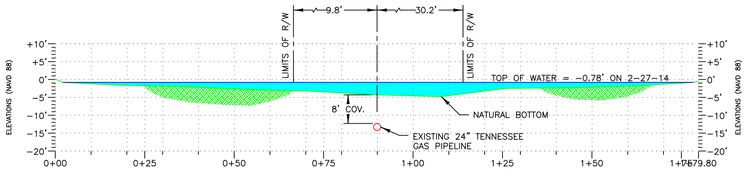

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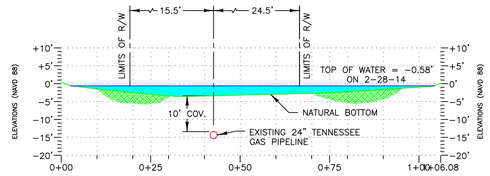

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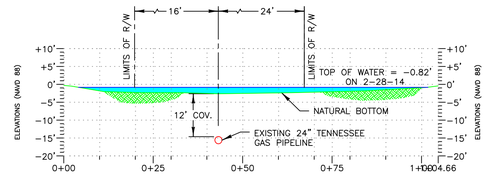

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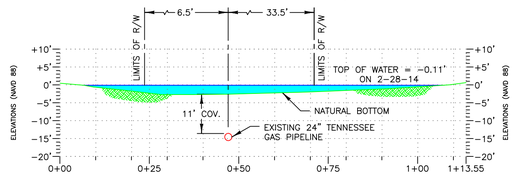

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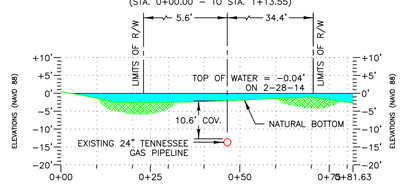

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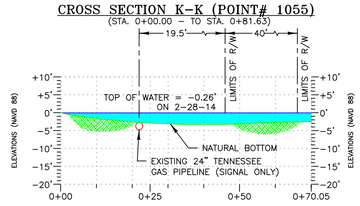

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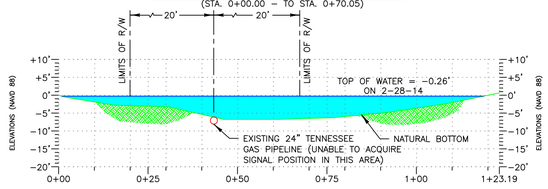

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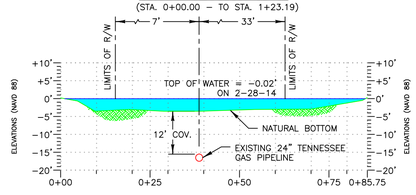

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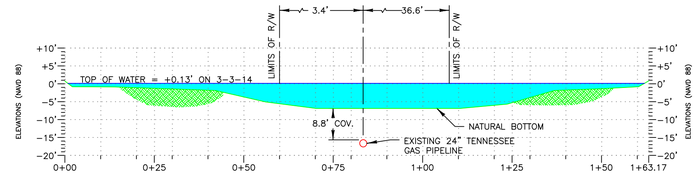

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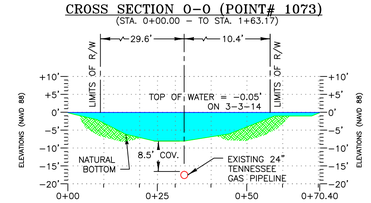

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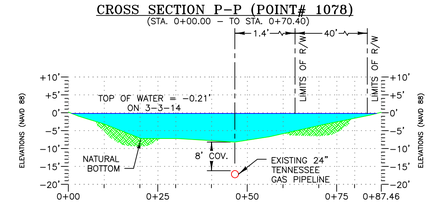

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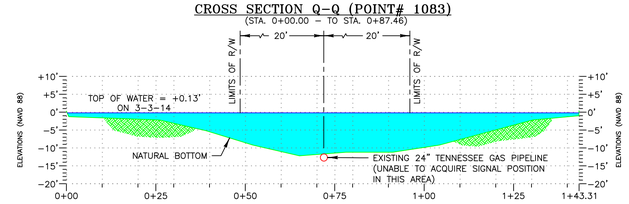

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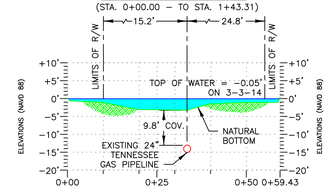

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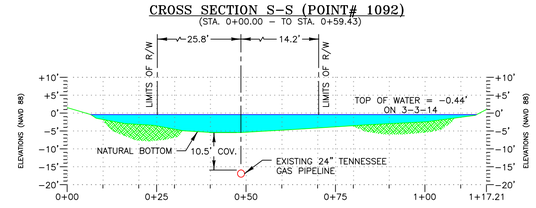

CROSS SECTION T-T (POINT# 1097)
(STA. 0+00.00 – TO STA. 1+17.21)

POINT TABLE

POINT #	NORTHING	EASTING	LATITUDE	LONGITUDE	WATER DEPTH	MUD COVER	EXISTING 24" PIPELINE
1001	267,976.45	3,490,754.84	N29°14'06.74"	W90°40'30.66"	0.5'	12.4'	EXISTING 24" PIPELINE
1010	268,045.85	3,480,232.00	N29°14'08.01"	W90°42'29.42"	3.5'	9.0'	EXISTING 24" PIPELINE
1015	268,111.89	3,469,452.46	N29°14'09.23"	W90°44'31.09"	2.5'	9.0'	EXISTING 24" PIPELINE
1020	268,205.02	3,456,964.67	N29°14'10.76"	W90°46'52.03"	2.0'	10.0'	EXISTING 24" PIPELINE
1025	273,882.72	3,448,217.39	N29°15'07.38"	W90°48'30.46"	3.5'	9.9'	EXISTING 24" PIPELINE
1030	280,189.61	3,440,574.49	N29°16'10.15"	W90°49'56.43"	6.0'	5.5'	EXISTING 24" PIPELINE
1035	286,903.95	3,431,670.25	N29°17'17.00"	W90°51'36.65"	3.5'	8.0'	EXISTING 24" PIPELINE
1040	293,677.75	3,422,674.13	N29°18'24.41"	W90°53'17.94"	2.8'	10.0'	EXISTING 24" PIPELINE
1045	300,718.08	3,413,315.14	N29°19'34.45"	W90°55'03.36"	1.8'	12.0'	EXISTING 24" PIPELINE
1050	306,776.19	3,405,240.24	N29°20'34.71"	W90°56'34.34"	2.5'	11.0'	EXISTING 24" PIPELINE
1055	313,774.53	3,395,705.96	N29°21'44.30"	W90°58'21.82"	2.1'	10.6'	EXISTING 24" PIPELINE
1061	319,876.08	3,387,352.43	N29°22'44.95"	W90°59'56.02"	2.7'	N/A	EXISTING 24" PIPELINE
1064	333,239.01	3,369,195.00	N29°24'57.72"	W91°03'20.89"	3.5'	12.0'	EXISTING 24" PIPELINE
1073	339,891.92	3,360,126.86	N29°26'03.79"	W91°05'03.26"	7.0'	8.8'	EXISTING 24" PIPELINE
1078	348,641.51	3,353,743.77	N29°27'30.54"	W91°06'15.25"	8.0'	8.5'	EXISTING 24" PIPELINE
1083	354,754.56	3,344,165.58	N29°28'31.23"	W91°08'03.47"	8.0'	8.0'	EXISTING 24" PIPELINE
1092	366,147.78	3,325,427.49	N29°30'24.30"	W91°11'35.31"	3.2'	9.8'	EXISTING 24" PIPELINE
1097	371,807.93	3,315,082.58	N29°31'20.44"	W91°13'32.33"	5.0'	10.5'	EXISTING 24" PIPELINE

HORIZONTAL GRAPHIC SCALE
0 10' 20' 40' 60'
VERTICAL GRAPHIC SCALE
0 10' 20' 40' 60'

THE PIPELINE RIGHT-OF-WAY SHOWN HEREON WAS PLOTTED FROM THE NAD 27 STATE PLANE COORDINATES PROVIDED IN INSTRUMENT NO. 150683 UNTIL THE POINT MARKED "X" ON SHEET 1 OF 2. THE COORDINATES PROVIDED FOR THE FOLLOWING POINT WERE FOUND TO BE ERRONEOUSLY RECORDED BASED ON THE PROPOSED ALIGNMENT SHEETS (TO-T2-500-1-50 & TO-T2-500-1-51) DATED 01/11/1971, AS WELL AS 2013 NAIP AERIAL PHOTOGRAPHY. THEREFORE THE PORTION OF THE RIGHT-OF-WAY EAST OF THE POINT MARKED "X" WAS PLOTTED USING THE BEARING AND DISTANCE RECORDED IN THE REFERENCED INSTRUMENT. AFTER THIS CENTERLINE WAS CONSTRUCTED IN NAD 27 COORDINATES, THE ENTIRELY OF SAID CENTERLINE WAS TRANSLATED FROM NAD 27 TO NAD 83 USING MODERN COMPUTATION TECHNIQUES.

NOTES:

1.) SEE SHEET 1 FOR PLAN.

2.) SURVEYED BY MORRIS P. HEBERT, INC. ON FEB. 27, 2014 BK. 1899, PG. 16–19, FEB. 26, 2014 BK. 1899, PG. 20–23, MAR. 03, 2014 BK. 1835, PG. 19–23.

NO.	DATE	REV. BY:	REVISION

CB&I

CROSS SECTIONS
EXISTING 24" TENNESSEE PIPELINE
SURVEY
LOCATED IN
TERREBONNE PARISH, LOUISIANA

Morris P. Hebert, Inc.
SURVEYING • ENGINEERING • ENVIRONMENTAL SERVICES • FIELD SERVICES • GIS
P.O. BOX 3106 * 283 CORPORATE DRIVE * HOUMA, LOUISIANA 70361 * (985) 879-2731
HOUMA, LA. * BATON ROUGE, LA. * HOUSTON, TX. * SAN ANTONIO, TX. * CLINTON, NJ.
TEXAS SURVEY FIRM REGISTRATION NUMBER: 10193786 (HOUMA OFFICE)

DRAWN BY:	NPB	SHEET:	2 OF 2
CHKD./APPD. BY:	AJG	SCALE:	1" = 20'
UPDATED BY:		DATE:	3/13/2014
DATA BASE:	11678	JOB NO.	11678

MPH CAD FILE: MAG BASEMAP.DWG

W:\dwg\11678\mag basemap.dwg PLOT DATE: 4/8/14 2:26:30pm

Appendix C

Geotechnical Desktop Study

30 May 2014

CB&I
4171 Essen Lane
Baton Rouge, Louisiana 70809

Attention Mr. Glenn Ledet, Jr., P.E.

Gentlemen:

Geotechnical Desktop Study
Terrebonne Parish Consolidated Government
Sediment Delivery Pipeline
Terrebonne Parish, Louisiana
CB&I Purchase Order No. 887046-000 OP
Eustis Engineering Project No. 22450

Transmitted are three copies (two bound and one unbound) of our engineering report covering a geotechnical desktop study for the subject project. An electronic copy is also being provided.

Thank you for asking us to perform these services.

Yours very truly,

EUSTIS ENGINEERING SERVICES, L.L.C.

STATE OF LOUISIANA
KARISHMA R. DESAI
License No. 37422
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

KARISHMA R. DESAI, P.E.

KRD:nfr/jkd

GEOTECHNICAL DESKTOP STUDY

TERREBONNE PARISH CONSOLIDATED GOVERNMENT

SEDIMENT DELIVERY PIPELINE

TERREBONNE PARISH, LOUISIANA

CB&I PURCHASE ORDER NO. 887046-000 OP

EUSTIS ENGINEERING PROJECT NO. 22450

FOR
CB&I
BATON ROUGE, LOUISIANA

By
Eustis Engineering Services, L.L.C.
Metairie, Louisiana

30 MAY 2014

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GEOTECHNICAL DESKTOP STUDY
TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP
EUSTIS ENGINEERING PROJECT NO. 22450

INTRODUCTION

1. This report contains a geotechnical desktop study performed for the proposed sediment delivery pipeline and four dredged material disposal areas, in Terrebonne Parish, Louisiana. This preliminary study was performed in general accordance with Eustis Engineering Services, L.L.C.'s proposal dated 16 August 2012. Authorization to proceed was provided by Ms. Jill J. Congemi via CB&I Purchase Order No. 887046-000 OP dated 21 January 2014. CB&I is the civil/structural engineer for the project.

SCOPE

2. For this desktop study, Eustis Engineering was required to describe the likely geological and geotechnical conditions at the site on the basis of existing data. This study was concentrated on the constructability of the sediment pipeline routes, containment dikes, and booster stations. Site visits and other means of obtaining information about the site and site history were excluded from this preliminary study. Engineering analyses, based on existing data from previous geotechnical explorations, were made to determine preliminary recommendations regarding estimates of allowable vertical pile load capacities and estimates of settlement. Slope stability analyses of containment dikes were also part of this desktop study. Preliminary general construction recommendations regarding site preparation,

drainage, dredged fill, and compaction have also been provided. Material properties are presented in this report. These plots are limited to the geotechnical properties of generalized soil type, undrained shear strength, moisture content, and soil unit weight. Recommendations for a site specific geotechnical exploration are also presented in this report.

AVAILABLE SUBSURFACE DATA

3. Previous Geotechnical Explorations. Eustis Engineering performed geotechnical explorations in the vicinity of this project. The following projects were determined to be in close proximity of the proposed pipeline and disposal areas, and were utilized to complete the required preliminary scope of services:

- "Subsoil Investigation, Proposed Levee - Lake De Cade, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 3231" dated 6 December 1963.
- "Geotechnical Investigation, Terrebonne Parish, Flood Protection Levee Along Bayou Dularge, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 15941" dated 4 June 1999.
- "Geotechnical Investigation, South Terrebonne Tidewater Management and Conservation District, Lower Bayou Dularge Levee Construction (Reach III), Terrebonne Parish, Louisiana, Eustis Engineering Project No. 16861" dated 7 August 2001.
- "Geotechnical Information for 40% Design Submittal, Terrebonne Levee & Conservation District, Morganza to the Gulf of Mexico, Hurricane Protection Levee, Modified Reach J, Segment 2, Using DNR Alignment, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 18879" dated 22 December 2005.
- "U.S. Army Corps of Engineers, Testing of Undisturbed and General Type Soil Samples, Retrieved from Morganza to the Gulf, Reach F-1, Terrebonne Parish, Louisiana, Contract No. W912P8-06-D-0069, Task Order No. 2, Eustis Engineering Project No. 19603" Laboratory test reports were published in January 2008.

- "Geotechnical Investigation, South Terrebonne Tidewater Management and Conservation District, Lower Bayou Dularge Levee Construction (Reach II), Terrebonne Parish, Louisiana, State Project No. 716-66-0001, CEEC Project No. 1623, Eustis Engineering Project No. 16182" dated 4 April 2000.

- "Geotechnical Investigation, Terrebonne Levee & Conservation District, Morganza to the Gulf of Mexico, Hurricane Projection Levee Project, Reach E, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 20569" dated 29 January 2010.

- "Geotechnical Investigation, Terrebonne Levee & Conservation District, Morganza to the Gulf Hurricane Projection Project, Floodgate Structure and Bayou Petit Caillou, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 21467" dated 24 October 2011.

- "Professional Geotechnical Services, Terrebonne Parish Consolidated Government, Cone Penetrometer Tests in Relocated Levee Alignment, Upper Bayou Dularge Levee, Bayou Provost to Falgout Canal, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 21857" dated 24 July 2012.

- "Geotechnical Exploration - Interim Report, Terrebonne Levee & Conservation District, Morganza to the Gulf of Mexico, Hurricane Projection Project, Floodgate Structure at Pointe-Aux-Chenes, Terrebonne Parish, Louisiana, CB&I Purchase Order No. 853120 OP, Eustis Engineering Project No. 22192" dated 24 October 2011.

- "Preliminary Geotechnical Exploration, Terrebonne Levee & Conservation District, Morganza to the Gulf of Mexico, Hurricane Projection Project, Floodgate Structure and Levee Embankment at Falgout Canal, Terrebonne Parish, Louisiana, CB&I Purchase Order Nos. 805344-000 OP and 805350-000 OP, Eustis Engineering Project Nos. 21948 and 21949" dated 17 July 2013.

4. We have not included boring and cone penetration test (CPT) logs from these projects in this report. These data can be made available upon request. The proximity of these projects to the proposed project features range from a few hundred feet to approximately two and one-half miles. This is illustrated on the vicinity map shown as Figure 1. Because of this available existing data, we did not request boring information from the U.S. Army Corps of Engineers (USACE)

through the Freedom of Information Act (FOIA). In our opinion, the available data were sufficient to perform preliminary engineering analyses.

DESCRIPTION OF EXISTING SITE CONDITIONS

General Geology

5. The proposed project site is located in Terrebonne Parish in southeastern Louisiana. The proposed site is located within the Louisiana Gulf Coastal Plain. Specifically, the site is located within one of the many distributary lobes of the Mississippi River as part of the deltaic system. As a result of the many bifurcations of the various distributaries, the entire area consists of abandoned distributary, natural levee, and interdistributary deposits. These deposits are all part of the Recent Holocene Age. The interdistributary deposits are underlain by substratum sand deposits of Holocene/Pleistocene Age followed by Prairie Pleistocene deposits. An idealized geologic profile was created across a distance of 40 miles. Section A-A' is shown on Figure 1. The geologic profile for this section is shown on Figure 2.

6. Generally, the subsurface soils encountered by our previous explorations consist of interdistributary clays and silts. These soils comprise extremely soft to stiff gray clay, silty clay, and sandy clay; and loose to medium compact gray clayey silt and sandy silt. Several zones of intradelta sands consisting of very loose to medium dense gray and tan fine sand, silty sand, and clayey sand were also encountered. In addition, zones of swamp/marsh, consisting of very soft to soft gray organic clay and soft to medium stiff dark brown and gray humus/peat exist as part of the interdistributary, were also encountered. Substratum deposits and Pleistocene deposits were not encountered by our previous borings and are interpreted from available geologic publications.

Preliminary Soil Parameters

7. Based on a review of the existing soil borings and CPTs performed by Eustis Engineering, we developed soil design parameters at each sediment disposal area. Table 1 summarizes our soil design reaches.

TABLE 1: SUMMARY OF SOIL DESIGN REACHES

SOIL DESIGN REACH DESIGNATION	EUSTIS ENGINEERING PROJECT NO.	FIELD EXPLORATION POINTS
Bay Raccourci	3231	B-1, B-3, and B-5
Falgout Canal	15941	B-1 through B-14
	16182	L-6 and L-11
	16861	1001A through 1015A
	19603	MGF-1U, MGF-2U, MGF-3G, and MGF-4U
	20569	MOTG-B-10U
	21857	CPT-1 through CPT-3
	21949	B-5
Wonder Lake and Lake Tambour	18879	B-1U, B-3G, B-4U, B-5G, B-7G, B-8U, B-11G, B-12U, B-14U, B-15G, B-16G, B-17G, B-19G, B-20G, B-21U, and B-22G
	21467	B-1 through B-3
	22192	B-1 through B-3, B-5, and B-7

8. The preliminary soil design parameters developed for engineering analyses are shown graphically on Figure 3, Sheets 1 through 3, for each of the soil design reaches. Plotted undrained shear strengths, total unit weights, moisture contents, and generalized soil stratum descriptions are provided on Figure 3, Sheets 1 through 3. The selected design parameters are shown as heavy lines over the plotted data.

9. ***This desktop study was limited to existing and available soil data. Engineering analyses presented in this report are preliminary. Extensive site-***

specific field exploration, subsequent laboratory test program, and engineering analyses are recommended, especially for Bay Raccourci sediment fill area, should this project proceed to the final design phase.

Areal Subsidence

10. The project area is being affected by ongoing areal subsidence, a typical phenomenon in southeastern Louisiana. This is due to previous loading with Holocene sediments, drawdown of ground water levels, and the biodegradation of limited near surface organic soils, especially in the Holocene swamp/marsh deposits. Areal subsidence is considered a background condition over which people have no control and should be relatively uniform in the project area. Sufficient information is not available to make accurate estimates of areal subsidence in the project area. Biodegradation and disintegration of near surface organic materials should also be anticipated and cannot be quantified. Further, this biodegradation may be concentrated to seasonal occurrences.

FOUNDATION ANALYSIS

Furnished Information

11. Furnished information for this project was provided by CB&I, and includes the following plans:

- Atchafalaya River Long Distance Sediment Pipeline, Preliminary Borrow Site Identification Report, dated 1 December 2013, and prepared by Moffatt & Nichol.

- Atchafalaya Long Distance Pipeline, Progress and Concepts (presentation document), dated 12 February 2014, and prepared by CB&I.

- Long Distance Sediment Pipeline Route Study, Aerial Maps (Sheets 1 through 8), dated 20 January 2014, and prepared by Morris P. Hebert, Inc.

- Survey Plan for Existing 24" Tennessee Pipeline (Sheet 1 of 2), dated 13 March 2014, and prepared by Morris P. Hebert, Inc.

- Cross-Sections of Existing 24" Tennessee Pipeline (Sheet 2 of 2), dated 13 March 2014, and prepared by Morris P. Hebert, Inc.

- Typical Section - Alternative No. 1, dated 8 January 2014, and prepared by CB&I.

12. Aerial maps of the sediment containment areas and overall sediment pipeline alignments were also provided.

13. We understand the Terrebonne Parish Consolidated Government desires a feasibility study to design and operate a sediment delivery pipeline that will extend from the Atchafalaya River in St. Mary Parish to Terrebonne Parish to restore marsh habitat. The overall project will span a distance of approximately 42 miles. The proposed sediment pipeline alignment is shown on Figure 1.

14. We understand sediments from the lower Atchafalaya River region will be hydraulically transported to four sediment/marsh creation areas. Initially, two routes were being considered. We now understand the northern route (Columbia Gas Pipeline route) is not being considered. The sediment pipeline route will be within the existing Tennessee Gas Pipeline right-of-way. Based on the furnished cross-sections, we understand the steel sediment delivery pipe will be 36 inches in diameter. The existing Tennessee Gas Pipeline is 24 inches in diameter and was installed at elevations ranging from el -7 to el -17 (NAVD 88). We understand the sediment pipes will be either grade supported or pinned to timber piles installed at appropriate spacings. Due to sediment friction and interior pipeline erosion, the sediment pipe will be rotated in the future for maintenance.

15. The sediment delivery pipeline system is proposed to span between the proposed borrow area and the proposed sediment creation areas. Table 2 provides a summary of the four sediment creation areas defined for this study.

TABLE 2: SUMMARY OF ANTICIPATED SEDIMENT CREATION AREAS AND STORAGE VOLUMES

SEDIMENT CREATION DESIGNATION FROM WEST TO EAST	ESTIMATED AREA IN ACRES	ESTIMATED STORAGE VOLUME IN CUBIC YARDS
Bay Raccourci	25,000	125,000,000
Falgout Canal	30,000	200,000,000
Lake Tambour	40,000	250,000,000
Wonder Lake	25,000	125,000,000

16. We understand borrow material will be hydraulically dredged and pumped into each sediment creation area. As requested, containment dikes for the proposed dredged storage areas within the proposed sediment units are presented in this report. We understand CB&I would like to consider various time scenarios in our settlement analyses. As requested, we evaluated in our settlement analyses three discrete time scenarios (2, 5, and 20 years) for containment dikes and 10 and 20-year time scenarios for sediment fill material.

General Recommendations

17. General. The following recommendations are preliminary in nature and are not based on site specific geotechnical data, but generalized information. As discussed in the "Recommendations for Site Specific Geotechnical Exploration" section of this report, site specific soil borings and CPTs should be performed prior to completing the final design plans and specifications.

18. Based on a review of the geology and boring logs, we recommend dikes be constructed for containment of the dredged sediment fill. We understand staged construction is not planned for the containment dikes. We note, however, staged construction will allow for an initiation of the consolidation process. Consolidation will affect a gain in foundation shear strength and reduce the potential for lateral plastic deformation ("lateral spread") and containment dike settlement while providing improved conditions for future lifts. Recommendations regarding containment dike construction are provided subsequently in this report.

19. The crown elevation of the containment dikes was established at el 4 with initial sediment fill to el 3. These elevations were considered from a constructability standpoint.

20. The sediment pipes may be grade supported or pinned to timber piles, as desired. Based on the furnished cross-sections along the proposed sediment pipeline alignment, we have performed preliminary slope stability analyses to determine the safe distance for sediment pipe placement within the Tennessee Gas Pipeline right-of-way. As requested, we have also presented slope stability analyses for a non-compacted clay fill berm to provide support of the sediment pipes, if this option is deemed to be financially feasible. A site specific geotechnical exploration is recommended in order to determine the final alignment of the sediment pipeline.

21. The proposed booster stations may be supported on a deep foundation system, such as driven timber piles provided the allowable and lateral pile load capacities are adequate and estimated settlement is tolerable. Eustis Engineering should be contacted to evaluate other foundation types, if considered or required. Consideration should be given to both total settlement and differential settlement when selecting the type of foundation for any structure.

Stability Analyses

22. Methodology and Design Criteria. Stability analyses of the earthen containment dikes were performed using Spencer's Method as coded within the Geo-Slope International, Ltd.'s SLOPE/W, Version 7.17, slope stability program. This program generally utilizes circular and non-circular slip surfaces to define the soil failure planes. A minimum acceptable factor of safety equal to 1.1 was assumed for local stability of the containment berm and uncompacted clay fill berm that would support the pipeline. However, any potential slip surfaces impacting the Tennessee Gas Pipeline were required to have a minimum factor of safety of 1.3.

23. Preliminary Slope Stability Design Parameters. Soil design parameters presented on Figure 3, Sheets 1 through 3, were used in our preliminary slope stability analyses. In addition, for the containment dike fill material, Eustis Engineering assumed a wet unit weight of 100 pcf and a cohesion (i.e., undrained shear strength) of 200 psf. We assumed this material will be excavated from within the sediment creation area. A borrow canal, approximately 20 feet from the inside toe of the containment dike, was modeled in our analyses for construction equipment work space. Furthermore, these parameters consider dike fill to be placed by uncompacted methods as discussed in the "Preliminary Construction Recommendations" section of this report. We also considered a wet unit weight of 100 pcf and a cohesion of 100 psf for the sediment fill material. These values were based on our previous experience with similar projects, measurements from the self-weight consolidation testing, and engineering judgement.

24. Another assumption made in our slope stability analyses was the initial elevation of the sediment fill and dike. Based on our previous experience, we assumed a 1-ft freeboard for the dike, with a crown at el 1 and crown width of 5 feet for the containment dike.

25. Water Levels. Our preliminary slope stability analyses presented in this report are based on a low water level at el 0. Water levels above or below that analyzed may result in localized sloughing or failure of the recommended section. Long term maintenance should consider this potential. We recommend determination of extreme low or high water levels due to storm events. These levels should be considered in final design of the containment dikes. Eustis Engineering should be consulted to evaluate alternate water levels.

26. Results of Preliminary Containment Dikes. The results of our slope stability analyses are presented on Figures 4 through 6. Our preliminary analyses indicate stability berms will be necessary in the area of Bay Raccourci for containment dikes to achieve a minimum factor of safety of 1.1. As stated previously, we recommend a site specific study within the Bay Raccourci area because of limited available existing soil data. This site specific study may help in reducing the size of stability berms. The dikes containing the other disposal areas (Wonderlake, Lake Tambour, and Falgout Canal) do not require stability berms.

27. The required minimum factor of safety of 1.1 for the design of containment dikes considers plastic displacements and gain in strength during construction inherently improve foundation conditions beneath the dikes. Detailed design should address these considerations. However, uncertainties of construction in a marsh environment are such that local sloughs of the dikes will require maintenance repair. This should be considered in your planning.

28. The results of our slope stability analyses are summarized in Table 3. Note, our analyses presented on Figures 4 through 6 present pre-settlement dike heights. Refer to the subsequent settlement section entitled "Preliminary Settlement Analyses" for estimates.

TABLE 3: SUMMARY OF PRELIMINARY SLOPE STABILITY ANALYSES RESULTS

SOIL DESIGN REACH/ AREA	INITIAL CONTAINMENT DIKE CONSTRUCTION ELEVATION IN FEET	FAILURE SEARCH	MINIMUM COMPUTED FACTOR OF SAFETY	FIGURE NUMBER (SHEET)	MINIMUM REQUIRED FACTOR OF SAFETY
Bay Raccourci	4 (With Berms) (Total Footprint = 105 feet)	Initial Construction, Towards Sediment Fill Side	1.10	4 (1 of 2)	1.1
		With Initial Sediment Fill to El 3, Towards Protected Side	1.17	4 (2 of 2)	
Falgout Canal	4	Initial Construction, Towards Sediment Fill Side	1.54	5 (1 of 2)	
		With Initial Sediment Fill to El 3, Towards Protected Side	2.28	5 (2 of 2)	
Wonder Lake and Lake Tambour	4	Initial Construction, Towards Sediment Fill Side	1.69	6 (1 of 2)	
		With Initial Sediment Fill to El 3, Towards Protected Side	1.73	6 (2 of 2)	

29. Preliminary Slope Stability Analyses of Sediment Pipeline. The purpose of the existing bank slope stability analyses was to determine placement of the sediment delivery pipeline. Based on a review of the furnished cross-sections and our understanding of the project requirements, we have analyzed cross-section M-M using Bayou Raccourci soil design parameters and cross-section B-B using Falgout Canal parameters. As requested, we modeled the 36-in. diameter steel pipeline on the bank of the right-of-way. We assumed the sediment pipeline will be fully flowing and exert a total downward pressure of 400 psf due to the weight of the pipe and sediment fill with a unit weight of approximately 100 pcf.

30. Results. Our preliminary slope stability analyses for cross-sections M-M and B-B are presented on Figures 7 through 9. The results are summarized in Table 4.

TABLE 4: SUMMARY OF PRELIMINARY SLOPE STABILITY ANALYSES FOR PROPOSED SEDIMENT PIPELINE

SOIL DESIGN REACH (CROSS-SECTION)	SEDIMENT PIPELINE SUPPORT SYSTEM	REFERENCES OF PROPOSED PIPELINE TO EXISTING FEATURES		FAILURE SEARCH	MINIMUM COMPUTED FACTOR OF SAFETY	MINIMUM REQUIRED FACTOR OF SAFETY	FIGURE NO.
		HORIZONTAL DISTANCE IN FEET FROM THE EXISTING TENNESSEE GAS PIPELINE	HORIZONTAL DISTANCE IN FEET FROM EDGE OF THE EXISTING TOP OF BANK				
Bay Raccourci (M-M)	At Existing Grade (El 0)	56	13	Local	1.32	1.1	7
				Global	1.51	1.3	7
Bay Raccourci (M-M)	On Uncompacted Clay Fill Berm (El 4)	147.5	105	Local	1.14	1.1	8
				Global	1.31	1.3	8
Falgout Canal (B-B)	At Existing Grade (El 0)	56	0	Local	2.14	1.1	9
				Global	3.25	1.3	9

Preliminary Settlement Analyses

31. General. Settlement of the proposed containment dikes for this project will occur over time due to consolidation of the foundation soils. Because the predominant soil deposit at this site is clay, the consolidation of the foundation soils occurs over long periods of time and at a diminishing rate. This settlement should be considered in the final design of the proposed containment dikes. The dike and berms were modeled as surcharge loads added instantly. Stress distribution followed Westergaard's theory and the rates and magnitudes of consolidation settlement followed Terzaghi's theory.

32. The sediment fill areas will also experience self-weight consolidation settlement that will occur within the dredged and pumped sediment fill material placed within the containment areas. The rates and magnitudes of this self-weight consolidation settlement will be different than the underlying naturally deposited foundation soils. The combination of these two types of settlement (self-weight settlement of the

dredged sediments and consolidation of the underlying foundation soils) need to be considered when estimating the total settlement of the sediment fill areas.

33. Estimated Settlement and Shrinkage of Containment Dikes. Consolidation settlement will occur within the foundation soils that underlie the dike sections on Figures 4 through 6. Staged construction will reduce the amount of lateral spread and post construction settlement of the dike section.

34. Shrinkage in the fill used for the containment dikes will also occur as sediments dry out and consolidate under their own weight. Volume change due to shrinkage is more pronounced in clayey soils than sandy soils. Our preliminary settlement estimates are summarized in Table 5. Note, the ultimate and time-rates of consolidation settlement values presented below are estimated post construction (i.e., to crown elevation as stated previously and without the knowledge of lift schedule and construction means and methods).

TABLE 5: SUMMARY OF ESTIMATED CONSOLIDATION SETTLEMENT OF CONTAINMENT DIKES

CONTAINMENT VICINITY (INITIAL CONTAINMENT DIKE HEIGHT IN FEET, ELEVATION IN FEET)	ESTIMATED CONSOLIDATION SETTLEMENT IN INCHES			ESTIMATED ULTIMATE SETTLEMENT IN INCHES
	2 YEARS	5 YEARS	20 YEARS	
Bay Raccourci (7, El 4)	9 to 13	13 to 18	21 to 29	31 to 42
Falgout Canal (4, El 4)	2 to 4	3 to 5	6 to 9	12 to 17
Wonder Lake and Lake Tambour (7, El 4)	3 to 4	5 to 7	9 to 12	19 to 26

35. Our settlement analyses assume the dikes are constructed to el 4 and allowed to settle. Our analyses accounted for ongoing submergence of fill material. We have estimated 1 foot of additional fill material will be necessary to compensate for settlement and displacement during construction.

36. Estimated Settlement of Dredged Sediment Fill. Settlement analyses were performed using a proprietary computer model and considering Terzaghi's theory of one-dimensional vertical consolidation. Our analyses for sediment fill accounted for ongoing submergence during construction. We recommend an additional 12 inches of fill material be assumed to account for settlement and displacement during construction.

37. Settlement of foundation soils due to the weight of the overlying dredged sediment fill was estimated. Self-weight consolidation tests are performed to estimate settlement of sediment fill. We have estimated self-weight consolidation settlement of the sediment fill based on our previous experience with similar projects. If this study becomes a design project, we recommend self-weight consolidation testing be performed to assess the total settlement magnitudes.

38. Table 6 presents estimated finished elevation due to consolidation settlement of foundation soils and self-weight consolidation settlement of an initial sediment fill elevation at 3. Please refer to Figures 10 through 12 that show time-rate of settlement curves between 0 and 25 years after construction of the sediment creation areas for other sediment fill elevations. We have included the target elevation of 0 as a reference.

TABLE 6: SUMMARY OF ESTIMATED FINISHED ELEVATION OF SEDIMENT FILL AND FOUNDATION SOIL DUE TO CONSOLIDATION SETTLEMENT

CONTAINMENT VICINITY	INITIAL SEDIMENT FILL ELEVATION IN FEET (INITIAL FILL HEIGHT IN FEET)	ESTIMATED ELEVATION IN FEET, NAVD 88, AT TIME = 10 YEARS	ESTIMATED ELEVATION IN FEET, NAVD 88, AT TIME = 20 YEARS	ESTIMATED TIME AFTER INITIAL FILL PLACEMENT WHEN SEDIMENT SETTLES TO TARGET ELEVATION 0 (YEARS)	FIGURE NUMBER
Bay Raccourci	3 (6)	0.2	-0.5	11.5	10
Falgout Canal	3 (3)	0.7	0.2	24	11
Wonder Lake and Lake Tambour	3 (6)	0.6	0.1	21.5	12

39. In addition, the amount of crust that will form due to drying out of near surface soils is a function of the decanting process. We estimate the sediment fill soils will be submerged (or nearly submerged) for a majority of the time due to large scale consolidation settlement. Assuming a crust of approximately 1 foot thick, we estimate an additional ½ to 1 inch of settlement will occur.

40. Estimated Settlement of Sediment Pipeline. Preliminary analyses have been made to determine the estimated settlement of the subsoils due to sediment pipeline. We estimate settlement may be in the range of 3 to 8 inches for a grade supported sediment pipe. This settlement range is based on an assumed uniform loading pressure of approximately 400 psf due to the weight of 36-in. diameter steel pipe and transported sediment fill with a unit weight of 100 pcf.

41. Estimated Settlement of Uncompacted Clay Fill Berm and Sediment Pipe. We also evaluated settlement of the uncompacted clay fill berm that will support the proposed sediment pipelines, if this option is feasible for construction. We estimate settlement of the uncompacted clay fill berm to el 4 with a width of approximately 117 feet will be in the range of 23 to 31 inches. Total settlement of the sediment

pipeline atop the clay fill berm will be in the range of 27 to 35 inches. Similar to the dike and sediment fills, we recommend an additional 1 foot of fill be estimated for settlement and displacement during construction. This settlement range also assumed a uniform loading pressure of approximately 400 psf, due to the weight of a 36-in. diameter steel pipe and sediment fill with a unit weight of 100 pcf loaded instantaneously to el 4. An existing ground surface elevation at 0 was assumed in our analyses.

Borrow to Fill Ratio

42. Proposed Dike Materials. Estimates of the amount of borrow material required to construct the proposed dike section were obtained from the USACE based on data compiled on similar levee and dike projects. Based on the available data, a typical borrow to fill ratio is 2:1 for natural moisture contents in excess of 50%. For higher silt and organic contents, a borrow to fill ratio of 3:1 or more may also occur. These borrow to fill ratios do not include the volume of fill required due to settlement and shrinkage which should be added to the theoretical volume prior to estimating the borrow required. In addition, any stripping or removal of organic material, which is considered to be unsuitable for the dike section, is not included in the estimated borrow ratio.

Preliminary Construction Recommendations

43. Constructability. The near surface organic and soft clay materials that exist in the proposed sediment creation areas will be displaced during fill placement and dredging operations. Construction techniques are critical to the constructability and ultimate stability of the dike section. Eustis Engineering is available to estimate the amount of displacement which may occur during construction to assist in determining the anticipated fill quantities and cost estimates. The stability of the

dike constructed of in situ materials will be dependent on the borrow materials used and the rate at which the dredged fill is placed.

44. Water Levels. Water levels along the project are subject to seasonal and tidal fluctuations. Site conditions should be investigated immediately prior to initiating construction.

45. Sediment Containment Dike. The sediment containment dike will be constructed of in situ materials. Uncompacted fill should be fat or lean clay, silty clay, or sandy clay (CH or CL material as defined by the Unified Soil Classification System). Such materials exist along the natural levees within the project area. However, with the swamp/marsh deposits, existing materials appear to be poor quality, comprising of organic materials mixed with high plasticity clay. Use of the materials is viable. However, their use will require maintenance as the organic materials oxidize and deteriorate.

46. Placement of Uncompacted Fill. The borrow material may be placed by uncompacted methods for construction of the dike. Our stability analyses assume these materials will be excavated and placed by mechanical methods using a dragline, clamshell or conventional bucket, or similar mechanical equipment. Uncompacted dike fill should be placed in lifts of no more than 3 feet. Depending on the depth of standing water and moisture content of the borrow materials, consideration should be given to placing an initial fill lift for the entire length of containment dike in each area before proceeding to the next lifts to mitigate the potential for "mud waves." This method will initiate consolidation of foundation soils as well as provide a means for the uncompacted fill to prepare a sufficient wearing surface. This will decrease the potential for lateral spread and slope failure within the fill as the containment dikes are constructed.

47. Consideration of Mud Waves. The contractor should expect the creation of a "mud wave" during construction due to the low shear strength and unit weights of the surficial material. Plans and specifications should alert the contractor to anticipate this phenomenon. Two options exist for handling these mud waves during construction of the containment dikes. Option 1 is to place the uncompacted fill from the centerline of the design section outward to the toes and parallel to the centerline to "push" the mud wave toward the outside of the dike section. This option is good because the magnitude of the mud wave will be smaller than working the mud wave from the edge of the design section to the other edge (Option 2). Option 2 is to place the uncompacted fill from the outside edge of the design section and push it inward toward the inside edge. Option 2 requires working parallel to the centerline to "push" the mud wave toward the inside (i.e., containment fill side) of the dike section. Option 2 would likely yield larger mud waves because the lateral distance the mud wave is pushed is longer than Option 1. Consideration of mud waves is a means and methods issue that is the responsibility of the construction contractor.

48. Staged Dike Construction. As mentioned previously, we recommend construction of the dike be performed in stages. Staged construction will allow consolidation of the subsoils to begin and affect a gain-in-strength in the rapidly consolidating deposits. This will minimize the potential for lateral plastic deformation of these soils. Staged construction will also minimize localized failures within the uncompacted fill as described above, particularly when these materials remain saturated during initial lift placement.

49. Dredged Sediment Fill. The placement limits of the dredged fill should be based on stability considerations as previously presented, as well as construction constraints and environmental factors. For decanting considerations, fill should be placed no higher than 1 foot below the crown of the containment dikes. Actual fill heights may be varied between these limits and based on the environmental goals.

50. Drainage Controls. During the placement of the fill, the contractor should provide drainage control measures to facilitate construction operations. Drainage control measures could include weirs, pipes, and drop inlets. The number, size, and location of these drainage control measures should be considered for construction and for the permit application. Some deciding factors will include the position of the dredge, natural slope of the land formations, and the type and size of the dredging equipment.

51. Dewatering/Decanting. Self-weight consolidation of the sediment creation fill will create ponding of water at the surface as the settlement occurs over time. Some of this water may be removed by evaporation, but decanting of free surficial water by weirs may be required.

52. Maintenance. Our preliminary stability analyses do not consider an overbuild to maintain the proposed dike crown elevation for sediment containment. Rather, long term maintenance of the dikes will be required to accommodate the estimated ongoing settlements.

53. Monitoring. Consideration should be given to the use of settlement plates or other surveying methods to monitor the actual rates of settlement for the project. Natural variations in the materials placed as well as the desiccation and biodegradation of these deposits may affect our estimates. In addition, construction of the containment area may affect water levels due to tidal fluctuations in areas of the project. If long term performance of the fill placement is to be evaluated, the monitoring should be performed at regular intervals to provide sufficient data.

Deep Foundations - Driven Piles

54. Estimated Vertical Pile Load Capacities. Based on the existing soil borings and laboratory tests, engineering analyses have been made to determine estimates of the allowable compressive and tensile load capacities for treated ASTM D 25 quality timber piles for the support the proposed booster stations. The results of our analyses for allowable pile load capacities are presented on Figure 13 (Sheets 1 through 3).

55. Factor of Safety. Our estimated capacities assume the piles are driven vertically and contain a factor of safety of 3 against failure of a single pile through the soil. A one-third increase in vertical load can be used for temporary loads, such as wind.

56. Due to the location of the site, we assume a test pile program is not economically feasible or desired. Therefore, we have recommended the factor of safety of 3 for allowable pile load capacities. Recommendations for a test pile program is not provided in this report. If a test pile program is desired, Eustis Engineering should be contacted to provide recommendations.

57. Structural Capacity. The estimated pile load capacities provided are based only on a soil-pile relationship. The structural capacity of the individual piles to transmit these loads, and any connections between the piles and the anchors, should be determined by a structural engineer.

58. Batter Piles. The pile load capacities shown on Figure 13 (Sheets 1 through 3) may be used to estimate horizontal load resistances for the batter piles. The vertical component of the batter piles are equated to the load capacities for identically sized vertical piles driven to the same approximate tip elevations. This relationship may be used to determine the axial capacities and horizontal components of the batter piles as shown on Figure 14.

59. Timber Piles. We recommend the treatment of timber piles meet the current American Wood Preservers Association Standards as outlined in Section 1014 of the Louisiana Standard Specifications for Road and Bridges (LSSRB), 2006 edition for both preservative and quality assurance. Treatment should also follow Section 812.06 where applicable. Furthermore, we recommend the timber piles meet the quality (clean peeled, straightness, etc.) requirements outlined in ASTM D 25 and size requirements outlined in Table X1.5 of ASTM D 25 for minimum pile tips. The pile dimensions assumed in our analyses are shown on Figure 13, Sheets 1 through 3.

60. Pile Group Capacity. The piles considered will derive the majority of their supporting capacity from skin friction; therefore, it is necessary to consider the effect of group action. In this regard, the supporting value of the friction piles installed in groups should be investigated on the basis of group perimeter shear by the formula shown on Figure 15. For pile groups used in tension, the second term of the formula should be deleted when evaluating group effects. These group effects only consider vertical loads. Laterally loaded groups should be further evaluated.

61. Please refer to the "Recommendations for Site Specific Geotechnical Exploration" section on field test recommendations. In our experience, sporadic sand strata may exist within the Recent Interdistributary deposits in Terrebonne Parish. When pile tips are embedded within sand deposits, the piles will derive a majority of their capacity from end bearing, in which case, group action is not considered; however, it will be necessary to evaluate pile refusal and driving stresses.

62. Temporary Lateral Load Capacity. Limited lateral capacity may be used on piles subjected to transitory loads. Transitory lateral loads may be present at the booster stations and potentially for the sediment pipe support. Treated ASTM D 25 quality timber piles, with minimum tip diameters of 7 to 8 inches and minimum butt diameters of 12 inches, may be assumed to provide a temporary lateral resistance

of 1 ton per pile. All piles resisting temporary lateral loads should have a minimum tip embedment of 30 feet below the mudline. We recommend soil-structure interaction analyses be performed if design lateral loads are greater than the lateral load resistance provided, or if piles other than those considered in this report are used for the project.

63. Pile Spacing. The minimum spacing between individual piles should be determined by the formula given on Figure 16. This spacing generally only considers the spacing required to achieve the estimated vertical capacity and avoid interference during construction. The spacing required to minimize lateral group effects may be greater than those values. The minimum spacing between rows or groups of piles should also meet the requirements discussed in the following paragraphs with respect to settlement.

64. Estimated Settlement due to Structural Loads. We estimate settlement of the piles, having embedments of at least 30 feet, to be 1 inch or less due to structural loads. Eustis Engineering should be contacted to verify this settlement once structural loadings, dimensions, and pile layouts are available. This estimate does not include short term elastic deformations of the piles which should be added to the consolidation settlement estimate. Elastic deformation of the piles may be estimated as 75% of the static column strain for piles acting as columns. ***All piles within a given structure should be installed to the same tip embedment in order to minimize differential foundation settlement.***

65. Our estimate of settlement is based on the assumption piles will be driven in small isolated groups, having maximum dimensions no greater than 20% of the pile embedment, or widely spaced rows. We assumed the center-to-center spacing between groups will be no closer than twice the largest group dimension and the center-to-center spacing between rows of single piles will be no closer than 8 feet or nine pile diameters, whichever is greater. Once group dimensions and loadings

are finalized, Eustis Engineering should evaluate the differential settlement potential.

Installation of Driven Piles

66. Quality Control. All pile driving operations should be supervised by experienced personnel to ensure proper procedures are followed and accurate records are kept during all pile driving operations. The driving records should include the date, type of pile, pile size (tip and butt diameters), overall pile length, hammer model, driving energy, depth and diameter of prepunch or predrill, and number of blows per foot of penetration for the full embedment of the pile. An accurate driving record is especially important to verify piles are installed to the required tip embedment and to give an indication of any unusual driving characteristics which may include pile breakage. We recommend Eustis Engineering be retained to observe, record, and evaluate all pile driving operations with respect to our recommendations presented in this report.

67. Hammers for Timber Piles. The treated ASTM D 25 quality timber piles, having tip diameters of 7 to 8 inches and butt diameters of 12 to 13 inches, may be driven using a single acting air hammer with a manufacturer's rated energy of 15,000 ft-lbs per blow. For these piles, the ram weight should not exceed 5,000 pounds and the maximum stroke should also be limited to 3 feet.

68. Pile Refusal. Refusal criteria for the timber piles may be taken as 25 blows per foot with the recommended hammer. If the piles are driven with the aid of a follower, or if the pile driving helmet is allowed to impact the ground surface, Eustis Engineering should be consulted to adjust this refusal criteria. If piles do not achieve their intended embedments, Eustis Engineering should be contacted.

69. Alternate Installation Methods. We do not recommend vibratory methods be utilized

for pile installation. If a vibratory hammer is selected for the project, Eustis Engineering should be contacted to evaluate the reduction in the estimated allowable pile load capacities presented. Also, we do not recommend the use of jetting to aid in the installation of the piles. Eustis Engineering should be consulted if these measures are allowed as this will also reduce the estimated capacities presented. If any other alternate installation methods are selected, Eustis Engineering should be contacted to evaluate the effects on our estimates of capacity.

Test Piles and Load Tests

70. Eustis Engineering considers a test pile program and load test as an extension of our geotechnical exploration. As stated previously, Eustis Engineering should contacted if a test pile program is desired.

Vibrations

71. Pile driving, as well as other construction activities, has the potential to generate vibrations that may affect nearby structures and underground utilities. Eustis Engineering recommends vibrations be monitored during construction activities of concern. This monitoring should evaluate peak particle velocities during pile driving at critical structures with a seismograph, as well as other construction activities generating vibrations (hauling fill, moving heavy equipment, etc.). The record of peak particle velocities will provide information in assessing potential damage and the need for changes in construction operations.

72. Peak particle velocities (measured at a structure) exceeding 0.5 in./sec may induce damage to the structure, particularly when this structure has been previously stressed by settlement or other movements. Peak particle velocities between 0.25 and 0.5 in./sec may be sensed as being detrimental by human perception. In

addition, sustained peak particle velocities of 0.25 in./sec have been documented to densify cohesionless materials. Such densification can result in settlement of structures and utilities founded over or in these deposits. Deposits of this nature were encountered at the site. Therefore, if sustained vibration levels of 0.25 in./sec are measured at a structure, pavement, or utility of concern, Eustis Engineering should be notified, the construction operations generating these vibrations suspended, and consideration given to altering these procedures.

RECOMMENDATIONS FOR SITE SPECIFIC GEOTECHNICAL EXPLORATION

73. General. The recommendations contained in this report are preliminary in nature and are based on prior geotechnical explorations performed in the project vicinity. In order to implement these recommendations into your design, the subsurface conditions and stratifications must be substantiated by a site specific geotechnical exploration. We understand the proposed project will generally include booster stations, sediment pipeline routes, and containment areas. Based on the furnished information, we recommend a combination of soil borings and CPTs be made for the proposed project features before final plans for design are developed. Eustis Engineering should be contacted to determine the number and depth of soil borings and CPTs once preliminary plans have been developed. For preliminary estimating purposes we recommend boring and CPTs be made at approximate 1,000-ft spacing along the pipeline alignments. Approximately one-third should be borings and two-thirds should be CPTs. Undisturbed borings should be made at the booster stations. The borings may be incorporated into the general 1,000-ft spacing described above.

74. Undisturbed Soil Borings. In order to recover samples of the various subsurface strata, we recommend the drilling of undisturbed sample type soil test borings beneath the proposed project features. We also recommend a geotechnical program for the sediment containment dikes. For booster stations, where deep

foundations are anticipated, we recommend drilling undisturbed soil borings to depths of 100 feet below the existing mudline. Along the sediment pipeline alignment (if pipes are supported by timber piles) and containment dike areas, we recommend drilling undisturbed soil borings to depths of 60 feet below the existing ground surface. The borings should be drilled by wet rotary methods from the deck of a marsh buggy.

75. Undisturbed samples of cohesive or semi-cohesive subsoils should be obtained at close intervals or changes in stratum using a 3-in. diameter Shelby tube sampler. Cohesionless soils, when encountered, should be sampled during the performance of Standard Penetration Tests. All samples should be preserved in moisture proof containers prior to laboratory testing. The borings should be sealed and/or grouted upon completion of drilling operations in accordance with the laws of the State of Louisiana and as stipulated by applicable permits.

76. Cone Penetration Tests. To further establish subsurface conditions and stratification beneath the proposed structures, we also recommend performing CPTs to various depths beneath the existing ground surface. The CPTs should be performed using a 10-cm^2 cross-sectional area cone with a 60° apex angled tip and 150-cm^2 sleeve area. The penetrometer should be hydraulically advanced into the ground at a rate of approximately 2 cm/sec from the deck of a marsh buggy. CPT parameters (tip resistance, friction resistance, and pore pressure) should be recorded at 5-cm depth intervals. Testing should be performed in accordance with methods and procedures outlined in ASTM D 5778-12. Upon completion of the CPTs, the exploration points should be backfilled in accordance with current State of Louisiana requirements.

77. Laboratory Testing. Samples obtained from the borings should be subjected to soil mechanics laboratory tests consisting primarily of natural water content, unit weight, and either unconfined compression shear or unconsolidated undrained triaxial

compression shear. In addition, Atterberg limits, grain size analyses, organic content, and consolidation tests should be performed on representative samples taken from the borings. These laboratory tests are necessary to determine the shear strength, relative compressibility, and consolidation characteristics of the existing subsoils encountered at the project site.

78. To evaluate the hydraulically dredged material, we recommend column settling tests be performed on bulk samples obtained from the borrow areas. We also recommend the performance of self-weight consolidation tests on this material to further define the borrow material's self-consolidation properties.

LIMITATIONS

79. This preliminary report has been prepared in accordance with generally accepted geotechnical engineering practice for the exclusive use of CB&I for specific application to the subject site. In the event of any changes in the nature, design, or location of the proposed features, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions of this report are modified and verified in writing. Should these data be used by anyone other than CB&I, they should contact Eustis Engineering for interpretation of data and to secure other information pertinent to this project.

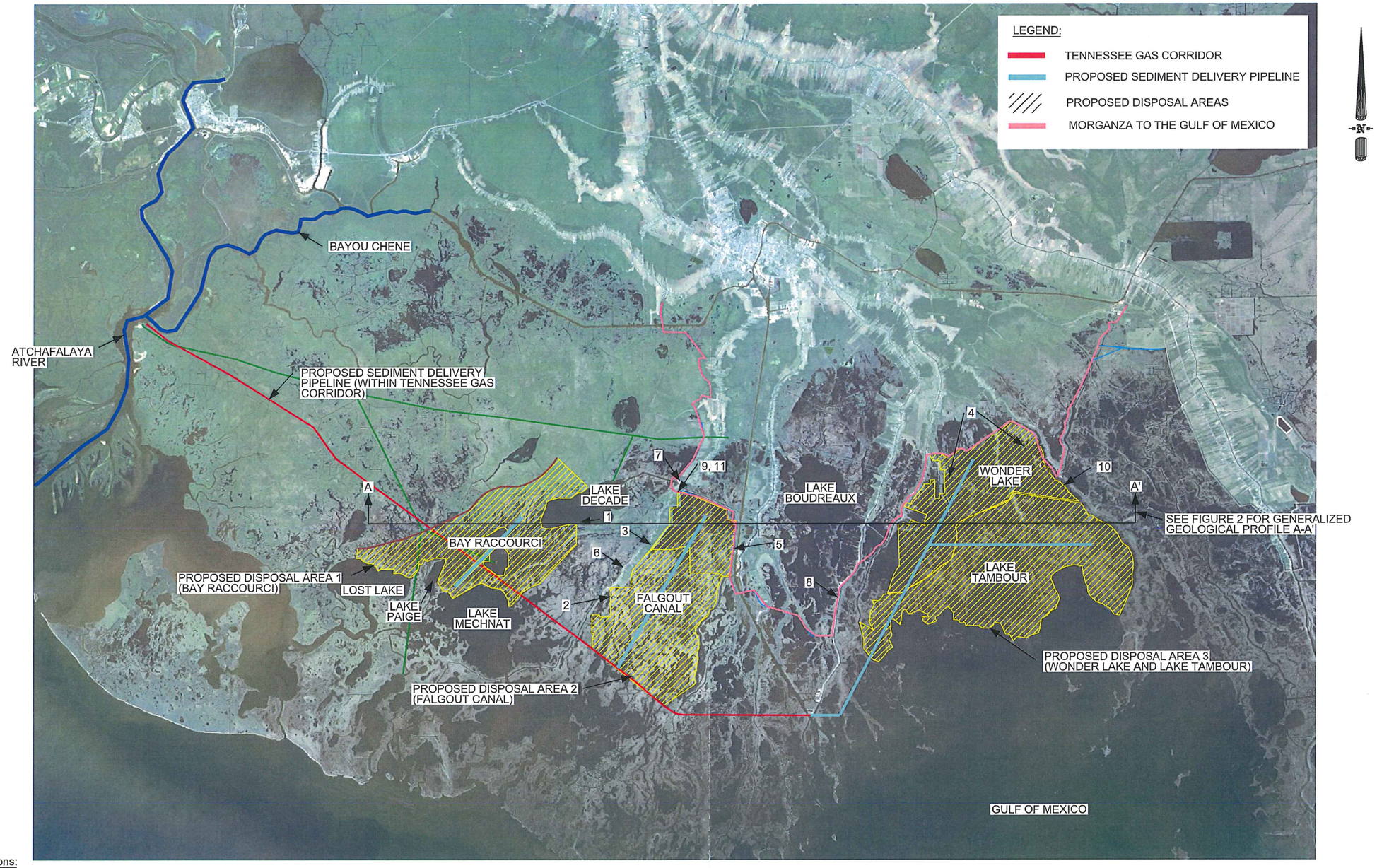
80. Recommendations and conclusions contained in this report are to some degree subjective having partial basis in engineering judgment and experience particular to the design engineer. This report is preliminary in nature and is based on available geotechnical and geological information in the vicinity of the site.

81. Further note, the analyses and recommendations contained in this report are based, in part, on data obtained from soil borings and CPTs obtained from prior

geotechnical explorations in the vicinity of the project. The borings and CPTs are considered representative of subsurface conditions at their respective locations on the dates completed. Variations in soil or ground water conditions will exist between and beyond the exploration points. No warranty is given that the geotechnical data obtained from previous explorations is representative of the current subsurface conditions at the project site. ***This report is preliminary and the recommendations contained herein should not be implemented until they are substantiated by a site specific geotechnical exploration.***

82. Eustis Engineering has striven to provide our services in accordance with accepted geotechnical engineering practices in this locality at this time. No warranty or guarantee is expressed or implied.

83. The scope of our services does not include an environmental assessment or an investigation for the presence or absence of wetlands and hazardous or toxic materials in the soil; surface water; ground water; or air on, below, or adjacent to the subject property. Furthermore, the scope does not include the investigation or detection of biological pollutants at the site. The term "biological pollutants" includes but is not limited to molds, fungi, spores, bacteria, viruses, and the byproducts of any such biological organisms.



Previous Geotechnical Explorations:

1 "Subsoil Investigation, Proposed Levee - Lake De Cade, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 3231," dated 6 December 1963.

2 "Geotechnical Investigation, Terrebonne Parish, Flood Protection Levee Along Bayou Dularge, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 15941," dated 4 June 1999.

3 "Geotechnical Investigation, South Terrebonne Tidewater Management and Conservation District, Lower Bayou Dularge Levee Construction (Reach III), Terrebonne Parish, Louisiana, Eustis Engineering Project No. 16861," dated 7 August 2001.

4 "Geotechnical Information for 40% Design Submittal, Terrebonne Levee & Conservation District, Morganza to the Gulf of Mexico, Hurricane Protection Levee, Modified Reach J, Segment 2, Using DNR Alignment, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 18879," dated 22 December 2005.

5 "U.S. Army Corps of Engineers, Testing of Undisturbed and General Type Soil Samples, Retrieved from Morganza to the Gulf, Reach F-1, Terrebonne Parish, Louisiana, Contract No. W912P8-06-D-0069, Task Order No. 2, Eustis Engineering Project No. 19603." Laboratory test reports were published in January 2008 as completed.

6 "Geotechnical Investigation, South Terrebonne Tidewater Management and Conservation District, Lower Bayou Dularge Levee Construction (Reach II), Terrebonne Parish, Louisiana, State Project No. 716-66-0001, CEEC Project No 1623, Eustis Engineering Project No. 16182," dated 4 April 2000

7 "Geotechnical Investigation, Terrebonne Levee & Conservation District, Morganza to the Gulf of Mexico, Hurricane Projection Levee Project, Reach E, Terrebonne parish Louisiana, Eustis Engineering Project No. 20569," dated 29 January 2010.

8 "Geotechnical Investigation, Terrebonne Levee & Conservation District, Morganza to the Gulf Hurricane Projection Project, Floodgate Structure and Bayou Petit Caillou, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 21467," dated 24 October 2011.

9 "Professional Geotechnical Services, Terrebonne Parish Consolidated Government, Cone Penetrometer Tests in Relocated Levee Alignment, Upper Bayou Dularge Levee, Bayou Provost to Falgout Canal, Terrebonne Parish, Louisiana, Eustis Engineering Project No. 21857," dated 24 July 2012.

10 "Geotechnical Exploration - Interim Report, Terrebonne Levee & Conservation District, Morganza to the Gulf of Mexico, Hurricane Projection Project, Floodgate Structure at Pointe-Aux-Chenes, Terrebonne Parish, Louisiana, CB&I Purchase Order No. 853120 OP, Eustis Engineering Project No. 22192," dated 24 October 2011.

11 "Preliminary Geotechnical Exploration, Terrebonne Levee & Conservation District, Morganza to the Gulf of Mexico, Hurricane Projection Project, Floodgate Structure and Levee Embankment at Falgout Canal, Terrebonne Parish, Louisiana, CB&I Purchase Order Nos. 805344-000 OP and 805350-000 OP, Eustis Engineering Project Nos. 21948 and 21949," dated 17 July 2013.

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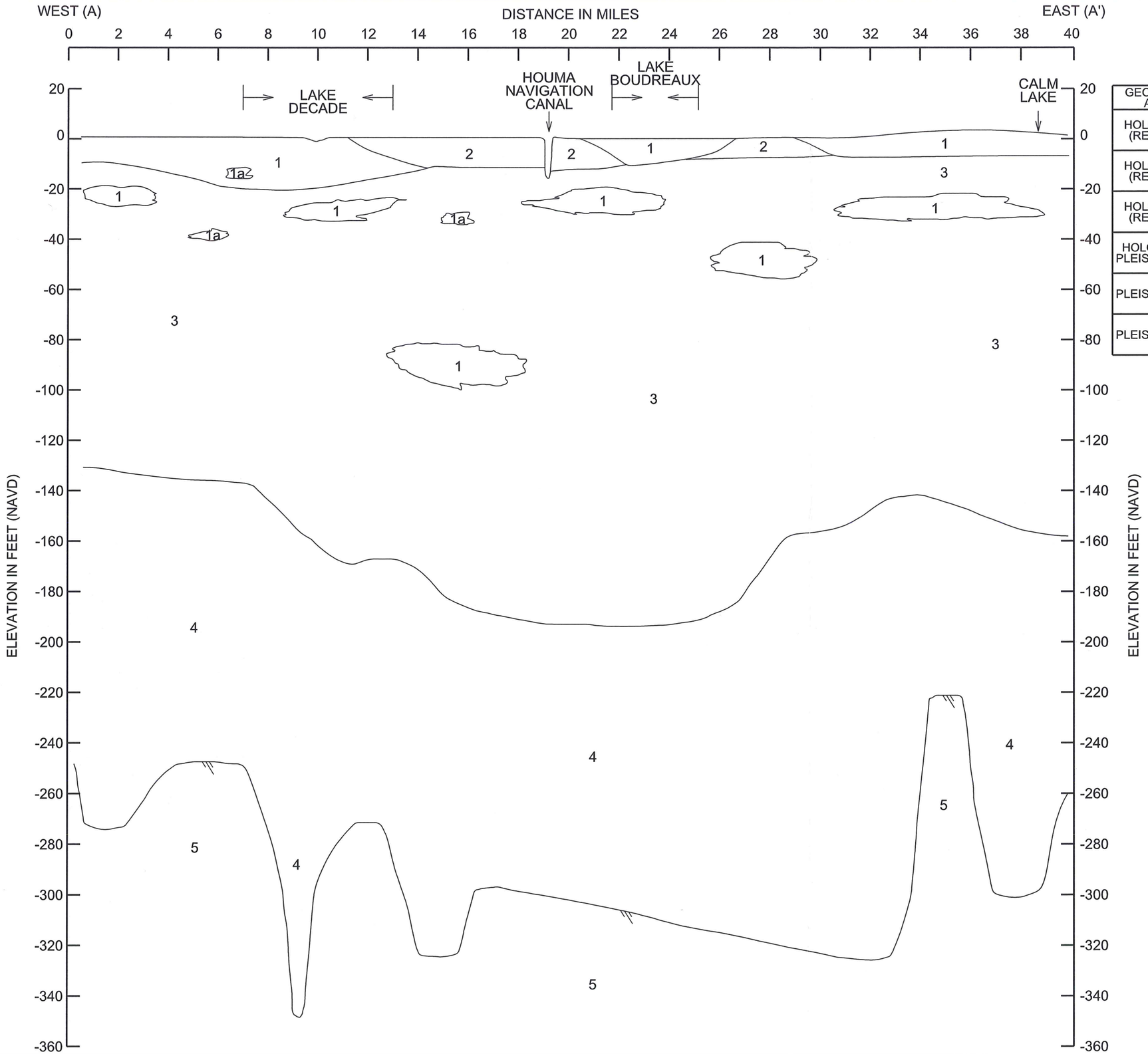
PROJECT VICINITY MAP

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 16 APR 14	CADD FILE: SEDIMENT PIPELINE SKETCH.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 1



GEOLOGIC AGE	STRATA NUMBER	GEOLOGIC NAME	GEOLOGIC DESCRIPTION
HOLOCENE (RECENT)	1	SWAMP/MARSH	DARK GRAY AND BROWN ORGANIC CLAY AND CLAYEY SILT
HOLOCENE (RECENT)	1a	PEAT	DARK GRAY AND BROWN HUMUS/PEAT
HOLOCENE (RECENT)	2	NATURAL LEVEE	GRAY AND BROWN CLAY AND SILTY CLAY
HOLOCENE/ PLEISTOCENE	3	INTERDISTRIBUTARY	GRAY CLAYEY SILT AND SANDY SILT, CLAY, SILTY CLAY AND SANDY CLAY
PLEISTOCENE	4	SUBSTRATUM DEPOSITS	GRAY SAND AND GRAVEL
PLEISTOCENE	5	PRAIRIE PLEISTOCENE DEPOSITS	LIGHT GRAY, GRAY, AND GREENISH GRAY CLAY, SILTY CLAY, SANDY SILT, SILTY SAND, SAND AND CLAYEY SAND

HORIZONTAL SCALE: 1" = 4 MILES
VERTICAL SCALE: 1" = 40'

REFERENCES:

1. GEOLOGICAL INVESTIGATION, MISSISSIPPI RIVER DELTAIC PLAIN MAPS OF LAKE DECADE, BAYOU DULARGE, AND DULAC, LOUISIANA.
2. UNITED STATES DEPARTMENT OF INTERIOR GEOLOGICAL SURVEY, QUADRANGLE MAPS OF LAKE DECADE, BAYOU DULARGE, AND DULAC, LOUISIANA.

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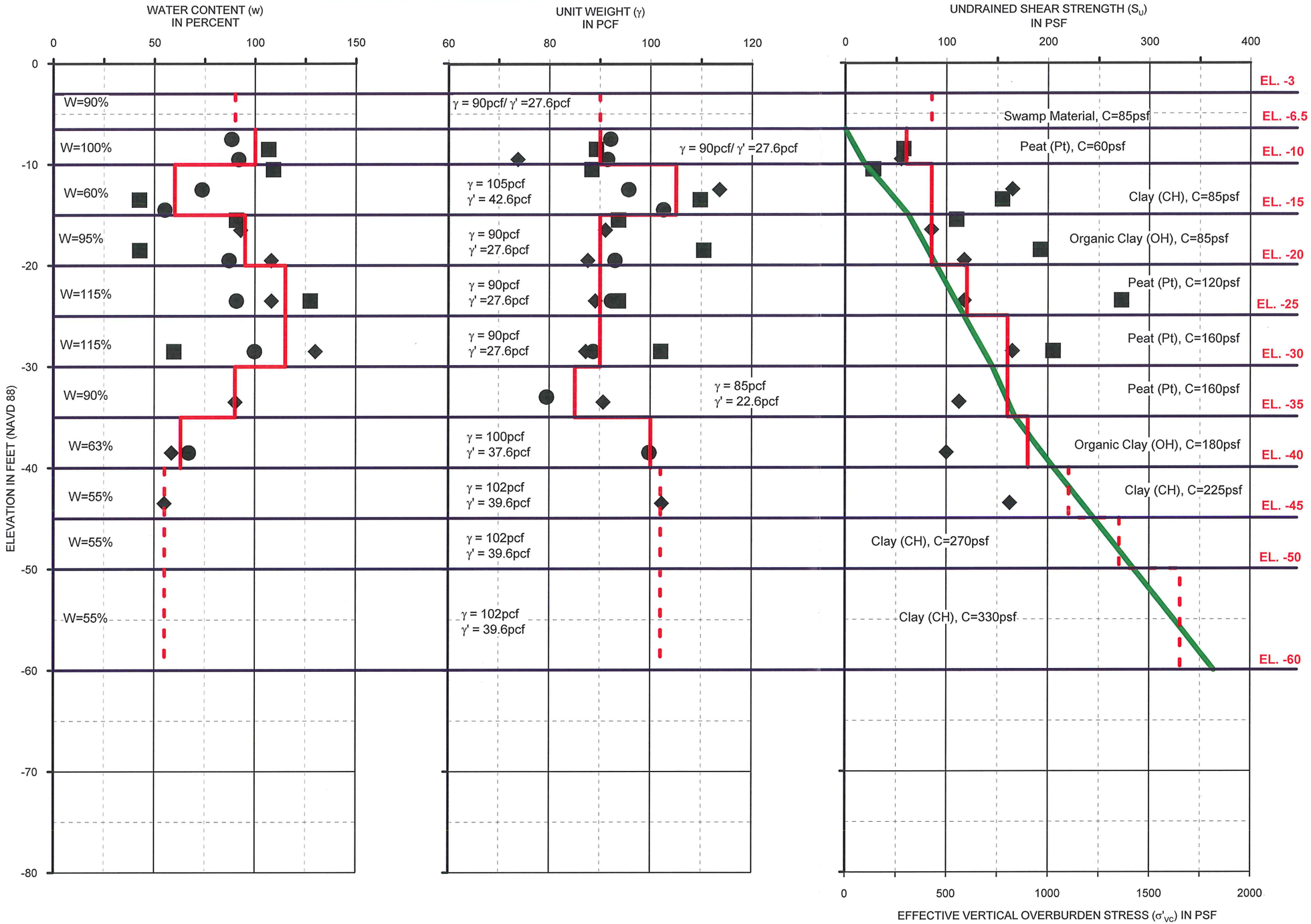
GENERALIZED GEOLOGICAL PROFILE A-A'

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 17 APR 14	CADD FILE: PROFILE.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 2



LEGEND

- ◆ 3231 B-1 UC
- ● 3231 B-3 UC
- ■ 3231 B-5 UC
- c/Po = 0.20 From EL -6.5
- Design Lines
- Estimated Design Lines

WHERE,

UC = UNCONFINED COMPRESSION STRENGTH TEST

NOTES:

1. THE BORINGS PRESENTED HEREIN, WERE PERFORMED IN THE VICINITY OF BAY RACCOURCI. REFER TO THE VICINITY PLAN, FIGURE 1, FOR THE APPROXIMATE VICNINTY OF THE BORING LOCATIONS SHOWN ABOVE.
2. DESIGN PROFILES SHOWN CANNOT FULLY ANTICIPATE ALL PARAMETERS WHICH MAY INFLUENCE SELECTION OF DESIGN VALUES FOR A SPECIFIC ANALYSIS. FOR THIS REASON, THE USER SHOULD CONTACT EUSTIS ENGINEERING SERVICES, L.L.C. PRIOR TO USE OF DESIGN PROFILES IN ANY ANALYSES.
3. ESTIMATED MUDLINE AT EL -3 WAS BASED ON THE FURNISHED CROSS SECTION BY CB&I, INC., DATED 13 MARCH 2014.
4. FOR S-CASE, ANGLE OF INTERNAL FRICTION IS 23 DEGREES FOR CLAY AND 28 DEGREES FOR SILT, UNLESS SPECIFIED. COHESION FOR CLAY AND SILT IS ZERO.

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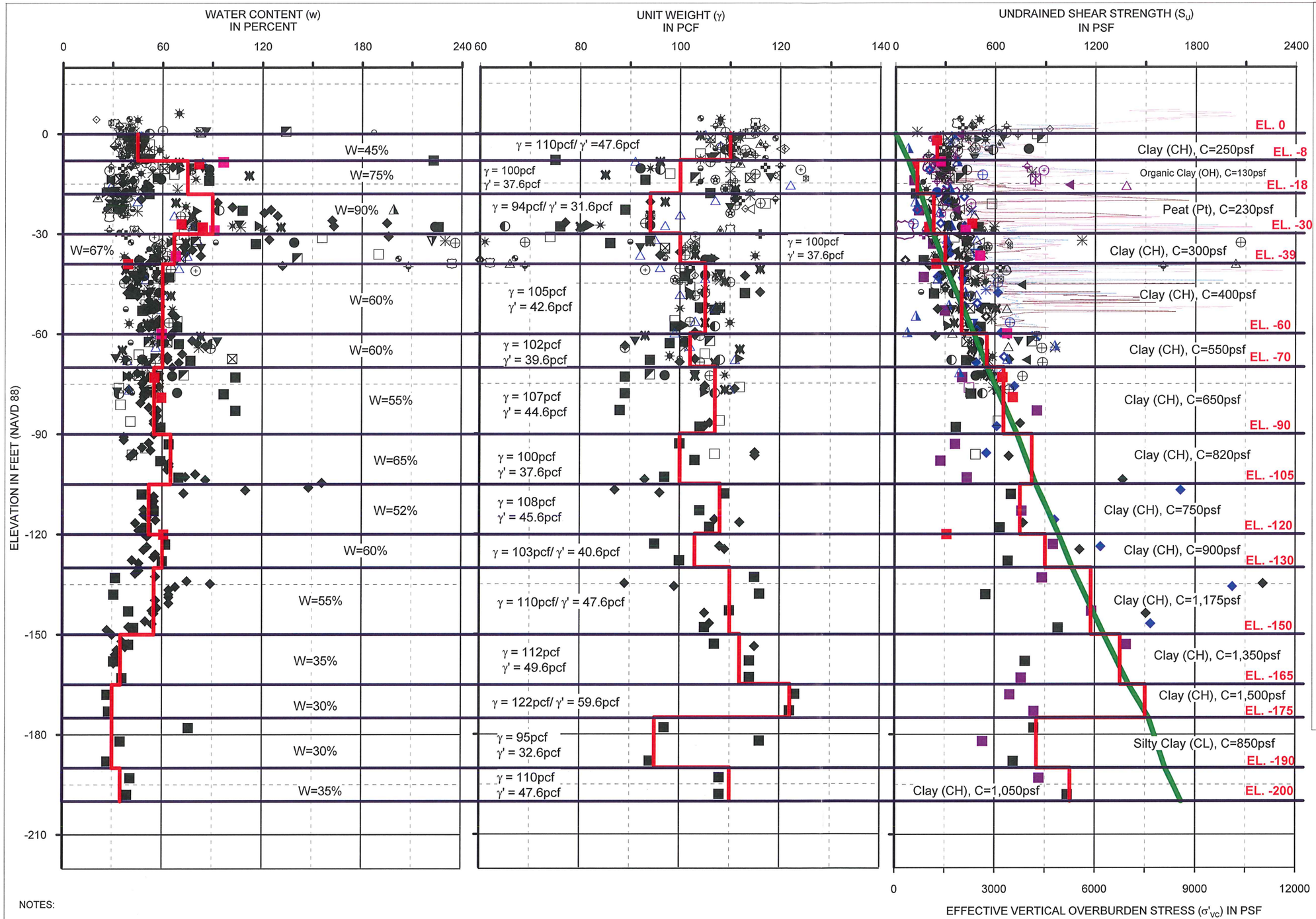
BAY RACCOURCI
SOIL DESIGN PARAMETERS

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: K.R.D.	DATE: 31 MARCH 2014	FILE: BAY RACCOURCI.GRF
CHECKED BY: J.J.H.	JOB NO.: 22450	FIGURE 3 (Sheet 1 of 3)



NOTES:

1. UC = UNCONFINED COMPRESSION STRENGTH TEST; UU = THREE POINT UNCONSOLIDATED TRIAXIAL SHEAR TEST; OB = ONE POINT UNCONSOLIDATED TRIAXIAL SHEAR TEST; AND CPT = CONE PENETRATION TEST

2. THE BORINGS PRESENTED HEREIN, WERE PERFORMED IN THE VICINITY OF FALGOUT CANAL. REFER TO THE VICINITY PLAN, FIGURE 1, FOR THE APPROXIMATE VICINITY OF THE BORING AND CPT LOCATIONS SHOWN ABOVE.

3. DESIGN PROFILES SHOWN CANNOT FULLY ANTICIPATE ALL PARAMETERS WHICH MAY INFLUENCE SELECTION OF DESIGN VALUES FOR A SPECIFIC ANALYSIS. FOR THIS REASON, THE USER SHOULD CONTACT EUSTIS ENGINEERING SERVICES, L.L.C. PRIOR TO USE OF DESIGN PROFILES IN ANY ANALYSES.

4. FOR S-CASE, ANGLE OF INTERNAL FRICTION IS 23 DEGREES FOR CLAY AND 28 DEGREES FOR SILT, UNLESS SPECIFIED. COHESION FOR CLAY AND SILT IS ZERO.

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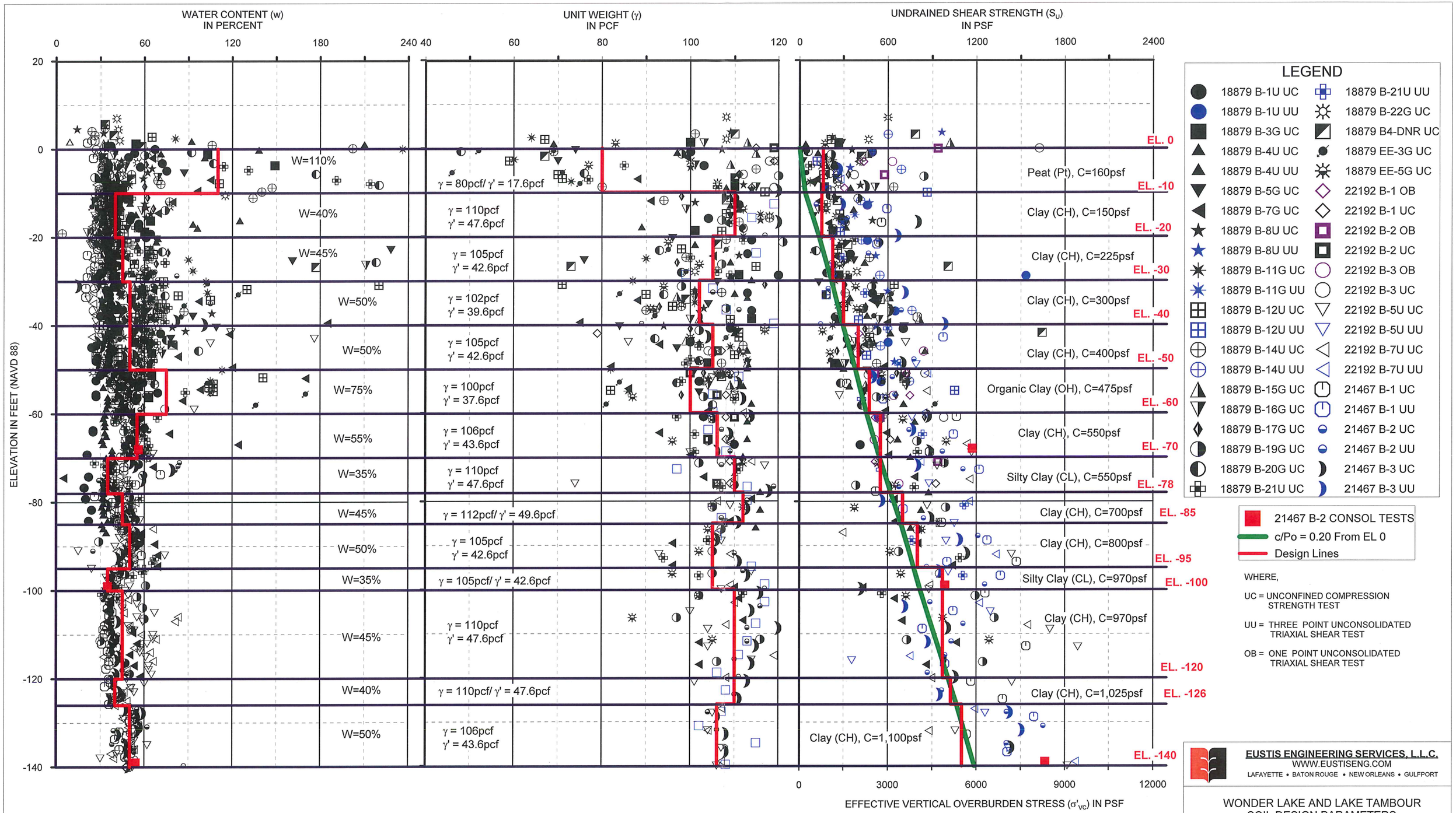
FALGOUT CANAL
SOIL DESIGN PARAMETERS

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: K.R.D.	DATE: 1 APRIL 2014	FILE: FALGOUT CANAL.GRF
CHECKED BY: J.J.H.	JOB NO.: 22450	FIGURE 3 (Sheet 2 of 3)



NOTES:

1. THE BORINGS PRESENTED HEREIN, WERE PERFORMED IN THE VICINITY OF WONDER LAKE AND LAKE TAMBOUR. REFER TO THE VICINITY PLAN, FIGURE 1, FOR THE APPROXIMATE VICINITY OF THE BORING LOCATIONS SHOWN ABOVE.
2. DESIGN PROFILES SHOWN CANNOT FULLY ANTICIPATE ALL PARAMETERS WHICH MAY INFLUENCE SELECTION OF DESIGN VALUES FOR A SPECIFIC ANALYSIS. FOR THIS REASON, THE USER SHOULD CONTACT EUSTIS ENGINEERING SERVICES, L.L.C. PRIOR TO USE OF DESIGN PROFILES IN ANY ANALYSES.
3. FOR S-CASE, ANGLE OF INTERNAL FRICTION IS 23 DEGREES FOR CLAY AND 28 DEGREES FOR SILT, UNLESS SPECIFIED. COHESION FOR CLAY AND SILT IS ZERO.

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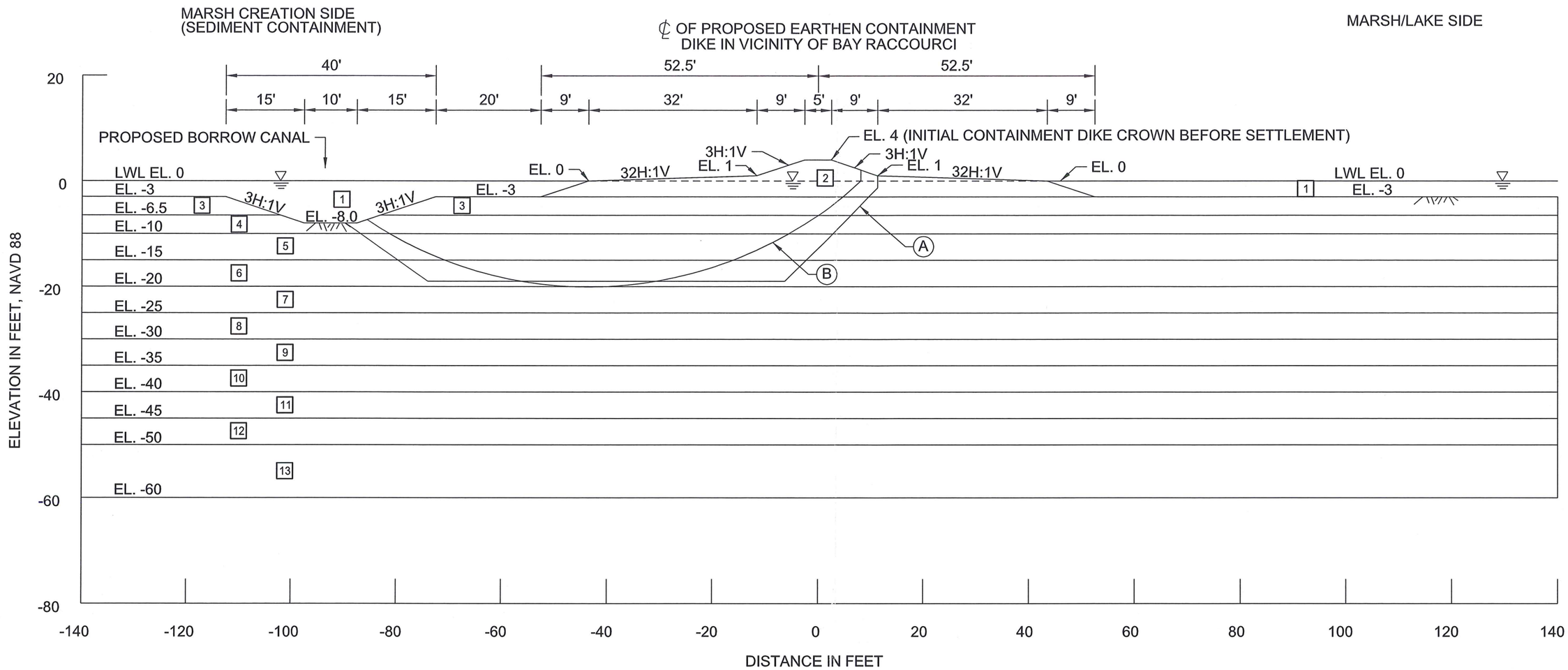
WONDER LAKE AND LAKE TAMBOUR
SOIL DESIGN PARAMETERS

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: K.R.D.	DATE: 31 MARCH 2014	FILE: WONDER LAKE -LAKE TAMBOUR.GRF
CHECKED BY: J.J.H.	JOB NO.: 22450	FIGURE 3 (Sheet 3 of 3)



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	SALT WATER	0	64.0	0	0
2	CONTAINMENT DIKE	0	100	200	200
3	CLAY	0	90	85	85
4	PEAT	0	90	60	60
5	CLAY	0	105	85	85
6	ORGANIC CLAY	0	90	85	85
7	PEAT	0	90	120	120
8	PEAT	0	90	160	160
9	ORGANIC CLAY	0	85	160	160
10	CLAY	0	100	180	180
11	CLAY	0	102	225	225
12	CLAY	0	102	270	270
13	CLAY	0	102	330	330

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	BLOCK SPECIFIED	1.10	22450 BAY RACCOURCI CONTAINMENT DIKE REV (FS TO MS BS).GSZ	1.10
B	ENTRY AND EXIT	1.43	22450 BAY RACCOURCI CONTAINMENT DIKE REV (FS TO MS EE).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. MUDLINE WAS ESTIMATED AT EL -3 BASED ON THE FURNISHED CROSS-SECTIONS BY CB&I, DATED 13 MARCH 2014.
4. LOW WATER LEVEL AT EL 0 WAS ASSUMED IN THE ABOVE ANALYSES.
5. SINCE BOTH SIDES OF THE CONTAINMENT DIKE ARE SYMMETICAL, ANALYSIS WAS PERFORMED ON ONE SIDE.
6. EUSTIS ENGINEERING SHOULD BE CONTACTED IF OUR ASSUMPTIONS ARE INVALID.

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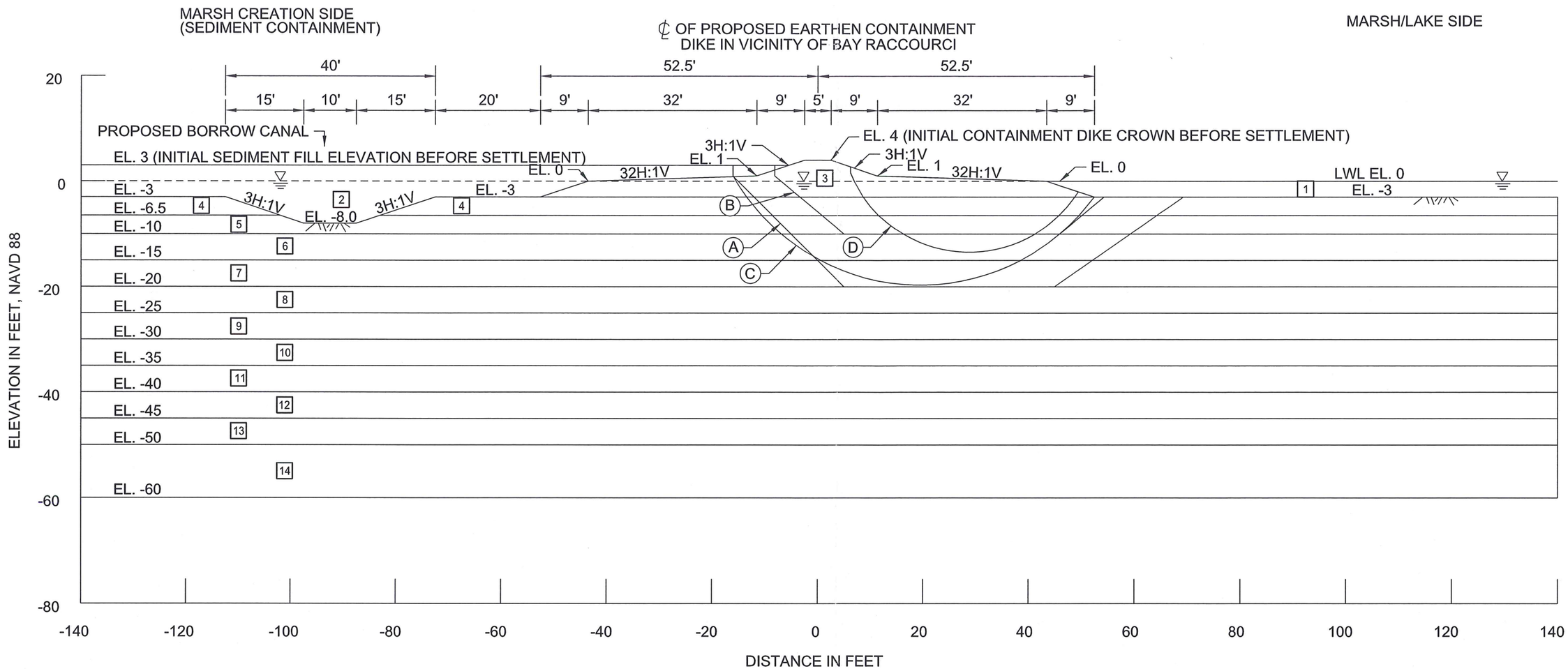
SLOPE STABILITY ANALYSES USING SPENCER'S METHOD
EARTHEN CONTAINMENT DIKE
BAY RACCOURCI SEDIMENT DISPOSAL SITE
INITIAL CONSTRUCTION
FAILURE TOWARDS SEDIMENT DISPOSAL SITE

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 29 MAY 14	CADD FILE: BAYRACC_INITIAL REDO.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 4 (SHEET 1 OF 2)



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	SALT WATER	0	64.0	0	0
2	SEDIMENT FILL	0	100	100	100
3	CONTAINMENT DIKE	0	100	200	200
4	CLAY	0	90	85	85
5	PEAT	0	90	60	60
6	CLAY	0	105	85	85
7	ORGANIC CLAY	0	90	85	85
8	PEAT	0	90	120	120
9	PEAT	0	90	160	160
10	ORGANIC CLAY	0	85	160	160
11	CLAY	0	100	180	180
12	CLAY	0	102	225	225
13	CLAY	0	102	270	270
14	CLAY	0	102	330	330

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	BLOCK SPECIFIED	1.17	22450 BAY RACCOURCI CONTAINMENT DIKE REV (BS).GSZ	1.10
B	BLOCK SPECIFIED	1.19	22450 BAY RACCOURCI CONTAINMENT DIKE REV (BS SHALLOW).GSZ	
C	ENTRY AND EXIT	1.46	22450 BAY RACCOURCI CONTAINMENT DIKE REV (EE).GSZ	
D	ENTRY AND EXIT	3.63	22450 BAY RACCOURCI CONTAINMENT DIKE REV (EE LOCAL).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. MUDLINE WAS ESTIMATED AT EL -3 BASED ON THE FURNISHED CROSS-SECTIONS BY CB&I, DATED 13 MARCH 2014.
4. LOW WATER LEVEL AT EL 0 WAS ASSUMED IN THE ABOVE ANALYSES.
5. PROTECTED SIDE BERM WAS EXTENDED TO MEET A MINIMUM FACTOR OF SAFETY OF 1.3 DUE TO SEDIMENT FILL LOADS ON THE MARSH CREATION SIDE.

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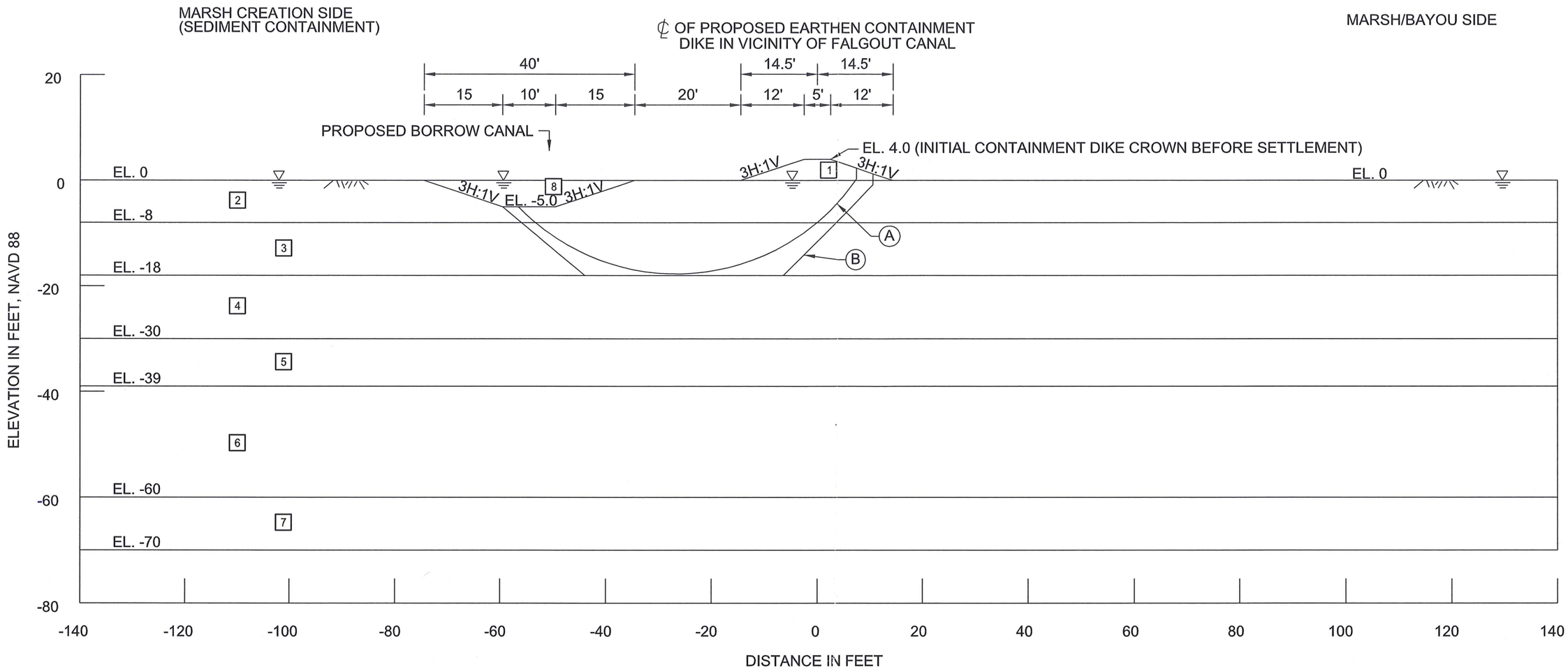
SLOPE STABILITY ANALYSES USING SPENCER'S METHOD
EARTHEN CONTAINMENT DIKE
BAY RACCOURCI SEDIMENT DISPOSAL SITE
WITH SEDIMENT FILL TO EL 3
FAILURE TOWARDS PROTECTED SIDE

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 29 MAY 14	CADD FILE: BAYRACC_SEDIMENT REDO.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 4 (SHEET 2 OF 2)



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	UNCOMPACTED BERM FILL	0	100	200	200
2	CLAY	0	110	250	250
3	ORGANIC CLAY	0	100	130	130
4	PEAT	0	94	230	230
5	CLAY	0	100	300	300
6	CLAY	0	105	400	400
7	CLAY	0	102	550	550
8	SALT WATER	0	64.0	0	0

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	ENTRY AND EXIT	1.94	22450 FALGOUT CANAL CONTAINMENT DIKE - REV (FS TO MS EE).GSZ	1.10
B	BLOCK SPECIFIED	1.57	22450 FALGOUT CANAL CONTAINMENT DIKE - REV (FS TO MS BS).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. MUDLINE WAS ESTIMATED AT EL 0 BASED ON AVAILABLE GEOLOGICAL MAPS.
4. LOW WATER LEVEL AT EL 0 WAS ASSUMED IN THE ABOVE ANALYSES.
5. SINCE BOTH SIDES OF THE CONTAINMENT DIKE ARE SYMMETICAL, ANALYSIS WAS PERFORMED ON ONE SIDE.
6. EUSTIS ENGINEERING SHOULD BE CONTACTED IF OUR ASSUMPTIONS ARE INVALID.

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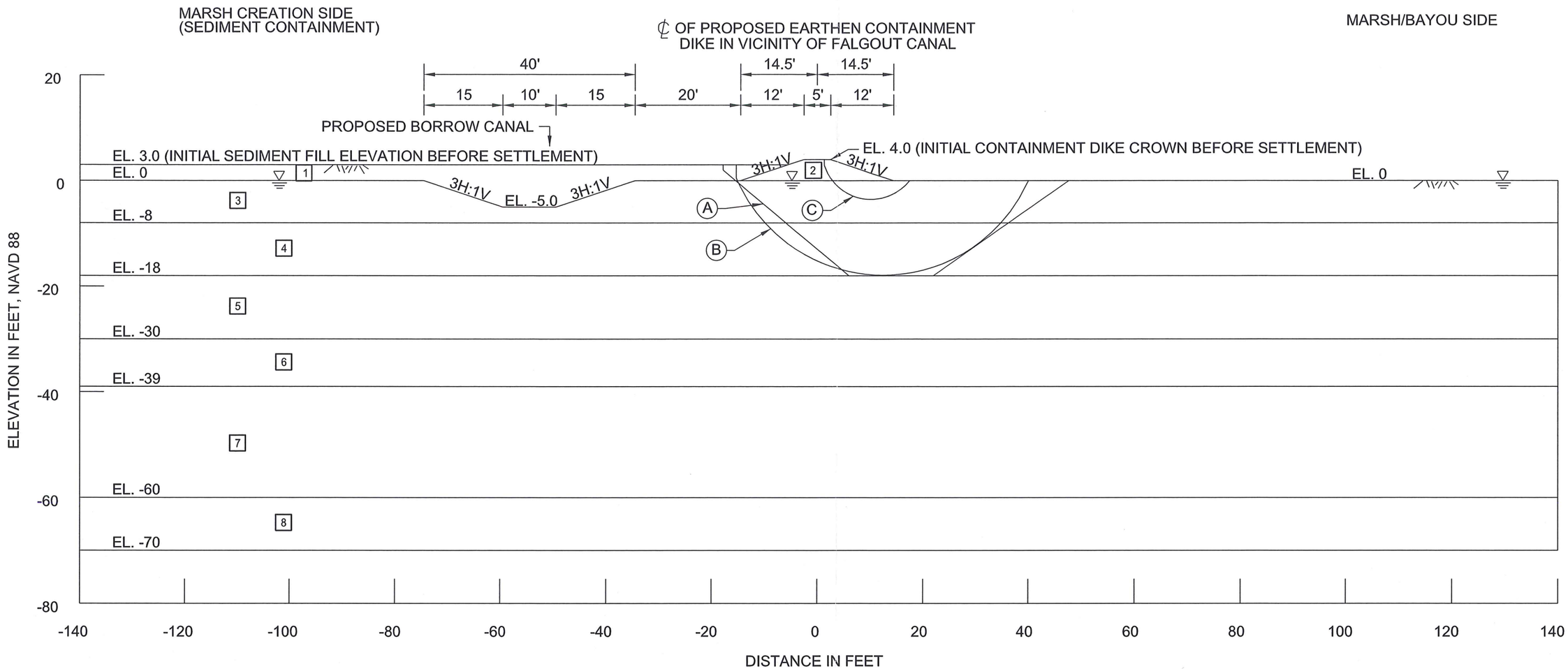
EARTHEN CONTAINMENT DIKE
FALGOUT CANAL SEDIMENT DISPOSAL SITE
INITIAL CONSTRUCTION
FAILURE TOWARDS SEDIMENT DISPOSAL SITE

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 29 MAY 14	CADD FILE: FALGOUT_INITIAL REDO.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 5 (SHEET 1 OF 2)



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	SEDIMENT FILL	0	100	100	100
2	UNCOMPACTED BERM FILL	0	100	200	200
3	CLAY	0	110	250	250
4	ORGANIC CLAY	0	100	130	130
5	PEAT	0	94	230	230
6	CLAY	0	100	300	300
7	CLAY	0	105	400	400
8	CLAY	0	102	550	550

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	BLOCK SPECIFIED	2.28	22450 FALGOUT CANAL CONTAINMENT DIKE - REV (BS).GSZ	1.10
B	ENTRY AND EXIT	2.73	22450 FALGOUT CANAL CONTAINMENT DIKE - REV (EE).GSZ	
C	ENTRY AND EXIT	4.04	22450 FALGOUT CANAL CONTAINMENT DIKE - REV (EE).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. MUDLINE WAS ESTIMATED AT EL 0 BASED ON AVAILABLE GEOLOGICAL MAPS.
4. LOW WATER LEVEL AT EL 0 WAS ASSUMED IN THE ABOVE ANALYSES.
5. EUSTIS ENGINEERING SHOUD BE CONTACTED IF OUR ASSUMPTIONS ARE INVALID.

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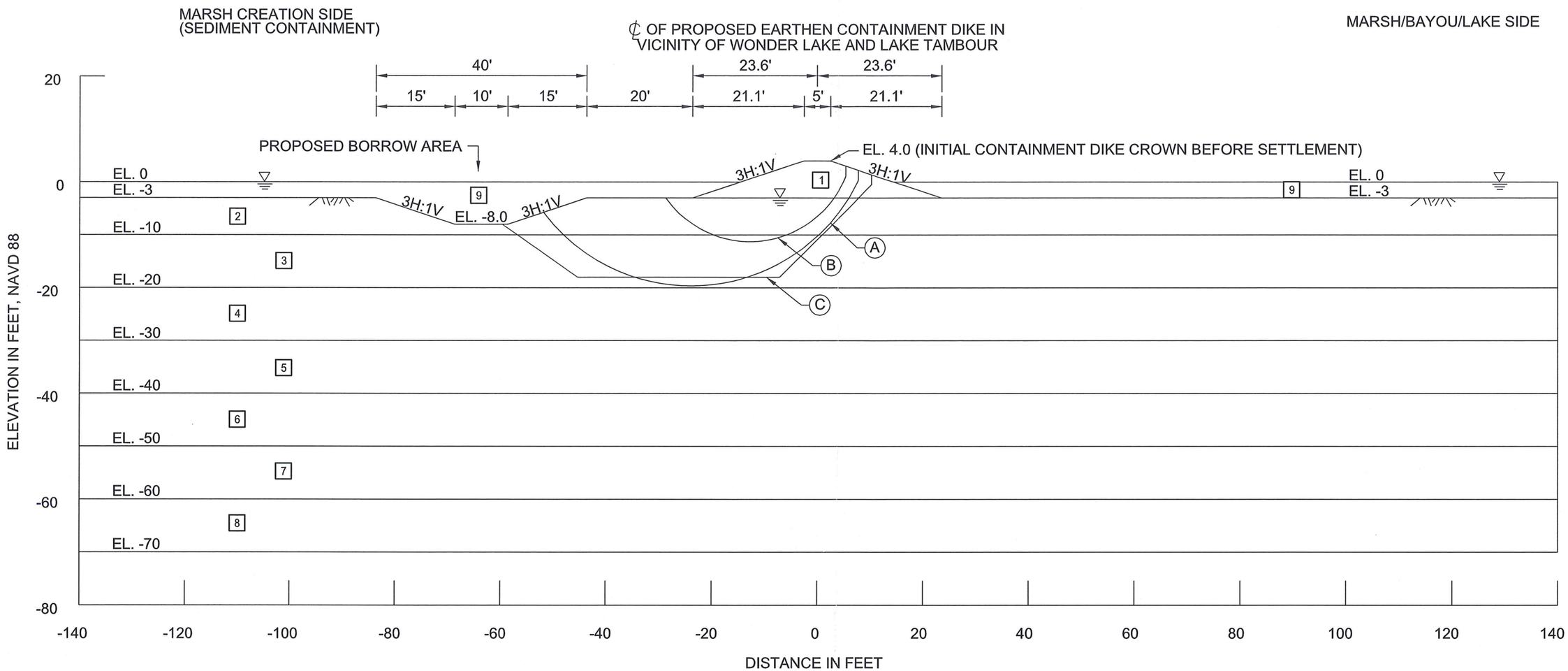
SLOPE STABILITY ANALYSES USING SPENCER'S METHOD
EARTHEN CONTAINMENT DIKE
FALGOUT CANAL SEDIMENT DISPOSAL SITE
WITH SEDIMENT FILL TO EL 5.5
FAILURE TOWARDS PROTECTED SIDE

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 29 MAY 14	CADD FILE: FALGOUT_SEDIMENT-REDO.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 5 (SHEET 2 OF 2)



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	UNCOMPACTED BERM FILL	0	100	200	200
2	PEAT	0	80	160	160
3	CLAY	0	110	150	150
4	CLAY	0	105	225	225
5	CLAY	0	102	300	300
6	CLAY	0	105	400	400
7	ORGANIC CLAY	0	100	475	475
8	CLAY	0	106	550	550
9	SALT WATER	0	64.0	0	0

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	ENTRY AND EXIT	2.01	22450 WONDER AND TAMBOUR CONTAINMENT DIKE - REV (FS TO MS EE).GSZ	1.10
B	ENTRY AND EXIT	1.87	22450 WONDER AND TAMBOUR CONTAINMENT DIKE - REV (FS TO MS EE 3).GSZ	
C	BLOCK SPECIFIED	1.69	22450 WONDER AND TAMBOUR CONTAINMENT DIKE - REV(FS TO MS BS 2).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. MUDLINE WAS ESTIMATED AT EL 0 BASED ON AVAILABLE GEOLOGICAL MAPS.
4. LOW WATER LEVEL AT EL 0 WAS ASSUMED IN THE ABOVE ANALYSES.
5. SINCE BOTH SIDES OF THE CONTAINMENT DIKE ARE SYMMETICAL, ANALYSIS WAS PERFORMED ON ONE SIDE.
6. EUSTIS ENGINEERING SHOULD BE CONTACTED IF OUR ASSUMPTIONS ARE INVALID.

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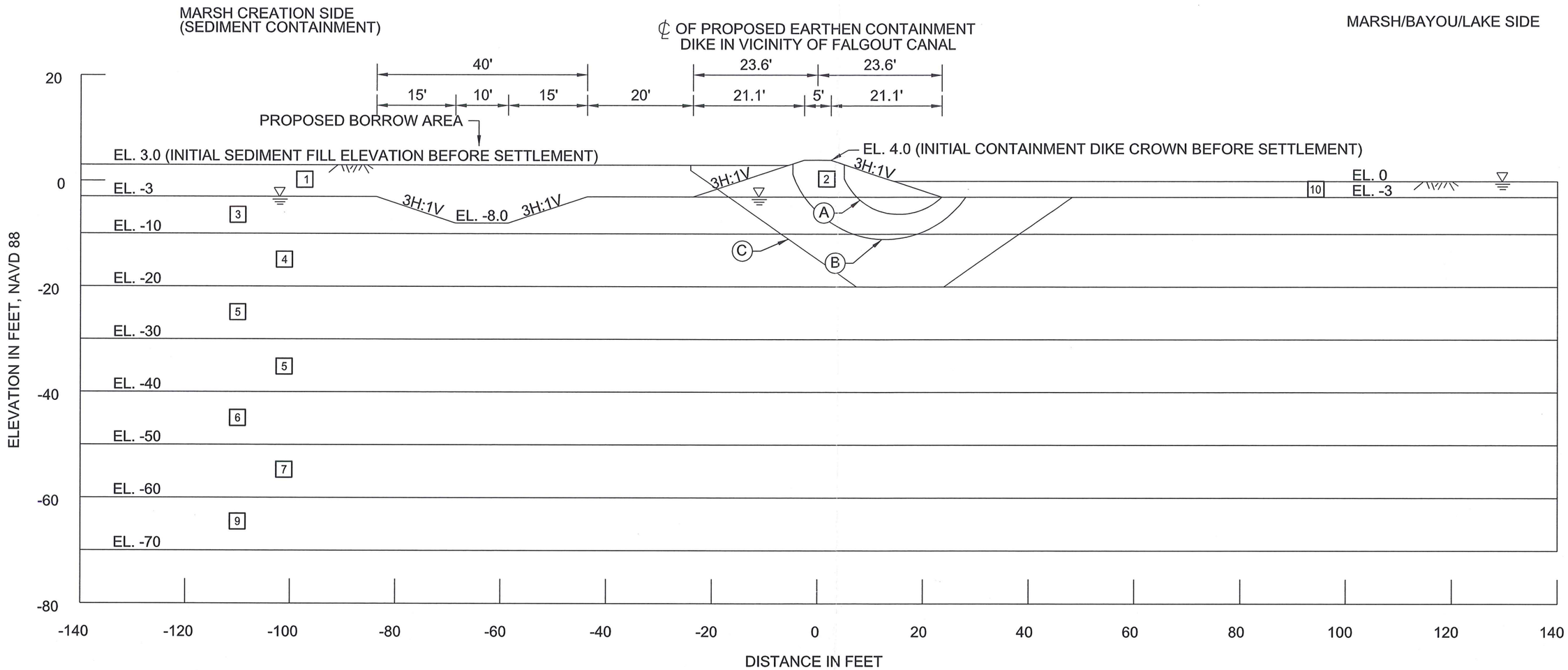
EARTHEN CONTAINMENT DIKE
WONDER LAKE AND LAKE TAMBOUR SEDIMENT DISPOSAL SITE
INITIAL CONSTRUCTION
FAILURE TOWARDS SEDIMENT DISPOSAL SITE

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 29 MAY 14	CADD FILE: WONDER_INITIAL-REDO.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 6 (SHEET 1 OF 2)



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	SEDIMENT FILL	0	100	100	100
2	UNCOMPACTED BERM FILL	0	100	200	200
3	PEAT	0	80	160	160
4	CLAY	0	110	150	150
5	CLAY	0	105	225	225
6	CLAY	0	102	300	300
7	CLAY	0	105	400	400
8	ORGANIC CLAY	0	100	475	475
9	CLAY	0	106	550	550
10	SALT WATER	0	64.0	0	0

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	ENTRY AND EXIT	2.76	22450 WONDER AND TAMBOUR CONTAINMENT DIKE - REV (EE LOCAL).GSZ	1.10
B	ENTRY AND EXIT	1.87	22450 WONDER AND TAMBOUR CONTAINMENT DIKE - REV (EE).GSZ	
C	BLOCK SPECIFIED	1.72	22450 WONDER AND TAMBOUR CONTAINMENT DIKE - REV (BS).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. MUDLINE WAS ESTIMATED AT EL 0 BASED ON AVAILABLE GEOLOGICAL MAPS.
4. LOW WATER LEVEL AT EL 0 WAS ASSUMED IN THE ABOVE ANALYSES.
5. EUSTIS ENGINEERING SHOULD BE CONTACTED IF OUR ASSUMPTIONS ARE INVALID.

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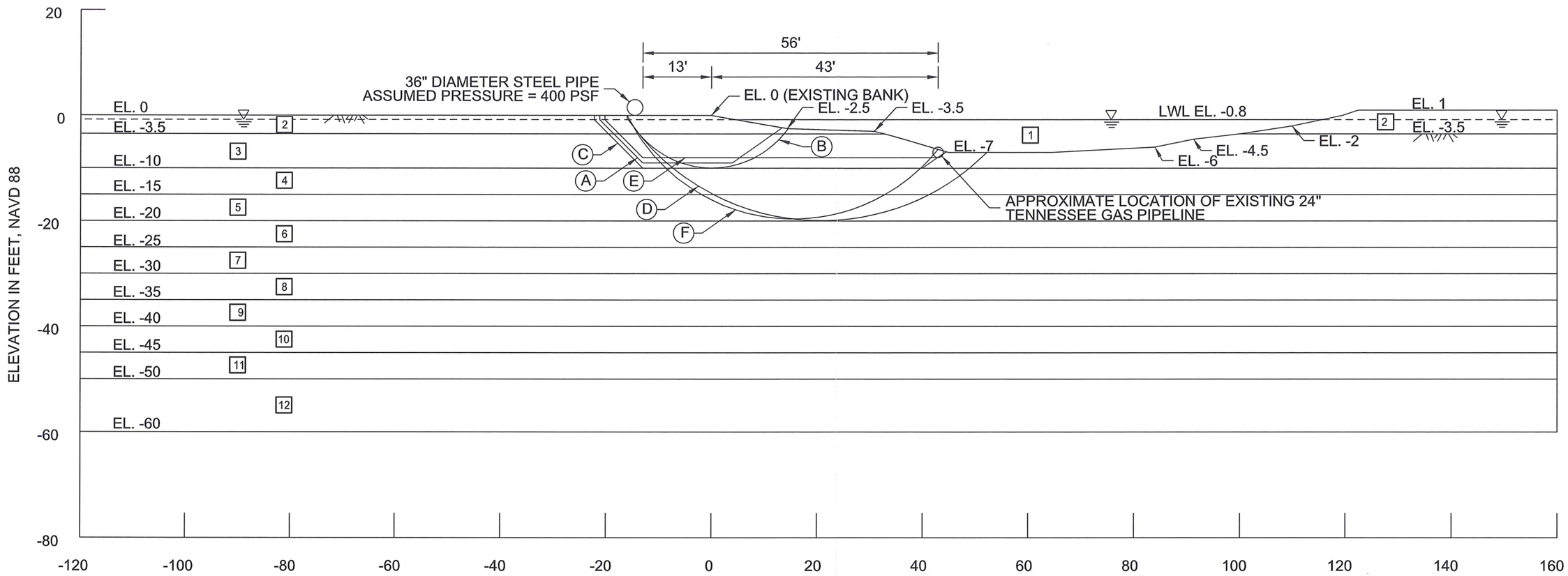
EARTHEN CONTAINMENT DIKE
WONDER LAKE AND LAKE TAMBOUR SEDIMENT DISPOSAL SITE
WITH SEDIMENT FILL TO EL 5.5
FAILURE TOWARDS PROTECTED SIDE

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 28 MAY 14	CADD FILE: WONDER_SEDIMENT-REDO.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 6 (SHEET 2 OF 2)

CROSS-SECTION M-M



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	SALT WATER	0	64.0	0	0
2	CLAY	0	90	85	85
3	PEAT	0	90	60	60
4	CLAY	0	105	85	85
5	ORGANIC CLAY	0	90	85	85
6	PEAT	0	90	120	120
7	PEAT	0	90	160	160
8	ORGANIC CLAY	0	85	160	160
9	CLAY	0	100	180	180
10	CLAY	0	102	225	225
11	CLAY	0	102	270	270
12	CLAY	0	102	330	330

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	BLOCK SPECIFIED	1.32	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M (BS).GSZ	1.30
B	ENTRY AND EXIT	1.45	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M (EE).GSZ	
C	BLOCK SPECIFIED	1.36	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M (BS 2).GSZ	
D	ENTRY AND EXIT	1.78	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M (EE 2).GSZ	
E	BLOCK SPECIFIED	1.51	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M (BS 3).GSZ	
F	ENTRY AND EXIT	1.86	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M (EE 3).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. THE ANALYSES SHOWN ABOVE WERE BASED ON CROSS-SECTION M-M, FURNISHED BY CB&I, AND DATED 13 MARCH 2014.
4. LOW WATER LEVEL AT EL -0.8 WAS ASSUMED IN THE ANALYSES.
5. IN ORDER TO MEET THE MINIMUM REQUIRED FACTOR OF SAFETY OF 1.3, THE GRADE SUPPORTED PIPE SHOULD BE PLACED AT LEAST 13 FEET FROM THE EDGE OF THE BANK OR 56 FEET FROM THE TENNESSEE GAS PIPELINE.

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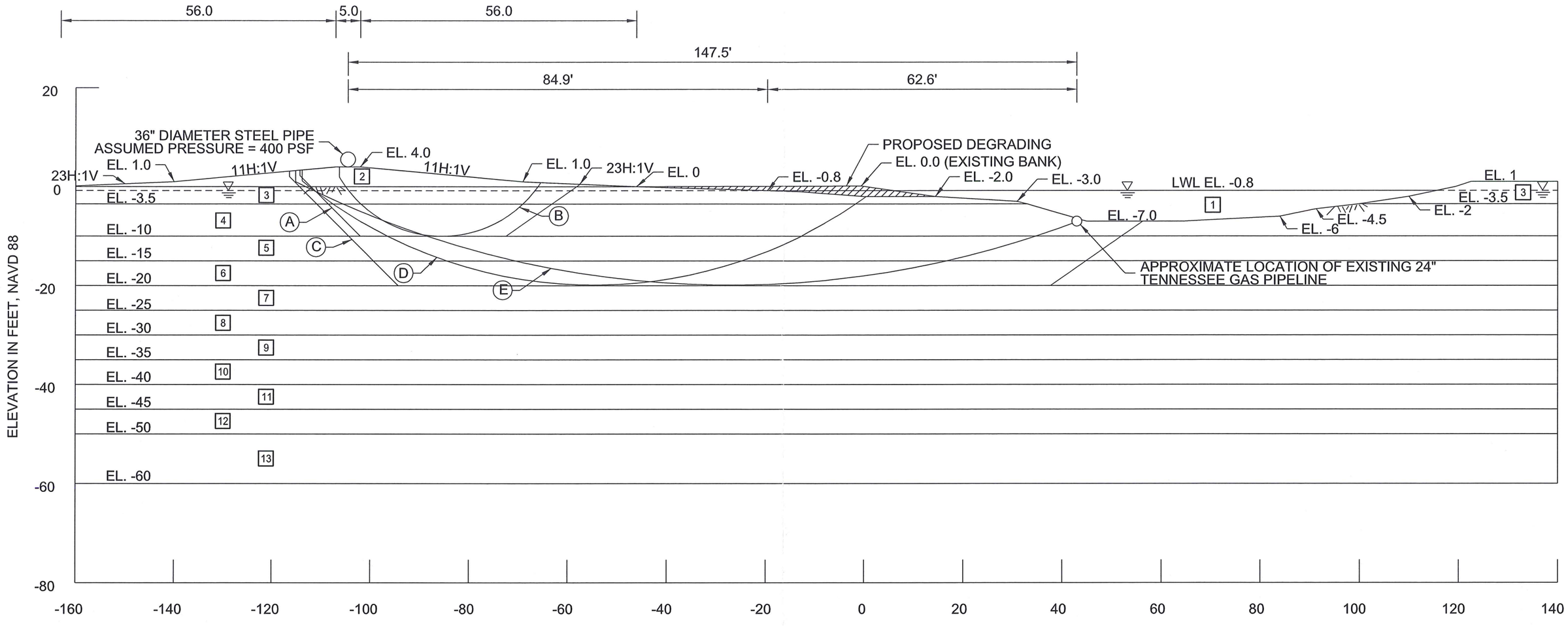
SLOPE STABILITY ANALYSES USING SPENCER'S METHOD
AT CROSS-SECTION M-M
SEDIMENT PIPE PLACEMENT ON EXISTING GRADE (EL. 0)
TENNESSEE GAS RIGHT-OF-WAY
IN THE VICINITY OF BAY RACCOURCI

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 29 MAY 14	CADD FILE: BAYRACC_PIPELINE REDO.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 7

CROSS-SECTION M-M WITH SOIL BERM



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	SALT WATER	0	64.0	0	0
2	UNCOMPACTED BERM FILL	0	100	200	200
3	CLAY	0	90	85	85
4	PEAT	0	90	60	60
5	CLAY	0	105	85	85
6	ORGANIC CLAY	0	90	85	85
7	PEAT	0	90	120	120
8	PEAT	0	90	160	160
9	ORGANIC CLAY	0	85	160	160
10	CLAY	0	100	180	180
11	CLAY	0	102	225	225
12	CLAY	0	102	270	270
13	CLAY	0	102	330	330

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	BLOCK SPECIFIED	1.10	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M WITH RIDGE (BS LOCAL).GSZ	1.10
B	ENTRY AND EXIT	1.16	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M WITH RIDGE (EE LOCAL).GSZ	
C	BLOCK SPECIFIED	1.31	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M WITH RIDGE (BS GLOBAL EXIT TENN PIPE).GSZ	1.30
D	ENTRY AND EXIT	1.33	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M WITH RIDGE(EE GLOBAL).GSZ	
E	ENTRY AND EXIT	1.71	22450 BAY RACCOURCI SEDIMENT PIPELINE SECTION M-M WITH RIDGE (EE GLOBAL - EXIST TENN PIPE).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. THE ANALYSES SHOWN ABOVE WERE BASED ON CROSS-SECTION M-M, FURNISHED BY CB&I, AND DATED 13 MARCH 2014.
4. LOW WATER LEVEL AT EL -0.8 WAS ASSUMED IN THE ANALYSES.
5. IN ORDER TO MEET THE MINIMUM REQUIRED FACTOR OF SAFETY OF 1.3, THE GRADE SUPPORTED PIPE SHOULD BE PLACED AT LEAST 147.5 FEET FROM THE EXISTING TENNESSEE GAS PIPELINE.

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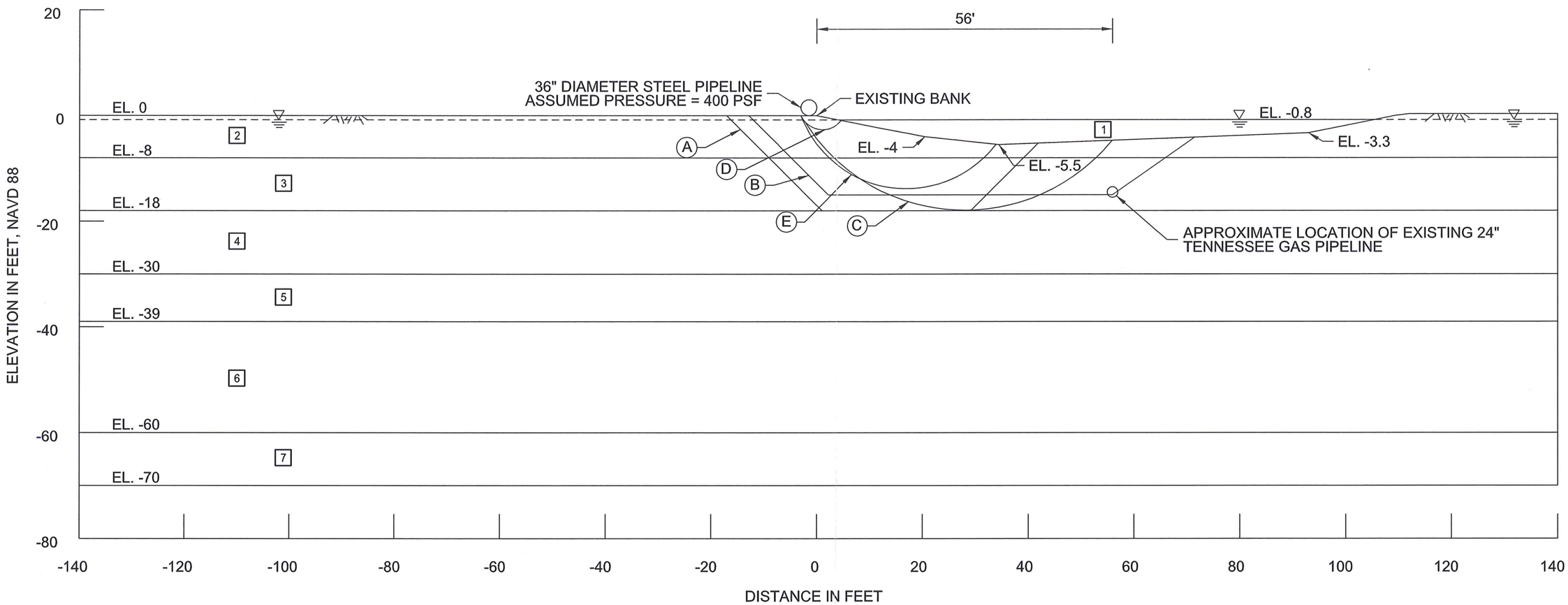
SLOPE STABILITY ANALYSES USING SPENCER'S METHOD
AT CROSS-SECTION M-M
SEDIMENT PIPE PLACEMENT ON UNCOMPACTED FILL BERM (EL. 4)
TENNESSEE GAS RIGHT-OF-WAY
IN THE VICINITY OF BAY RACCOURCI

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 29 MAY 14	CADD FILE: BAYRACC_RIDGE.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 8

CROSS-SECTION B-B



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	SALT WATER	0	64.0	0	0
2	CLAY	0	110	250	250
3	ORGANIC CLAY	0	100	130	130
4	PEAT	0	94	230	230
5	CLAY	0	100	300	300
6	CLAY	0	105	400	400
7	CLAY	0	102	550	550

SLIP SURFACE DESIGNATION	TYPE OF SEARCH	FACTOR OF SAFETY	FILE NAME	MINIMUM REQUIRED FACTOR OF SAFETY
A	BLOCK SPECIFIED	2.14	22450 FALGOUT CANAL SEDIMENT PIPELINE SECTION B-B (BS).GSZ	1.30
B	BLOCK SPECIFIED	3.25	22450 FALGOUT CANAL SEDIMENT PIPELINE SECTION B-B (BS 3).GSZ	
C	ENTRY AND EXIT	3.47	22450 FALGOUT CANAL SEDIMENT PIPELINE SECTION B-B (EE 4).GSZ	
D	ENTRY AND EXIT	2.82	22450 FALGOUT CANAL SEDIMENT PIPELINE SECTION B-B (EE).GSZ	
E	ENTRY AND EXIT	2.69	22450 FALGOUT CANAL SEDIMENT PIPELINE SECTION B-B (EE 2).GSZ	

NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED BY SPENCER'S METHOD USING SLOPE/W SOFTWARE, VERSION 7.17.
2. A TENSION CRACK WAS INCORPORATED IN THE ANALYSIS TO ELIMINATE NEGATIVE NORMAL FORCES AND NEGATIVE INTERSLICE FORCES WHEN FOUND AT THE BASE OF THE UPPER SLICES.
3. THE ANALYSES SHOWN ABOVE WERE BASED ON CROSS-SECTION B-B, FURNISHED BY CB&I, AND DATED 13 MARCH 2014.
4. LOW WATER LEVEL AT EL -0.8 WAS ASSUMED IN THE ANALYSES.

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SLOPE STABILITY ANALYSES USING SPENCER'S METHOD
AT CROSS-SECTION B-B
SEDIMENT PIPELINE PLACEMENT ON EXISTING GRADE (EL. 0)
TENNESSEE GAS RIGHT-OF-WAY
IN THE VICINITY OF FALGOUT CANAL

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP

DRAWN BY: J.L.S.	PLOT DATE: 29 MAY 14	CADD FILE: FALGOUT_PIPELINE REDO.DGN
CHECKED BY: K.R.D.	JOB NO.: 22450	FIGURE 9

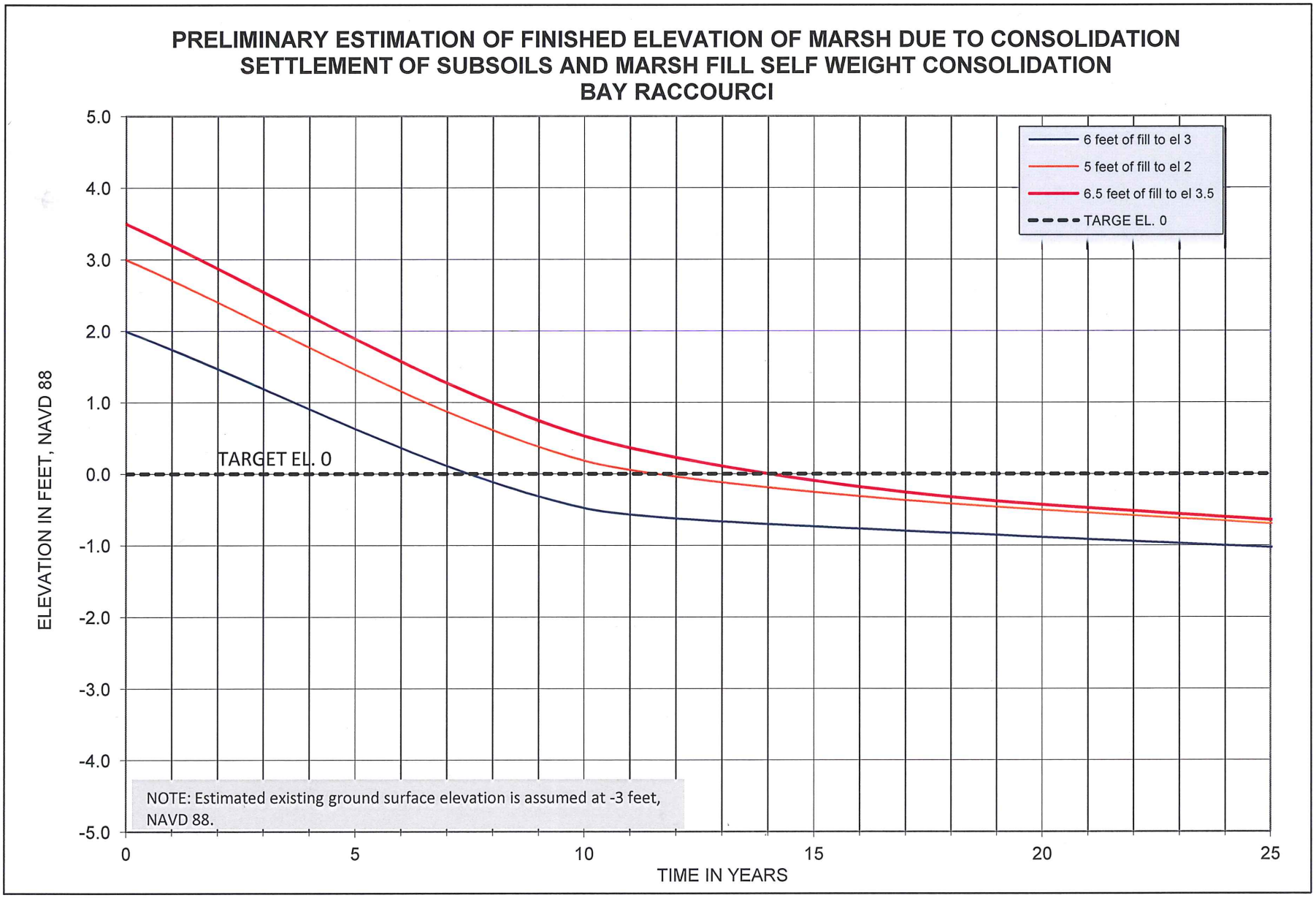

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FIGURE 10

PRELIMINARY ESTIMATION OF FINISHED ELEVATION OF MARSH DUE TO CONSOLIDATION SETTLEMENT OF SUBSOILS AND MARSH FILL SELF WEIGHT CONSOLIDATION FALGOUT CANAL

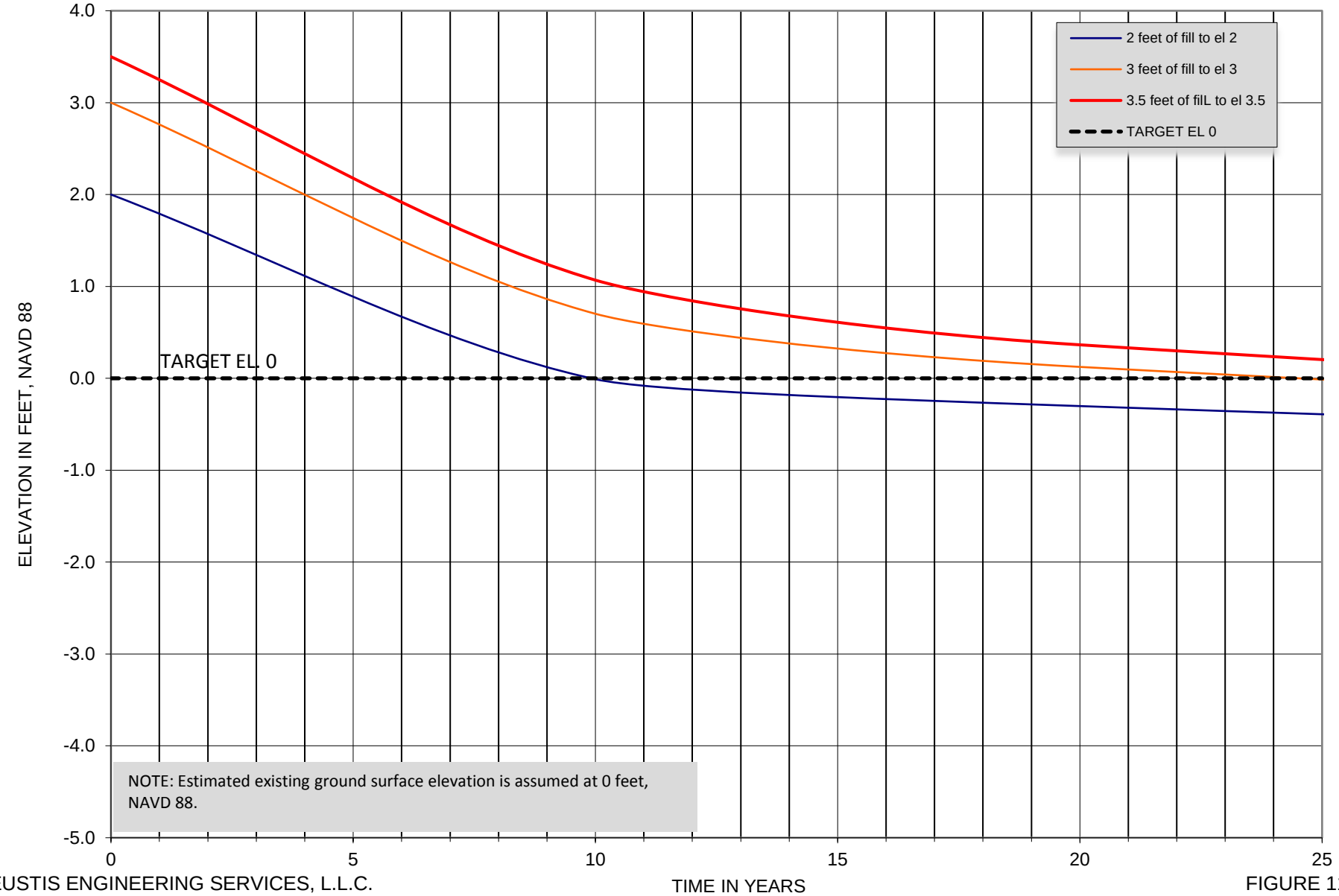

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FIGURE 11

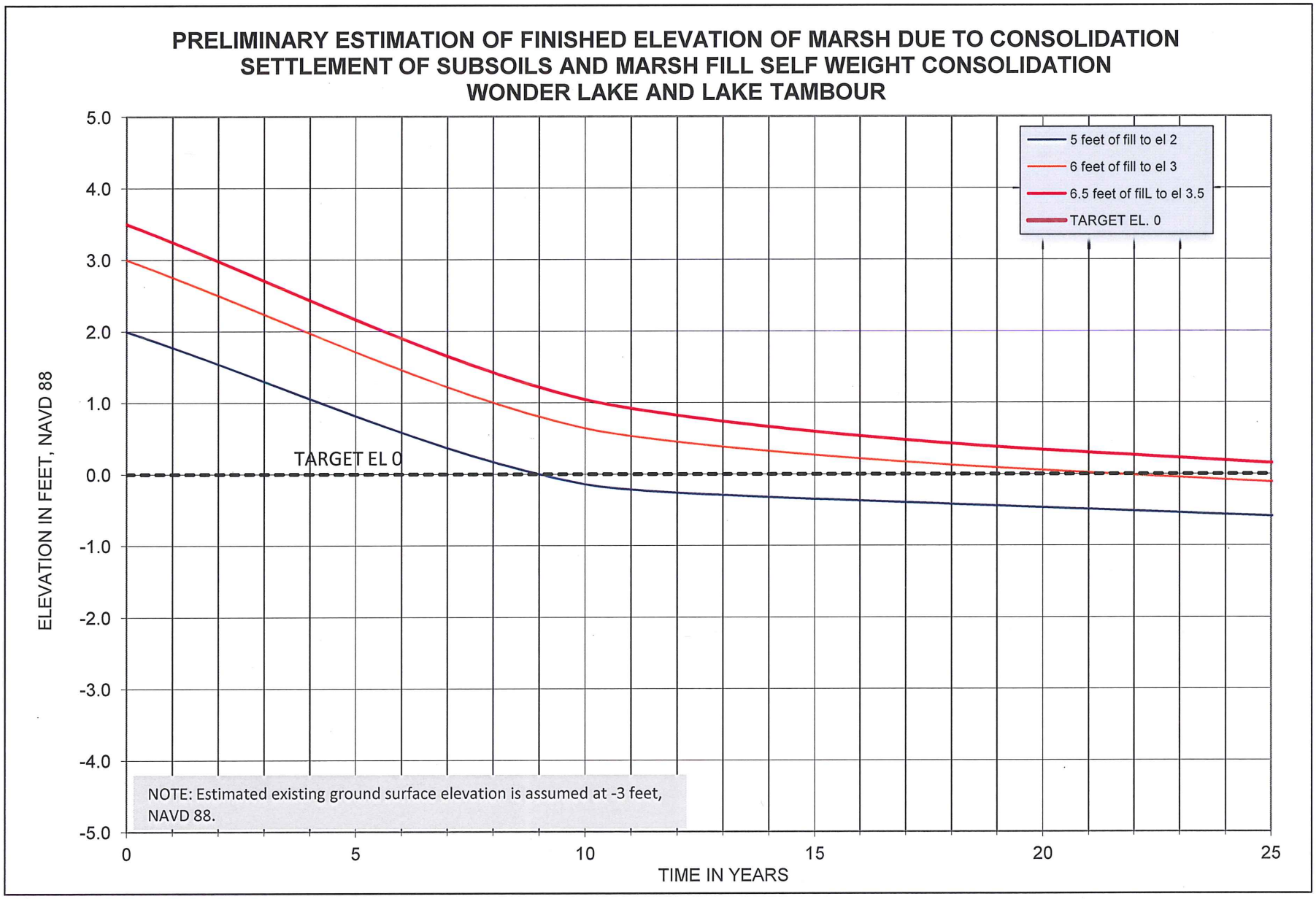

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FIGURE 12

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP
EUSTIS ENGINEERING PROJECT NO. 22450

ESTIMATED ALLOWABLE SINGLE PILE LOAD CAPACITIES
TREATED ASTM D 25 QUALITY TIMBER PILES

BORROW VICINITY	PILE DIAMETER	PILE TIP EMBEDMENT DEPTH BELOW EXISTING GROUND SURFACE IN FEET[1]	ESTIMATED ALLOWABLE SINGLE PILE LOAD CAPACITIES IN TONS[2] FACTOR OF SAFETY ≈ 3[3]	
			COMPRESSION	TENSION
Bay Raccourci	8-In. Tip 12-In. Butt	30 35	2 2	1 1½
	7-In. Tip 12-In. Butt	40 45	2½ 3	2 2

[1]Selection of pile tip embedment should also consider settlement potential and installation requirements. If fill is planned to raise the site, the actual pile embedment below proposed grades will be greater than what is shown above.

[2]Piles are assumed to be installed by impact driving equipment without assistance from jetting or vibratory equipment. Timber piles are also assumed to be installed vertically and not along incline (batter).

[3]Use of a factor of safety of 3 assumes a static pile load test will not be performed. If a static pile load test is performed, a factor of safety of 2 may be utilized.

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP
EUSTIS ENGINEERING PROJECT NO. 22450

ESTIMATED ALLOWABLE SINGLE PILE LOAD CAPACITIES
TREATED ASTM D 25 QUALITY TIMBER PILES

BORROW VICINITY	PILE DIAMETER	PILE TIP EMBEDMENT DEPTH BELOW EXISTING GROUND SURFACE IN FEET[1]	ESTIMATED ALLOWABLE SINGLE PILE LOAD CAPACITIES IN TONS[2] FACTOR OF SAFETY ≈ 3[3]	
			COMPRESSION	TENSION
Falgout Canal	8-In. Tip 12-In. Butt	30 35	3 3½	2 2½
	7-In. Tip 12-In. Butt	40 45 50 55	4 4½ 5½ 6	2½ 3 4 4
	7-In. Tip 13-In. Butt	60 65 70 75	7½ 8½ 9½ 11	5 6 6½ 7½

[1]Selection of pile tip embedment should also consider settlement potential and installation requirements. If fill is planned to raise the site, the actual pile embedment below proposed grades will be greater than what is shown above.

[2]Piles are assumed to be installed by impact driving equipment without assistance from jetting or vibratory equipment. Timber piles are also assumed to be installed vertically and not along incline (batter).

[3]Use of a factor of safety of 3 assumes a static pile load test will not be performed. If a static pile load test is performed, a factor of safety of 2 may be utilized.

TERREBONNE PARISH CONSOLIDATED GOVERNMENT
SEDIMENT DELIVERY PIPELINE
TERREBONNE PARISH, LOUISIANA
CB&I PURCHASE ORDER NO. 887046-000 OP
EUSTIS ENGINEERING PROJECT NO. 22450

ESTIMATED ALLOWABLE SINGLE PILE LOAD CAPACITIES
TREATED ASTM D 25 QUALITY TIMBER PILES

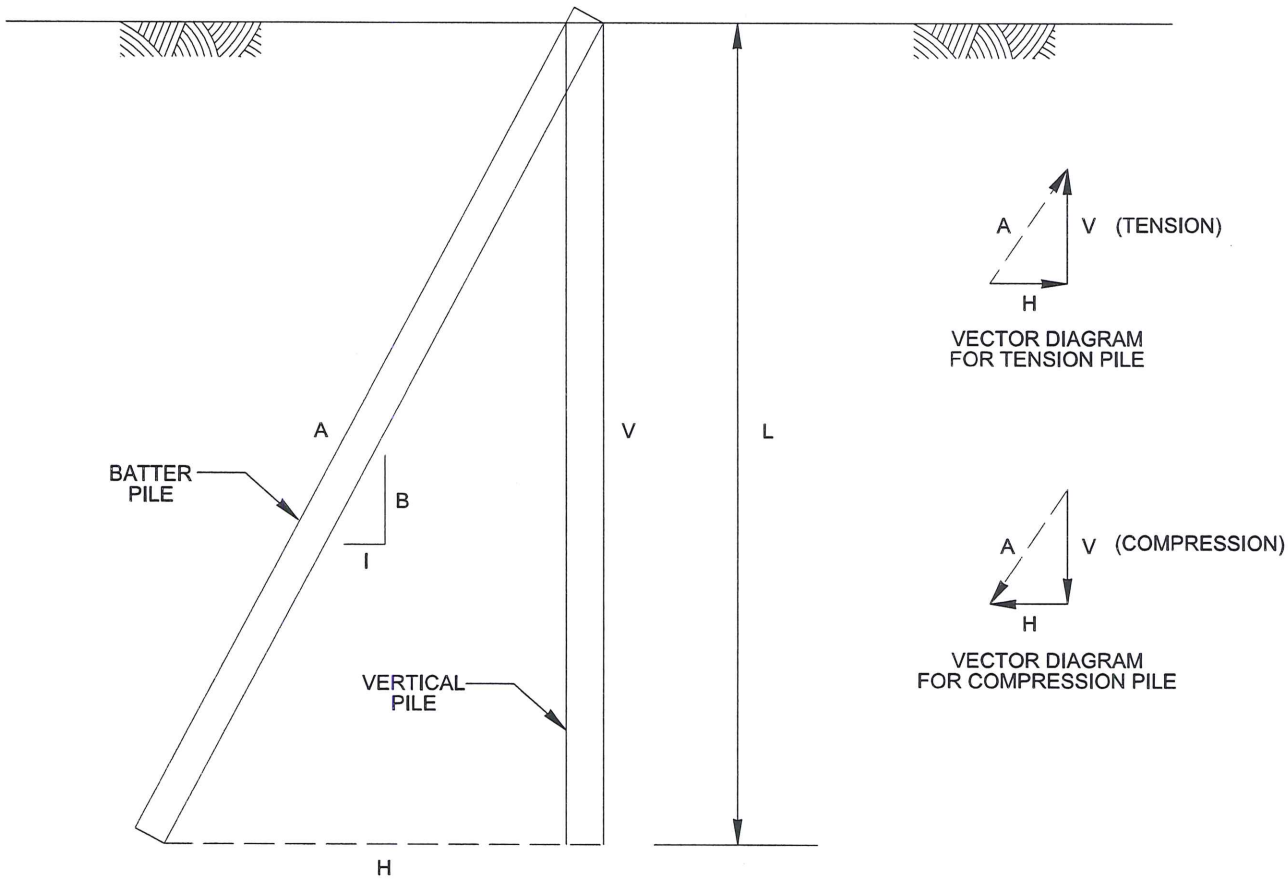
BORROW VICINITY	PILE DIAMETER	PILE TIP EMBEDMENT DEPTH BELOW EXISTING GROUND SURFACE IN FEET[1]	ESTIMATED ALLOWABLE SINGLE PILE LOAD CAPACITIES IN TONS[2] FACTOR OF SAFETY ≈ 3[3]	
			COMPRESSION	TENSION
Wonder Lake and Lake Tambour	8-In. Tip 12-In. Butt	30 35	2½ 3	1½ 2
	7-In. Tip 12-In. Butt	40 45 50 55	3½ 4½ 5 6	2½ 3 3½ 4
	7-In. Tip 13-In. Butt	60 65 70 75	7 8½ 9½ 10½	5 5½ 6½ 7

[1]Selection of pile tip embedment should also consider settlement potential and installation requirements. If fill is planned to raise the site, the actual pile embedment below proposed grades will be greater than what is shown above.

[2]Piles are assumed to be installed by impact driving equipment without assistance from jetting or vibratory equipment. Timber piles are also assumed to be installed vertically and not along incline (batter).

[3]Use of a factor of safety of 3 assumes a static pile load test will not be performed. If a static pile load test is performed, a factor of safety of 2 may be utilized.

AXIAL AND HORIZONTAL RESISTANCE OF BATTER PILES
ESTIMATED FROM ALLOWABLE VERTICAL LOAD CAPACITIES



L = VERTICAL COMPONENT OF BATTER PILE EMBEDMENT LENGTH.

V = ESTIMATED ALLOWABLE SINGLE LOAD CAPACITY OF A PILE DRIVEN VERTICALLY WITH EMBEDMENT LENGTH, L.

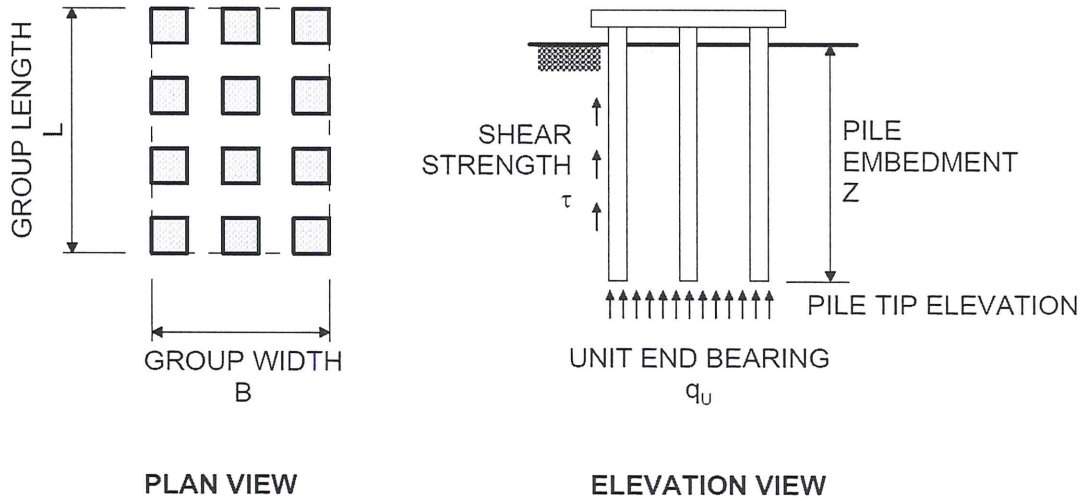
B = BATTER OF PILE EXPRESSED AS A RATIO OF VERTICAL DISTANCE TO ONE FOOT HORIZONTAL DISTANCE.

H = HORIZONTAL RESISTANCE OF BATTER PILE ESTIMATED AS FOLLOWS: $H = \frac{V}{B}$

A = ALLOWABLE AXIAL PILE LOAD CAPACITY OF A SINGLE BATTER PILE ESTIMATED AS FOLLOWS: $A = \sqrt{V^2(1+\frac{1}{B^2})}$

NOTE: THE AXIAL LOAD RESISTANCE OF A VERTICAL PILE, V, IS DEPENDENT ON THE TYPE OF LOADING - TENSION OR COMPRESSION. CAUTION SHOULD BE EXERCISED TO ENSURE THE CORRECT VERTICAL CAPACITY IS USED.

Load Capacity of Rows or Groups of Driven Piles



The capacity of a row or group of piles may be equal to or less than the sum of the individual load capacities of piles within the group. The pile row or group may be considered a single equivalent pier, in which case the row or group capacity may be investigated using the following formula.

$$P_{GROUP} = \frac{(2L+2B)(\tau)(z)}{FS_{SIDE}} + \frac{(B)(L)(q_U)}{FS_{BASE}}$$

where:

B	=	The width of the pile group in plan dimension,
L	=	The length of the pile group in plan dimension,
Z	=	The embedded pile length,
τ	=	The average unit shear strength acting on the embedded pile length,
q_U	=	The ultimate unit end bearing pressure appropriate for the pile group,
FS_{SIDE}	=	A factor of safety against mobilization of the ultimate skin friction, typically 2, and
FS_{BASE}	=	A factor of safety against mobilization of the ultimate end bearing, usually at least 3.

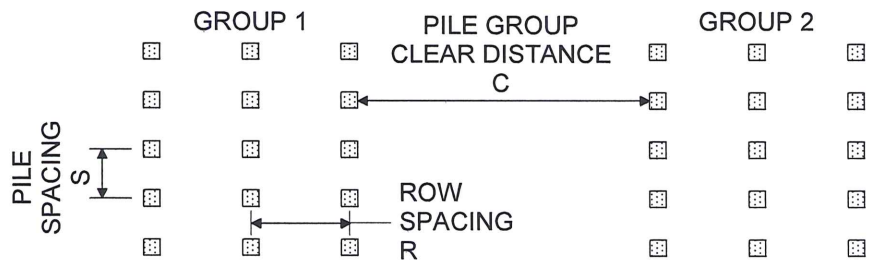
Notes:

(1) The average unit shear strength acting on the embedded pile length may be taken as the weighted average value of undrained shear strength (or undrained cohesion) acting over that length for assessments of the short term load capacity of the group.

(2) For assessments of the short term load capacity of the group, the ultimate end bearing is commonly estimated by multiplying an undrained shear strength (or undrained cohesion) by a bearing capacity factor, which typically varies between 5 and 6. The appropriate undrained shear strength and bearing capacity factor should consider the width and length of the pile group and the presence of any weak strata beneath the pile tips. In general, the unit end bearing pressure applicable to the pile group is not the same as the unit end bearing pressure used to estimate the load capacity of a single pile.

(3) The factor of safety against base failure should consider that large deformations may be required to mobilize the ultimate end bearing soil pressure estimated for the pile group.

Spacing of Pile Groups and Spacing of Piles Within Rows or Groups



Piles should be arranged to provide a minimum center-to-center spacing, S, within rows or groups. This minimum recommended spacing may be taken as the largest value from the following criteria:

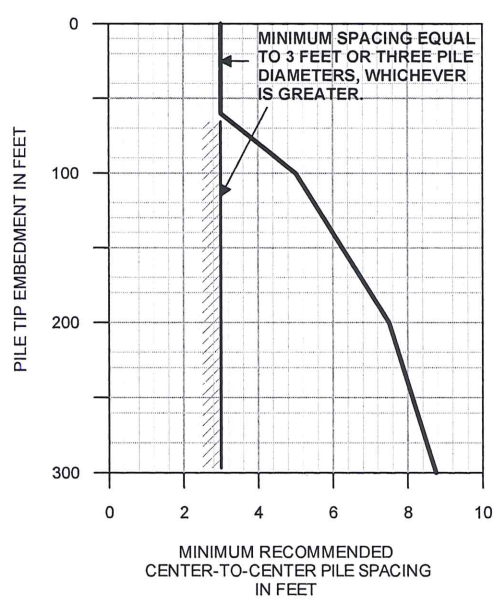
$$S = \frac{L_1}{20} + \frac{L_2}{40} + \frac{L_3}{80} \text{ ,or}$$

$$S = 3B \text{,or}$$

$$S = 3 \text{ feet}$$

where
- S = Center-to-center pile spacing, as illustrated above,
- L_1 = Pile embedment up to 100 feet,
- L_2 = Pile embedment between 100 and 200 feet,
- L_3 = Pile embedment between 200 and 300 feet, and
- B = Pile outside diameter or side dimension.

These criteria can be presented graphically as follows:



In addition, rows of single piles should provide a minimum center-to-center spacing, R, that is at least as large as the center-to-center pile spacing, S. Finally, individual pile groups should be arranged to provide a clear group spacing, C, equal to twice the largest dimension of the larger pile group. It should be noted that pile spacings greater than the minimum values presented above may be required to minimize the influence of individual piles on each other with respect to lateral load resistance and settlement or to ensure pile group capacity is adequate when investigated for group perimeter shear.

Appendix D

Cultural Resources Survey

Archaeological and Historical Research to Identify Cultural Resource Surveys Associated with Pipelines Extending from the Atchafalaya River Across the Central Terrebonne Hydrologic Basin and Four Areas of Marsh and Ridge Habitat Restoration

Submitted to:

Mohan Menon, Ph.D.
Client Program Manager
Coastal Services
Environmental & Infrastructure
CB&I, 4171 Essen Lane
Baton Rouge, Louisiana 70809

Submitted By:

Gordon P. Watts, Jr., Ph.D. RPA
Tidewater Atlantic Research, Inc.
P. O. Box 2494
Washington, North Carolina 27889

7 July 2014

Abstract

Shaw Coastal, Inc. (SC) of Baton Rouge, Louisiana is working under contract to provide Terrebonne Parish, Louisiana with options for the installation and operation of a sediment delivery pipeline, extending from the Atchafalaya River near Morgan City across the central Terrebonne Hydrologic Basin, to restore marsh and ridge habitats. The areas of marsh and ridge habitat restoration are in the vicinity of Bay Raccourci, south of Falgout Canal, the vicinity of Lake Tambour, and the vicinity of Wonder Lake. In order to ascertain the proposed projects potential impacts on cultural resources along the proposed pipeline routes and in areas where sediment will be deposited, SC contracted with Tidewater Atlantic Research, Inc. (TAR) of Washington, North Carolina. Under that contract TAR carried out a program of historical, literature, cartographic and site file research to identify areas previously surveyed for cultural resources and archaeological sites within the footprint of proposed project activities. Those sites were digitized and included in a project specific geographic information system (GIS).

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Introduction

Shaw Coastal, Inc. (SC) is working under contract to provide Terrebonne Parish, Louisiana with options for the installation and operation of a sediment delivery pipeline, extending from the Atchafalaya River near Morgan City across the central Terrebonne Hydrologic Basin, to restore marsh and ridge habitat (Figure 1). The areas of marsh and ridge habitat restoration are in the vicinity of Bay Raccourci (Figure 2), south of Falgout Canal (Figure 3), the vicinity of Lake Tambour (Figure 4), and the vicinity of Wonder Lake (Figure 5). In order to ascertain the proposed projects potential impacts on cultural resources along the proposed pipeline routes and in areas where sediment will be deposited, SC contracted with Tidewater Atlantic Research, Inc. (TAR) of Washington, North Carolina. Under that contract TAR carried out a program of historical, literature, cartographic and site file research to identify areas previously surveyed for cultural resources and archaeological sites within the footprint of proposed project activities. Those sites were digitized and included in a project specific geographic information system (GIS). GIS shape files illustrating surveyed areas are identified by the corresponding Louisiana Division of Archaeology (LDA) site file reference number. The LDA site number identifies shape files associated with archaeological sites. Four 1:100,000 topographic maps make up the background for the GIS project. For each survey an abstract for the report has been included. A series of maps exported from the GIS are used to graphically illustrate report specific terrestrial and/or submerged cultural resource survey coverage that corresponds with the project footprint.

Research Methodology

Project research was initiated by contacting the Louisiana State Archaeologist Dr. Charles McGimsey and Section 106 Review and Compliance officer Rachel Watson. Based on that contact, TAR initiated a program of historical and literature research designed to support development of prehistoric and historical backgrounds for the Terrebonne Project area. As scheduling and coordination permitted, TAR personnel traveled to Baton Rouge, Louisiana, consulted with Dr. McGimsey and Ms. Watson to provide project details and to coordinate surveying the LDA maintained archaeological site files for specific information on previous surveys and investigated cultural resources in the immediate vicinity of pipelines and restoration areas. While in Baton Rouge TAR personnel also visited libraries and archival repositories to collect historical background information.

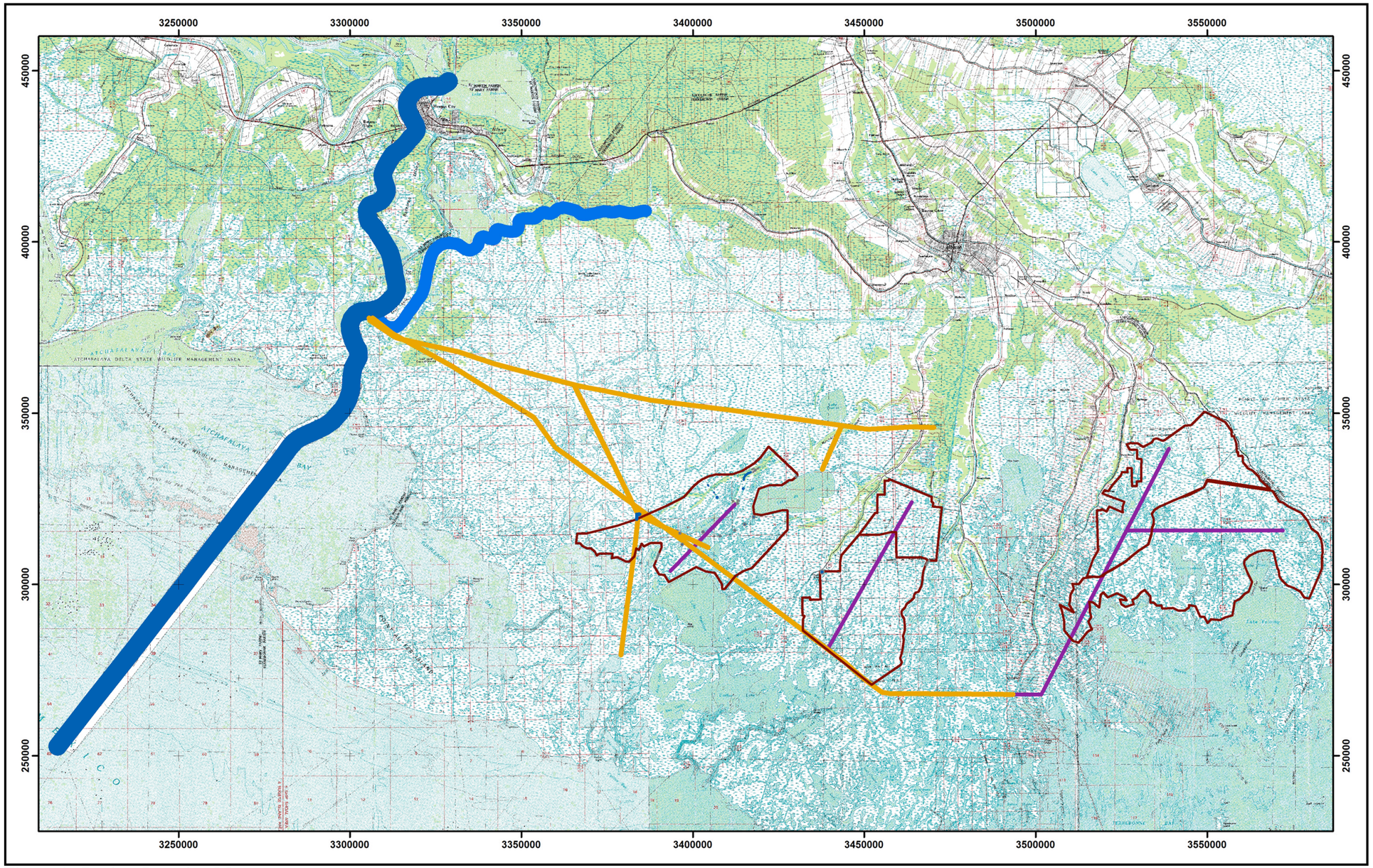

Figure 1. Project Location Map.

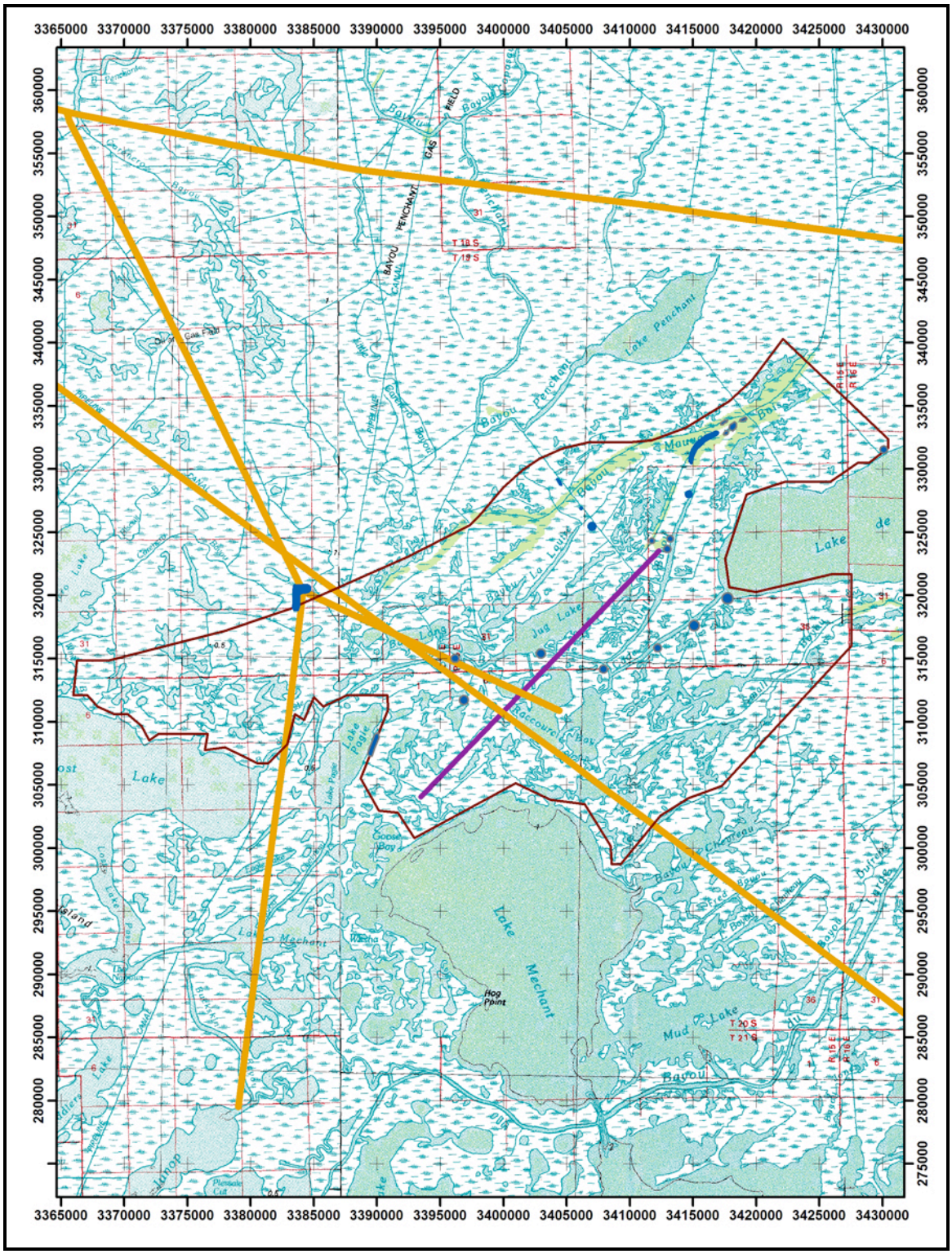

Figure 2. Marsh and ridge habitat restoration area in the vicinity of Bay Raccourci.

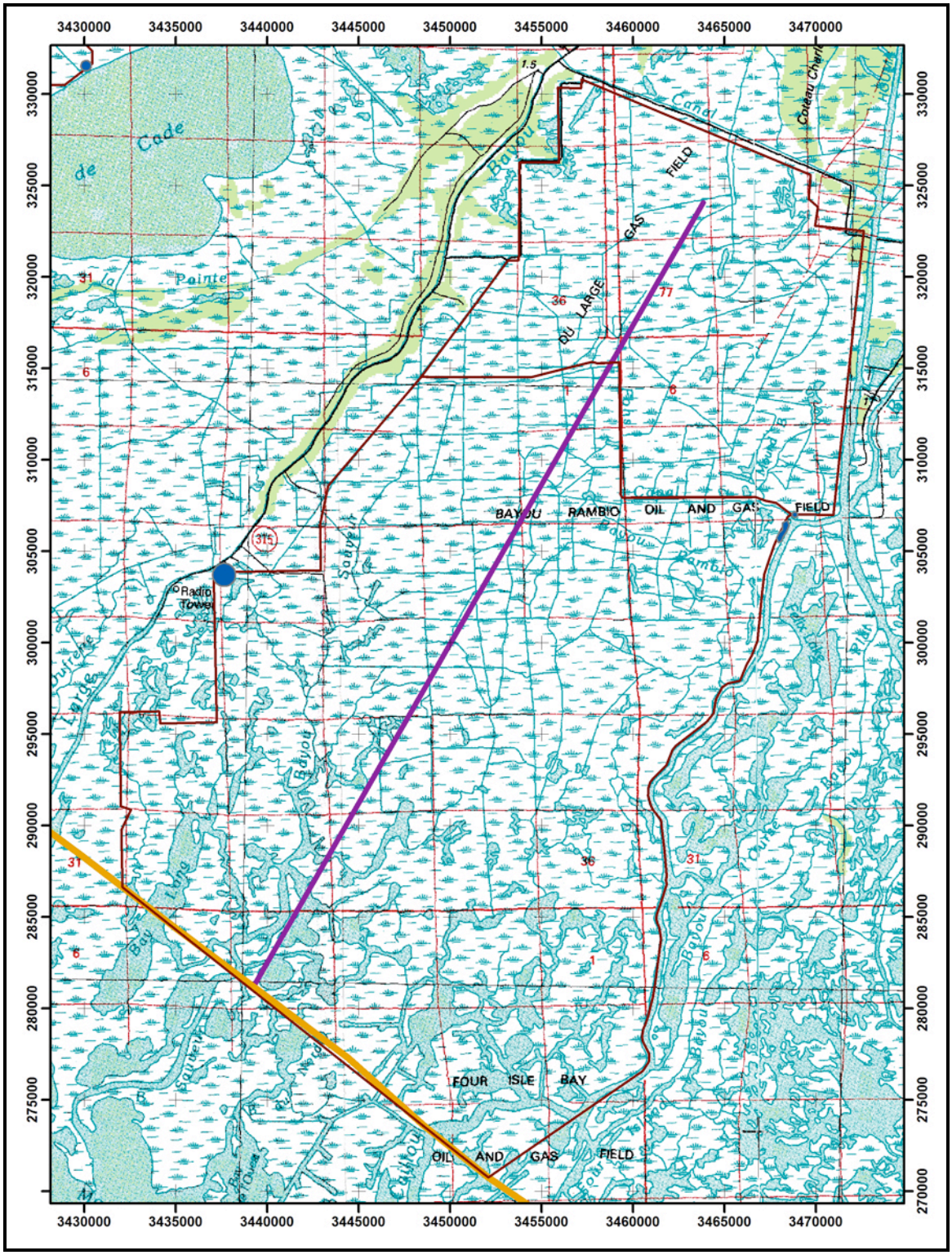

Figure 3. Marsh and ridge habitat restoration area south of Falgout Canal.

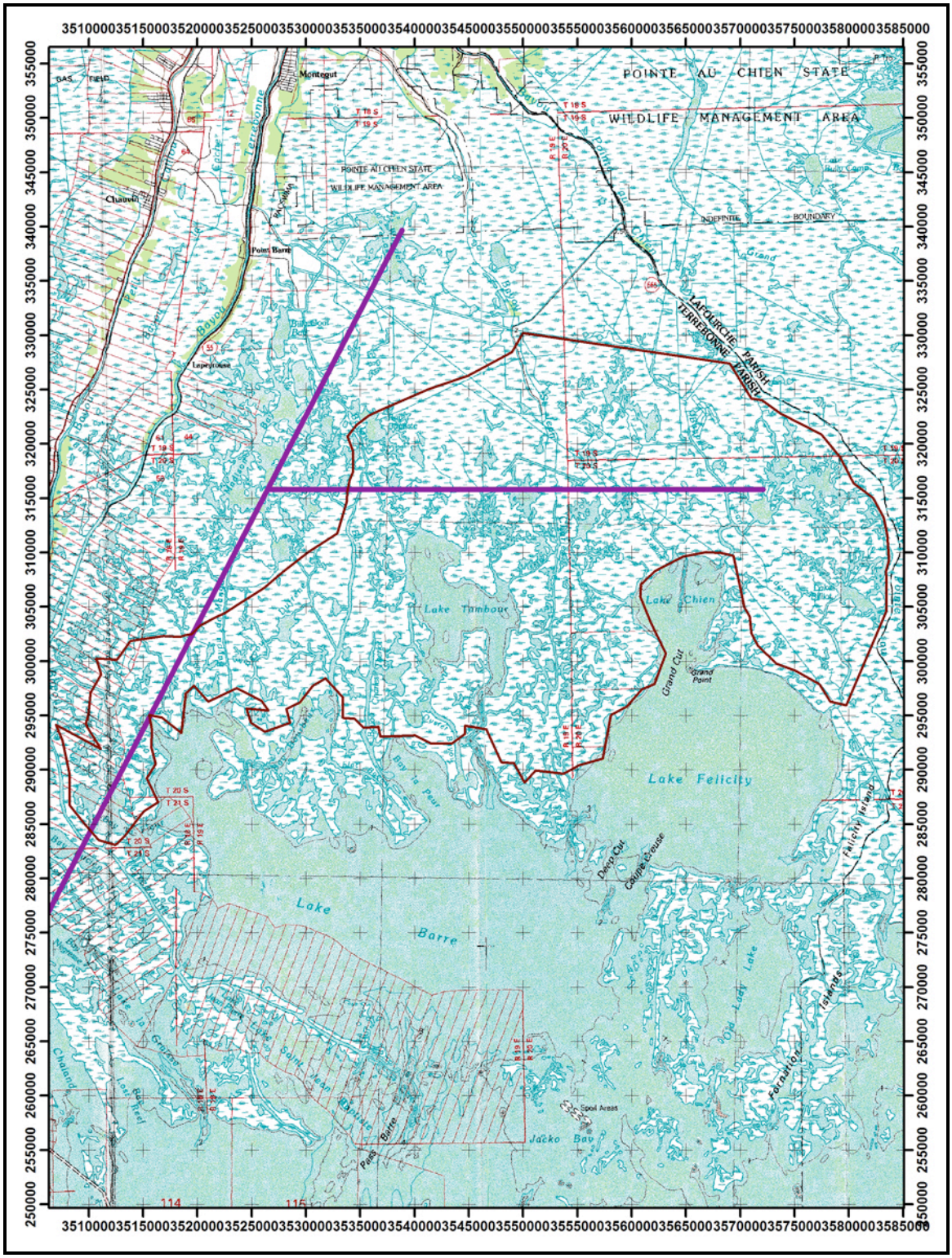

Figure 4. Marsh and ridge habitat restoration area the vicinity of Lake Tambour.

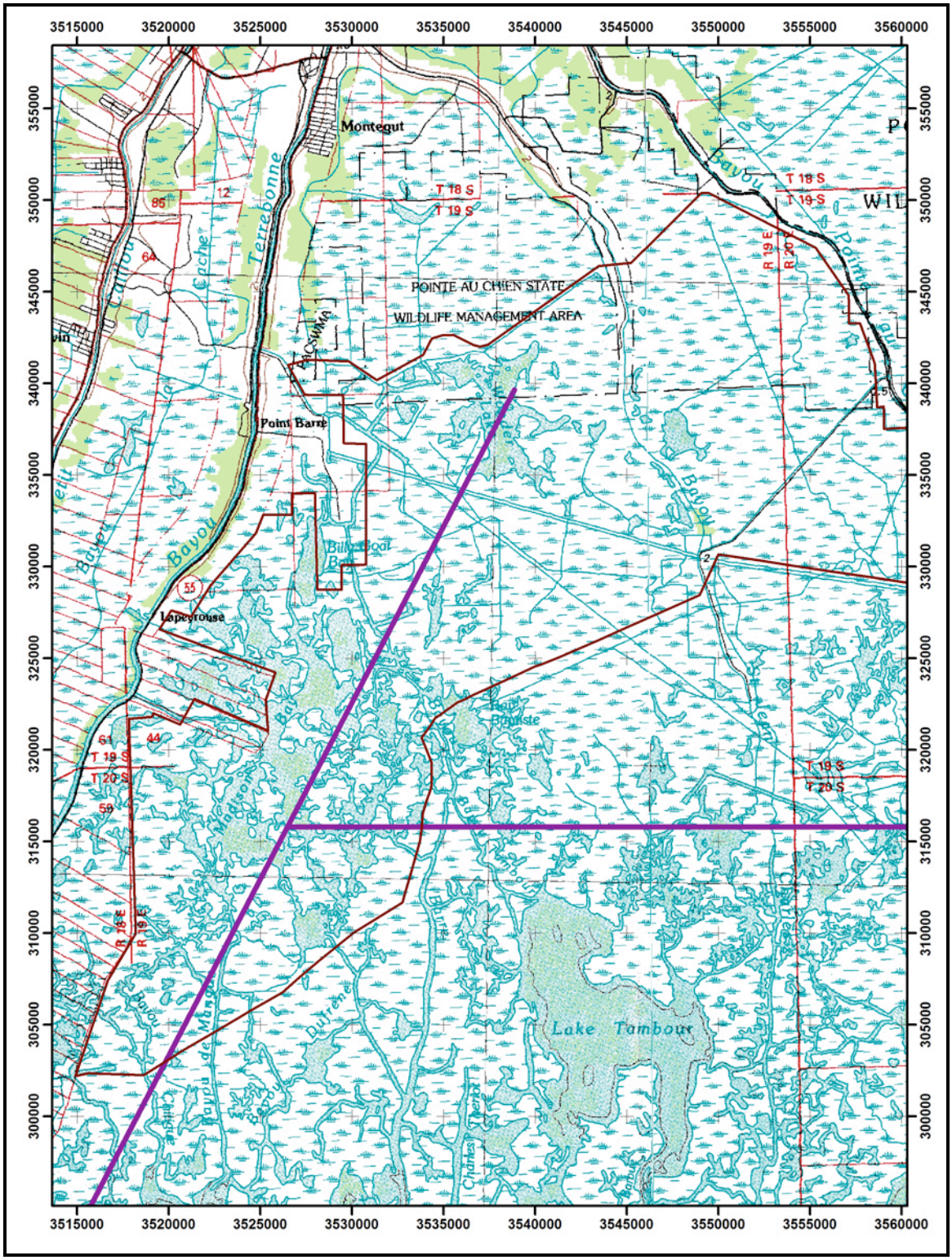

Figure 5. Marsh and ridge habitat restoration area the vicinity of Wonder Lake.

With access to LDA site files established and data sources identified, TAR began building a project specific GIS using ESRI ArcMap 10.1. The background for the Terrebonne GIS consists of four 1:100,000 topographic maps downloaded from ChartTiff at Image Peak Systems in Berthound, Colorado. The Morgan City, Afchafalaya, Terrebonne and New Orleans topographic maps were installed in the GIS using the Louisiana South NAD 83, U.S. Survey foot state plane coordinate system. With the background in place, shape files illustrating the existing pipeline canals, new pipeline corridors, dredging areas in the Atchafalaya and along the Intra-Coastal Waterway and locations for marsh and ridge habitat restoration in the vicinity of Bay Raccourci, south of Falgout Canal, the vicinity of Lake Tambour, and the vicinity of Wonder Lake.

Using data from the LDA site files, each survey area that extended into or was contained within the project footprint was digitized. Each digitized survey area was converted to a shape file and identified according to the corresponding LDA alphanumeric report designation. An abstract of each survey report is included in this document with an accompanying map exported from the GIS. Known archaeological sites that extend into or are included within the project footprint have also been digitized, converted to point shape files and identified according to the corresponding LDA alphanumeric site designation.

The Digital Archaeological Record

The Digital Archaeological Record (tDAR) was accessed intermittently during the contract period to ascertain if additional information regarding the subject project area was uploaded. The last query was conducted on 20 June 2014. According to McManamon, Kintigh and Brin (2010):

> The tDAR repository encompasses digital documents and data derived from ongoing archaeological research, as well as legacy data and documents collected through more than a century of archaeological research.

Project Area Environment

The Terrebonne barrier shoreline and associated wetlands represent some of the most rapidly eroding wetlands in the United States. More than twenty percent of Terrebonne's wetlands have disappeared since 1932. Loss of that protective barrier shoreline will result in the subsequent destruction of the habitat for coastal fisheries, inshore wetlands and coastal communities by tidal inundation, storm surge and wave action. Due to this ongoing phenomenon, the Terrebonne barrier shoreline has been identified as one of the critical areas for coastal erosion. It has been identified as a candidate area for restoration projects made possible by the Federal Coastal Wetlands Planning, Protection and Restoration Act passed in 1990. Anthropologist Diane E. Austin (2006) remarked that:

> Southern Louisiana occupies a dynamic landscape, marked by coastal wetland interrupted by both natural and human-made levees, and vulnerable to both the Mississippi and Atchafalaya rivers and major storms coming off the Gulf of Mexico. It is also a region into which, for centuries, exiled and threatened populations have moved and found refuge. Systematic and dramatic changes along the entire reach of the Mississippi River coupled with activities within the region's wetlands such as levee construction, canal dredging, and petroleum extraction have contributed to both pollution and extensive land loss.

Geological Setting

The geological environment in the project vicinity, northern Gulf of Mexico, is dominated by the sedimentary geology and geomorphology of the Mississippi River Delta Plain. Since the Late Jurassic, Mississippi River alluvium has been forming coastal Louisiana. A sedimentary pile over 15 km in thickness accumulated during the Mesozoic and Cenozoic (Coleman et al. 1991). Along the northern margin of the Gulf of Mexico Basin, Tertiary and Quaternary sedimentation prograded the shelf edge by 300 km. The rate of progradation was approximately 5 to 6 km per ka (thousand years).

Quaternary glacio-eustatic fluctuations were accompanied by marine regressions and transgressions. The last glacial advance (Last Glacial Maximum [LGM]) occurred during late Wisconsin time about 18,000 to 20,000 years ago. Sea level during the LGM was about 394 to 426 ft. (120 to 130 m) lower than present sea level (Saucier 1994).

As the shoreline regressed seaward across the continental shelf, Pleistocene sediments were exposed to subaerial weathering and erosion. During Quaternary lowstands, rivers flowed seaward across the shelf to lowered base levels (as determined by a falling sea level). Shelf gradients induced intricate channel networks that cut into Pleistocene sediments (Figure 6). Late Pleistocene and Holocene marine transgressions, resulting from deglaciation (glacial retreat) caused a landward shift in deltaic sedimentation and shoreface erosion (Berryhill 1986). During sea-level rise, estuaries were infilled, subaerial landforms were submerged and eroded and exposed sediments were reworked (Saltus et al. 2003).

Although Quaternary marine transgressions and regressions impacted near-surface (shallow) geology in the project area, the primary influence on local sedimentation was avulsion and shifting of Mississippi River delta lobes. The Callous Lake survey area lies within the Lafourche/Terrebonne Delta Complex, a constructional landform assemblage comprised by numerous lakes, channels and swamps. These features were formed by Mississippi River delta building, abandonment, associated land erosion, and subsidence to form the present landscape.

In an active deltaic environment, net deposition (sedimentary accumulation) exceeds net subsidence (compaction and loss of volume). Therefore, when sedimentary build-up exceeds the rate of subsidence, land is created. When sedimentary accumulation decreases, subsidence dominates and there is land loss (by drowning) over time. Faulting, sea level rise, geosynclinal down warping and displacement from fluid withdrawal are other factors that contribute to subsidence (Penland et al. 1989; Saucier 1994).

Seven different delta complexes were built and abandoned by the Mississippi River over the last 9000 years. For the last 600 years, the Mississippi River has occupied the Balize (modern) Delta (Figure 6). In the subject study area, delta formation began approximately 1500 B.P. as the Mississippi River began to shift its course westward, forming the Lafourche/Terrebonne Delta Complex. According to Saucier (1994), approximately 150 to 400 ft. (46 to 122 m) of deltaic silts and clays accumulated in this area during the Holocene. These thick deltaic units form a wide delta front. These deltaic deposits contain very fine-grained sediments (such as silt and clay).

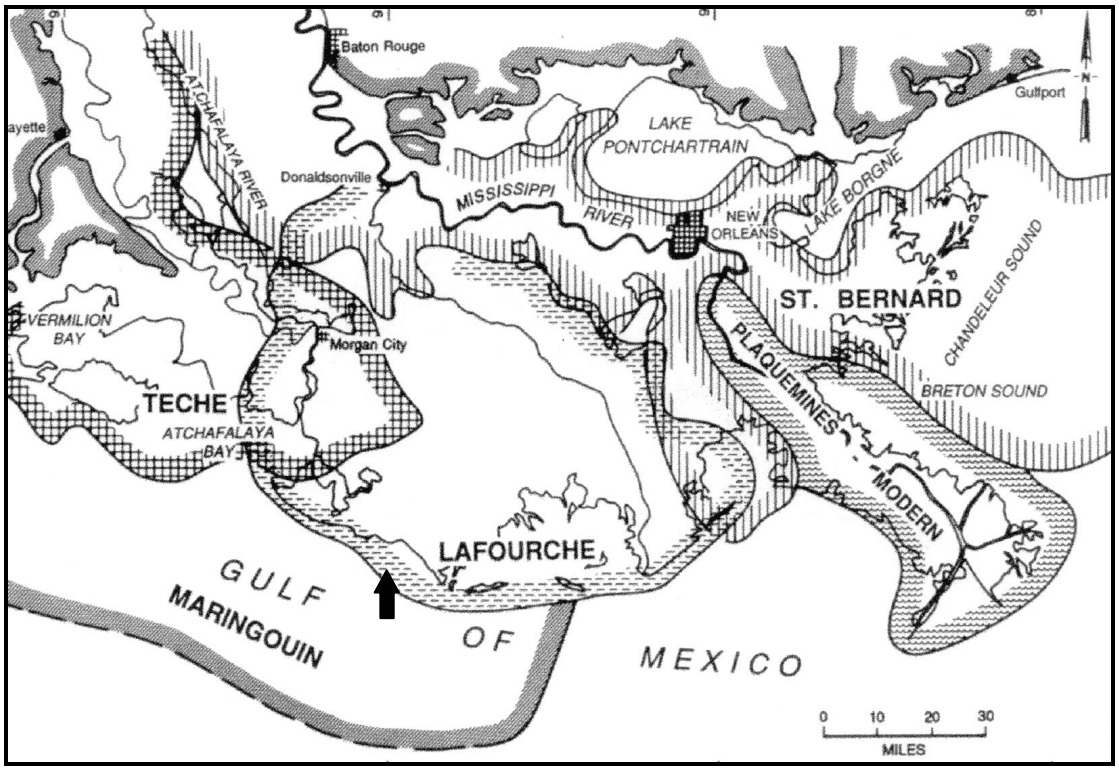

Figure 6. Map showing project location (arrow) in relation to deltaic lobes (after Frazier 1967).

The Terrebonne Basin is an inter-distributary wetland system located in the center of the abandoned Lafourche/Terrebonne delta complex. The basin, varying between 18 and 70 miles wide, contains over 1.71 million acres. To the north the basin is bounded by the Mississippi River, in the east by Bayou Lafourche and on the west by the Atchafalaya

Basin. A series of barrier islands separate the basin from the Gulf of Mexico to the south. Reworked sands from distributary sediments, formed on the perimeter of delta lobes, are deposited on beaches (Figure 7). Isles Dernieres are barrier islands that formed during the retreat of the Lafourche/Terrebonne Delta Complex approximately 600 to 800 years ago (Birchett and Pearson 1998).

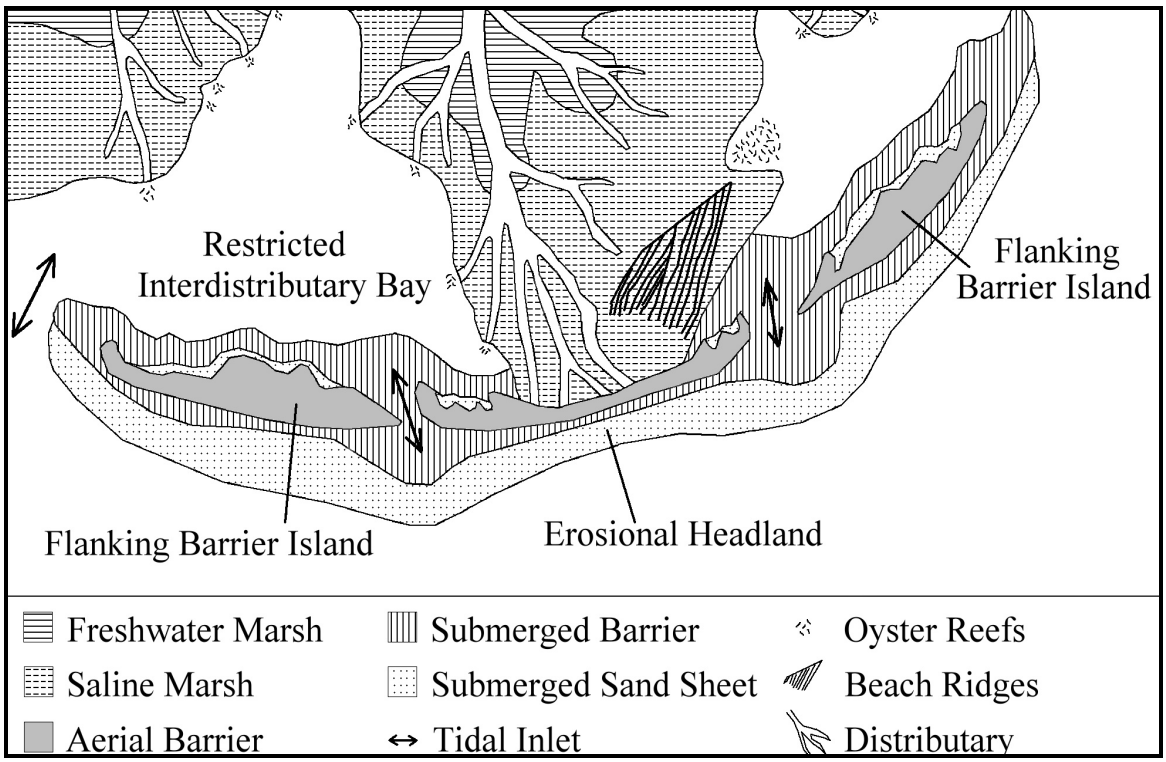

Figure 7. Barrier island formation at delta mouth (adapted from Penland et al. 1988).

The present delta, a system of distributaries that form a distinct pattern (in plan view), is referred to as a birds-foot delta. It includes subdelta formations that are created when trunk channels silt up and new channels follow hydrodynamic paths of least resistance. This type of delta growth depends on sediment supply being greater than dispersal by current and wave action (Krumbein and Sloss 1953). Delta growth may be slow or fast, depending on various factors. Lobeck (1939), for example, noted an average Mississippi River deltaic growth rate at seaward passes (1908) as 250 ft. (76 m) per year. He also stated that a levee break at Garden Island Bay (1912) advanced a crevasse splay by 2,000 ft. (610 m) in only a few months.

In floods, coarser sediments drop out of suspension, as water velocity decreases, along trunk and distributary channels (Saucier 1994) to form natural levees. During delta construction, intervening areas between sublobes are enclosed by natural levees to form broad basins and lakes. Marshes typically form in these basins.

Natural levees provide elevated dry locations for human settlement. Many prehistoric and historic sites are located on active and relict natural levees in the coastal zone (Hunter et al. 1988). The natural levees created by the deltaic channels eventually subside over time. Sediment deposition from low velocity inter-distributary streams and/or subsequent deltaic episodes buries these landforms and their identification becomes problematic. Archaeological testing and core-hole data have identified several buried natural levees, but most remain hidden beneath more recent sediments (Hunter et al. 1988).

Terrebonne Parish Drainage

Speaking on behalf of the Louisiana Agricultural Experiment Station and the Soil Conservation Service, Lytle, McMichael, Green and Francis ([Lytle et al.] 1960:2) remarked that "Terrebonne Parish is generally poorly drained", and that:

> The channels of many of the streams, bayous, and canals are at or near the level of the gulf and do not remove water effectively. The Lower Atchafalaya River, the largest active stream, flows along the western border of the parish. It brings sediment from the Mississippi and Red Rivers and distributes them over the western marshes. Other large streams that were once active in building up the natural levee ridges—Bayou Black, Little Bayou Black, Bayou Terrebonne, Bayou du Large, Bayou Grand Caillou, and Bayou Petit Caillou—now [1956-1960] carry little drainage water except from their narrow water sheds. Bayou Black, Bayou Terrebonne, and Little Bayou Black enter the parish from the north and northwest. They follow narrow channels between levee ridges southeasterly to Houma. From Houma the streams generally flow to the south and southwest. Approximately 10 miles south of Houma, most of the stream channels area at sea level. These streams flow slowly or are stagnant. The direction of their flow is determined by the direction of the winds and the height of the tides in this area. During prolonged periods of high tides, the water in the streams and canals is raised and the surface water cannot flow from the land. In the southern part of the parish, many bayous end in shallow lakes or bays. Most major stream channels can be traced across the marshes and into the bays, the lakes, and the Gulf of Mexico. Numerous small and large lakes, bayous, and segments of bayous occur in the coastal marshes. Many canals have been constructed in the marshes and swamps for use in the exploration and production of oil, gas, and sulfur. The Intracoastal Waterway crosses the northern part of the parish and intersects the Lower Atchafalaya River.

Parts of the waterway are occasionally flooded by the Lower Atchafalaya River, and water is impounded in adjacent land areas.

Regional Climatology

The project area lies in the Louisiana Gulf Coast subtropical zone. This area of Louisiana's Gulf coast is generally characterized by mild winters and by hot, humid summers. Average temperatures (Fahrenheit) range from 54 degrees in January/February to 81 degrees in July/August. Rainfall is heaviest during the storm season between April and September and annually averages 59 inches. The storm season is characterized by summer thunderstorms and hurricanes that sporadically pass through the area. Winds in southern Louisiana are predominately southeasterly but shift sporadically to the north for periods during the winter months (Matthews 1983).

Local Nature of Tides and Currents

The inshore waters of the Gulf Coast off Terrebonne are influenced by both local weather and the general patterns of the Gulf of Mexico. In the open Gulf, the Loop Current flows into the Gulf of Mexico between the Yucatan Peninsula and Cuba. It flows north toward the Mississippi Delta before heading east-northeast toward the Cape San Blas region of Florida. The loop is completed when the current heads southeast before turning east and flowing through the straits between Cuba and the Florida Keys (Garrison et al. 1989).

Littoral currents in the project area are influenced by shoreline trends, regional winds and to a degree, eddies associated with the Loop Current. During the year from September to May counter clockwise circulation dominates the pattern on the Gulf Coast Continental Shelf. That flow is driven by prevailing easterly winds. During the summer months from June through August, winds prevail from the southwest resulting in a reverse of the inshore currents along the Gulf Coast (Andrews 1978; Blumberg and Mellor 1981). With the exception of periods of extreme weather currents along the Gulf of Mexico continental shelf are generally about one half knot (Garrison et al. 1989).

Normally, the lunar tidal range is approximately two feet in the Terrebonne region. However, winds frequently have a greater impact on the tide than the moon. Strong winds out of the south can significantly increase both tide heights and currents. Winds from the north can also impact tide elevations, reducing the amount of water flowing into the shallow bays behind the barrier islands. Wave patterns and heights are also a factor of weather. While wave heights of one meter or less represent the norm, storms can generate swells in excess of three meters (McGrail and Carnes 1983). Due to the combined impact of the lunar influence and weather, currents in the area are strong enough to create shoals in the vicinity of the passes (Matthews 1983).

Literature and Historical Research Methodology

In conjunction with previous cultural resources management projects carried out in the vicinity of Terrebonne Parish over a 15-year span, TAR personnel conducted literature searches of primary and secondary sources to assess the potential for finding significant historic and/or cultural resources in the proposed study area. Research in Louisiana repositories was previously carried out in numerous libraries and archives in New Orleans and Baton Rouge. Maps in the collections of the National Archives Cartographic Repository in College Park, Maryland and online archive and library sources at Louisiana State University, the University of Alabama, the National Oceanic and Atmospheric Administration and U.S. Geological Survey were previously examined. During research in each repository, agency and library, material was copied physically or digitally for future reference and scholarly area histories were purchased for permanent inclusion in the TAR research library. The most recent onsite research in regard to Terrebonne Parish was carried out in during early February 2014. This research methodology included consultations with officials affiliated with the Louisiana SHPO and Louisiana State Archives in Baton Rouge. In addition, the TAR historian consulted relevant research materials archived at Louisiana State University, Baton Rouge.

Cultural Background

Regional Prehistoric Overview

The prehistory of Louisiana is divided into five stages based on archaeologically recognized cultural aspects. These five stages, Paleo-Indian (ca. 12,000 to 8000 B.P.), Archaic (ca. 8000 to 3500 B.P.), Gulf Formational (ca. 4500 to 2000 B.P.), Woodland (ca. 2000 to 800 B.P.) and Mississippian (ca. 800 to 300 B.P.), conform to general developmental trends that are documented archaeologically across the southeastern United States. Each stage is further subdivided by distinct subsistence and settlement patterns and/or artifact assemblages that were prevalent during certain time periods and usually represent regional preferences.

Few archaeological sites have been located that pre-date the Tchula period of the late Gulf Formational stage in the coastal zone south of New Orleans. Those sites are on salt dome structures and remnant natural levees of the Teche complex. The natural levees associated with the eastern portion of this complex possibly were habitable between about 4500 and 3500 B.P. (Saucier 1994). Kniffen (1936) outlined four types of sites that were found in the coastal zone of southeast Louisiana; earthen mounds, shell mounds, shell middens and wave-washed shoreline deposits. Beavers (1977) and Gagliano (Gagliano et al. 1979) noted that most sites are located at the junction of two bodies of water; bayou and bayou, bayou and bay, or bayou and lake.

In the southern portion of the Terrebonne Basin these older natural levees either are lacking or are deeply buried. Using core and seismic data in 1983, Penland and Suter identified a possible Teche delta complex revinement surface approximately 30 – 32 feet below sea level beneath Isle Dernieres (Pearson 2001:7). The oldest landforms in or near the current study area consist of barrier islands, which are estimated to be approximately 600 - 800 years old (Pearson 2001:10).

For the purpose of this report the discussion of prehistoric sequences will start with the Tchula period in Louisiana, which is the earliest culture likely to be encountered in the current project area. Earlier occupations of the area undoubtedly occurred, but any sites would be so deeply buried by Holocene deposits that the probabilities of encountering them during proposed project activities would seem to be remote.

Late Gulf Formational Stage (ca. 3000 to 2000 B.P.)

The Late Gulf Formational stage (ca. 3000 to 2000 B.P.) contrasts significantly with the preceding Poverty Point period of the Archaic stage. During this period, small, low earthen mounds were favored over the monumental earthworks of the past. The extensive trade networks developed during the Poverty Point period declined and local resources were emphasized. Gibson (1974) originally proposed that the decline of the Poverty Point culture was caused by a breakdown in the hierarchy. His reasoning stemmed from observations that exotic goods increased at the Poverty Point Site (16WC5), while decreasing at regional centers and their peripheral hamlets. This was viewed as the result of the elite taking more and giving less. At approximately the same time that the Poverty Point Site was abandoned, the Tchefuncte culture arose in the Lower Mississippi Valley and along the coast.

Tchula Period (ca. 2500 to 2000 B.P.)

Ford et al. (1945) defined the Tchefuncte culture from investigations at the Tchefuncte Site (16ST1) on the north shore of Lake Pontchartrain. The cultural period is referred to as the Tchula period (ca. 2500 to 2000 B.P.), named for a town near the Jaketown Site (22HU505), where a substantial number of Tchefuncte ceramics were recovered (Ford et al. 1955). Subsequent excavations at Bayou Jasmine (16SJB2), Beau Mire (16AN17), Morton Shell Mound (16IB3), Big Oak Island (16OR6), Little Oak Island (16OR7) and other sites contributed in establishing attributes of the culture and defining regional phases (Neuman 1984; Shenkel 1974, 1982; Weinstein and Rivet 1978; Byrd 1994). The artifact assemblage of the Tchefuncte culture was very similar to that of the preceding period. First, baked clay Poverty Point objects, while still manufactured, were less abundant and restricted to a few forms during the Tchula period (Ford et al. 1945). Next, while exotic lithic materials are not as common on Tchefuncte sites, worked shell and bone artifacts appear in relatively high frequencies (Ford et al. 1945; Kidder and Barondess 1982; Shenkel 1974). Last, the Tchefuncte people are identified as the first culture in Louisiana to manufacture ceramic in quantities indicative of everyday usage (Ford et al. 1945; Neuman 1984).

Throughout the southeast fiber-tempered ceramics were being replaced by sand, grit and clay-tempered ceramics (Walthall 1980). Weinstein (1995) states that the present evidence suggests that the untempered Tchefuncte ceramic tradition and its northern equivalent, Tchula ceramics, developed out of the Wheeler fiber-tempered ceramic tradition. This reasoning stems from the fact that early Tchefuncte ceramics at Beau Rivage (16LY5) and early Tchula ceramics in the Yazoo Basin contain decorations identical to those found on Wheeler ceramics in the same deposits.

Subsistence during the Tchula period combined the utilization of shellfish, fish, turtle, alligator, large and small mammals and native cultigens (Shenkel 1982; Byrd 1994). One of the more notable features of the Tchula period along the coast is their large *Rangia* shell middens. Most of these middens are several meters thick, attesting to their heavy consumption of shellfish. At the Morton Shell Mound (16IB3) in southern Louisiana, Byrd (1994) found evidence of squash and gourd, suggesting that small-scale agriculture also was practiced during this period.

As originally defined by Ford et al. (1945), Tchula period sites contain Tchefuncte Incised, Tchefuncte Stamped, Tammany Punctated, Lake Borgne Incised and Orleans Punctated ceramics, along with Pontchartrain and Macon projectile points. Socketed bone points also were produced and are more common at coastal sites than at inland sites. Tchefuncte Stamped and Tchefuncte Incised ceramic types occur in higher frequencies than the other decorated ceramic types. In the Pontchartrain Basin, Tchefuncte sites generally are restricted to the shores of Lakes Pontchartrain, Borgne and Maurepas, and the lower portions of the bayous and rivers that drain into these lakes (Ford et al. 1945; Smith et al. 1983). Along natural levees and adjacent terraces of the Mississippi River and its tributaries from approximately Baton Rouge to the head of Bayou Lafourche late Tchula sites exhibit thinner ceramics. In this region Tammany Punctated sherds occur more frequently than the other types, while Tchefuncte Stamped sherds are a minority (Weinstein and Rivet 1978).

Hays and Weinstein (1999), after a reexamination of ceramic sherds recovered from the Bayou Jasmine site (16SJB2), have designated a new ceramic type for the Tchula period. Chene Blanc Plain is described as "relatively thick, well-made sherds with nonlaminated [sic] pastes that contain specks of hematite, bone, possibly shell and sometimes grog" (Hays and Weinstein 1999). Chene Blanc Plain, *var. Chene Blanc* was identified in the upper portion of the Bayou Jasmine midden, thus a late Tchula type. Chene Blanc Plain, *var. Fountain* was found to occur in the very top portion of the midden, indicating a very late Tchula or very early Marksville association.

Carbon samples from the Bayou Jasmine site (16SJB2) recently submitted by Hays (1995) yielded uncalibrated dates from ca. 140 B.C. (2140 B.P.) to ca. 980 B.C. (2980 B.P.). Most of these uncalibrated radiocarbon dates ranged between ca. 630 B.C. (2630 B.P.) and ca. 880 B.C. (2880 B.P.). If these dates are upheld, the currently recognized temporal span of the Tchefuncte culture will need readjusting. These radiocarbon dates also could substantiate Gibson's (1974) original theory that the Tchefuncte people

actually were the Poverty Point people that had migrated into the Mississippi River floodplain during the decades prior to the abandonment of the Poverty Point site ca. 700 B.C. (2700 B.P.). In fact, Hays and Weinstein (1999) agree that the Tchefuncte culture has ties to the Poverty Point culture, but the relationship is not wholly understood. Gibson (1995) notes that the occurrence of Tchefuncte-like ceramics in Poverty Point cultural contexts at the type site (16WC5) could mark the appearance of ceramics in the Lower Mississippi Valley, but widespread manufacture of ceramic vessels did not occur until the Tchula period.

An unnamed phase of the late Tchula period occurs in Terrebonne and Assumption parishes (Weinstein 1995). Coastal Environments identified two sites (16TR211 and 16TR212) of this phase located on subsided natural levees that were assumed to have been dated post-Tchula in age (Weinstein and Kelley 1992). Ceramics recovered from these sites included Lake Borgne Incised, *vars. Cross Bayou* and *Lake Borgne*, Orleans Punctated, *var. Boothe*, Tammany Punctated, *vars. Brittany* and *Tammany*, Tchefuncte Incised, *var. Bayou Braud* and Tchefuncte Plain, *var. Tchefuncte*.

North of the study area Tchula period shell midden sites (16JE91 and 16JE93) have been recorded along Bayou Dupont (Gagliano et al. 1979). These sites yielded Orleans Punctated, *var. Boothe* and Tchefuncte Plain, *var. Tchefuncte* ceramic sherds. Like the sites in lower Assumption and Terrebonne Parishes, no phase has been assigned to Tchula sites in this area.

Woodland Stage (ca. 2000 to 800 B.P.)

Typically, the Woodland stage (ca. 2500 to 800 B.P.) in the Southeast is seen as a time when ceramics composed a significant portion of the artifact assemblage, native inhabitants practiced ceremonial burials and plant husbandry or agriculture was practiced to some degree (Walthall 1980). While several criteria have been used to define the Woodland stage in the southeast, it is generally considered that those three traits together define the period.

The Early Woodland period does not occur in southern Louisiana, as it does in other parts of the Southeast. Instead, the transitional Tchefuncte culture (ca. 2500 to 2000 B.P.) flourished (Green 1999). The Tchefuncte were the first peoples in Louisiana to produce pottery in quantity, however monumental earthen mound construction, ritual interments and agriculture were not common (Ford et al. 1945; Neuman 1984).

Marksville Period (ca. 2000 to 1600 B.P.)

The first true Woodland culture in Louisiana was the Marksville culture (ca. 2000 to 1600 B.P.). The Marksville culture, named for the Marksville site (16AV1) in Avoyelles Parish, originally was described as the southern expression of the Hopewell culture, which was located primarily in Illinois and Ohio (Ford 1936; Toth 1988). Toth (1988) argues that the origins of the Marksville culture appeared during the Tchula period. This

argument primarily stems from the presence of rocker-stamping, and other ceramic traits that occur on late Tchefuncte ceramics and are present on early Marksville period ceramic wares. Accordingly, the transformation of the Tchefuncte culture into the Marksville culture was initiated by the Hopewellian intrusion into the Lower Mississippi Valley (Toth 1988). While there is little doubt as to the similarity of Marksville decorative motifs and vessel forms to those of the Hopewell, influences in ceramic decorations also can be correlated with coeval cultures to the east (Walthall 1980; Neuman 1984). Walthall (1980) notes that these ceramic traditions, Swift Creek, Porter and Santa Rosa cultures in southern Alabama and Georgia, and northwest Florida, were also the result of Hopewell interaction. The most compelling evidence of the ties that these cultures had to the Hopewell culture manifest itself in exotic trade goods and ceremonial objects. Copper and mica artifacts identical to those recovered from Hopewell sites have been found at the numerous sites of the same time period with similar ceramic decorations and forms (Neuman 1984). Zoomorphic pipes, typically associated with the Hopewell, also appeared at sites in the Southeast during this same period (Walthall 1980).

The Marksville culture is seen as having a highly organized social structure demonstrated by the presence of burial mounds for the elite containing special items apparently manufactured expressly for internment with the burials. Several Marksville sites also exhibit log tomb burial chambers similar in construction to those found on Hopewell sites (Toth 1988).

Subsistence during the Marksville period was similar to prior periods. In southeast Louisiana, Marksville sites generally were located on natural levees and terraces along the lakes, rivers and bayous. Gagliano (1964) suggests that the Marksville practiced a cyclical seasonal pattern. During the summer, sites on or adjacent to lakes and streams were occupied to take advantage of shellfish, turtles, alligators, fish and mammals. Permanent or semi-permanent camps were occupied in the uplands and on the Prairie terrace during the fall and winter in order to exploit available nuts and acorns, as well as local fauna.

No phases have been designated for the Marksville period in the present study area. Ceramics recovered from Bayou Cutler and other sites in the area indicate that both the early and late Marksville period are represented. Early Marksville ceramics found on these sites consist of Baytown Plain, *var. Marksville*, Churupa Punctated, *vars. Boyd*, *Hill Bayou* and *unspecified*, Indian Bay Stamped, *var. Cypress Bayou*, Mabin Stamped, *vars. Mabin*, *Point Lake* and *unspecified*, Marksville Incised, *var. Sunflower*, Marksville Stamped, *vars. Marksville* and *Old River* and crosshatched rims (Gagliano et al. 1979). Late Marksville ceramics include Baytown Plain, *var. Satartia* and Marksville Incised, *var. Yokena* (Gagliano et al. 1979).

Coles Creek Period (1200 to 800 B.P.)

By circa 1300 B.P., the cultural traits that define the Coles Creek culture had taken shape. Coles Creek sites appear to be larger, more numerous and more complex than earlier sites. The emergence of a chiefdom-like society could be implied from the complexity of the Coles Creek mound system. A sizable labor force must have been necessary to build, maintain and utilize these mounds and it could be assumed that a central authority figure controlled the labor force (Muller 1983). Evidence for the elite residential or mortuary structures often said to be associated with Coles Creek mounds remains elusive prior to ca. 1000 B.P. (Fritz and Kidder 1993; Smith 1975; Steponaitis 1983). Nevertheless, both the form of the platform mounds and their arrangement around plazas are possibly indicative of Meso-American influence (Willey 1958; Williams and Brain 1983). The general population occupied the region surrounding the large ceremonial centers (Neuman 1984).

The Coles Creek ceramic complex consisted primarily of simple rectilinear designs usually present on the upper half of the vessel. French Fork Incised, a ceramic type originating during the Troyville period, was an exception (Phillips 1970; Springer 1977). Interestingly, Coles Creek designs suggest that the culture had contact with the Weeden Island culture along the Northwest Florida Gulf Coast (Willey 1949). French Fork Incised motifs are identical to those found on Weeden Island Incised vessels. Other parallels can include Evansville Punctated and Carabelle Punctated; Hollyknowe Ridged Pinched and Tucker Ridged Pinched; Mazique Incised and Carabelle Incised and Pontchartrain Check Stamped and Wakulla Check Stamped.

These ceramic decorative parallels were not temporal, suggesting the infusion of these decorative motifs into the Coles Creek culture as their popularity was waning with the Weeden Island culture. Another less common decoration along the coast during the Coles Creek period, with parallels in the Swift Creek and Weeden Island cultures of Florida, was complicated stamping (Brown 1980, 1982, 1984; Neuman 1981). Brown (1984) assigned the sherds recovered from the Morgan site (16VM9) to the Gainesville Complicated Stamped ceramic type, typically found in the Gainesville Lake area of Mississippi and Alabama (Jenkins 1981). Saunders and Stoltman (1999) decided that a new ceramic type, Cameron Complicated Stamped, was warranted after petrographic studies of the ceramic pastes indicated that they were of local manufacture during the Coles Creek period. Cameron Complicated Stamped has been recovered from the Bayou Cutler I site (16JE3) north of the current study area.

Only limited archaeological evidence has been found to support the theory of subsistence based on maize agriculture during the Coles Creek period (Kidder 1992a). Archaeological efforts have resulted in the recovery of only the smallest amounts of maize from Coles Creek midden deposits. Tooth enamel decay, indicative of the consumption of maize, was thought to be attributed to the consumption of starchy foods other than maize (Kidder 1992b; Steponaitis 1986). Evidence now available suggests

that the growth and consumption of maize was not widespread in the Lower Mississippi Valley until after the Coles Creek period, ca. 800 B.P. (Fritz and Kidder 1993; Kidder 1992b). A better example of subsistence in the Lower Mississippi Valley during this time period can be demonstrated by the faunal remains recovered from the St. Gabriel Site (16IV128), a late Coles Creek/early Plaquemine site in Iberville Parish. These remains included both large and small game such as bear, deer, opossum, rabbit, squirrel, raccoon and alligator. Evidence of several native species of waterfowl, fish and turtle were also recovered. Botanical remains recovered included maize, honey locust, persimmon and grape (Woodiel 1993). Ramenofsky (1989) found evidence of intensive usage of acorns during the Coles Creek period and also notes that the use of acorns increased over time.

A large majority of inland Coles Creek sites have been found to occur along stream systems and particularly on the natural levees of old cutoffs and inactive channels. Soils in these locations would provide nutrients for agriculture (Neuman 1984). Small Coles Creek sites consisted mostly of hamlets with no mounds, while the larger Coles Creek sites contain one or more mounds. Coles Creek mounds typically are larger, and exhibit more building phases than the earlier Marksville burial mounds. Plazas are associated with multiple mound sites (Gibson 1985). Shell middens are the most common forms of Coles Creek period sites in the coastal zone. These middens are commonly on higher portions of natural levees (Springer 1974) along bayous and streams, and along lake shorelines.

The Coles Creek period in southeast Louisiana is divided into three phases: Bayou Cutler, Bayou Ramos and St. Gabriel. Kniffen (1936) designated the Bayou Cutler phase (ca. 1300 to 1150 B.P.) of the early Coles Creek period based on his examination of materials from the Bayou Cutler I site (16JE3) in Jefferson Parish. Phillips (1970), relying on information supplied by McIntire (1958), interpreted the ceramics described by Kniffen as endemic of this phase to include Coles Creek Incised, *vars. Coles Creek* and *Chase*, Beldeau Incised, Chevalier Stamped, Pontchartrain Check Stamped, *var. Ponchartrain*, Evansville Punctated, *var. Rhinehart*, Mazique Incised, *var. Mazique* and several varieties of French Fork Incised.

The Bayou Ramos phase (ca. 1150 to 1000 B.P.) was described by Weinstein from information obtained during excavations at the Bayou Ramos I site (16SMY133) in St. Mary Parish. The ceramic assemblage of the Bayou Ramos phase consists of Avoyelles Punctated, *var. Avoyelles*, Beldeau Incised, *var. Beldeau*, Coles Creek Incised, *var. Mott*, Mazique Incised, *var. Mazique* and Pontchartrain Check Stamped, *var. Tiger Island* (Weinstein et al. 1978). Bayou Ramos phase sites primarily occur west of the Terrebonne Basin.

St. Gabriel (ca. 1000 to 800 B.P.) was established by Brown (1985) based on Woodiel's (1980, 1993) excavation of the St. Gabriel site (16IV128) in Iberville Parish. Woodiel concluded that the St. Gabriel site (16IV128) contained a very late Coles Creek occupation just prior to changes that would define the Plaquemine period. Ceramics typical of the St. Gabriel phase include Addis Plain, *var. Addis*, Coles Creek Incised, *var.*

Hardy, Evansville Punctated, *var. Wilkinson,* Harrison Bayou Incised, *var. Harrison Bayou*, Mazique Incised, *var. Manchac* and small amounts of Plaquemine Brushed, *var. Plaquemine* (Brown 1985; Weinstein 1987; Woodiel 1980, 1993).

Archaeological findings suggest that by the end of the Coles Creek period the population had increased and became more socially and politically complex. Large-scale mound construction occurs. The implication of the reemergence of a chiefdom-like society is evidenced by the return of long-distance trade of a scale not seen since the Poverty Point period (Muller 1983). The introduction of sociopolitical and material concepts into the Lower Mississippi Valley from the established Mississippian traits associated with Cahokia in southeastern Missouri (Kelly 1990) possibly initiated the transformation of Coles Creek cultural traits into what is now recognized as the Plaquemine culture about 800 B.P.

Mississippian Stage

During the late prehistoric period, Mississippian influence radiated from the middle Mississippi River Valley across the Southeast (Haag 1971). Mississippian sites in Louisiana typically are located along the Mississippi River and the southeastern coast (Neuman 1984). Mississippian culture continued to influence the lifeways of indigenous southern Louisiana populations until contact with European cultures.

The consistent variation of Mississippian sites suggests that the Mississippian culture was a complex, non-egalitarian, stratified society. Larger sites contain flat-topped, truncated pyramidal mounds facing onto a central plaza that probably served, at least in part, as platforms for the residences of high-status families. Low-status families occupied single room, rectangular wattle-and-daub buildings (Walthall 1980).

The cultivation of maize, beans, squash and pumpkins; gathering of local plants, nuts and seeds; and fishing and hunting of local faunal species served as the basis of Mississippian subsistence. Terrestrial faunal remains from Mississippian sites indicate that approximately 70% of the animals consumed were deer, raccoon, squirrel or turkey. These animals utilized both maize and mast for their own dietary needs and were the hunted game (Neumann 1989). Increased consumption of opossum is evident (Neumann 1984). A byproduct of swidden horticulture practiced during this time was the growth of persimmon groves on the abandoned fields; as persimmons were exploited heavily by humans and animals.

The inclusion of shell tempering in the Mississippian pottery enabled potters to create larger vessels. Typical Mississippian ceramic vessels include globular jars, plates and bottles, and loop- and strap-handled pots. These vessels were decorated by engraving, negative painting and incising. Modeled animal heads and anthropomorphic images were also used to decorate ceramics. Chipped and ground stone tools; shell items such as hairpins, beads and gorgets and mica and copper artifacts are a few of the items recovered from Mississippian sites (Neuman 1984; Steponaitis 1983; Walthall 1980).

Plaquemine Culture (ca. 800 to 300 B.P.)

Previously thought to be a transitional phase from the Coles Creek culture to a pure Mississippian culture (Neuman 1984) recent investigations categorize the Plaquemine culture (ca. 800 to 300 B.P.) as Mississippian (Kidder 1988, 1990). The intensification of agriculture, sociopolitical structure and religious ceremonialism suggests the development of a complex social hierarchy.

Plaquemine subsistence was probably based mainly on agriculture and supplemented by native plants and animals. Kidder (1992a) notes that the Emerson Site (16TE104), a late Plaquemine site in the Tensas Basin yielded a large volume of maize, but the quantity of acorn remains from the site indicate that this resource was intensely utilized. In the coastal zone, Williams (1999) identified substantial amounts of *zea maize* associated with late Plaquemine cultural deposits at the Discovery Site (16LF66).

Settlement patterns, economic organization and religious practices of the Plaquemine peoples continued in the tradition of the earlier Coles Creek period. Sites are typically characterized as ceremonial sites with multiple mounds surrounding a central plaza, with dispersed villages and small hamlets (Neuman 1984; Smith et al. 1983). According to Gregory (1969), Plaquemine sites are generally found in lowland areas, including swamps and marshes. Numerous *Rangia cuneata* shell midden sites in the coastal zone contain Plaquemine components, not unlike the preceding Coles Creek period. Identified Plaquemine sites in the region include 16JE2, 16JE45, 16LF29, 16LF31 and 16LF37 (Neuman 1977).

Plaquemine ceramic decorations demonstrate their Coles Creek tradition, while late Plaquemine ceramics reflect an interaction with cultures to the north and east (Kidder 1999; Phillips 1970). Typical early Plaquemine ceramic types included Leland Incised, Coles Creek Incised, *var. Hardy*, L'Eau Noire Incised, Anna Incised and Plaquemine Brushed (Quimby 1951). The inland Plaquemine culture apparently had evolved into a true Mississippian culture by ca. 550 B.P. (Kidder 1988). In the coastal zone of Louisiana, the Plaquemine culture adopted fewer Mississippian cultural traits. Kidder (1990, 1999) notes that Mississippian ceramics represent a minority of the ceramics found on Plaquemine sites in this region dating to the same time period. The Plaquemine culture also did not adopt shell tempering to the same degree as other indigenous cultures in the Southeast. Instead, the Plaquemine people continued utilizing grog as a tempering agent.

Two phases have been established for the Plaquemine culture along the coastal region of Louisiana. The early Plaquemine culture is represented by the Barataria phase. The Barataria phase (ca. 800 to 500 B.P.) was created based on excavations at the Fleming Site (16JE36) in Jefferson Parish (Holley and DeMarcay 1977). Ceramics defining the Barataria phase include Anna Incised, *vars. Anna* and *Evangeline*, Carter Engraved, L'Eau Noire Incised, *vars. L'Eau Noire* and *Bayou Bourbe*, Mazique Incised, *var.*

Manchac, Maddox Engraved and minor amounts of Plaquemine Brushed (Weinstein 1987). Ceramic decorations also include Southern Cult motifs, particularly on L'Eau Noire Incised vessels. The Delta-Natchezan phase (ca. 500 to 300 B.P.) represents the late Plaquemine culture in the region (Phillips 1970).

Ceramics during this phase include early Plaquemine types, along with Addis Plain, *vars. Addis* and *Greenville*, Fatherland Incised, *vars. Bayou Goula* and *Fatherland*, Maddox Engraved, *var. Emerald*, Mazique Incised, *var. Manchac* and Plaquemine Brushed (Brain 1988; Phillips 1970; Weinstein 1987). The latter two types generally occur in minor frequencies. Another trait of the late Plaquemine culture is the occasional presence of Moundville Incised and Pensacola Incised, indicating some form of contact with Mississippian societies to the east (Kidder 1999).

Initial European Contact

Great social disruption suffered by aboriginal groups after De Soto's entrada (1539-1543) causes difficulty in understanding historic Indian cultures of the southeastern United States. Severe population depletions, a result of epidemics caused from a lack of immunity to normal European illnesses (Ramenofsky 1982; Smith 1986) created extreme circumstances that necessitated major social reorganization. The breakdown of the complex Mississippian societies during the terminal prehistoric period, the social and demographic reorganizations during the Protohistoric period (ca. A.D. 1539 to 1673), and even the better documented, but little studied, colonial period yield little information concerning the cultural continuity of most historic aboriginal groups in the region (Peebles and Kus 1977; Peebles and Mann 1981; Welch 1991).

This lack of information has prompted difficulties in delineating the ancestral archaeological cultures from which the historic groups were derived. Historic Native Americans continued with many practices of the Late Mississippian and Plaquemine peoples. Maize, beans, squash and pumpkin were the principle agricultural crops. The gathering of wild plants along with hunting and fishing remained important components of the aboriginal subsistence system.

Villages remained similar to those observed at Plaquemine and Mississippian sites. The larger villages featured one or more truncated pyramidal mounds surmounted by elite houses and temples; the remaining villagers lived in the area surrounding the mounds and in satellite hamlets. Houses apparently were rectangular in shape and were constructed of poles placed in the ground with wattle and daub walls and thatched roofs (Swanton 1946).

Initial European contact with the Houma tribe occurred at the tribe's primary village near the confluence of the Mississippi and Red Rivers, at the present site of Angola, when La Salle visited there in 1682. The rectangular Houma houses were arranged in a large circle surrounding a central plaza. By the early eighteenth century, the tribe had been driven from the region by the Tunica. They settled briefly along Bayou St. Jean (Bayou

St. John), near New Orleans, and eventually moved to the Great Houmas Village (16AN35) and Little Houmas, both located near the Mississippi River approximately eight km (5 mi.) down river from Donaldsonville. These lands were sold in 1776. The tribal remnants moved into the coastal swamps and marshes near present-day Houma (Kniffen et al. 1987).

Numerous resident southeastern Louisiana tribes likely utilized the hunting and fishing resources of Terrebonne Bay and its margins at various times. In the period of initial contact between the French and Native Americans, Terrebonne was near the border of the areas occupied by Muskogean-speaking Indians to the east and Chitimachan-speaking Indians to the west. In 1682, the Quinipisa-Mugulasha were residents on the west bank of Jefferson Parish, but by the turn of the eighteenth century, they had moved further up the Mississippi River. In 1700, the Chawasha (or Chaouacha) were centered on Bayou Lafourche in the vicinity of modern Lockport and the Washa (or Ouacha) were resident above modern Thibodaux. Both tribes moved closer to New Orleans in the early eighteenth century.

The late-seventeenth-century Chitimacha tribe apparently controlled much of the coastal parishes along both Bayou Lafourche and the Mississippi River. Their population was decimated during the eighteenth century by disease, war and cultural pressures applied by the French settlers. In response to increasing pressure from the European settlers, the tribe moved into the largely unpopulated areas of southeastern Louisiana, enabling it to survive as an entity into the twentieth century (Swanton 1946; Kniffen et al. 1987). Prehistoric Plaquemine period pottery designs identified at the Discovery Site (16LF66) in Lafourche Parish share several similarities with traditional designs used by the Chitimacha tribe. This suggests that the Chitimacha possibly are the descendants of the coastal Plaquemine people (Miller et al. 1999).

Several other tribes, including the Bayou goula, the Quinapisa, the Acolapissa, the Mugulasha, the Okelousa and the Tangipahoa, frequented the lower Mississippi River during the early eighteenth century. As French and Spanish settlement expanded during the eighteenth century, these tribes died out, moved westward or were assimilated into remnant tribes scattered throughout the unpopulated portions of southern Louisiana (Kniffen et al. 1987).

Sixteenth-Century Historical Overview

Spanish explorers were the first Europeans to lay claim to the Mississippi Delta and northern Gulf of Mexico. In 1519, Admiral Alonzo Álvarez de Pineda explored and mapped the northern Gulf for the Spanish Governor of Jamaica. Ten years later, Pánfilo de Narváez, the sixth governor of La Florida, led another expedition of five vessels and 400-armed men to the Gulf. Due to mistreatment of the natives, Narváez and his men were continuously harassed as they reconnoitered the region. Eight years later, only four survivors of the original party reached Mexico. One of those survivors, Alvar Núñez

Cabeza de Vaca, wrote an account of the expedition including a detailed description of the Mississippi River and the southern Louisiana coastline.

In 1539, Hernando de Soto arrived on the west coast of Florida to establish a colony and search for gold. De Soto landed in the Tampa Bay area and, recognizing the futility of finding gold there, marched his men northward. His quest for gold brought him through the entire southeast and possibly as far west as Texas. The conquistador left a legacy of destruction and violence related to his expedition that ended in May 1543 with his death near the Mississippi River. Spain's interest in the northern Gulf waned as it became evident that the region held little in the way of treasure and other sources of wealth.

Seventeenth-Century Historical Overview

In 1682, the French began exploratory ventures down the Mississippi River from their outposts along the Great Lakes. In April of that year, Réné Robert Cavalier, Sieur de la Salle traveled to the mouth of the river. Along the shores of the Gulf, LaSalle claimed the following territory for King Louis XIV: "the seas, harbors, ports, bays, adjacent straits, and all nations, peoples, provinces, cities, towns, villages, minerals, fisheries, streams and rivers within the extent of Louisiana" (Nuzum 1971:31).

French colonization began at the turn of the eighteenth century. In late 1698, Pierre Le Moyne, Sieur d' Iberville departed from Brest, France with five ships and more than 200 men to reconnoiter the northern coast of the Gulf of Mexico. After encountering Spaniards at Pensacola Bay, they continued their expedition, navigating westward along the Gulf coastline. Although they had intended to establish settlements along the Mississippi, its swampy shoreline deterred Le Moyne. Soon thereafter, the French explorers set up an encampment called Fort de Maurepas (at contemporary Ocean Springs, Mississippi) (Nuzum 1971:32).

In 1699, Peirre sent his brother, Jean Baptiste Le Moyne, to conduct further exploratory missions along the Mississippi. During his travels he visited "la Fourche des Chetimachas" along the upper Laforche Bayou near present-day Donaldsonville. Lands were granted along the Mississippi in the hopes to establish a colony, but fears of native attacks and little support from France, resulted in its failure (Goodwin et al. 1998:61). However, the French did not give up on settling the Mississippi, and by 1718, New Orleans was founded. The settlement grew slowly, spreading along the banks of the river. The bayous were virtually ignored by the French, being exploited by only a few fur trappers and the Houma tribe, who moved into the Terrebonne Basin during the first quarter of the eighteenth century.

Eighteenth-Century Historical Overview

In the 1762 Treaty of Fontainebleau, Spain acquired New Orleans and all French territory west of the Mississippi River. During their 38-year rule, the Spanish expanded the

Louisiana colony. Among the many grants given out were those to Acadians relocating from Nova Scotia. The Acadians settled along Bayou Lafourche, preferring that region for its isolation that allowed them to maintain their traditional culture with little interference (Goodwin et al. 1998:61). Terrebonne received its name from these settlers; the word means "the good earth," after the richness of the surrounding lands. The colonists quickly adapted to their new homeland growing corn, cotton, beans and figs. In addition, the Acadians exploited the natural resources of the region through fishing, trapping and hunting. The swampland forests also offered timber for shipbuilding and domestic construction.

It was during this period that the first canals were cut through the marshes. These canals were used to drain farmlands, provide access for trapping and to provide navigable waterways for shipping goods to New Orleans. Many of these canals have become artificial bayous and many are still maintained and used to this day (Goodwin et al. 1998:62).

The Spanish ventured into Louisiana swamps to promote settlements and to explore the coastal bays, bayous, and the vast "trembling prairie". Bernardo de Gálvez was appointed governor of the province in early 1777, and his future nemesis Francisco Bouligny was selected as lieutenant governor. In mid-June 1779, Bouligny tasked two groups of veteran pilots to reconnoiter specific portions of the coast. Traveling the same route in reverse, one expedition used a large pirogue while its counterpart chose a felucca [single-mast, flat bottomed sailing vessel] (Weddle 1995:91-93). One survey journal survived, and some historians speculate whether both expeditions were actually carried out (Weddle 1995:99). The extant log related these details:

> Shoving off from the bank of Bayou Teche at six thirty in the morning, the expedition coursed through the bay past the Isle des Chaines (Chêne), then cruised down the Atchafalaya to the Gulf. Passing Four-League Bay and Oyster Bayou—according to compass directions given in the journal—they sailed along the coast, registering Bayou du Large and the mouths of several creeks flowing out of Caillou Lake. The journal refers to one of these as Riviere Acayou (Caillou). After entering the lake through one of these channels, the pathfinders emerged again into the sea and at the end of the second day reached some islands called Des Ciriers (Deneieres) (Weddle 1995:98).

Outlying islands "inclosing" Terrebonne and Caillou bays were considered for settlement by experienced seamen in the late eighteenth century. On 3 October 1787, Joseph and James Neris submitted a petition to "Senor Gobernador General" Estevan Miro for permission to settle Caillou Island. The correspondence stated:

> Joseph and James Neris, brothers, neighbors and inhabitants of this province, with due respect, present themselves and say that they desire to form a settlement on it, the object of which is to work and reside there. We have deserved that you concede to this effect a small island, commonly called "Lile a Cayou," measuring about three-fourths of a league, situated at the north of the Bayou Terrebonne, surrounded by the sea. Observing to Your Excellencies that the said island is of very little importance, being entirely composed of sand and able to serve only as a farm for cattle and other animals, being much in demand by those adjacent to it, but adjudicated to none. We hope for this concession, justified by the distribution which you direct (Joseph and James Neris Petition as transcribed by Cusachs in: *The Louisiana Historical Quarterly* [*TLHQ*] 1919[2]3:304).

In late February 1788, state registrar Carlos Trudeau duly recorded the governor's affirmative response to the Neris brothers. In the official *Order of Survey*, Miro requested that the provincial land surveyor should:

> [E]stablish the petitioners on the island called "Lile a Cayou"…it being unoccupied and causing prejudice to none, with the distinct conditions of making a road and the regular clearing within the determined limit of a year and of forfeiting his claim if one-third of the land is not established at the expiration of this space of time, the concessionist [*sic*] having no right to transfer same, to be extended and a title in form to be remitted to prove right of whom it concerns (Order of Survey as transcribed by Cusachs in: *TLHQ* 1919[2]3:304-305).

By June 1793, Baron de Carondelet considered a petition from Bartholomew Lebluc for the concession of Timbalier Island. As a consequence of the New Orleans creole's request to settle the island with three companions, Captain Don Jose Hevia reconnoitered the desolate locale for the baron [and new governor] and remarked:

> In compliance with your preceding decree I must inform you that the island asked for by the petitioner, called Timbalier, is seven Leagues in length and one in breadth, distant from the northern coast three leagues and twenty-six leagues from the entrance of the river. It produces nothing but trees…in proportion, some game and fish.

> The establishment of the petitioner appears to be useful and opportune if he wishes for traffic…on this coast as experienced expert (Don Jose Hevia correspondence as transcribed by Cusachs in: *The Louisiana Historical Quarterly* 1919[2]3:303).

During the late 1700s to early 1800s, individuals including Edmund Fanguy, Joseph Hache [Achee], and Etienne Billiot were granted tracts by the Spanish not normally exceeding 640 acres (Cenac 2011:81). The Billiot land grant was later sold to J. B. Duplantis circa 1824, and then to Euphrosin Hotard (Cenac 2011:82). A United States Treasury document alluded to the earliest grants with this comment:

> No. 257. John Mary Campo claims a tract of land situate in the county of Lafourche, containing six hundred and forty superficial acres on both sides of the Terrebonne bayou, adjoining the lands of Thomas Fitch. The claimant produces the certificate of the proper Spanish officer, stating his permission to settle on said land, and, also, proof that the land was inhabited and cultivated prior to 1803. No. 258. Joseph Hache claims a tract situate in the county of Lafourche, interior, lying on both sides of the Bayou Terrebonne, containing twenty arpens front, and ten arpens in depth, adjoining the lands of Thomas Fitch (USTD 1824:59).

In respect to Native Americans moving into what is modern-day Terrebonne Parish, Miller (2004:161) commented that:

> During the late Spanish colonial period three United Houma ancestral families secured land grants on Bayou Terrebonne near present-day Montegut, a town approximately ten miles south of modern-day Houma, Louisiana. Here several ancestors including Houma Courteau, Louis le Sauvage [likely French for savage], Jean Billiot, and Alexander Verdin settled together.

It is generally believed that Native Americans living in the Lafourche area prior to 1700 were the Chitimacha-speaking tribes, namely, Chitimacha, Washa, and Chawasha. Choctaw also settled in this region and following a 1788 smallpox epidemic coupled with tensions with Europeans, Houma presumably settled near the contemporary town that adopted their name (Peña 2004:8, 15).

Acclaimed Louisiana philologist William Alexander Read (2008:36) suggested that the word *Houma* was related to the "Choctaw adjective *humma* or *homma*, 'red', and that:

> This term may have been used with reference either to the paint that the Houma warriors daubed on their bodies, or to the color of their moccasins and leggings. A third possibility is that the name Houma represents an aphetic form of Choctaw *Shakchi humma*, or 'red crawfish'; the red crawfish is known to have been the war emblem of the Houma tribe. The name is variously spelled—*Houma, Ouma, Homas, Omats, Oumats,* [and] *Ommas*

Nineteenth-Century Historical Overview

American Acquisition of Louisiana

In 1803, Spain relinquished control of Louisiana to France. As a consequence of this favorable reversion, the French naturally desired to reestablish an empire in the Americas. Fearing that French control would upset American trade through New Orleans, President Thomas Jefferson authorized the negotiation for the purchase of the city. However, French setbacks in Haiti and the coming war with Britain induced France to offer the entire territory to the United States for 15 million dollars. The purchase of Louisiana essentially doubled the size of the United States and opened the door to expansion to the Pacific coast.

The Emigrant's Guide to the Western and Southwestern States and Territories, published during 1812, presents an interesting view of early-nineteenth-century Louisiana. In its opening pages, author William Darby (1818:5) provided an enlightened explanation of why "the tenure of land in this state differs so essentially from that of other parts of the United States". As a witness to a Louisiana land office inauguration [1815], Darby (1818:5-6) could confidently relate that:

> As the governments of France and Spain never considered public land as a source of revenue, the grants were generally small, and made to actual settlers, for specific purposes. The *requete*, (petition) sets forth the pursuits of the claimant, the number of his family, and the quantity of land desired. The commandants or surveyor's certificate, [sic] certified that the land prayed for, was vacant. The order of survey, directed the commandant or surveyor, to put the petitioner into possession of the land prayed for, without doing injury to prior possessions. The concession, or document of survey, set forth, that on a certain day, and almost always in presence of the neighboring land owners, the petitioner was put into possession, pursuant to the tenor

of the order of survey. When the papers containing the whole of these preliminary proceedings were returned to the land office in New Orleans, the final patent issued, granting the land in (Franc-alleu,) allodial tenure. In this manner were most of the land titles of Louisiana framed. Large grants, such as those of *Bastrop, Maison Rouge* and the *Houmas*, were exceptions in principle…After the termination of the war between France and Spain, at the commencement of the French revolution [sic], and the provisional recession of Louisiana to the former, but few patents for land were issued by the Spanish government in Louisiana. The inhabitants proceeded as usual to frame their petitions, upon which they easily procured the certificate of the commandant or surveyor, and in many instances, orders of surveys were made. When the land offices were opened in New Orleans, and Opelousas under the act of congress [sic] of 27th March, 1804, the commissioners found the land titles of the country composed of all the various grades, from the simple petition, to the complete grant, or patent…After the opening of the land offices in Louisiana, the commissioners found a number of claims for land held by actual settlement, without any title from the Spanish government…Another species of claim presented itself in the shape of purchases from the Indians. As this mode of procuring land was so repugnant to the policy of the United States, the commissioners did not, perhaps, in every instance, make due allowance for the different principles upon which the former and present government, that held Louisiana, had proceeded respecting the Indian tribes. Those claims were, however, in most instances finally confirmed. The land of Louisiana is generally surveyed in the form of a parallelogram, forty *arpents* deep, from front to rear: this mode, which commenced on the banks of the Mississippi, was pursued in all other parts of the country. In some of the larger claims, this principle was departed from, but in the common tracts, only a few deviations are to be found. The arpent of Paris, was the universal measure of land, and by it were all grants and sales made. The acre is not yet, and perhaps, in respect to land held under the ancient titles, never will be introduced into use, in Louisiana.

Early Settlement of Terrebonne Parish

Peña (2004:18) provides this succinct yet insightful overview of nineteenth-century settlement into the region now called Terrebonne Parish:

> As the Anglo-Americans began to arrive in the district after the purchase of the Louisiana Territory in 1803 from France, it became apparent to them that all the rich farmlands fronting the many bayous of the district were in the hands of small landowners, such as the exiled Acadians. With their wealth and ease of credit, the Anglo-Americans began buying up large tracts of property from these people. Many of the poorer landowners, who were forced to sell their property, principally the Acadians, moved further down the bayous of Lafourche and Terrebonne or migrated to the brulés looking for new land to settle and cultivate. From these individual plots of farmland in the upper district, the Anglo-Americans were able to fashion huge plantations with sugar as the principal cash crop. In order to manage such vast pieces of property, additional African slaves were needed on a large scale[.] By the time of war [1861], there were some 21,276 slaves among the three principal parishes of the district [including Terrebonne]…compared with 19,820 whites, 315 blacks, and 103 Native Americans.

Erection of Terrebonne Parish (March 1822)

Following American acquisition, Louisiana was partitioned into 12 counties. In 1807, that system was abandoned and the territory was reorganized into parishes. By 1822, the population of La Fourche Parish had grown to such an extent to warrant the creation of a new parish. In that year, Senator Henry Schuyler Thibodaux sponsored legislation to create Terrebonne Parish. On 22 March, the Parish of Terrebonne "was carved out of the Parish of LaFouche Interior, a part of the old county of La Fourche, consisting of the present parishes of Assumption, Lafourche, and Terrebonne (Pierce 1851b:603).

The former parish was split along Bayou Blue with the western portion becoming Terrebonne Parish and the eastern portion remaining as La Fourche Parish. Bayou Cane was designated as the original parish seat for the nascent parish. However, by 1834, Houma became known officially as the seat of justice in Terrebonne Parish with its town center resting along Bayou Terrebonne [strategically located just over 50 miles from the Walnut Street ferry landing in New Orleans] (Read 2008:36-37).

Houma would be incorporated on 16 March 1843, and at that date, the town was confined to just the south bank of Bayou Terrebonne. Within three years, settlement had spread to the north bank and circa 1899 the city limits were expanded to include that section (Birchett and Pearson 1998:9).

A "Petitory" action [party claiming ownership but not in possession of immoveable property] heard before the LASC in its February 1851 term offers interesting insight into the early nineteenth-century chain of title for a waterfront tract in Terrebonne Parish. An excerpt from *Ann W. Winston v. Joseph Prevost* related that:

> On the 6th of April, 1829, *H. C. McNeil* sold to *Samuel L. Winston*, whom the plaintiffs now represent, thirteen and a half arpents of land front on the Grand Caillou by eighty arpents in depth. *McNeil* had acquired this land from *James Bowie*, on the 19th December, 1827. *Bowie* had acquired it, with other lands, at a forced sale of the property of *John Gravier*, made on the 17th March, 1827. *John Gravier* had acquired it from *F. Pothier*, on the 30th April, 1818. The act of exchange by which it was acquired, contains a declaration that *Pothier* exhibited and delivered to *John Gravier* a private act of sale of this land from *Jumonville Devilliers* to him. *Devilliers* held for it, at the time, an inchoate Spanish grant, which has since been confirmed by the Government of the United States (King 1852a:164-165).

James Bowie's ownership of the Grand Caillou tract during the 1820s is relevant due to the fact that Bowie and at least two of his brothers operated contemporary sugar plantations and they were involved in the importation of Captive Africans into Louisiana. Both enterprises relied heavily on regional waterborne commerce and the Bowie family certainly operated and/or owned vessels to support their activities.

Some years later, the portage of "Bayou Country" sugar and other goods was addressed, when Benjamin Buisson reported to the Board of Public Works that:

> I was struck with the disadvantageous situation [ca. 1835] of the western, and southwestern parishes, the inhabitants of which, during the low state of the river, have but very expensive and uncertain means of sending their crop[s] down to New Orleans. All the plantations of Lafourche, of Darbonne, Black and Caillou bayous…are under the necessity of waiting for the rise of the river to send their produce to market. As regards the population, there is at least one third of the state that is subject to this kind of embargo (Brasseaux and Fontenot 2004:41-42).

Expansion Along Terrebonne Waterways

During the 1830s, homesteaders and land speculators began purchasing tracts along Bayou Little Caillou. According to Westerman (n.d) these tracts sold for "1.20 an acre" with most patents assigned to those claims dating in the 1840s. While grantees could assume ownership of tracts on both sides of Terrebonne Bayou, only right descending or left descending tracts were granted on Bayou Little Caillou (Westerman n.d.). Genealogical research conducted by Westerman (n.d.), in which the compiler consulted U.S. Land Office and Louisiana State Land Office records provided valuable insight into Terrebonne Parish landowners of this period. Applicable surnames identified by Westerman (n.d.) "Going downstream on the right bank of Bayou Little Caillou" included; Cage, Toups, Fanguy, Watkins, Gaudin, Verret, Fitch, Pelegrin [or Pelegin], Landry, Brunet, Duplanti, Charpentier, Lecompte, Gisclair, Babin, Robison, Guidry [or Guidrey], Blanchard, Domingo [or Domingue], Smith, Hodge, Bourke, Leblanc, Yearbry, Belanger, Lecompte, Billiot, Babin, Bourg, Tyson, Perkins, Laperouse, Allen, Pedler, Rody, Dupree, Millaudon, Robert R. Barrow [1844], Jacco, Gregoire, Marshall, Forest, Virdin, Verrette, Hotard, Billis, Aucoin, Coteau Houma and Antoine Houma [1845], Abbey, Julien Houma [1841], Bausergant, Syng, Diene, Greenleaf, Brown, Scuddy, Laforest, Bergeon, Lagarde, Duplairty, Peter Welsh [1844], and Lefort.

Federal and state records associated with tracts "Going downstream on the left bank" of Bayou Little Caillou identified these family names; Billiott, Melome, Fonguy, Thomas R. Shields [1844], Valishparc, Billiot, Louph, William Bisland [1845], Watson, Heuri [or Henri], Pichof [or Pichauf], James B. Grinage [1842], Calle, Canciel, Callais, Cancienne, Gosset, Roger, Francois Thibodeaux and John Thibodeaux [1840], Vito, Savage, Duplanta, Brunet, Forest, Marshall, Peter Welsh [1840], Robert R. Barrow [1844], Millard, Sutherland, Verret, Duval, Lagarde, Belles, Parfait, Clifton, Ellenor and Lefort (Westerman n.d.).

Ascent of the Terrebonne Planter Class

According to Sell and McGuire (2008:9), Robert Ruffin Barrow began acquiring tracts in Terrebonne Parish in 1828, and this son of a former wealthy North Carolina planter [who migrated to Louisiana ca. 1820] would own six plantations by 1850. The younger Barrow's holdings in Terrebonne by this date included Residence, Caillou Grove, Honduras, Myrtle Grove, Crescent Farm, and Point Farm (Sell and McGuire 2008:9-10). The agrarian leader also held title to significant properties in Lafourche, Assumption and Ascension parishes. Barrow also figured very early on in another capacity besides his affluent planter status, when he became the primary owner of the Barataria and Lafourche Canal Company (B&L). Sell and McGuire (2008:10) related that the private canal system and "precursor to the Intracoastal Canal" opened in 1829 and "connected New Orleans with Houma and Morgan City using existing lakes and bayous linked by artificial canals and locks".

It was during this period that Terrebonne Parish became an epicenter for sugar production. As Anglo-American planters like the Barrows moved into the region the Acadians were pushed into more remote locations along the coast. Tradition indicated that Michel Theriot established the first plantation in Terrebonne circa 1839. By 1846, there were 106 plantations in Terrebonne cultivating sugar cane (Goodwin et al. 1998:64). Of these, 12 were located in lower Terrebonne. Locally respected planter and colonel Van Perkins Winder purchased tracts comprising Ducros Plantation circa 1846 and lived "in the old home until his death during 1854' (WPA [193-]:1). Just three years earlier, Edmund J. Forstall provided a report to the United States Treasury regarding agriculture in Louisiana. The New Orleans merchant related that the principal products cultivated in the Gulf state consisted "chiefly of two articles, to wit: sugar and cotton" (USTD 1851:440).

A legal case argued before the Louisiana Supreme Court (LASC) during its January 1845 term attested to the then customary practice of forwarding important letters to Terrebonne Parish planters via steamboats to the "parish of Lafourche Interior" post office at Thibodeauxville (Robinson 1845a:428). In the subject case *Priestley and others* v. *Bisland and another*, witnesses suggested that critical business correspondence and/or legal documents were generally addressed to Terrebonne residents at the Thibodeauxville post office instead of the Houma post office. The former location was elected due to the fact that steamboats carried mail from New Orleans to Thibodeauxville, and that Terrebonne mail was then carried to Houma only twice a week. The origins of the case centered on a $233.76 hardware order intended for the Bisland and Shields plantation located just three miles from Houma (Robinson 1845a:426).

During the high court's next term, February 1845, Louisiana justices heard three cases involving Terrebonne planter Robert Ruffin Barrow, one of which also named the previously mentioned T. B. Shields (Robinson 1845b; Robinson 1845c; Robinson 1845d). In addition to identifying contemporary landowners, the lawsuits touched on the complexities of land and moveable property transfers, the sequestration of property [including slaves], and the litigious atmosphere found in antebellum Terrebonne Parish. In respect to *Thomas Welsh* v. *Robert Ruffin Barrow,* the "the reputation and character" of one party's witness as to "truth and security" was questioned in that it potentially affected a lower court verdict (Robinson 1845b).

In the case of *Robert Ruffin Barrow* v. *Holden Wright,* the LASC heard evidence regarding two tracts situated along Terrebonne Bayou. As in other Louisiana land cases, the historical practice of using arpents frequently caused future title disputes and subsequent conversions. This particular case made mention of a tract owned by "the heirs of Doucet on the left bank of the bayou Terrebonne", and one owned by Madame Thibodeaux (ca. January 1839) (Robinson 1845c:523-524). The final February 1845 term case, *Thomas Welsh* v. *Robert Ruffin Barrow and another*, stemmed perhaps from indebtedness owed to a former Terrebonne plantation overseer circa 1841 (Robinson 1845d:536).

Late-Antebellum Population Centers

In describing the current condition of Terrebonne Parish, a writer for the popular New Orleans *DeBow Review* emphasized its numerous waterways in this 1851 excerpt:

> Terrebonne takes its name from a navigable bayou rising in the vicinity of Thibodaux, and running south and southeast, empties into the Gulf of Mexico. The original name of this bayou was, I believe, Derbene [or Darbonne], from one of the first settlers, but afterwards assumed the most appropriate designation of Terrebonne, or good land, which for fertility cannot be surpassed by any in the world. There are other large water-courses or bayous traversing the parish, the principal of which are, the Grand and Petit Caillous [sic], De Large, and Blue, that bounds the parish on the east. All of these rise in the northern part of the parish and run southward into the Gulf…All of these bayous are more or less inhabited, but the principal settlements are on the Caillous, Black, and Terrebonne. The majority of these settlements consist of small creole [sic] farmers, though on the bayous Grand Caillou, Black, and Terrebonne, there are as fine plantations as may be found in the state (Pierce 1851b:603).

During that same year, another article published by DeBow's Review commented on relevant "Indian mounds in Louisiana" (Neuman 1984:13). In writing for the popular American magazine, the author suggested that "along bayous Grand, Petite [sic] Caillou, Terrebonne and Black in Terrebonne Parish, there were fifteen to twenty mounds from which human skeletal remains had been collected" (Neuman 1984:13).

The case of *John Dooley v. Patrick Delaney* argued before the LASC in February 1851 suggested the long-term legal difficulties of owning a single tract divided not only by a Louisiana bayou but also by two parish boundaries. Facts in evidence proved that John Dooley purchased the tract (under controversy) from Jeremiah Dooley in 1845, and that the land was situated in Terrebonne and St. Mary parishes (King 1852b:67). Another case heard before the LASC during the same late winter term related that South Carolina residents John A. Boykin and Edward M. Boykin jointly owned a sugar plantation in Terrebonne Parish situated on Bayou Black. Due to their nonattendance, the Boykins appointed Duncan McRea Lang of Bayou Black circa 1849 to manage the property and slaves attached to the working plantation (King 1852c:115).

A publishing error substituting "640 acres" for "640 arpents" was at the heart of lengthy litigation between a Terrebonne landowner and the parish sheriff that reached the LASC on three occasions (King 1852d:73).

In hearing the February 1850 case of *Littleberg Wright* v. *P. B. Roussel*, Louisiana justices repeatedly voiced their frustrations in rendering a judgment due to ambiguous language and a lack of overall clarity in reviewing evidence.

Case law highlighted by Schafer (1994) in her authoritative work entitled *Slavery, the Civil Law, and the Supreme Court of Louisiana* provided more antebellum era details about Terrebonne Parish planters. In 1857 LASC justices heard the controversial case *Barrow* v. *McDonald,* in which the plaintiff and wealthy Terrebonne Parish slaveowner applied for damages against the defendant "for the 'malicious killing' of a slave" owned by both parties (Schafer 1994:55). The former, Robert Ruffin Barrow, at the time "owned four sugar plantations; Residence, Myrtle Grove, Caillou Grove, and Point Farm"; while defendant McDonald previously acted as a manager of one (Schafer 1994:55fn). In *Kessee* v. *Mayfield and Cage,* the state's high court heard evidence during 1859 in another "improper conduct" case involving an overseer and slave affiliated with a Terrebonne Parish plantation owned by Messrs. Mayfield and Cage (Schafer 1994:53).

In his celebrated work *Eyes of an Eagle*, Christopher Cenac (2011:87) eloquently described the contemporary agrarian and maritime environment in lower Terrebonne as such:

> Among the segment of the population who lived along Terrebonne's more southerly reaches, many ran often-smaller landholdings than did their plantation-owning neighbors. Because even the southernmost stretches of land along the bayou communities had not yet succumbed to subsidence or present-day [2011] high-water encroachment, many residents of these areas cultivated sugar plantations and operated sugar mills as well. In fact, the high-and-dry nature of even the most southerly farmlands which have now become marshlands is attested to the fact that Dulac's large plantations, Live Oak and Dulac, in 1858-59 produced higher yields than any of the other major plantations of the parish.

Late-Antebellum *Petit Habitant*

With regard to small farming interests of the subject era, Brasseaux (1992:21-21) remarked that:

> The 1850 agricultural census indicates that although the typical yeoman was capable of tilling fifteen acres of land, most farmers cultivated only four to twelve acres, depending on the needs of their families and the number of sons in the family labor pool.

> Indeed, of the ninety Acadian farms listed in the 1850 agricultural census of Terrebonne Parish, only twenty-three boasted more than fifteen cultivated acres. Such small-scale farming obligated the Acadian farmer to engage in seasonal occupations to support his family. Plowing, planting, hoeing, mending fences, branding calves, and seasonal relocation of his herd, which usually grazed on public land throughout the cooler portion of the year, to summer pasturage, filled the farmer's spring and early summer days. The comparatively inactive summer and the early fall growing season provide the petit habitant with the opportunity to undertake extended hunting and fishing expeditions. The prairies and woodlands of south-central Louisiana abounded with game…and edible varieties were killed indiscriminately by hunters. Seasonal hunting forays, which occasionally ranged as far as the central Atchafalaya Basin and the Gulf Coast and lasted as long as two weeks, furnished Acadian families with a steady supply of fresh meat. The killing of wild game minimized the need to slaughter domesticated livestock, which in the prairie parishes ranged without supervision on unclaimed land in the spring and sultry summer months.

Remarkably, as social and political differences sharply divided the Union during those years, "approximately 180 sugar-producing plantations hugged the banks of Terrebonne's bayous" (Cenac 2011:100). John C. Rodrigue (2001:20) related that although the cultivation of sugarcane was a historically labor-intensive undertaking, the enterprise could function without "complex equipment." Furthermore, the author of *Reconstruction in the Cane Fields* suggested that*:*

> For centuries, farmers in the Old World and New grew small cane crops to make molasses or syrup. Large-scale sugar production, however, necessitated a substantial investment in land, labor, and equipment, pricing it beyond the reach of all but the wealthiest of planters. This defining feature of sugar plantation held true in Louisiana, where the 525 elite planters (owners of fifty or more slaves) in 1860 boasted an average of 110 slaves, 730 acres of improved land, and $14,500 worth of farm equipment. This planter elite made up a small fraction of the sugar region's slaveholders, who were themselves a minority of the adult white male population (twenty years of age or older) in 1860 (Rodrigue 2001:20).

At the onset of the American Civil War, historical records suggested that there were at least 248 Terrebonne slaveholders. Of that number, 204 owned less than 50 slaves, while the remaining number owned 50 or more captive laborers (Rodrigue 2001:21). Some 6,785 slaves called Terrebonne Parish "home", and circa 1860, they were all most likely affiliated with the 323 landholders of "Improved Acreage" in that Gulf parish (Rodrigue 2001:22-23).

When Priscilla Bond arrived in Louisiana to marry the wealthy heir to Crescent Place (located on Bayou Black near Houma), she "would have found the southeast portion of the state dotted with sugar plantations. Many of the large landowners of Terrebonne had purchased Acadian-owned small farms to create large sugar plantations, and in 1861 there were 1,291 operating cane plantations" (Harrison 2006:5). Of the larger environment, the author of *Scarred By War: Civil War in Southeast Louisiana* remarked that:

> Most of Terrebonne Parish during the war consisted of either fresh or saltwater marshes and vast regions of swampland. Though this region did not have the same economic impact as its sister parishes of the district, it came to serve the cause of the Confederacy in other ways. The swampy and marshy terrain made a southern invasion of the district by way of the Gulf of Mexico nearly impossible for the Union. In other ways this harsh terrain, like that found in the western portions of Assumption Parish, made for excellent staging areas for Confederate guerilla warfare on Union occupation forces. Staging their raids from the swamplands of southern Terrebonne Parish, as well as those swamp and marshes in other regions of the districts, bands of guerilla fighters often harassed their Yankee adversaries. Suddenly appearing from nowhere, these Southern patriots inflicted what damage they could upon the unsuspecting and ill-prepared Yankee soldiers. Then just as quickly, they disappeared back into the untraceable wetlands before there was time to mount a counter offensive (Peña 2004:9).

Rodrigue (2001:31) related that while Secession "enjoyed popular support in Louisiana", the "support was not unanimous…as Unionist sentiment, or at least misgivings over secession, prevailed among many white southerners during winter and spring 1861". After voting to secede during the Baton Rouge special convention on 26 January 1861, Terrebonne Parish sugar planter Andrew McCollam exclaimed the decision "as the 'bitterest pill that I ever took'" (McCollam in: Rodrigue 2001:31).

The Civil War Era

Terrebonne Parish was minimally impacted by major military events of the Civil War. At the onset of the conflict, an earthen battery was constructed on Grand Caillou Bayou. Originally named Fort Butler, but later renamed Fort Quitman, the fortification was built to protect blockade runners putting into Grand Caillou and to prevent Federal raids into the region (Goodwin et al. 1998:64). Confederate privateers that cruised under Letters of Marque frequently sought refuge in remote Caillou Bay and safety under the protection of Fort Quitman's cannon.

For the remainder of 1861, and through early spring 1862, Caillou Bay remained a safe haven for Confederate privateers and blockade runners. On 27 February 1862, Major-General M. Lovell reported to Confederate Secretary of War Judah Benjamin that the vessel *Miramon* had recently come into Caillou Bayou with good quality powder for Louisiana forces, and that he was fitting up "twelve luggers, for a coast guard, to watch the enemy and prevent communication with the shore" (TNHS, ser. II, vol. 1 1987:683)

Fort Quitman was abandoned on 27 April 1862 by Confederate forces soon after the Union fleet, under the command of Flag Officer David G. Farragut, bypassed the forts at the mouth of the Mississippi River and captured New Orleans (Strait 1902:54). On 21 May 1862, the Louisiana governor wrote President Jefferson Davis to apprise him of the consequences of Fort Quitman's recent evacuation and the current, dire status of Terrebonne Parish. The state's chief executive related:

> It is absolutely necessary that some steps should be take to stop the incursions of the enemy in the lower part of the State. The only means I now have is to organize bands of Partisan Rangers. If I wait for captains to apply through General Lovell to the Secretary of War the delays will be ruinous, and I therefore have given to-day authority to Captain Goode to raise a company of rangers for operation in Terre Bonne. I shall grant similar privileges to such others as circumstances may suggest (U.S. War Department ser. I, vol. 15 1886:740-741).

Wartime Plantation Operations

A committee of leading Terrebonne planters petitioned Major General Nathaniel Banks in January 1862 [probably 1863] to express grievances and ask for "some amelioration" in regard to the difficulties in raising their "usual crops" (Minor, McCollam, Robertson, and Gibson [Minor et al.] 1862 [1863]). Spokesmen W. J. Minor, Andrew McCollam, F. E. Robertson, and T. Gibson were authorized to represent the universal views of approximately 170 parish residents.

Not surprisingly, the planters touched on a variety of issues including obstacles encountered in reaching Terrebonne's natural and manmade waterways to send local commodities to market. An excerpt from the petition follows:

> General, The undersigned, comtee, appointed by the citizens of the Parish of Terre Bonne–La– to lay before you the deplorable condition of their once florishing & happy Parish–Respectfully reprisent–that–nine tenths of all the horses, saddles & bridles & at least two thirds of all the mules, carts, wagons & harness necessary to carry on the plantations have been seized by the U.S. (to say nothing of cattle, hogs, sheep poultry & other things necessary to support our families & negroes) consequently many planters are not able to haul necessary supplies from the depots nor will they be able to dilever at depots & landings the Sugar & molasses now in their Sugar-Houses–neither will they be able to cultivate their crops this year– Large quantities of corn necessary for the use of the planters their negroes & teams remain in the fields, & without carts teams & harness must so remain & be entirely lost– That– many of the negroes led astray by designing persons, believe that the plantations & everything on them belong to them, the negroes–They quit work, go & come when they see fit–Ride off at night the mules that have been at work all day– Fences are pulled down gates & bars are left open– Cattle, & sheep hogs & poultry are killed or carried off & sold– Negroes in numbers from one plantation to an other at all hours night & day– They travel on the rail road– They congregate in large numbers on deserted plantations– All these things are done against the will & in defiance of the orders of their masters.– In Some instances negro Soldiers partially armed have been allowed to visit the plantations from which they inlisted– In a word we are in a State of anarchy.– The time has come when preperations for planting & cultivating the crops of 1863 should be made.– But without teams, & the ability to command the labour of our negroes, nothing can be done.– Unless a full crop of corn can be grown this year Starvation Stares us in the face– In the rear of famine march insurrection & pestilence–General–We ask relief from our present evils & security for the future.– To obtain these ends, we respectfully suggest–

> That–To each planter be restored not less than half of all the team, carts, wagons & harness, that he has heretofore used in the cultivation of his plantation, & that they be secured to him to be used in the cultivation of his plantation or plantations if he has more than one (Minor et al. 1862[1863]).

Conversely, a group of Louisiana Freedmen petitioned the Federal provost marshal general of the Department of the Gulf on 5 April 1863 from Camp Hoyt, Terrebonne Parish. Representing over 60 former slaves, the spokesmen collectively wrote:

> Sir[,] We the undersigned Negroes residing on Major Potts Plantation Parish Terre Bonne La. respectfully submit to you the following statement; Captain Goodrich Provost Marshal at Thibodeaux told us to go on and cultivate the land on the Plantation, and do something for ourselves, until the Government could do something for us and gave orders for all the Stray Mules belonging to the plantation to be brought in, so that we could work the land, and we understood that we were to be protected in our labor– We have about 60 Arpents1 of land broken up a large portion of which is already planted, and the balance ready for planting. Now a Mr Wright comes on the plantation with Authority from the Government to work it and claims the result of our labor– We have had a hard struggle to get along and we feel it hard now that we have succeeded in making ourselves in a measure independent, to have to [turn] it all over to someone else. We have at present on the place about 14 men, 23 women 10 of whom are old and with Children, 24 Small Children & Babies. Under the circumstances we think it but just that we should be allowed to work the land already broken up and planted on equal shares with the Government. We therefore ask your aid and assistance in having secured to us what was promised us by Provost Marshal Cap't Goodrich–and the posession [sic] of the property we [have?] and land acquired by our labor. Henry Norvall, Littleton Saunders, Claiborn Thomas, Thos Essex, Thornton Boller, Phil Sergeant, Thos Mathews, Parker Williams, Jefferson Rounds, [and] Nelson McClenny (Norvall et al. 1863).

Union Presence and Occupation of Key Locations

Within weeks of the surrender of New Orleans, armed Terrebonne civilians ambushed four units of Union General Benjamin F. Butler's soldiers while the military contingent traveled to Houma. As a consequence of the attack, 400 Federal soldiers marched into Houma and "began a wholesale arrest of the citizens." In order to demoralize the townsfolk, livestock and wagons were seized and "the home of a Doctor Jennings was burned, two other houses were torn down, and the home and slave quarters of an outlying plantation were burned" (Winters 1963:150-151).

Federal troops occupied Thibodeaux in 1863, which impeded Confederate offensives in Terrebonne Parish. Despite the presence of numerous Union gunboats that patrolled Caillou and Terrebonne bays, elusive Confederate guerillas continued to operate in the region. In November 1864, military intelligence intercepted by Federal forces suggested that a band of these resourceful Confederate raiders were in the vicinity of Houma (Brasseaux and Fontenot 2004:105).

On 30 November 1864, the U.S. Army commander of the district of La Fourche reported on the most recent "affair" at Bayou Grand Caillou. Brigadier General Robert Cameron related that on 23 November several Union infantry officers and soldiers were temporarily captured at the mouth of Grand Caillou while ostensibly investigating a smuggling enterprise (U.S. War Department [USWD] 1893:927-928). Several associated U.S. Army documents revealed the names and locations of the Confederates and local residents that were involved in the moving of contraband goods aboard sloops and vernacular boats from points near Caillou Bay to the vicinity of Houma (USWD 1893:928-933).

Freedmen Labor Company Activities

The universal desire for land among former slaves prevailed in Louisiana, and "Freedmen in Terrebonne and Lafourche Parishes…organized themselves into 'labor companies' that tilled abandoned estates" (Rodrigue 2001:55). By January 1865, "a group of Terrebonne freedmen successfully petitioned a Treasury Department official to work one plantation", and by the war's end (April 1865) this arrangement was deemed successful according to a Federal inspector (Rodrigue 2001:55). Unfortunately, these "and other attempts at independent, landed proprietorship turned out to be short-lived, since most of the abandoned plantations would be returned to their owners soon after the war" (Rodrigue 2001:55).

Immediate Post-bellum Atmosphere

According to U.S. Army records, the Third Rhode Island Cavalry assisted with a security detail related to Caillou Bay at the conclusion of the Civil War. The expedition involved a round-trip voyage on Grand Caillou bayou. On 29 April 1865, U.S. Captain Joseph Rhodes reported to his post superior that:

> I have the honor to report that, pursuant to instructions from headquarters post Terre Bonne, dated April 19, 1865, whereby I was to proceed, with a portion of my command, to Pelton's plantation, below Houma, La., for the purpose of protecting a schooner laden with molasses to go from said plantation to New Orleans, I left Terre Bonne with twenty-four men and two non-commissioned officers April 19, 1865, at 5 p.m., and arrived in Houma at 9:30 p.m., where we encamped for the night. April 20, left Houma at 9 a.m. and arrive at Pelton's plantation at 3 p.m., seventeen miles below Houma, where we found the schooner waiting for fair wind, the wind being ahead, and hence we were obliged to encamp at Pelton's for the night. Next morning, the wind being favorable, everything was got in readiness for the trip. Taking fifteen men and leaving the balance in charge of the horses until our return, we embarked on the schooner at 10:30 (April 21) and proceeded down Grand Caillou toward the Gulf, a distance of seventeen miles, where, owing to the darkness, we were obliged to anchor for the night. April 22, got the vessel under way at sunrise and continued our run down the bayou. We arrived at the mouth of Grand Caillou at 9 a.m. and went outside with the schooner, seeing her safely over the bar, some six miles at sea. No rebels, or any signs of them, were seen during the entire course. At 10 a.m. we left the schooner in a small sail-boast, which was taken from Mr. Pelton's plantation for the purpose of conveying us back again. The wind being ahead, we were compelled to beat the boat back into the bayou. After hard pulling and towing the boat with a rope from the bank, we made some seventeen miles, and went into camp on the bayou at the house of an old Frenchman, where we were refreshed with supper and a good night's rest. April 23, at 9 a.m. we resumed our course for Pelton's plantation, which we finally reached after six hours' hard pulling against wind and tide. Mr. Pelton was glad to see us on our return, and served up a good dinner to both officers and men. Possessing a plenty

> with which to accommodate both men and horses, he insisted on our remaining with him all night, and the men being very tired I cheerfully accepted his proposition. April 24, at 9 a.m. left Pelton's plantation for Houma, were we arrived at 3 p.m., and went into camp for the night. April 25, resumed our march at 9 a.m., and arrived in Terre Bonne at 1 p.m., not having seen or heard anything of the enemy during our entire march (USWD 1896a:185).

Postwar Period and Reconstruction Era

U.S. Army Southern Division officials continued to deal with active remnants of the Confederacy at Grand Caillou in late May 1865. The serious nature of the threat was brought to the attention of General William Tecumseh Sherman. As a consequence, a clandestine operation was employed to identify the Rebel parties. On 25 May, the U.S. La Fourche district commander advised Terre Bonne headquarters that:

> The two men sent here by General Sherman to break up the smuggling going on from Grand Caillou having caught the principal, Raymond Luke, and an accessory Felix Hutchinson, who offers to turn Government witness against Luke and others, have reported to me. Shall I send them to you to be paid and discharged, or shall I employ them to look up other parties engaged in smuggling and giving information to the enemy? They are good men for the business, and well posted here, and will work for $75 a month (USWD 1896b:593).

In September 1865, President Andrew Johnson "ordered bureau-controlled [Louisiana] property returned to its former owners once they had received presidential pardons, which by this time he was dispensing quite freely" (Rodrigue 2001:62). Terrebonne planters "soon wielded authority bestowed by Johnson to subdue their workers", and by late summer 1865 this group of agrarian elites "reactivated the state militia and revived the old patrol system to arrest freedmen who moved about without their employers' permission" (Rodrigue 2001:67).

By Christmas time 1865, a Federal officer investigating the questionable activity in Terrebonne Parish remarked that the patrols appeared [to freedmen] to be designed 'to crush out what freedom they now enjoy and reduce them once more to comparative slavery' (T. Kanady in: Rodrigue 2001:67). Some Federal intervention was applied to restrict "egregious violations" of their [freedmen] civil rights, however, in order "to shape the labor market to their [planters] advantage" the Louisiana legislature enacted the "infamous Black Codes in late 1865 and early 1866" (Rodrigue 2001:67).

Among other intentions, the statutes hindered the movement of freedmen from one parish to another. In the interim, Terrebonne Parish freedmen continued "to express their desire for land", and 'form[ed] ideas & hopes from the general government, which had not been realized…Every man became impressed with the idea that he soon to become a landed proprietor' (Rodrigue 2001:62). In order to quell this notion of "land redistribution", the Louisiana Freedmen's Bureau issued a circular in December 1865 explaining the situation to former slaves now squatting "on unimproved swampland or on unclaimed estates" (Rodrigue 2001:62).

Like most of Louisiana, Terrebonne Parish recovered slowly after the cessation of hostilities, and this dismal condition prompted officials to survey the entire state. Samuel Henry Lockett's series of summer surveys (July 1869 to August 1872) of Louisiana provide an intriguing view of postwar Terrebonne Parish and, in particular, its labyrinthine waterways (Lockett 1969:3).

Although Lockett was born in Virginia during 1837, his parents moved to Alabama when he was an infant. His cadetship at the U.S. Military Academy was completed with distinction, and in 1860, young Lockett was assigned to Eighth Lighthouse District duties in Florida under Colonel W. H. C. Whiting. When his adopted home state of Alabama seceded on 11 January 1861, Lockett elected to resign his commission and was immediately appointed to the Confederate engineers department (Post 1964:421-422). Due to his undisputed intellect and integrity, Lockett eventually was charged with the Southern defenses of Vicksburg and later those of postwar Mobile.

As Lockett (1969:7) commenced the subject historic Louisiana survey on 6 July 1869 at the Alexandria campus of Louisiana State Seminary, he described his state-of-the-art equipage and provisions in this manner:

> The following is an inventory of outfit in all departments: what was supposed to be a first-class, stout army ambulance drawn by a fine pair of mules, a good wall tent and fixtures, a camp chest with a small supply of cooking and table utensils, a couple of camp-stools, a drawing board so arranged as to serve as a dining table or for drawing and writing purposes, as necessity required, a little bedding for each of us, and a few rations of dry provisions to meet the grosser requirements of our new life in the field. For scientific purposes we had an odometer [intro. 1846], a barometer, a spirit level, two pocket compasses with clinometer attachment, a tape line, a box of mineralogist's tools, a box of drawing instruments, maps, drawing and tracing paper, sketchbooks, notebooks, several geological works, pens, pencils, *et cetera*. We took, to enable us to make excursions from camp, a couple of riding saddles and bridles. All of which, with the two professors and our English driver, made a very full vehicle of our ambulance.

At the onset of his second field survey on 5 July 1870, Lockett left Baton Rouge alone with a streamlined outfit of just two saddlebags filled with essentials astride "a good riding horse" (Lockett 1969:19). For several days, Lockett rode through a succession of parishes reaching Lafourche Parish and stopped at the town of Thibodeaux [sic] situated near the boundary of Terrebonne. Although the celebrated former Confederate engineer took scant notice of "plantations and mansions", Lockett did highlight his summer 1870 stay at "Powhatan", owned by Colonel W. W. Blackford (Lockett 1969:21, 21fn). Prior to this interlude, he remarked that:

> From Thibodeauville [Thibodaux] I turned southwestward down Terrebonne Bayou and rode to Houma, stopping at noon at the residence of Mrs. Ellis, the mother-in-law of General [Braxton] Bragg. In Houma there was no map of Terrebonne Parish, but in a long conversation with Mr. Sam Woods, an old resident and former parish office, I gathered all the facts necessary to give me a good idea of the topography of the parish. In Houma, Mr. John Berger, formerly one of the cadets of the University, offered me the hospitality of his home. Leaving Houma I traveled along the banks of Barrow's Canal, now nearly filled with weeds and tall marsh grass, to its juncture with Bayou Black, or Petite Terrebonne; thence along Bayou Black to the plantation of Mr. McCollam; here I was directed by a cross-road to Bayou Chacahoula, which I followed to Tigerville, a station on the Opelousas Railroad. From this station I again followed the course of Bayou Black for three miles, until I came to Powhatan Plantation belonging to Colonel W. W. Blackford. I had now been two weeks in the saddle and felt the need of a short respite from my labors, and, although it was Friday evening when I reached Colonel Blackford's, it took but little persuasion on his part to induce me to remain under his roof until the following Monday. At Colonel Blackford's, Bayou Black is a deep, clear, brackish stream, navigable for any kind of boat. Its banks are clothed with a dense growth of cypress, liveoak [sic] and gum trees, all of which are draped in long festoons of the sombre [sic] but graceful Spanish moss. On its surface, innumerable broad leaves and beautiful flowers of the water-flag, or *graine à volée*, float, and at every bend a quiet scene of great beauty is presented to view. Colonel Blackford, being by nature and cultivation an artist—as was testified by the numerous pictures of his handiwork as well as others by eminent artists which adorned his walls—was altogether the most perfectly congenial spirit I had ever

> met. The two days and nights I spent in his delightful company will be remembered as on the pleasantest periods of my life. Our walks over his broad fields of sugarcane and to his young orchard of orange trees, our strolls along the banks of the bayou, our moonlight and daylight dreamy floating upon its glassy bosom in his light canoe, our sketched taken together of that huge liveoak [sic] in front of his house, [and] our moonlight baths in the soft balmy water of Bayou Black (Lockett 1969:21-22).

Regarding coastwise navigation of Terrebonne Parish as he left Timbalier Bay behind (literally), Lockett (1969:131) recorded in his journal that:

> The next bay westward is Terrebonne Bay, which is separated from that last noticed by the delta of Bayou Terrebonne and from the main waters of the Gulf by Caillou Island, Vine Island, and Isle Dernière. Bayou Terrebonne is navigable to M. Emile Pasque's plantation, a distance of forty-five miles. Bayou Petit Caillou, which flows into Terrebonne Bay on the west, is navigable to Mr. Richard Ellis' plantation, a distance of thirty-five miles…West of Terrebonne Bay is an open-mouth indentation called Caillou Bay. Into this, through Lake Caillou, Bayou Grand Caillou flows, which is navigable to Mr. D. S. Cage's plantation, a distance of forty miles…Bayou de Large, next going westward, is navigable to the Mr. Chouvion's a distance of thirty-seven miles…Atchafalaya Bay has flowing into it the large river of the same name which, with the numerous lakes in its course, has already been considered in discussing the rivers of Louisiana. Atchafalaya Bay, though an extensive sheet of water, is generally shallow and has numerous shell banks in its bottom. It can be used, however, for coastwise navigation, and the channel to the mouth of the river is indicated by lights and buoys.

According to the *Census of 1870*, there were 12,451 inhabitants in Terrebonne Parish. Of that number, the census taker counted 875 residents in the parish seat of Houma (Dimitry 1877:194-195). At this time, geographers suggested that the coast-marsh was "generally impassable", and that with the exception of planters living near the bayous, including Grand Caillou, Petit Caillou, and De Large, the population was "very small, consisting mostly of hunters and fishermen" (Dimitry 1877:164, 197).

Although much of the regional commerce was destroyed during the Civil War, sugar cane production continued to dominate the local economy. However, unlike before, this industry now required salaried laborers. Major plantations that survived the war and continued production into the twentieth century included Ashland, Terrebonne, Red Star and Hard Scrabble plantations. The Terrebonne Sugar Mill opened in Montegut in 1891 as a central processing plant for the cane plantations operating in lower Terrebonne (Birchett and Pearson 1998:10).

Some plantations failed to recover after the war, and in several cases extensive real estate and formerly grandiose structures were lost through bankruptcy and other forfeitures. Circa 1872, Ducros Plantation "was sold for a division among the heirs" of Martha Grundy Winder (WPA 193[-]:5). The Woods family later purchased Ducros, and the house and property remained in that family until the early twentieth century (WPA 193[-]:5).

Other real estate opportunities presented themselves to qualified buyers during the Reconstruction Era. In 1873, Louisiana's superintendent of public education identified numerous parties buying public school lands sold from Terrebonne Parish Section 16 tracts. The individuals and respective acreages follow; James J. Hanna (170), John Laidlaw (719), Robert Dasfit (?), A. La Orest (161), E. De Braillou (160), V. and E. Severin (64), James C. Knox (160), Charles E. Barberou (160), W. S. Pike (41), Hamilton Leroy (?), John Lombard (682), C. C. Barberou (320), E. S. Patterson (202), Eugene Ory (80), W. H. Sheppard (320), E. McIlhenny (160), and J. A. Ray (160) (Louisiana State Board of Education 1874:147-149).

The paltry 1873 harvest precipitated a reduction of wages for freedman, and on 5 January 1874, "Terrebonne freedmen assumed a militant stance" (Rodrigue 2001:162). Over the course of several days, some 50-armed strikers "descended upon Henry Minor's Southdown plantation and attempted to prevent [non-cooperating] freedmen from working" (Rodrigue 2001:163).

As the Reconstruction Era concluded, the Southern Land Company of New Orleans published "A List Of The Farms, Plantations, Wild Lands, Timber Lands, Etc., In The Gulf States" (Southern Land Company [SLC] in: Dennett 1876:264). Real estate broker W. P. Freret offered two premium Terrebonne properties "For Sale on Commission"; "No. 93. 400 acres: a sugar plantation on both sides of Bayou Terrebonne, Parish of Terrebonne"; and "No. 94. 900 acres, a sugar plantation on both sides of Bayou Terrebonne, Parish of Terrebonne" (SLC in: Dennett 1876: 265, 268).

Information regarding sugar and rice production for 1874 by parish provided by "Mr. L. Bouchereau" suggested that Terrebonne produced only 9,005 hogsheads of sugar that year, as compared to 28,839 hogsheads for 1861 (Dennett 1876:224-225). At 230 pounds to a barrel, Terrebonne produced "1,988 bbls." of rice for calendar year 1874 (Dennett 1876:225).

However, planters and smaller concerns produced cotton, hay, potatoes, corn, beans, cattle and dairy products in Terrebonne Parish. During the postwar years, "cultivated fruits and wild fruits" were also successfully tended in the coastal parishes. By 1877, the former included "Japan plums, figs, oranges, cherries, peaches, grapes, pears, olives, dates, almonds, pine-apples, citrons, bananas, lemons, limes, shaddocks, strawberries, and the Chinese quince." Wild fruits were identified as: "Dewberries, blackberries, mulberries, chinquapins, wild strawberries, and the excellent muscadine grape, or black scuppernong" (Dimitry 1877:206-207).

In regards to the epiphyte *Tillanitsia Usnevides*, the "best" Spanish or long moss still came (ca. 1876) "from the Atchafalaya basin" and "all the main lakes and bayous" of Terrebonne, Teche, Lafourche, Plaquemine, and Barataria (John B. Robinson in: Dennett 1876:239-240). According to Louisiana Judge John B. Robinson, this curious and popular native commodity provided much needed income for all classes of society, and the jurist added:

> That from Lafourche, Terrebonne and Bayou Black is coarse, gummy, hard to clean, but very strong. It is gathered largely from gum trees and seems to be glued with the gum. It is gathered by wood choppers and laborers who follow the wood choppers, but there are hundreds of whites and blacks who make it a business. They go into the swamps through canals and bayous; they push their way along in skiffs, flats or canoes; they carefully pick up all that the wind has blown down in great flakes; they reach up long poles, armed with hooks, and pull down the hanging bunches, and they, if necessary, climb the trees and throw the moss down. It is piled up in heaps, if on highland, where it is gathered, or if in the swamps, it is brought out in boats and piled in convenient heaps of several hundred pounds, like hay ricks or shocks. When cured to the owners satisfaction, it is scattered and dried, it is then hauled or sold to the country dealers who bale it. Country moss is baled like hay in bales of unequal size, weighing from 200 to 500 pounds weight…There are some half dozen different firms in this city [New Orleans] engaged in receiving on consignment and selling moss…Moss is sent to all parts of the United States and Canada, and large quantities are sent to France and Germany. It is used for making mattresses, stuffing chairs, cushions, car seats and all uses to which hair was applied (Robinson in: Dennett 1876:240-242).

Early Federal Improvement of Bayou Terrebonne

In 1879, the U.S. Congress authorized the first Federal examination of Bayou Terrebonne (U.S. Army Corps of Engineers [USACE] 1888:1250). An initial amount of $18,000 was approved "for dredging and removing logs, snags, and other obstructions", however, the preliminary assessment was "made in high water" and was later found insufficient for necessary improvements (USACE 1888:1250). With a final appropriation of $38,000 set aside, dredging commenced in 1880 and continued in 1881 "from a point about 23½ miles below Houma" (USACE 1888:1250). Through this contract work some 7.5 miles of channel was improved, and;

> In 1882 work was resumed with Government plant and hired labor, and completed to within about 10½ miles of Houma. In 1886 work was again resumed by Government plant and hired labor, and about 164,165 cubic yards were dredged out and 4.1 miles advanced during the year 1886-'87. Work was continued until December 17, 1887, when the channel was completed to the railroad depot at Houma and a turning-basin dug there thus completing it, according to project, $3,000 within the estimate. The Government dredge had done excellent work at a cost of about 4 cents per cubic yard for dredging. The bayou between its low-water banks was of less width than the dredge-boat; consequently to do any work she had to first cut a channel of her own width and then cut turnouts or passing places every few hundred yards to enable floating, sailing, or steam craft to pass. When this improvement was commenced, the Bayou Terrebonne was in places little more than a drainage ditch. Where the dredge began work, the bayou was but 11 feet wide. Nearly every plantation on the bayou has a drainage ditch emptying into the bayou, and below the mouth of each ditch a bar is formed so that work done by the dredge one year is frequently obliterated during the next. The improvement enables planters on the bayou to float their produce to Houma, the nearest railroad station, instead of hauling it there over wagon-roads, and it drains the neighboring country (USACE 1888:1250).

The work described was conducted for the most part under the direction of Major W. H. Heuer of the U.S. Army Corps of Engineers (USACE). His successor, Captain W. L. Fisk, assumed leadership on 1 November 1887, and the general consensus of all parties engaged in the Federal work agreed that the improvements were only temporary. This condition would remain unless drainage ditches empting into Bayou Terrebonne were permanently closed, and "drainage was turned towards the swamps" (USACE 1888:1250). In the preceding fiscal year (1886-1887), the products cultivated along Terrebonne Bayou consisted of sugar and molasses with a value of $967,500 (USACE 1888:1250).

Early Federal Improvement of Bayou Black

The initial Federal examination of Bayou Black commenced during January 1881 through the 14 June 1880 authorization by the U.S. Congress. Thirty-five thousand dollars was set aside for improvements over the course of the next four years. Exactly as the case of Bayou Terrebonne, intervals of work were supervised by Major Heuer and by Captain Fisk. In April 1885, the bayou was inspected and an excerpt of the report follows:

> From the village of Tigerville [Gibson] to the spot where the dredge is at work, about 10 miles above, the Bayou Black has now a depth of 5 to 6 feet of tide-water. The width of this water-way varies from 45 to 100 feet. The greater portion of this 10 miles has been worked over by the dredge, and the last 4 miles is practically a canal in the bed of the bayou, which has been dug by the dredge. As fast as the digging progresses the ditch or canal which is being dug becomes filled with sediment, grass, logs, roots, and stumps, and contains so little water, that at present it is impossible to float the lightest skiff. When the examination was made in April, 1885, and resulted in a stoppage of the work, principally because the appropriation [$] was about exhausted, I doubt if there was 50 gallons of water per minute flowing in the bayou, and a few days before this the ground in front of the dredge was so hard that it became necessary to hire four mules and a plow to break the ground so that the dredge could work. In fact, following the rank, tall grass growing in the old bed of the bayou is the practical method of tracing its course. From the point where the dredge has now stopped working to the town of Houma via the line of the bayou (the proposed improvement) is 14 miles in length. The bed of the bayou is filled up with mud and obstructions very nearly to the level of the roads on each side of it; so that to complete the work contemplate will yet practically require the digging of a canal

> 45 feet wide by 6 feet deep by almost 14 miles in length. The muck, &c, thrown out of the canal is so oozy or semi-fluid that much of it will run back into the canal, and it is probable that a pile and timber revetment may have to be built over a considerable portion of the route to prevent this. On each bank of the bayou is a wagon-road 25 to 40 feet in width, just beyond which are the fences of plantations and small farms. The muck must therefore be thrown on the road, obliterating that on one side, perhaps on both, and making either of them for the time being almost if not entirely impassable. When the canal, or ditch, shall have been completed to Houma it will enable small boats (probably flat-boats) to carry sugar and the material products of the country from the plantations bordering on the bayou from Tigerville to Houma, an extreme distance of about 24 or 25 miles. It is said that upwards of twenty-five years ago a steamboat once ran in this bayou up as far as Houma, but one can judge of th[e] character and capacity of a steamboat that can run in a ditch 40 feet wide and no place in this ditch where such a boat can turn around, and it is also probable that should a steamboat be put on this route, the wash of her waves would again cause the soft banks to slough and cause the closure of the canal (U. S. Army Corps of Engineers [USACE] 1886:1400-1401).

Postwar and Late-Nineteenth Century Growth of Seafood Industries

Marine resources also became an important industry in the region by the end of the nineteenth century. In 1865, Chinese immigrant Lee Yim introduced a method to dry shrimp, which prevented spoilage (Goodwin et al. 1998:69). With trawling, which was introduced during World War I shrimp could now be caught and processed in large numbers. Oysters provided a second source of export for Terrebonne residents. Oysters were off loaded from luggers by air suction and conveyed to steamers to be brined and cooked in the shell; once cooked they were mechanically shucked (Birchett and Pearson 1998:10). As the industry expanded a number of canning houses opening in Houma, and soon the city became one of the largest shrimp and oyster shipping ports in the world (Birchett and Pearson 1998:10).

Reemergence of Terrebonne Plantation System

In April 1890, *The Louisiana Planter And Sugar Manufacturer* (*TLP&SM*) published the following account related to agricultural interests near Caillou Bayou. The journal remarked that:

> A drive on Grand Caillou the other day revealed fine crops of cane and corn on the Honduras, Woodlawn, and Ashland places, and the crops were clean, well worked, and of that healthy dark green color, which delights the heart of the agriculturist (Louisiana Sugar Planters' Association [LSPA] 1890a:296).

During the following month, *TLP&SM* reported in its *Terrebonne Letter* section that "the tail end of the cyclone which devastated northern Texas struck our parish, accompanied by a tremendous flood of rain…planters on the Dularge are well protected by levees, and if they hold, the lower part of Grand Caillou is safe (LSPA 1890b:335-336).
In November 1891, the American Bankers' Association (ABA) members convened at New Orleans, where they socialized with representatives of the city's cotton exchange, the Mechanics, Dealers, and Lumbermen's exchange, the board of trade, and the Southern Pacific Company (SPC) (American Bankers' Association [ABA] 1891:9). On 9 November, President Hutchinson of the Morgan Company (and SPC) sent this invitation to ABA members:

> With a view of affording the members of your Association an opportunity to inspect the *modus operandi* of sugar making in all its phases on our Louisiana plantations, this company takes pleasure in tendering a special train for a trip to Mr. Hal Minor's Southdown Plantation, Terrebonne Parish, leaving our ferry landing, Elysian Field street, 9 A. M., Friday, 13 November, and returning to the city before dark same afternoon (ABA 1891:14).

Nineteenth-Century Navigation On Terrebonne Waterways

Boats were the main form of transportation along the bayous of Terrebonne Parish. Roads were virtually nonexistent, and those few present were confined to high ground along the levees. Because of the importance of water travel, maintenance of waterways was a primary concern for area residents. As early as 1823, Terrebonne landowners were required to keep clear 10-foot-wide channels along the bayous that bordered their lands (Birchett and Pearson 1998:10). In 1825, a canal was cut between bayous Lafourche and Terrebonne. Though shallow, the canal served as the main shipping route to the Thibodaux. During the 1840s, the Barataria Canal was dredged creating a continuous waterway between Morgan City and New Orleans. Products shipped via the canal included lumber, sugar, moss and molasses (Birchett and Pearson 1998:10).

A variety of craft were employed in the waters of Terrebonne. These included: pirogues, chalands, esquifs, bateaus, flats, keelboats, luggers, sloops, schooner and steamboats. All of these varieties were involved in the moving of people and goods to markets in New Orleans or regional centers such as Houma, Thibodaux or Donaldsonville. Goods shipped to market consisted of rice, corn, cotton, sugar, molasses, indigo, tafia [un-aged rum] and lumber. Sugar, molasses and rice was typically transported to New Orleans in sailing craft such as pirogues, luggers, sloops and schooners (Birchett and Pearson 1998:10-11).

For bulk shipments flats were the preferred watercraft. Flats were well suited to shallow waters of the bayous and were cheap to build and maintain. Even after the introduction of the steamboat flats continued to be popular. One popular regional type was the Cordelle boat, which was a flat pulled by a rope by men or draft animals along the levees. Steamboats arrived in the shallow marshes of Terrebonne Parish during the 1830s. One of the first to operate exclusively in the parish was the *S. F. Archer*. The *Archer* was owned by the J. J. Schaffer & Company. This steamer navigated along Bayou Black bringing regional goods and passengers to the railroad terminal at Tigerville (Birchett and Pearson 1998:12).

The Daigle Barge Line operated a number of steamers in Terrebonne including: *Harry*, *Laura*, *N. H. Breaux* and the *Sadie Downman*. These steamers usually towed barges loaded with agricultural products to New Orleans and returned to Houma with foodstuffs, dry goods and other supplies. The *Harry* and *Laura* were also employed in the shipping of Beaumont Oil. When shipping oil, steamers towed long streams of barges with as many as 10. The last barge trailed an anchor to keep the entire train from swinging in the channel (Birchett and Pearson 1998:13). The Daigle company built and maintained its own barges and often dredged the bayou to keep their steamers in operation.

Houma served as the head of navigation on Bayou Terrebonne and developed into the main port for the region during the nineteenth century. Prior to the Civil War flats traveled throughout the lower bayou collecting freight from the plantations for shipment at Houma by rail or sailing vessel to New Orleans. After the Civil War concluded, steamers supplanted flatboats. The bulk of their cargoes consisted of sugar and molasses. Other important cargoes included lumber, grain, fertilizer, oil and potatoes.

By the early decades of the twentieth century, oyster and shrimp became major regional exports. Between 1888 and 1935 tonnage shipped through Terrebonne increased from 5,416 to 115,666 (Birchett and Pearson 1998:16). During that same period, vessel traffic increased from 15 steamers and 9 barges to 252 steamers and 2,184 barges (Birchett and Pearson 1998:16).

The reliance on water travel led to the development of a local shipbuilding industry. Though a vast majority of area boats were built for personal use there were a few commercial builders within Terrebonne by the end of the nineteenth century.

Cypress was the wood of choice among area builders. One prominent builder was John A. Boyne, who employed his sons: John Madison, Andrew and Bill (Birchett and Pearson 1998:11). Boyne's yard was located in lower Terrebonne at Madison's Canal and was comprised of two slipways. Another area builder, Ernest Rhodes, established one of the first and largest slipways in Terrebonne (Birchett and Pearson 1998:12).

As the nineteenth century concluded, perhaps the most interesting individuals plying the waterways of the parish were the descendants of Louisiana's original inhabitants. Miller (2004:176) related that anthropologist M. Raymond Harrington spoke about this Louisiana group:

> [R]reporting that the 'Houma tribe, near Houma, Terrebonne Parish, is now nearly extinct; French is the prevailing language to-day, and the Houma live like the white people about them'. Harrington also went on to report, however, that they possessed surviving Indian arts, including fine double baskets of apparently Indian type and a unique cypress wood blowgun, and that they fashioned dolls stuffed with Spanish moss and decorated with gar scales. At the turn of the century the scholars noted Houma men continued to produce dugout canoes, or pirogues, using them to traverse the network of area canals.

Twentieth-Century Historical Overview

Ramping Up of State Regulation of the Shellfish Industry

By the turn of the nineteenth century, Louisiana legislators concluded "that it was time that the [oyster] industry should be studied, and that some intelligent information should be gathered concerning the subject" (Oyster Commission of Louisiana [OCL] 1904:6). Even though state regulations were first enacted in the years following the American Civil War, most interested parties agreed that it "was a notorious fact that these oyster laws, existing from 1870 to 1900, were recognized more in their breach than in their observance" (OCL 1904:6).

During its first meeting on 11 August 1902, the Oyster Commission of Louisiana (OCL) resolved to "instill into the minds of those engaged in the oyster industry the necessity of observing laws" (OCL 1904:7). Acting under authority of the Louisiana legislature, the nascent commission "divided the ten coast parishes of the State into …inspection Districts, appointed therefor [sic]… inspectors and collectors[,]… and established… ports of entry" (OCL 1904:7). Governor W. W. Heard appointed five commissioners to lead the original organization, and these included "MR. JAS. M. BREAUX" of Terrebonne Parish (OCL 1904:5).

Owing to its geographical importance, Terrebonne Parish was looked to for the appointment of two of the five executive officers, president (J. M. Breaux) and chief inspector (Harry Cage) (OCL 1904:5). The two regulatory [and taxing] districts related to the current project area, and their respective personnel, were identified as follows:

> Inspection District No. 6, to include that portion of the Parish of Lafourche, West of Bayou Lafourche and that portion of the Parish of Terrebonne as far as the east bank of Bayou Little Caillou, and Last Island, Thomas Prevost, Deputy Inspector, at $60.00 per month. Ports [sic] of entry, Houma, La., J. D. Brown, Collector, at $50.00 per month [and] Inspection District No. 7, to include that portion of the Parish of Terrebonne, west of the east bank of Bayou Little Caillou, including Last Island, Alidore Guidry, Deputy Inspector, at $60.00 per month. Port of entry, Houma, La. (OCL 1904:8).

In order to "evolve order out of chaos", approximately 1500 "boats and vessels engaged in the oyster business" were "measured up so that licenses might be issued to them" in respect to what district the oystermen identified as their permanent residences (OCL 1904:8). A list of Terrebonne Parish oyster bedding grounds leased by the "Police Jury" prior to 11 August 1902, and registered by the OCL identified 112 leaseholders (OCL 1904:46-48).

Of that number, 14 reported Houma as their legal address and included members of the Blum, Cenac, Cellestin, Dumons, Dupont, Frazier, Hotard, LeBoeuf, and Palmieri families (OCL 1904:46-48). Similarly, four Dulac residents holding oyster leases in Terrebonne included three members of the well-known Cenac family and "Carlos, S., Est" (OCL 1904:46).

The 1902 aggregate for Terrebonne Parish reached over 1000 acres, with an average oyster bedding ground of 10 acres. The largest bed leased to Hypolite Aymar ["& wife"] of Cut Off, Louisiana amounted to 20 acres [southern shore of Bay Des Mangles], while the smallest of 2.24 acres [western shore of Bay Aux Huitres] was leased to T. Engerran of Daspit (OCL 1904:46-47).

A sensational maritime accident involving a local oyster lugger occurred in Terrebonne Parish during early 1911. Ultimately, a lawsuit developed that was heard by the Supreme Court of Louisiana in June 1915. The summary of *Landry et. al v. Duplantis et al.* follows:

> Omer Landry is a fisherman, who had been engaged for a number of years in boating oysters and fish from the coast of Terrebonne parish to Houma, La., by way of Bayous Terrebonne and Little Caillou, both navigable streams in said parish. About 3:30 o'clock a.m. on February 8, 1911, the said Landry was pursuing his usual course to Houma through Bayou Little Caillou in his lugger laden with oysters, the said boat being propelled by a gasoline motor, and having on board his wife, their three children, and a helper, when the said lugger struck an unopened bridge spanning the said bayou, which was left closed negligently, through the fault of the defendants; that the collision broke the top of the boat, and burst open a tank containing gasoline, which, being ignited by a lighted lamp caused an explosion which enveloped the boat in flames; that the said Landry, his wife, and their three children were severely burned; that their two little girls died about four hours after receiving the injuries, and their infant boy remained under medical treatment for more than two months (*The Southern Reporter* 1916:271).

Contemporary Agriculture in Terrebonne Parish

At the turn of the century, a national "Newspaper Annual" reported that the *Courier* (Democratic-circulation 350), and the *Terrebonne Times* (Republican-circ. 400) was available for the parish audience of 24,464. Both newspapers were printed in Houma, which now boasted a population of 3,212. The only other comment was: "Dem. Vote in 1900, 740; Rep. 490. Level, with much forest and marsh land; soil fertile. Products—Sugar and molasses largely produced; corn, rice cotton; [and] live stock" (*N. W. Ayer* 1902:1124).

At this date, State Chemist William C. Stubbs (and director of Agricultural Experiment Station-Louisiana State University) studied samples of fertilizers distributed at numerous cultivated sites in Terrebonne Parish. In the conduct of the investigation aimed to protect Louisiana's farmers from fraudulent fertilizer dealers and to monitor cultivation, a 1902 bulletin compiled by Dr. Stubbs and his colleagues at the state-sponsored organization identified several sugarcane plantations (and owners/managers) in the subject parish (Stubbs 1902:1-3).

Terrebonne cane growing interests operating in 1901/1902 included; J. W. Martin (Houma), H. C. Minor of Southdown Plantation (Houma), H. C. Minor of Hollywood Plantation (Houma), Greenwood Planting and Manufacturing Company-Greenwood Plantation (Gibson), L. F. Suthon of Honduras Plantation (Houma), J. J. Shaffer of Magnolia Plantation (Minerva), John D. Shaffer of Ardoyne Plantation (Ellendale),

Crescent Farm Planting Association of Crescent Farm (Houma), Charles B. Maginnis of Ranch Plantation (Houma), Charles B. Maginnis of Ashland Plantation (Houma), Charles B. Maginnis of Woodlawn Plantation (Houma), Charles B. Maginnis of Sarah Plantation (Houma), Charles B. Maginnis of Aragon Plantation (Houma), Caillouet & Maginnis of Cane Brake Plantation (Houma), Argyle Manufacturing and Refining Company (Houma), Cambon Brothers (Houma), David Levy of Isle of Cuba Plantation (Schriever), John T. Moore Planting Company (Schreiver), McCollum & Cocke of Cedar Grover Plantation (Ellendale), Lower Terrebonne Refining Company of Point Farm Plantation (Houma), Lower Terrebonne Refining and Manufacturing Company of Lucashe [or Lacashe or Lacashi] Plantation (Houma), Cambon & Champagne of Klondyke Plantation (Bourg) (Stubbs 1902:44, 124, 131-132, 136-140, 144-145, 159).

Owing to the international importance of many of these sugar interests, the 21 May 1906 issue of *The American Sugar Industry And Beet Sugar Gazette* reported from New Orleans that:

> One of the largest transfers of sugar property ever recorded in Louisiana was the sale of the Terrebonne properties of Caillouet & Maginnis to the Ashland Planting & Manufacturing Company for $450,000. The sale includes the Ashland, Woodlawn and Ranch plantations, in Terrebonne parish [sic], together with their swamp lands and machinery equipment. The Ashland Planting & Manufacturing Company was organized especially for the purposed of taking over the Caillouet & Maginnis holdings. J. N. Caillouet, the former half owner of the three plantations, has been elected president of the new company, and his son, J. L. Caillouet, is vice-president and general manager. They are heavily interested in the corporation…The firm of Caillouet & Maginnis was in existence for more than twenty years.

Sections of southern Louisiana, including the subject parish, were "Hit Heavily" during the late September 1915 hurricane, in which "[m]ost of the sugar factories in Terrebonne…were unroofed and had their smokestacks blown down" (*TLP&SM* 1915a:236). Additional reports indicated that the "Old Dulac sugar-house in Lower Terrebonne was demolished" (*TLP&SM* 1915a:236).

Despite widespread local damage to the industrial infrastructure, *TLP&SM* (1915b:299) suggested that grinding commenced by late October and the "Terrebonne sugar situation" showed " a very satisfactory condition". The journal specifically related that:

> Some sections have suffered from the unfavorable hot, dry weather which characterized the past summer, but other sections more favored by peculiar climatic conditions, due to their proximity to the Gulf will give gains to offset in the parish total the damage done in the unflavored places. The best Terrebonne crops are said to be found in the lower Terrebonne, Little Caillou, Grand Caillou and DuLarge sections. Cane cutting began on the Terrebonne Sugar Company places on last Tuesday and the mill began grinding Thursday. On that same day the Ashland refinery started grinding. Rebecca [Plantation] started grinding Thursday too, while Ardoyne was scheduled to begin on Thursday also, Southdown will start grinding about November 8th. The Marmande refinery will not be ready until about Nov. 15th until the repairs of the damage done by the September hurricane are completed (*TLP&SM* 1915b:299).

The same leading industry publication announced more news regarding Terrebonne in its 4 December 1915 issue. At that time, "Residence plantation", owned by Wilson Gaidry [sic], was producing 30 tons of cane per acre [20 considered good average], and advice reprinted from the Houma Courier announced that prominent Terrebonne sugar planter F. T. Landry had "dropped dead while supervising the harvesting of his crops" (TLP&SM 1915c:363). The sequential issue mentioned that Terrebonne factories were "the last" in the state to stop grinding due to better weather than experienced in other sugar growing parishes (TLP&SM 1915d:377). In regard to local yields, the New Orleans based editors remarked that:

> The Terrebonne Sugar Company will not finish grinding until after Christmas. They expect to grind about 60,000 tons this year. Their new 12-roller mill, erected last summer, is reported to be giving them a 5 per cent higher extraction than they got before or that has been gotten heretofore by any of the other mills in that parish. Ashland is making Ashland Standard Granulated and has about three weeks' grinding ahead of it yet. Argyle will finish grinding about December 18th having ground about 16,000 tons and got about 2,750,000 lbs. of sugar. Marmande Bros. expect to grind about 11,000 tons, yielding about 160 pounds of firsts to the ton. Marmande makes only first sugars and molasses and no seconds. Their stubble cane is reported to have yielded about 15 tons to the acre. Ardoyne will grind about 13,000 tons when they only ground about 11,000

> tons in 1914. Their yield is averaging about 150 pounds total with a yield of about 120 pounds of firsts. Ardoyne will finish some time next week. Southdown is expected to finish about December 20th. Southdown is reported to have gotten a yield of about 160 tons total, with a yield of 135 pounds of firsts. Rebecca was expected to finish about the end of this week, having ground about 8,000 tons (*TLP&SM* 1915d:377).

A "successful live stock [*] and diversified products farmer" elected to join the "raise cane contingent in Terrebonne Parish" during late December 1916 (TLP&SM 1916:393). Describing Norman L. Davidson as a "convert" and a complete novice, TLP&SM (1916:393) editors stated that the "lure of cane growing and the prospects for profitable cane seasons for several years yet in Louisiana has got him this time, however, and he is going to plant about 40 acres for next season. His farm is located on Bayou Black, near Houma." [*For superlative history of this local industry consult Livestock Brands and Marks: An Unexpected Bayou Country History: 1822-1946 Pioneer Families, Terrebonne Parish, Louisiana (Cenac 2013)].

In addition to sugarcane, fruits and vegetables (and shellfish) that continued to provide valuable commodities to locals, a by-product of sugarcane became a major industrial concern during the twentieth century. In 1922, the Celotex Company began turning bagasse into insulation board (Goodwin et al. 1998:69). In 1927, Celotex formed the South Coast Company and purchased 26 plantations, including Ashland and Terrebonne. The endeavor lasted until the 1970s when cane production at the historic Terrebonne Plantation was shut down.

Contemporary Navigational Concerns

In 1909, the newly created U.S. Bureau of Corporations remarked on the status of water-borne traffic plying the subject Louisiana coast. Writing to its governing agency (U.S. Department of Commerce and Labor), Commissioner Herbert Knox Smith reported that the region situated between Southwest Pass and the entrance to Atchafalaya Bay was:

> [L]ow and broken by numerous passes which lead from the Gulf to the network of bays and bayous traversing the country west of the Mississippi River. These inland waters are navigable only for small, light-draft vessels. There are no towns along the coast and no harbors that can be used by vessels of over 8 feet draft, even under favorable conditions (*United States Coast Pilot* in: U.S. Bureau of Corporations [USBC] 1909:137).

In regard to local "Louisiana Canals", Commissioner Smith elaborated that:

> The numerous short canals of southern Louisiana contribute to some extent to the water-borne commerce of New Orleans. The Bayou Teche section of southern Louisiana is connected with the Mississippi River at New Orleans by the Barataria and Lafourche ('Company') Canal and Harveys Canal. Through the former of these canals, Bayou Terrebonne, is reached by small boats, and an extension is contemplated to Morgan City, on Grand Lake. Small steamers, gasoline boats, luggers, and skiffs carry through the canal lumber, sugar, moss, molasses, produce, fish, oysters, and game. No records are kept of the annual tonnage movement on these waterways (USBC 1909:135).

Due to the severe storm that struck the locale in September 1909:

> Bayou Terrebonne and adjacent waterways became much obstructed by trees, marsh grass, etc., and, under the provisions of the emergency appropriation act of March 3, 1905, allotments aggregating $10,000 were made by the Secretary of War for the restoration of usual channel depths and removal of obstructions. In Bayou Terrebonne 4,550 feet of channel was dredged; in Bush Canal 5,222 feet; and in Bayou Little Caillou 4,400 feet. Bayou Terrebonne was also cleared of obstructions for a distance of 6,260 feet. The cost of this work was $8,422.73, the balance, $1,577.27, reverting to the Treasury (USACE 1913:751).

Development of Improved Roads and Bridges

The early development of "goods roads" and "better bridges" in Terrebonne Parish coincided with national automobile interests that emerged by 1900. Along with other Americans, Louisianians lobbied for improved roads that would not only support agriculture and industrial interests, but would assure the delivery of mail. This last highly desirable goal was based on the "federal government's establishment of Rural Free Delivery mail service in 1896" (Mead & Hunt 2013:11). As Mead & Hunt (2013:11) aptly commented, "[s]ince a mail route had to be passable in all weather, the designation of a road as a mail route became a reason for funding improved surfaces".

In their excellent report "Historic Context for Louisiana Bridges", Mead & Hunt (2013:54) confirmed the unique trials widely encountered in late-nineteenth-century to early-twentieth-century rail, road and bridge construction projects in the subject state. The authors related that:

> Because great expanses of Louisiana's geography, particularly the southern area of the state, are comprised of rivers, floodplain, marshes, and large areas impacted generally by water, the soils and river beds have presented severe challenges to highway and bridge design and construction. In particular, these soil conditions have pose major problems for the construction of bridge substructures, which include the foundation…The categories of foundations used in Louisiana may not be different from those used nationally, but some Louisiana applications may be more complex, advanced, or experimental because of the special soil conditions encountered in the state (Mead & Hunt 2013:54).

Despite these daunting geological obstacles, by early June 1911, an impressive infrastructure project was completed in Louisiana that greatly (and favorably) affected Terrebonne Parish. According to the national contractor publication *Good Roads*:

> Recent improvements in the reclamation of swamp lands in the parishes of Jefferson, St. Charles, Lafourche and Terrebonne, in the state of Louisiana, have resulted in the construction of a thoroughfare through that territory. This, together with the drainage, will make available an extensive area of very rich alluvial land for agricultural purposes, and open better communication between several business centers. Before the recent improvements were undertaken, the only road between New Orleans and Houma was up along the Mississippi river [sic] to Bayou Lafourche, and down the Bayou to Houma, a distance of approximately 150 miles. Since the reclamation work has been in progress a road has been constructed which, on its completion, will cut off 100 miles of the distance. Only about 3½ miles remain to be built and the business men of Houma are preparing to construct that this season (*Good Roads* 1911:252).

A report submitted to the U.S. War Department for the fiscal year ending 30 June 1913 related that numerous bridges were approved by the Secretary of War to be erected in Terrebonne Parish. The official approval was mandatory under provisions of the March 1899 River and Harbor Act relating to bridges built over navigable waters entirely within the limits of any State. The relevant owner/builder and location follow:

> *Bridges of John D. Minor across Bayou Black near the Argyle Refinery, at the Southdown Refinery, near Houma, Terrebonne Parish, and the Waterproof Plantation (Ormond post office), La.*—Plans and maps of location of theses three bridges were approved July 12, 1912….*Bridge of the police jury of Terrebonne Parish, La., across Black Bayou at its intersection with the Barataria Canal, La.*—Plans for the reconstruction of a bridge at this point were approved September 6, 1912….*Bridge of Katherine L. Minor across Bayou Black at Mandalay Plantation, Terrebonne Parish, La.*—Plans and map of location were approved April 3, 1913. *Bridge of John D. Minor across Bayou Black at Waterproof Plantation, Terrebonne Parish, La.*—Plans and map of location were approved April 5, 1913….*Bridge of the Morgan's Louisiana & Texas Railroad & Steamship Co. across Bayou Cane on the Houma branch of the railroad in Terrebonne Parish, La.*—Plans and map of location for a bridge at this point to replace an existing trestle bridge were approved June 21, 1913 (USACE 1913:1440, 1442, 1447, 1449).

The privately financed bridges identified above were precursors of Louisiana's "earliest bridge standard plans, prepared in 1915 by the Highway Department of the Louisiana Board of State Engineers" (Mead & Hunt 2013:55). Contemporary Louisiana engineers indicated "spread footings as the only option for bridge foundations", and on plans were called 'mud sills'. Mead & Hunt related the sizes varied among designs, but they were "typically rectangular blocks of reinforced concrete, ranging from 3 to 6 feet in length, 2 to 3 feet in width, and not more than 3 feet in depth". By 1917, Louisiana engineers elected to endorse "pile-supported foundations" to construct bridges in the state (Mead & Hunt 2013:55). Pilings were actively utilized in the 1870s to promote railroad bridge construction in the state (Mead & Hunt 2013:56).

In its discussion of historical bridges, Mead & Hunt (2013:75) forwarded the little known fact that "[e]xamples of cable-stayed swing bridges [introduced ca. 1924] are restricted to small bayous in Terrebonne Parish near the Gulf of Mexico and are considered highly uncommon nationally with no other know examples outside of Louisiana". Swing-span bridges were later erected "along Bayou Black, Bayou du Large, and Petit Caillou Bayou" (Mead & Hunt 2013:75).

Navigational improvements undertaken on Bayou Terrebonne during the subject period "consisted in making survey of that section of the bayou under improvement, with a view to using a suction dredge for deepening the bayou and depositing the dredged material on riparian lands" (USACE 2013:752). Federal engineers related that commerce carried on the bayou during calendar 1912 "was valued at approximately $3,394,987, consisting of logs, lumber, fuel oil, cane, sugar, oysters and shrimp, and miscellaneous other products" (USACE 1913:752). A more retroactive study confirmed that short tons carried on Terrebonne Bayou amounted to 189,788 and 142,498 for 1911 and 1912, respectively (USACE 1913:752).

The Emergence of Oil and Gas Industries

Harris (1910:5) related that commencing circa 1899 the "Louisiana Geological Survey, in the course of its geologic work [since 1899] …gather[ed] facts concerning the occurrence of oil and gas in Louisiana, and …published an elaborate report regarding the occurrence of salt within the State, which necessarily brought out many facts relating to oil and gas, the common if not universal accompaniments of saline deposits".

In 1917, a welcome discovery was made that would dramatically change the economy and face of coastal Louisiana, as well as the entire Gulf coast. On 17 March of that year, the first commercial gas well was struck at the Lirette Gas Field near Montegut. Nearly 100 million cubic feet of gas was produced from the well (Goodwin et al. 1998:69).

Public Lands and Private Use

Speaking for the State Land Office (SLO) in May 1920, Fred J. Grace reported that under the authority of the U.S. Congress (September 1841) 500,000 acres were "approved to the State of Louisiana, for internal improvements" (State Land Office [SLO] 1920:12). Register Grace also reported that 9,742,310 acres of land had been "approved to the State under the Swamp Grants of 1849 and 1850" (SLO 1920:11).

The state land register identified 11 "unsurveyed lakes" in Terrebonne Parish due to the fact that lake bottoms had "become very valuable for mineral purposes and [the agency was] frequently called upon to furnish such lists" (SLO 1920:14). According to "original plats of surveys" found in state archives, the water bodies (and their estimated acreage) were Theriot (1,500 acres), Batch (1,000), Quitman's (7,500), Decade (3,700), Allen (1,000), Mechani (7,500), Washa [Penchant] (12,000), Chien (2,000), Billiot (800), Felicity (15,000), and Caillou (18,000) (SLO 1920:14). In addition, Lake Field (6,200) and Lake Long (4,600) were both reported to be situated in Terrebonne and Lafourche parishes (SLO 1920:13).

A *disclaimer* warned that the overall statewide list did not include every lake in Louisiana, and added this interesting explanation:

> We [SLO] find, especially along the lower parishes bordering on the Gulf of Mexico, numerous lakes and bays or bodies of water, the areas of which we have been unable to estimate, for the reason that most of the country is sea marsh and impassable trembling prairies and by not having been surveyed we are unable to arrive at any reasonable estimates, hence we have omitted them (SLO 1920:15).

Contemporary redemption certificates related to Terrebonne Parish land and issued by the SLO identified these adjudicates; Bayou Cane Improvement Company (BCIC), W. P. Langworthy, Adolph Doorak, O. W. Crawford, and E. P. Brady, Albert Davis, and Joseph Gunn "and Wife" (SLO 1920:24, 34, 36). BCIC apparently faced financial difficulties by May 1918 and was forced to forfeit "certain property" to the state, as mentioned in the Louisiana attorney general's report to the governor submitted at that time (Louisiana Attorney General 1918:567). Due to the nonpayment of taxes for the subject period (1916), property formerly belonging to Alfred J. Sterne of Terrebonne Parish was also forfeited to the State of Louisiana circa 1920 (SLO 1920:46-47).

Incongruously, the Terrebonne Police Jury was poised "to reclaim 12,000 acres [of] swamp land" as of 15 July 1920 according to news filed under the heading "Water and Waterworks: Louisiana" as reported by the *Texas Trade Review and Industrial Record (TTR&IR)* (1920:17). The Dallas-based journal also remarked that the parish would pay $60,000 for the former parish real estate (*TTR&IR* 1920:17).

A groundbreaking story published in the December 1920 issue of *Building and Engineering Digest* (1920b:16) remarked under its "Mining" column that:

> Drilling for oil and gas in portion of Terrebonne parish hitherto untried is to be started immediately; Southern Development Co. of St. Louis, owners of leases on several thousand acres in Bayou Cane district, about 3 miles north from here [Houma] [are] completing arrangements for their first deep test.

Established in 1916, *The Oil Weekly* regularly advised industry leaders and interested parties about oil production in the United States, Canada, Mexico, and South America. In looking at the April 1922 edition under the "*Louisiana Wildcats"* column, two firms were reportedly operating in Terrebonne Parish at that time. These companies were identified as Terrebonne and Southern Development Company (Bayou Cane field) and Foundation Oil Company (Lirette well) (*The Oil Weekly* [*TOW*] 1922:66-67, 73).

Advertisements found in the publication featured contact information for experienced petroleum geologists, mining engineers, and expert iron dealers such as Chicago Bridge and Iron Works of Dallas, and F. W. Heitman Company of Houston (*TOW* 1922:67).

Sell and McGuire (2008:14) commented that The Texas Company (TTC) (est. 1902 by entrepreneur Joseph S. Cullinan) eventually developed a Port Arthur pipeline system and refinery that expanded into East Texas and Louisiana fields. By 1928, TTC [marketer of TEXACO brand] contracted with Louisiana Land and Exploration Company "to explore and drill in southern Louisiana" (Sell and McGuire 2008:14). Subsequently, TTC negotiated directly with Louisiana officials "to develop oil fields in the water areas of coastal Louisiana", and needless to say, this legal and political foray "meant dealing with Huey Long" (Sell and McGuire 2008:14).

Extant records indicate that oil "was first discovered in Terrebonne Parish in 1929" after TTC purchased wells located at Lakes Pelto and Barre (Sell and McGuire 2008:14). The "major field of Caillou Island started producing in 1930", followed by successful drilling at Four Isle Bay (1934), and Gibson (1937) (Sell and McGuire 2008:14). There was an immediate reaction in the very rural jurisdiction including the creation of numerous new commercial ventures. Sell and McGuire (2008:35) remarked that: "Houma was the largest town in the parish, and the oil field businesses tended to locate there. In the Houma City Directory of 1938-39, a total of 22 businesses were listed as 'oil and oil services'.

Oilfield services naturally required a tremendous amount of specialized equipment as well large numbers of indispensable vessels called supply boats. Sell and McGuire (2008:35) described less obvious but equally critical equipment as such:

> The oil fields of Terrebonne Parish, as all of the inshore and offshore areas, demanded new approaches – the soft wetlands required submersible drilling barges and a host of specialized boats, the soft sediment required use of heavy drilling fluids ('muds') and cemented casings to hold the wells open, the high pressure mixture of oil and natural gas necessitated precautions for preventing blowouts, the highly corrosive gases in the wells required special metal products to maintain product integrity, and the list goes on. All of these requirements, and more mundane needs to supply and service the rigs, spawned a large oilfield service industry.

As of 1938, the total annual production of oil in Terrebonne reached over eight million barrels and that of natural gas over 63 million cubic feet (Goodwin et al. 1998:70). By the following year, natural gas production had increased over eight times to more than 528,810,000 cubic feet (Goodwin et al. 1998:70).

To support the growing industry, canals were cut through the marshes to service the wellheads and to transport oil products for shipping. Port Fourchon was later developed as a deep-water access for tankers servicing the wells of Terrebonne and the surrounding region.

Early Modern Period (1950-1989)

Along with purpose built and jury-rigged watercraft utilized by the oil and gas industries, locals continued to navigate the bayous and canals in an equally diverse array of vessels. During the 1950s, Bill Cenac operated the lugger *Flossie,* originally built circa 1910 as a sailboat (Cenac 2011:20). After collecting ice and supplies, Cenac's general route would commence behind a Houma oyster house and he would then proceed down Bayou Terrebonne until reaching Presque Island. At that point, Cenac would arbitrarily elect to stay in that waterway or veer right into Bayou Little Caillou (Cenac 2011:19). After trawling within interior waters, Cenac would normally conclude the descent at Timbalier Island or Isle Dernière (Cenac 2011:19).

During 1956, a comprehensive soil survey of Terrebonne Parish was conducted by a team of scientists affiliated with the Louisiana Agricultural Experiment Station, and the U.S. Department of Agriculture. The ensuing report issued during 1960 remarked that:

> In making this survey, soil scientists walked over the fields and woodlands and explored marsh areas that could only be reached by boat. They dug holes and examined surface soils and subsoils [sic]; measured slopes with a hand level; noticed differences in growth of crops, weeds, and brush; and, in fact, recorded all the things about the soils that they believed might affect their suitability for farming, trees, wildlife, and related uses (Lytle, McMichael, Green and Francis [Lytle et al.] 1960:i).

The 1956 soil study also provided a contemporary look at rural Terrebonne Parish with respect to private and commercial development. In regard to residential development, Lytle et al. (1960:4) suggested that all settlements were situated on elevations along the parish's navigable streams, and that in several of these communities, "there [was] a continuous row of houses along each side of the highways that parallel the major streams". Furthermore, the report remarked that:

> Small settlements or communities have been built up around many of the large plantation headquarters in the parish. These plantation settlements include[d] the dwellings of landowners or operators, tenants and laborers, and outbuildings such as barns, implement sheds, and shops.

> Many plantation settlements have 10 to 30 dwellings as well as a general store. Large community settlements have been built up around the two sugar mills in the parish (Lytle et al. 1960:4).

With respect to the industrial environment of 1956-era Terrebonne Parish, the authors noted that the production of sugar (raw and processed) ranked as the principal agriculture. At the time of the soil survey, two large sugar mills offered full-time employment for many workers. Data related to 1954 harvests confirmed that sugarcane was cultivated on at least 15,419 acres in the parish, and that number equated to six percent of the total crop harvested in the state. Lytle et al. (1960:4) described other contemporary [1956] industries as such:

> Commercial fishing and seafood processing bring in large sums each year. A number of plants for processing and canning shrimp, crabmeat, and oysters employ skilled and unskilled labor. There are several meatpacking plants in the parish. Terrebonne Parish is in the large fur-producing area of southern Louisiana. The annual take of muskrat, mink, otter, raccoon, nutria, and opossum is valued at thousands of dollars. The areas of coastal marsh are a winter feeding ground for wild geese and ducks. Considerable income is derived from hunting and fishing licenses, sports equipment and transportation.

In looking at skilled labor and land use within the parish, Lytle et al. (1960:4) also touched on the construction and maintenance of vessels other than vernacular fishing watercraft, such as tugboats, barges, trawlers utilized by agricultural and oil and gas interests in Terrebonne. Circa 1956, the "construction and maintenance of many miles of pipelines for oil, gas, and water [was also] a major enterprise in the parish" (Lytle et al. 1960:4).

Contemporary journals such as *International Oil and Gas Development (IO&GD)* provided the discovery dates of wells, depths, and geological assessments of each well located in Terrebonne Parish. For example, a 1960 issue of *IO&GD* identified several parish wells including these fields; Bay Baptiste (discovered August 1938), Bourg (March 1952), Bourg South (August 1957), Gibson (February 1937), and Gibson East (1943) (International Oil Scouts Association 1960:222, 224, 226). That journal, its predecessor, and other similar industry sources serve as excellent archival collections to search for more man-made land and waterway disturbing activities of this era.

A quantitative comparison of crude petroleum and natural gas shipments for 1958 and 1963 years originating in South Louisiana was compiled by the U.S. Bureau of the Census (USBC) in its *1963 Census of Mineral Industrie*s.

In respect to the subject region of interest, statistical information for Lafourche, Terrebonne and "Saint Mary" parishes are shown in Table 1.

PARISH	CRUDE PETROLEUM PER 1000 BARRELS		NATURAL GAS PER MILLION CUBIC FEET	
	1958	1963	1958	1963
LAFOURCHE	29,935	37,079	129,615	198,750
TERREBONNE	24,827	54,572	214,775	553,531
SAINT MARY	13,487	23,642	61,473	235,070

Table 1. Quantity of crude petroleum and natural gas shipped from select parishes for 1958 and 1963 (U.S. Bureau of the Census [USBC] 1967:13B-64).

The 1963 report also verified the number of active oil and gas drilling interests in the three parishes for the census year. This tally provided relevant information regarding exploration services and field support services (surveys, logging and cement work) in Lafourche, Terrebonne and St. Marys. The breakdowns for these chiefly rural parish activities are shown in Table 2.

PARISH	DRILLING	EXPLORATION	FIELD SUPPORT
	1963	1963	1963
LAFOURCHE	49	38	33
TERREBONNE	35	12	12
ST. MARYS	33	NA	NA

Table 2. Quantity and industry type from select parishes for 1958 and 1963 (USBC 1967:13D-29).

Terrebonne Parish School Board v. Mobil Oil Corporation

In addition to the obvious land-use activities previously described, oil and gas interests also dredged canals in Terrebonne Parish that supported their commercial efforts. In some locations, where these activities ceased, abandoned canals contributed to significant erosion and adversely impacted outlying swamp or marsh areas. An interesting example of this set of circumstances was illustrated by the case of *Terrebonne Parish School Board* v. *Mobil Oil Corporation* (*Terrebonne Parish School Board* v. *Mobil Oil Corporation* [*Terrebonne Parish School Board v. Mobil Oil Corp*.] *2002*).

In December 1957, the Terrebonne School Board (TSB) leased a 640-acre tract to Southern Natural Gas (SNG) for an initial sum of $38,835. The subject public land comprised of "coastal marsh" was located in western Terrebonne and was "one of many Section 16 tracts managed" by the parish board (*Terrebonne Parish School Board v. Mobil Oil Corp*. 2002).

According to a case synopsis, TSB granted SNG "and its assignees the right to dredge canal on the property and to perform other works conducive to oil and gas exploration" without a mandatory requirement to "refill any canals upon termination of the lease" (*Terrebonne Parish School Board v. Mobil Oil Corp*. 2002).

At some point, Magnolia Petroleum Company (MPC) [and predecessor of Mobil] contracted through a "farm-out agreement"* with SNG to dredge a canal in the southeast section of the subject TSB tract (*Terrebonne Parish School Board v. Mobil Oil Corp*. 2002). By Christmas 1959, all drilling and dredging activities ceased and a well on the subject tract "was plugged and abandoned" (*Terrebonne Parish School Board v. Mobil Oil Corp*. 2002).

However, the accessory canal dug by MPC to access the well was also abandoned and commenced to diminish TSB marshland (*Terrebonne Parish School Board v. Mobil Oil Corp*. 2002). *[Farm-out agreements are frequently utilized in the petroleum industry in instances where the owner of a mineral lease is unable or unwilling to drill a lease nearing expiration but is willing to assign an interest to one willing to assume the drilling obligations and save the lease from expiring (*Terrebonne Parish School Board v. Mobil Oil Corp*. 2002fn).

By 1965, the New Orleans Geological Society had plotted nearly 36 oil and gas fields in Terrebonne Parish plus "17 offshore blocks" that were under production at that date (Sell and McGuire 2008:14). According to research conducted by Sell and McGuire (2008:14), Texaco was the largest oil concern operating in the subject parish.

In the same year, the oil colossus was named in a lawsuit that reached the Louisiana Court of Appeal, First Circuit. The subject case, *Terrebonne Parish School Board v. Texaco, Inc*., 178 So. 2d 428 (1965), hinged on the disputed rights of Texaco which had assumed mineral rights from a perfectly legal assignment from Union Oil Company of California dating to the late 1940s.

The case provides an excellent overview of the complexities related to the leasing of mineral rights on public land during the 1900s in Terrebonne Parish, and how this class of modern litigation correlates with the equally complicated unique nature of eighteenth-century and nineteenth-century laws regulating land use in Louisiana. Ironically, the contentious and expensive suit centered on:

> [T]he bed of what is known as Mud Hole Bay and Mud Hole Bayou situated in Section 16, Township 21 South, Range 14 East. Mud Hole Bay and Mud Hole Bayou are situated along the Louisiana Coast line. The Bay comprises the greater portion of Sections 15 and 16 of said township and range and Mud Hole Bayou runs in a southerly direction to Mud Hole Bay (*Terrebonne Parish School Board* v. *Texaco, Inc*. 1965).

Early Environmental Impact Marshland Survey

Although a dual marine and terrestrial survey [supported by aircraft] carried out in Terrebonne Bay and adjacent marshland during 1972 was not engineered to collect cultural resources data, the resultant document reported interesting cutting-edge field activities. Scientists affiliated with Earth Resources Laboratory and Lockheed Electronics Company performed the survey to "assess or predict" human impacts in the bay and marshland. Study results were compiled in the collaborative document entitled "Terrebonne-Barataria Bay I Remote Sensing Study May 5, 1972, Part 1, Surface Measurements. Report No. 016.". The published abstract for the forward-thinking 1972 study follows:

> The Terrebonne/Barataria Bay I experiment was performed on 5 May 1972, as a cooperative venture of the Earth Resources Laboratory (ERL), the New Orleans Corps of Engineers (NOCOE), the Louisiana Wildlife and Fisheries (LWF) and Louisiana State University (LSU). Much of the mission planning and ground truth data compilation was done or directed by the Lockheed Electronics Company, the support contractor to ERL. The purpose of the experiment was to develop techniques for water and marsh parameter measurements which could help assess or predict man's Impact upon the Terrebonne and Barataria Bay regions. The experiment consisted of simultaneous collection of remote aerial, ground, and atmospheric information. Remote data was gathered by two aircraft, the Lockheed Electra Earth Resources Aircraft from the Manned Spacecraft Center at Houston, and an E-18 Twin Beech leased by ERL. Ground information was gathered by 33 boats, 30 of which were supplied by NOCOE, the other three by LWF. Atmospheric Information was gathered from weather stations adjacent to the experiment area and from regional information supplied by the National Weather Service. Water analysis was done by scientists from Louisiana -State University. Remotely gathered data consisted of color and color IR imagery, thermal imagery and microwave radiometric measurements at 21cm wave- length. Color, color IR and thermal imagery were obtained three times at 6 hour intervals to provide sequential data for circulation analysis. The 21cm data is being used to evaluate a technique for remote salinity measurement. The ground truth data gathered by the boats, and the atmospheric data are presented in this report (Earth Resources Laboratory and Lockheed Electronics Company 1972:1).

Mitigation Studies Addressing Parish Land Loss

In the early 1980s, with a view to address factors contributing to the alarming rate of land loss in the jurisdiction, several studies were prepared for Terrebonne Parish officials. A particular report submitted to the TSB followed the body's May 1981 reconsideration of a request by a private concern to dredge a new canal on public marshland (a Section 16 tract). In describing the document authored by a leading engineering firm, germane case law commented that:

> Indeed, the stated purpose of T. Baker Smith's January, 1982 preliminary erosion study was 'to assist the Terrebonne Parish School Board and residents of Terrebonne Parish to become aware of the rate of erosion occurring within Terrebonne Parish.' The School Board intended that the January 13, 1982 erosion study of Section 16 lands 'serve as a basis for approximating land loss rates throughout the parish.' Summarizing the causes of erosion affecting all of Terrebonne Parish's Section 16 lands, T. Baker Smith, Inc.'s 1982 report concluded that 'direct, man-influenced causes' included '(1) the breakup of fresh marsh and flotant because of increased salinities introduced by navigation, drainage, and petroleum-related canals, [and] (2) the replacement of land area by canals.' Hence, on August 17, 1982, the School Board passed a resolution that acknowledged the erosion problem (*Terrebonne Parish School Board v. Mobil Oil Corp*. 2002).

Major Hurricane Events (1900-1999)

According to local research compiled by *The Daily Comet* (Thibodaux LA) and accessed from NOAA sources, a brief chronology of tropical storms affecting Terrebonne Parish and the region during the twentieth century follows:

> Sept. 20, 1909: A hurricane struck south Louisiana with winds of 80 mph reported in Thibodaux. The storm, which reportedly tracked between New Orleans and Baton Rouge, packed a 15-foot storm surge and killed 353 people. Damage totaled $6 million. Oct. 16, 1923: A minimal storm struck near Point Au Fer, an island off the western Terrebonne Parish coast. In Morgan City, tides rose 3.6 feet. Aug. 25-27, 1926: A Hurricane struck near Houma with winds estimated at 100 mph at Grand Isle.

A 10-foot storm surge was reported at Timbalier Bay. Tides as high as 15-feet above normal were reported throughout southern Terrebonne Parish. The storm killed 25 people and caused $4 million in damage. Thibodaux and Napoleonville had winds of 120 mph. Thibodaux lost three churches, a warehouse and 10 stores. June 16, 1934: A storm hit near Morgan City, killing seven and causing $2.6 million in damage. Winds were registered at 68 mph in Morgan City. Sept. 3, 1948: A hurricane hit Timbalier Bay in Terrebonne Parish, bringing 90 mph gusts. A 5-foot storm surge was reported. Damage: $888,000, most to offshore oil and gas rigs. Sept. 10, 1961: Hurricane Carla struck southwest Louisiana, spawning 10 tornadoes. It killed six people and caused $25 million in damage. Oct. 3, 1964: Hurricane Hilda hit Salt Point and spawned tornadoes in Golden Meadow, Galliano. Larose, Kenner, Metairie and New Orleans. Thirty-nine deaths were associated with the storm, including 24 in Larose. The storm dumped more than 17 inches of rain on Iberia Parish and pushed more than 7 feet of water into Cocodrie. Damage totaled $53 million. July 11, 1979: Hurricane Bob struck Terrebonne Bay as a minimal storm. One person was killed. Oct. 27-31, 1985: Hurricane Juan was a minimal but wet storm that looped across south Louisiana for several days. More than 15 inches of rain fell in spots in Lafourche and Terrebonne parishes. Storm surges of 8 feet were reported at Cocodrie, and floodwaters topped levees in Montegut, Lockport and Marrero. About 200 head of cattle drowned in Terrebonne Parish. Grand Isle was under about 4 feet of water. About 1,200 residents of Grand Isle were trapped on the island after the storm surge cut off evacuation routes early on. Total damage exceeded $300 million, and 12 people died. Oct. 5-8, 1996: Hurricane Josephine began as a gale center in the Gulf that teamed with a high- pressure ridge over the southeastern United States. The storm brought tides of more than 4 feet above normal to the entire Louisiana coastline. La. 1 was under a foot of water in southern Lafourche Parish. Damage exceeded $5.5 million. July 13, 1997: Hurricane Danny began just south of Terrebonne Parish and brought heavy rain and wind. The storm hung around, and by July 17 the center of circulation jumped about 80 miles to the east-northeast, and it began to intensify. Grand Isle reported 95 mph winds and a 5.4-foot tidal surge before the storm made landfall in Mobile.

> Sept. 27-28, 1998: Hurricane Georges left destruction from the Lesser Antilles to Louisiana. The storm struck the Mississippi Coast, but tidal surges of more than 8 feet affected south Louisiana. Two people died in Louisiana. Damage: $2 billion.

Twenty-First Century Overview

Turn of the Century Demographical Statistics

Statistical information compiled in 2000 for the U.S. Census Bureau (USCB) revealed relevant demographical numbers for Terrebonne Parish, Louisiana. In the subject year, the total population was recorded as 104,503 with a median age of 33.0 years. Of that aggregate, parish residents lived within nine districts; the largest (by population) was District 6 with 14,409 residents. In comparison, Federal census takers identified the smallest (pop.) as District 1 with 9,907 residents.

The parish's major population centers were identified as Houma, Bayou Cane, Gray, Schriever, Dulac, Chauvin, and Montegut (U.S. Census Bureau [USCB] 2002:28, 30, 76). The racial makeup of the parish, according to the 2000 Census suggested the following breakdown (self reporting); White (77,401), Black or African American (18,594), American India and Alaska Native (5,533), Asian (845), Native Hawaiian and Other Pacific Islander (16), "Some other race" (568), "Two or more races" (7), and "Hispanic or Latin" (1,631) (USCB 2002:76-77). The number of United Houma Nation American Indians living in Terrebonne Parish circa 2000 totaled 5,500 individuals comprising 1,446 households (USCB 2002:226).

The land area of Terrebonne Parish measured in square miles for the subject year totaled 1,254.93. With the previously reported population of just over 104,000, the human density averaged 83.3 per square mile (USCB 2002:215). The National Research Council examined major sectors, which served as the parish's principal employers by 2000. These more traditional industries were identified as wholesale trade, manufacturing, construction and the most diverse: agriculture, forestry, fishing, hunting, and mining. Employment numbers follow, respectively; 1,668, 3,437, 3,248, and 4,916 (National Research Council 2006:54).

During 2005, Louisiana native and author of *American Energy, Imperiled Coast* toured Cocodrie and noted significant changes from a visit made some 15 years before. To his surprise on that occasion and those in the following years, Theriot witnessed dramatic and continuous changes to the lower Terrebonne landscape. In speaking of his experiences there, Theriot (2014:xi-xii) eloquently commented that:

> The amount of land loss and changes to the wetlands, levees, oyster grounds, camps, oak ridges along the bayou banks, and even the oil field canals is astonishing. The impacts of hurricanes, subsidence, salt water intrusion, sea level rise, and the man-made canals that crisscross the landscape completely altered the wetlands around Cocodrie. Points of reference etched in my memory as a child have either completely disappeared or will in the very near future. The fishing in the area has not declined; in fact, Cocodrie continues to be one of the most productive fishing grounds in coastal Louisiana, in part because of the rapidly deteriorating marsh vegetation that provides an important, if fleeting, food source for fisheries. No one knows how long this productivity will continue, as the estuaries that produce these fisheries have been threatened as well. What is certain is that people ad local governments will have to make tough choices abut how best to maintain the community life, culture, and jobs once the encroaching Gulf waters ultimately force people in vulnerable places like Cocodrie to move to higher ground. Oil and gas companies will also have to make tough decisions about protecting and maintaining the billions of dollars of critical energy infrastructure built in the wetlands. As more wetlands disappear, more pipelines and related assets will be exposed.

A 2003 oil and gas profile compiled for the parishes of Terrebonne, St. Marys and Lafourche verified the number of wells in those jurisdictions and the associated monies collected by the State of Louisiana. Royalties are paid to the state from production on state-owned lands and bottoms of waterways, while severance taxes are collected on production within the state and out to the three-mile offshore boundary. The first is negotiated, and the second is assessed at 12.5 [2003 rate] percent of the value of the product (NRC 2006:49). This breakdown is shown in Table 3.

PARISH	WELLS	ROYALTIES	GAS SEVERANCE	OIL SEVERANCE
Terrebonne	6,459	55,402,555	15,888,415	59,095,001
St. Marys	5,533	54,746,858	8,008,321	12,539,741
Lafourche	6,884	25,460,199	5,193,455	30,155,887

Table 3. Tri-Parish oil and gas profile for 2003 (National Research Council 2006:49).

Twenty-First Century Hurricane Events

Circa 2008, Sell and McGuire (2008:13) remarked that:

> The 'down the bayou' settlements of Montegut, Dulac, Chauvin, Theriot, Cocodrie, Boudreaux, and especially Point-Aux-Chenes rest precariously on small fingers of land that are threatened with further inundation as land loss continues and storm threat increases. These smaller settlements contain a core of Cajun settlement in the area…The Bayou Cajuns have strong ties to the very same land that is disappearing.

Hurricane Isaac

A marsh management levee located in Montegut was severely damaged during Hurricane Isaac, which struck the Louisiana coast in late August 2012. According to a Houma publication, "the Category 1 storm's tidal force destroyed one of the levee's water control structures…washing it away and leaving behind a 50-foot gap" (Buskey 2012). A parish spokesman related that "the vulnerable levee, which crosses open water in the Wildlife and Fisheries' Pointe-aux-Chenes Wildlife Management Area…has failed during nearly every storm that has blown through the parish" (Reggie Dupre quoted by: Buskey 2012).

Damages incurred during a 2011 tropical storm (Lee) similarly washed out a 60-foot-wide section of the Montegut Marsh Management Levee, which destroyed a recently repair to the water control structure. At the time of the 2012 Isaac event, the Terrebonne Levee District was administering funds amounting to $2.4 million set aside by FEMA to strengthen (armoring technique) the subject structures (Buskey 2012).

Hurricanes Katrina and Rita Events

Fortunately, the Port of Terrebonne experienced little damage during hurricane Katrina (29 August 2005). However, in the case of Hurricane Rita (23 September 2005) excess water remained elevated for nearly one week following the tropical cyclone. At the time of the Category 3 hurricane event, the port's infrastructure was largely "protected by a 5-ft high levee around its perimeter" (Curtis 2007:122).

Hurricane Gustav Event

Originating in the central Caribbean Sea on 25 August 2008, Gustav rapidly intensified and struck Haiti, Jamaica, and Cuba before making landfall at Cocodrie, Louisiana as a Category 2 hurricane on 1 September (Keim and Muller 2009:189-190).

Gustav's "winds and the storm surge were particularly destructive in Plaquemines, Lafourche, and Terrebonne Parishes, including the city of Houma" (Keim and Muller 2009: 191).

A subsequent environmental assessment (EA) prepared by the USACE (Mississippi Valley Division) evaluated the potential impacts that could be associated with repairs, replacements, modifications, and improvements of about 6.1 miles [near Dulac] of non-Federal levees (NFL) in Terrebonne Parish" needed due to damages perpetuated especially by Hurricanes Rita, Gustav and Ike (USACE n.d:1,2). At that date, some 100 miles of NFL [64] were located in the parish, as part of its forced drainage system. The subject EA, No. 450) remarked that "Hurricane Rita brought catastrophic tidal inundation from its storm surge to the communities of Terrebonne Parish…causing millions of dollars in property damage" (USACE n.d:1).

Contemporary Terrebonne Parish

As of 2009, the population of Terrebonne Parish was estimated at 109,291. The capital city of Houma reported some 32,657 citizens ca. 2006 (U.S. Census Bureau n.d.:a; U.S. Census Bureau n.d.:b). The three principal parish employers were identified in 2007 as oil and gas drilling companies (2) and medical service (1) providers. Oil and gas pipeline construction and oil field support services are also important local industries.

Chief maritime enterprises include Cenac Towing Company, Delta Towing, Saia Motor Freight Line and North American Fabricators. The latter interest "builds & repairs offshore supply boats" (South Louisiana Economic Council 2007).

In October 2010, the U.S. Travel Association (2010:12) summarized the economic impact of contemporary travel in Louisiana parishes, including Terrebonne as such:

> Travel, as one of [the] most important industries in Louisiana's economy, benefitted from the 2010 economic recovery. But it was a challenging year for Louisiana tourism as well. Tourism to Louisiana was unambiguously affected by the oil spill resulting from the explosion of the Deepwater Horizon oil rig in April, 2010. The threats from the oil spill, both real and perceived, to the gulf shoreline, waters, and seafood have impacted Louisiana tourism. However, the loss in tourism caused by BP oil spill in 2010 was offset by the growth from the economic recovery.

Louisiana Division of Archaeology Research Database System

National Register of Historic Places Eligibility Database

The Louisiana Division of Archaeology (LDA) National Register of Historic Places Eligibility Database was queried for "Terrebonne Parish" intermittently during the contract period. The last query was conducted on 23 June 2014. That search returned 69 eligible or potentially eligible entries. Of that number, only two are located in the project area. These sites are identified as 16TR22 (Mound Bayou) and 16TR206 ("bankline restoration"-U.S. Corps of Engineers permit process correspondence). In respect to the first site, the associated report reference number is 22-1876. There is no associated report for the second site (Louisiana Division of Archaeology [LDA] 2014a).

National Park Service National Register of Historic Places Database

According to the National Park Service's National Register of Historic Places database last queried 23 June 2014, 17 Terrebonne Parish sites are currently listed on the Federal register. Of that number one (Gibson Methodist Episcopal Church) is located at Gibson, ten (Ardoyne Plantation House; Argyle, Herman Albert Cook House, Houma Historic District, Orange Grove Plantation House, Residence Plantation House, Clifford Percival Smith House, Southdown Plantation, St. Matthew's Episcopal Church, and Wesley House) are situated in Houma, one (Montegut School) is located in Montegut, four (Armitage, Magnolia, Polmer Store, and St. George Plantation House) are located in Schriever, and one (Ducros Plantation) is located in Thibodaux (National Register of Historic Places 2014).

Cultural Resources Management Bibliography Database

According to the Cultural Resources Management Bibliography (CRMB) database sponsored by LDA, 109 reports (as of 19 June 2014) relate information regarding surveys conducted in Terrebonne Parish (LDA 2014b). Although many of those reports were not directly related to the current project area, all abstracts were reviewed due to the fact that the authors touched on relevant archival information pertaining to the subject parish.

Louisiana Excavated Sites Database

According to the LDA Excavated Sites Database, five sites in Terrebonne Parish have been excavated. These sites and their associated reports are identified as 16TR114 (Good Land Sawmill Community) Report No. 22-1363, 16TR116 (Donner Sawmill) Report No. 22-1850, 16TR22 (Mound Bayou) Report No. 22-1876, 16TR38 (Indian Mound-Grand

Caillou) Report No. 22-0464, and 16TR5 (Gibson Mounds) Report No. 22-2439, LAS#26 (LDA 2014c).

Surveyed Areas Extending Into or Included in the Project Footprint

A total of 22 surveys [per the CRMB] that extend into, or are contained within, the project footprint were identified, digitized and included in the project GIS **(Figure 6)**. Fifteen remote-sensing surveys were carried out in the Atchafalaya where plans call for sediment associated with channel dredging to be recovered for transport through temporary pipelines laid in gas pipeline canals that transect the Terrebonne Hydrologic Basin. Six more surveys correlated with the location of those pipeline canals or with additional pipeline canals proposed to transport material to the four marsh and ridge habitat restoration areas. The remaining 56 surveys extend into or are included within the restoration areas.

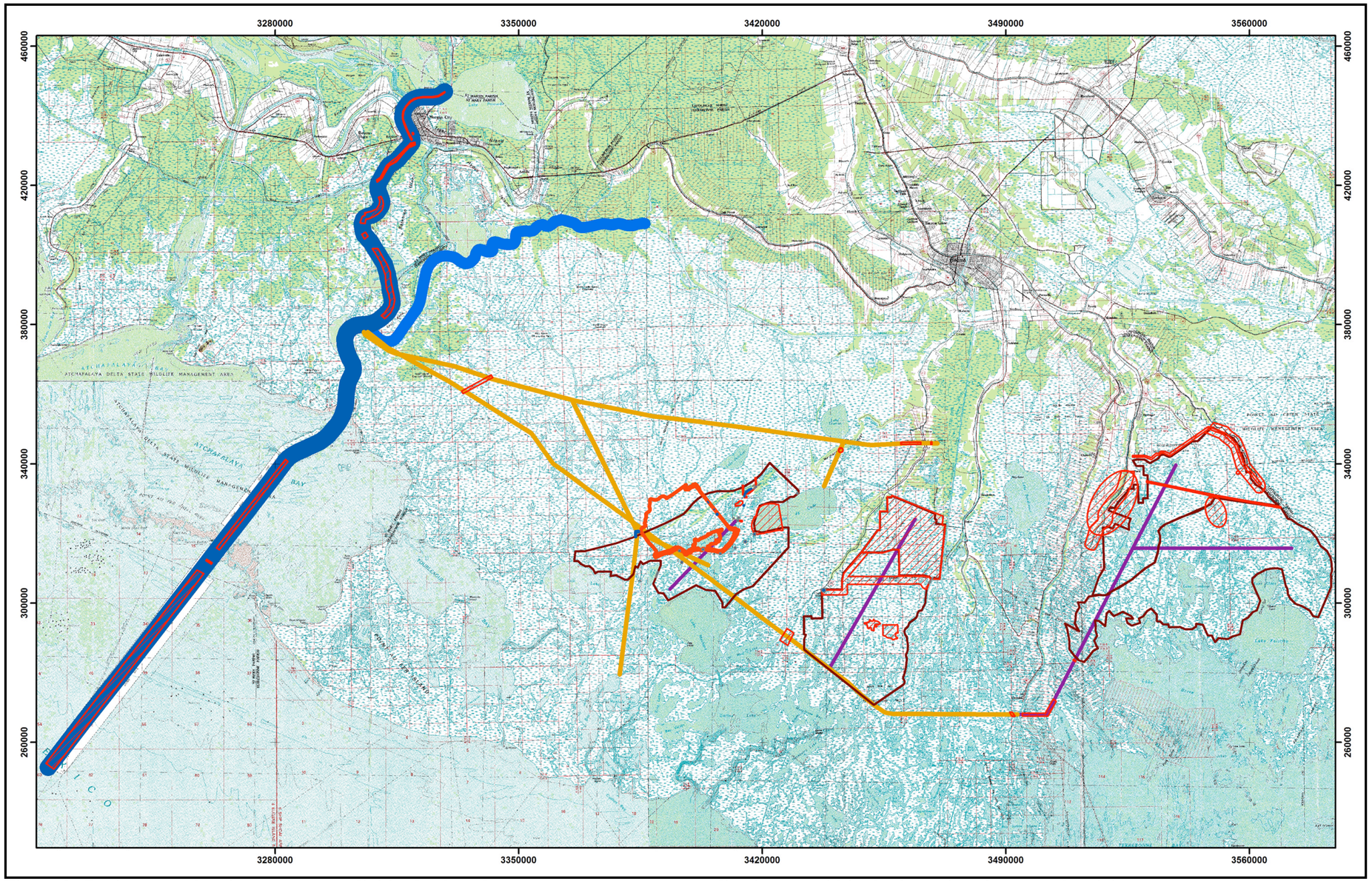

Figure 8. Project area showing twenty-two digitized cultural resource survey areas extending into or within the footprint of proposed activity.

Report No.: 22-0080

Title: An Archaeological Survey of the Houma Navigational Canal and Bayous La Carpe, Terrebonne, Petit Caillou, and Grand Cailloou [sic], Terrebonne Parish, Louisiana.

Date: 1974

Author: Robert W. Neuman
Contractor: Robert W. Neuman

Abstract:
Between November 29th and December 8th, 1974, an archaeological survey, via truck, boat, and helicopter was conducted along the above titled bayous south of Houma, Louisiana. No in situ archaeological deposits were in evidence in the above areas of Bayou La Carpe, the Houma Navigational Canal or Bayou Petit Caillou. Three archaeological sites were located along Bayou Grand Caillou and one site was recorded along Bayou Terrebonne. Site 16TR6 is a shell midden and mound. Site 16TR37 is an earthen mound. Site 16TR38 is a large, earthen mound. Site 16TR86 consists of two, low earthen mounds (LDA 2014b).

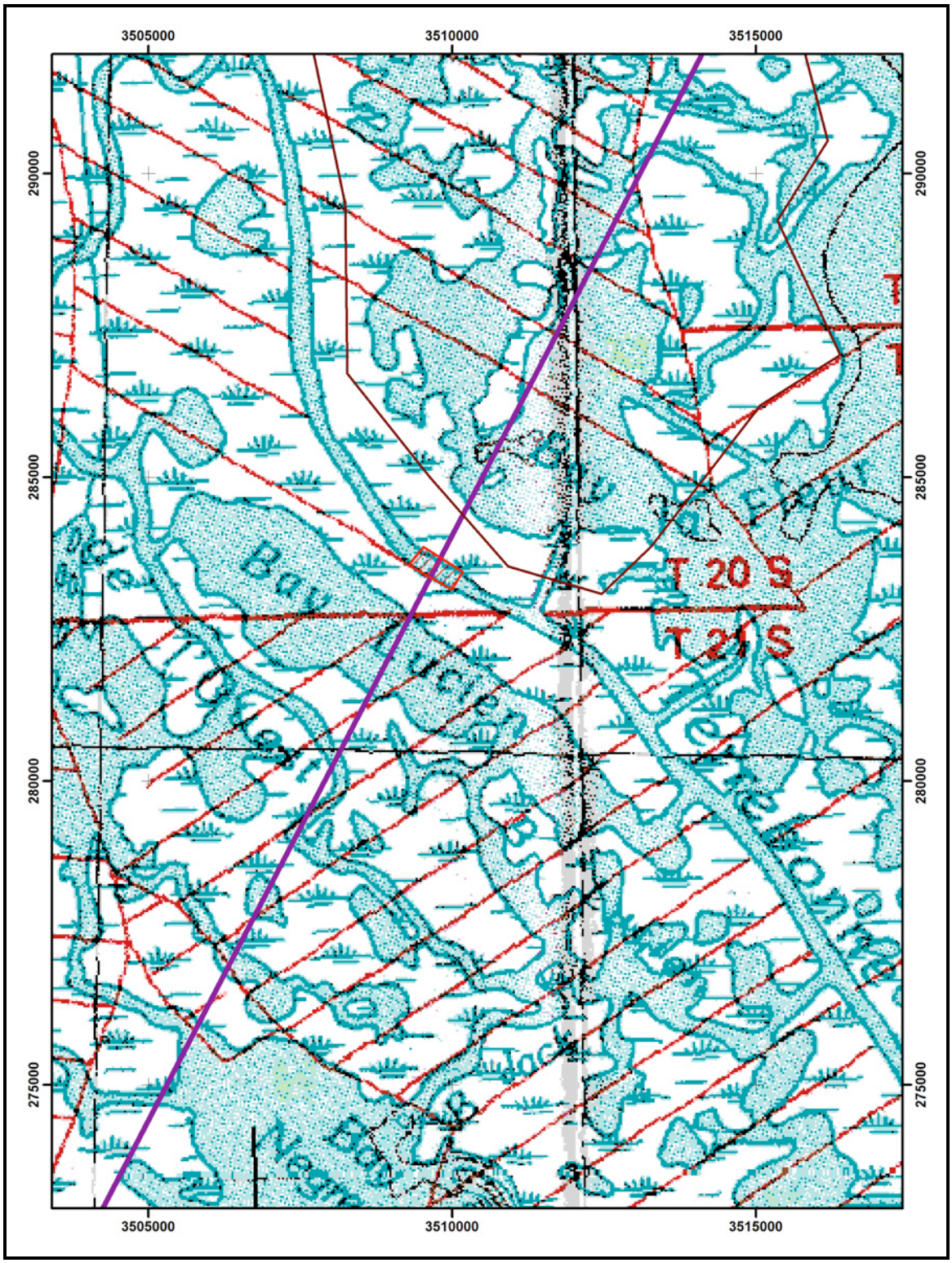

Figure 9. Location and project related extent of Survey 22-0080.

Report No.: 22-0317

Title: Environmental Assessment of Proposed Pipeline Construction in Terrebonne, Lafourche, Jefferson, and Plaquemine Parishes, Louisiana

Date: 1975

Author: Allen R. Saltus, Kay G. Hudson and Leslie Clendenon

Contractor: Gulf South Research Institute

Abstract:
This final report to Louisiana Gas Corporation (LIGC) and Louisiana State Gas Corporation (LSGC) contains the results of a study conducted by Gulf South Research Institute (GSRI) to assess the economic, social, and environmental effects of proposed pipeline construction in Terrebonne, Lafourche, Jefferson, and Plaquemines Parishes, Louisiana. A search was conducted on foot and by helicopter for prehistoric and historic settlements and related cultural features within 500 feet of either side of the proposed pipeline. Three prehistoric camp sites and one historic house site were discovered in the Terrebonne Parish portion of the survey area. These are 16TR215, 16TR193, 16TR194, and 16TR32. One prehistoric sites, 16TR32, consisting of a mound complex, was found in the Lafourche Parish portion of the survey area. One historic site, 16PL147, was found in the Plaquemines Parish portion of the survey area. A mound site, 16PL8, outside the survey area was visited briefly to obtain comparative data (LDA 2014b).

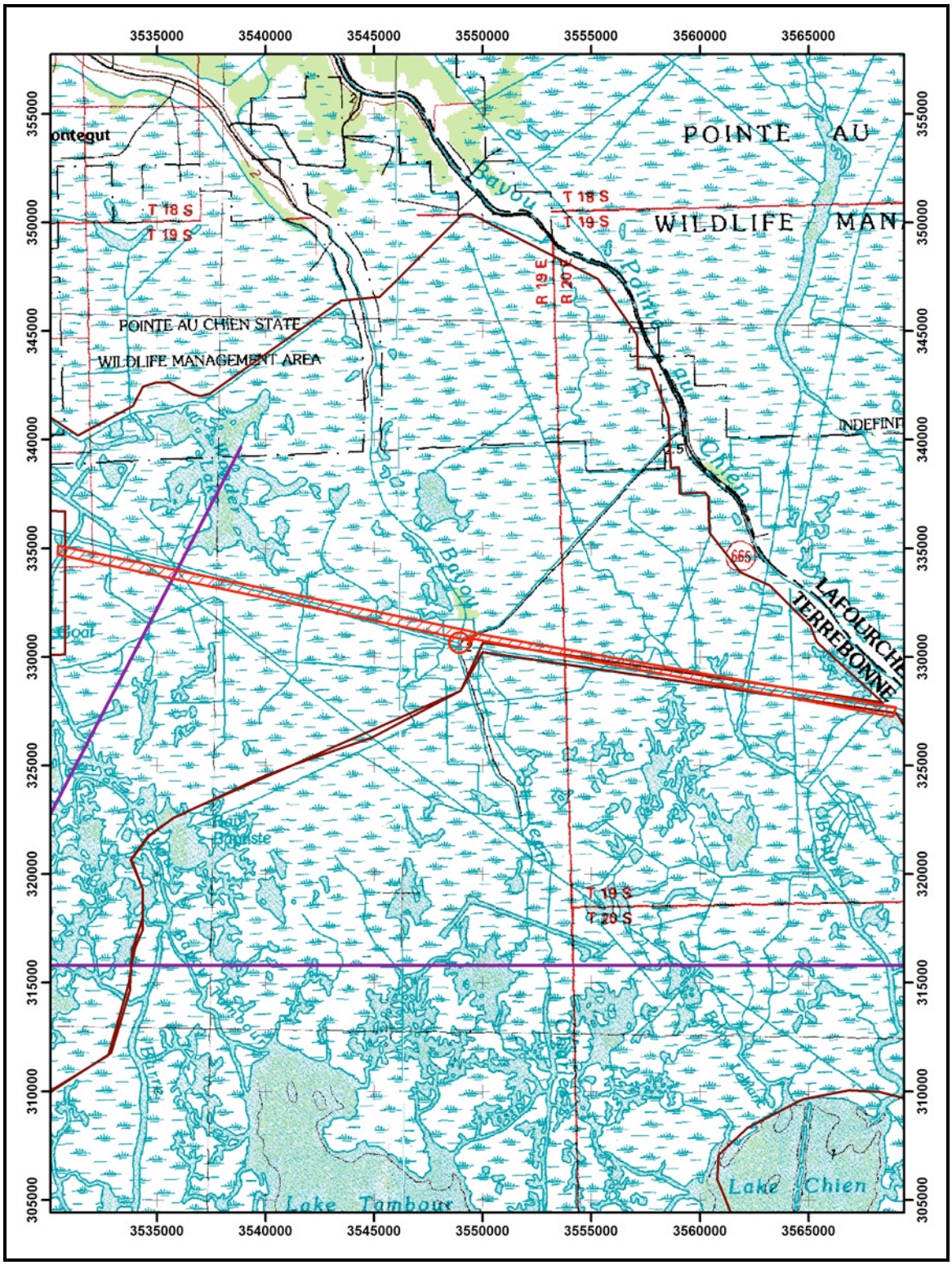

Figure 10. Location and project related extent of Survey 22-0317.

Report No.: 22-0619

Title: Archaeology and Ethnology on the Edges of the Atchafalaya Basin, South Central Louisiana. Avoyelles, St. Landry, Iberia, St. Martin, St. Mary, and Iberville Parishes, Louisiana

Date: 1982

Author: Jon L. Gibson

Contractor: University of Southwestern Louisiana

Abstract:
A cultural resources survey of the East And West Atchafalaya Basin Procection [sic] Levees investigated by Jon Gibson investigated a total of 33 prehistoric and historic sites. Indian sites ranged in age from Archaic to Plaquemine, and historic sites from Contact to 20th Century. Ethnographic research showed the complexity of ethnic identity and the powerful influence of the Atchafalaya swamp in molding a rather unique subculture. A total of 12 cultural resources was recommenced [sic] as significant, and mitigation recommendations are tendered. 10 sites are potentially eligible for the National Register (LDA 2014b).

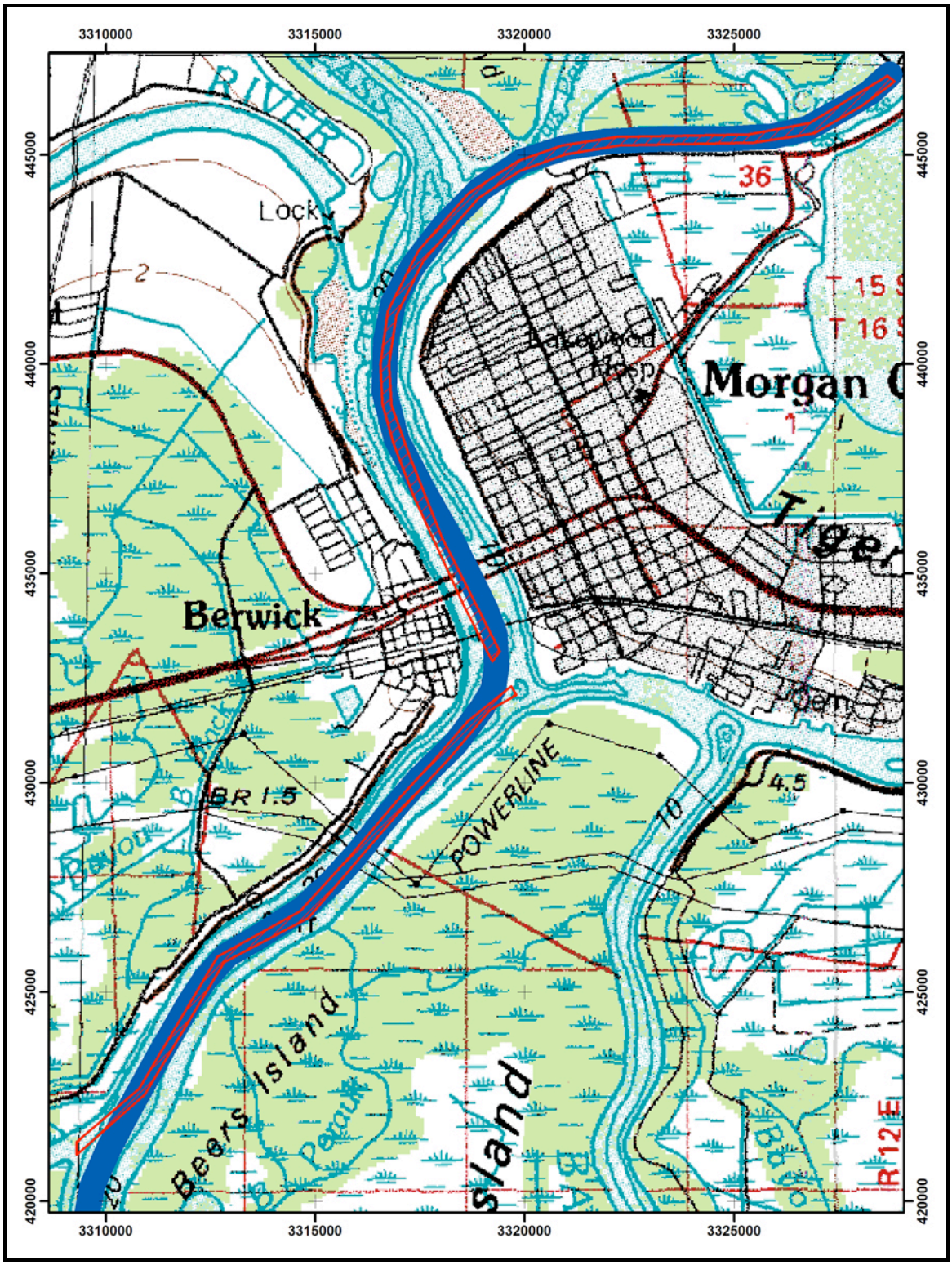

Figure 11. Location and project related extent of Survey 22-0619.

Report No.: 22-0675

Title: Crawfish Pipeline Extension Eugene Island Area, Block 18, to Gibson, Louisiana

Date: 1981

Author: William G. McIntire

Contractor: None

Abstract:
This cultural resource survey of the proposed Crawfish 10" natural gas pipeline route was conducted by William McIntire under contract to Shell Pipe Line Corp. The proposed route begins offshore in the Eugene Island Area, Block 18 and extends across Gulf bottom and Atchafalaya Bay waters. It landfalls on the east shore of Atchafalaya Bay and terminates in Gibson. The survey will satisfy Level II requirements. Literature search and survey via boat and foot were done. Also air boat gradiometer was used. No sites were discovered and the project was cleared (LDA 2014b).

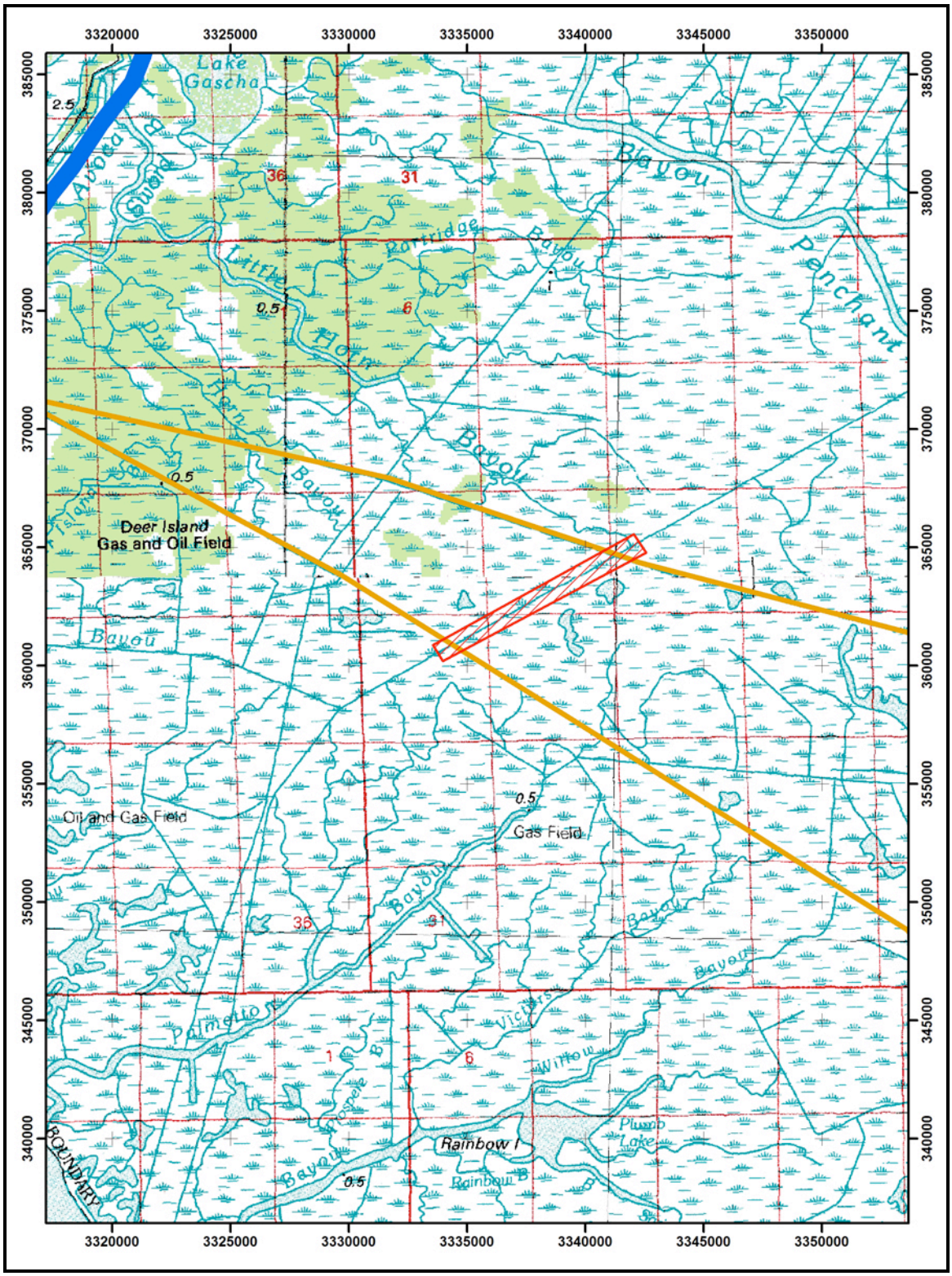

Figure 12. Location and project related extent of Survey 22-0675.

Report No.: 22-0938

Title: Archival and Historical Assessment of the Morgan City Floodwall Boat

Date: 1984

Author: R. Christopher Goodwin and Selby Walker Galloway

Contractor: R. Christopher Goodwin & Associates, Inc.

Abstract:
Archival and historical assessment of the Morgan City Floodwall boat was done by Goodwin and Selby. The report details archival and historical research and oral interviews undertaken to determine the historical setting of the area. A preliminary determination was made that the origin of the site dates to between 1835 and 1885. Further investigation is needed to definitively identify the Morgan City Floodwall boat as perhaps the USS Kinsman (LDA 2014b).

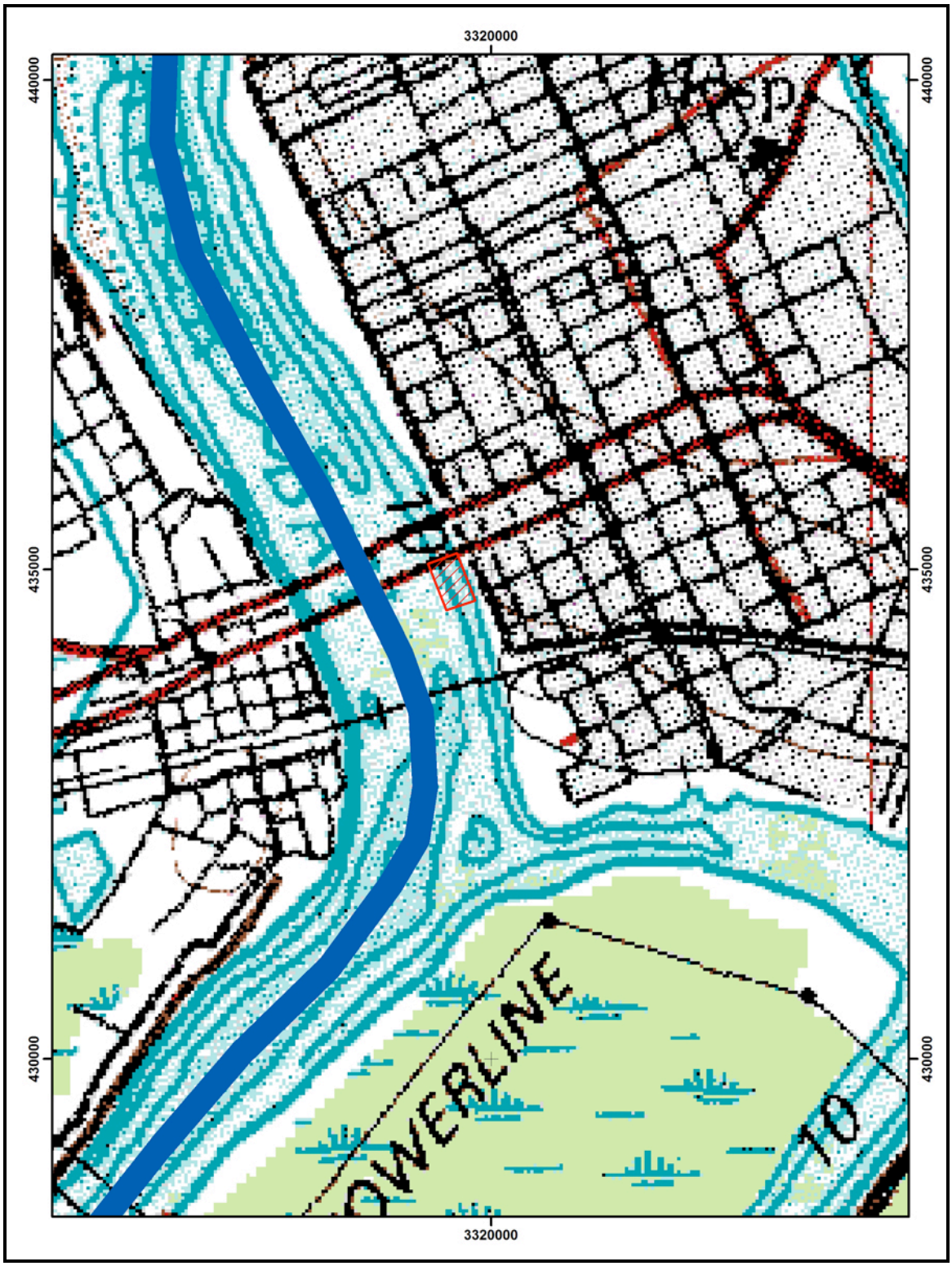

Figure 13. Location and project related extent of Survey 22-0938.

Report No.: 22-0953

Title: Cultural Resources Survey of a Proposed Weir Near Marmande Ridge and Minors Canal, Terrebonne Parish, Louisiana

Date: 1984

Author: William G. McIntire and Robert H. Baumann

Contractor: Louisiana State University

Abstract:
An archival and intensive field survey was conducted of a proposed weir near Marmande Ridge and Minors Canal in Terrebonne Parish. No cultural resources were found at the weir site. A determination was made that the prehistoric archaeological site 16TR69 is located approximately 125 yards from the construction site. In the event that prehistoric or historic artifacts are revealed during construction, personnel in the Division of Archaeology and Historic Preservation should be notified so that significant material could be recovered (LDA 2014b).

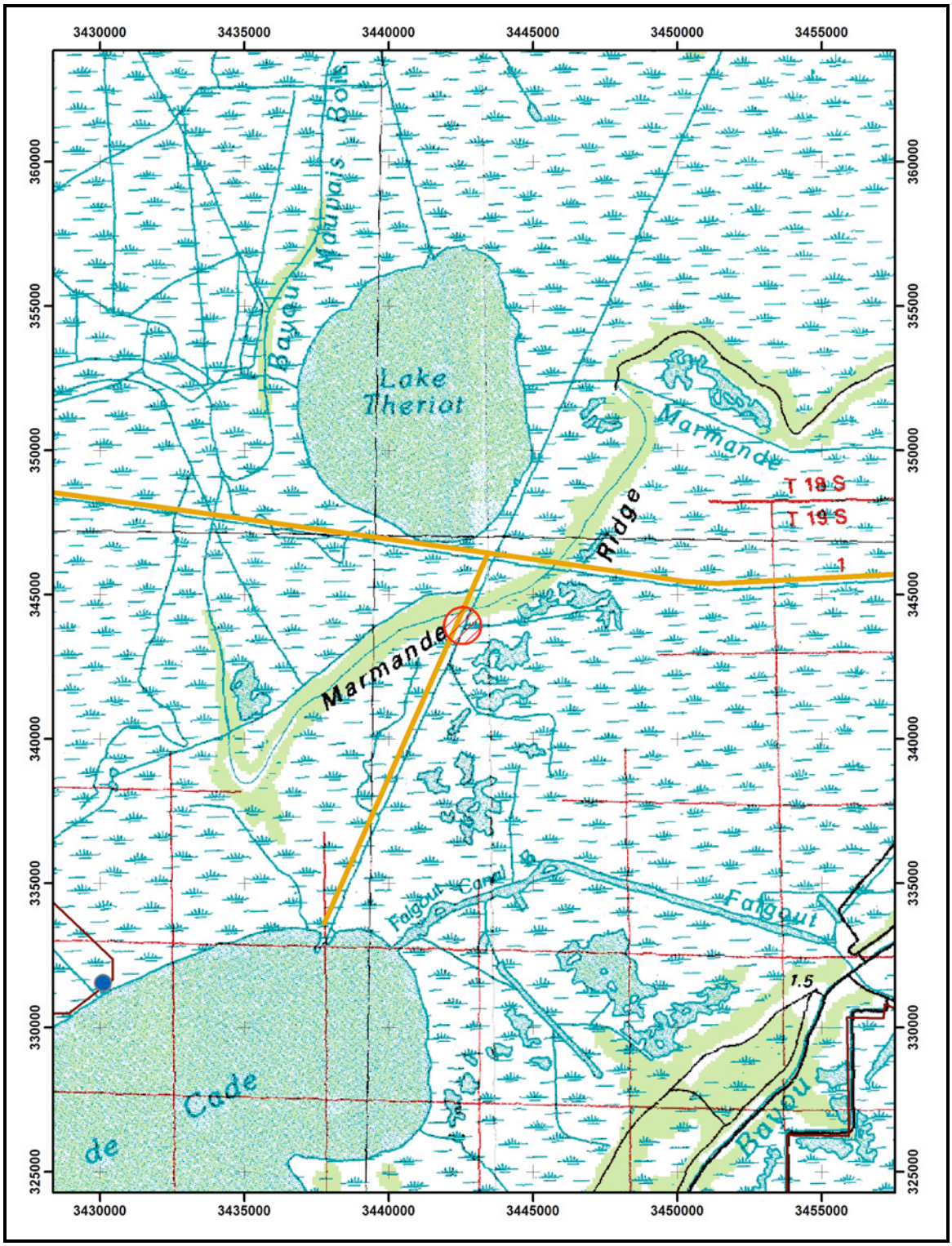

Figure 14. Location and project related extent of Survey 22-0953.

Report No.: 22-1160

Title: Archeological Survey of Three Proposed Forced Drainage Projects - 4-4, 4-3B, & 4-3C; Parish Project No 83-G-25, Terrebonne Parish, Louisiana.

Date: 1985

Author: William G. Haag

Contractor: None

Abstract:
Archaeological assessment of three proposed forced drainage projects in lower Terrebonne Parish was conducted by William Haag. A pedestrian survey was conducted of all the proposed construction areas. High probability areas were shovel tested. There are no previously recorded cultural resources in the survey areas and none were found during the survey (LDA 2014b).

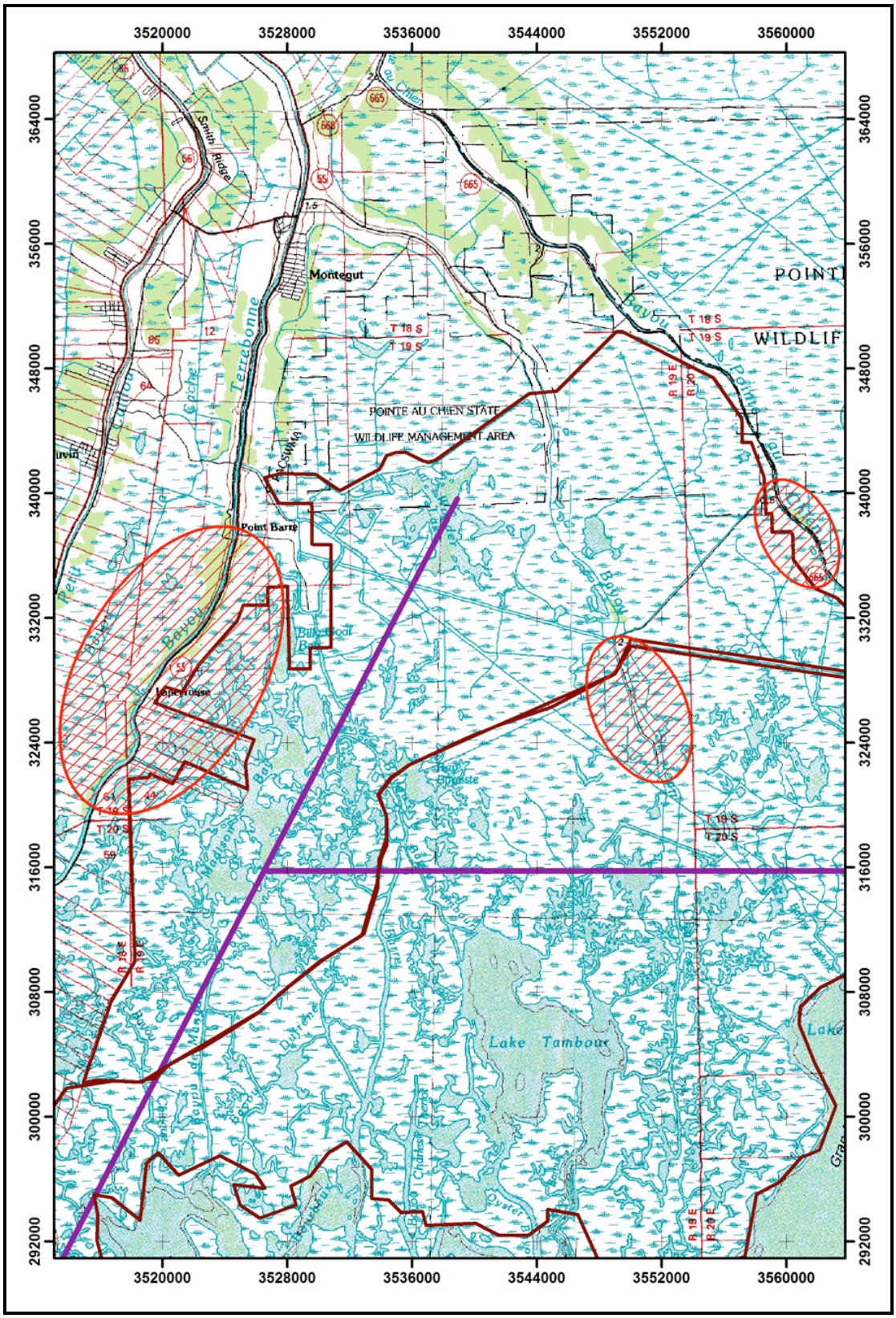

Figure 15. Location and project related extent of Survey 22-1160.

Report No.: 22-1190

Title: Preliminary Archaeological Investigations at Site 16TR195, Terrebonne Parish, Louisiana

Date: 1987

Author: Richard A. Weinstein

Contractor: Coastal Environments, Inc.

Abstract:
Preliminary archaeological investigations at Site 16TR195 in Terrebonne Parish were conducted by Coastal Environments. The Level II survey of a canal and slip location revealed a previously unrecorded Rangia Cuneata midden found to be in close proximity to the proposed project site. Site limits were determined by auguring and a map was drawn. The site is considered potentially eligible for the National Register. The recommendation is made that the proposed canal be moved to avoid site 16TR195, and no spoil be placed in the vicinity (LDA 2014b).

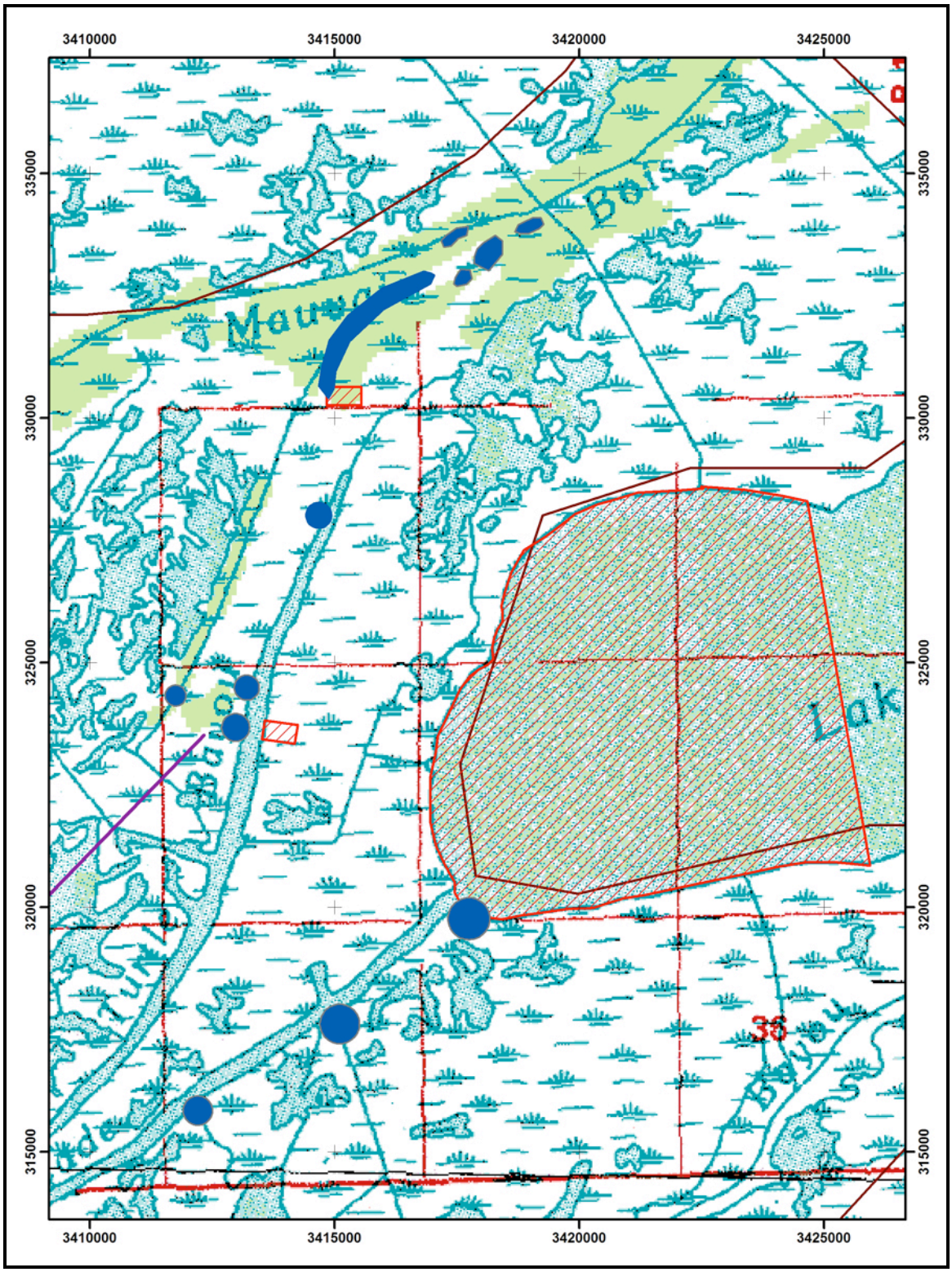

Figure 16. Location and project related extent of Survey 22-1190 and archaeological sites in the vicinity.

Report No.:22-1211

Title: A Cultural Resources Survey of Portions of Two Proposed Pipeline Routes, Terrebonne Parish, Louisiana

Date: 1987

Author: Richard A. Weinstein

Contractor: Coastal Environments, Inc.

Abstract:
A pedestrian survey of portions of two alternate pipeline routes in Terrebonne Parish to determine which would have the least impact on known archaeological sites in the area was conducted by Coastal Environments. It was found that the preferred alignment would directly damage site 16TR192, an extensive, linear Rangia Cuneata shell midden, while alternate 2 was clear of any potential impact. Alternate 2 is recommended as no sites would be impacted.

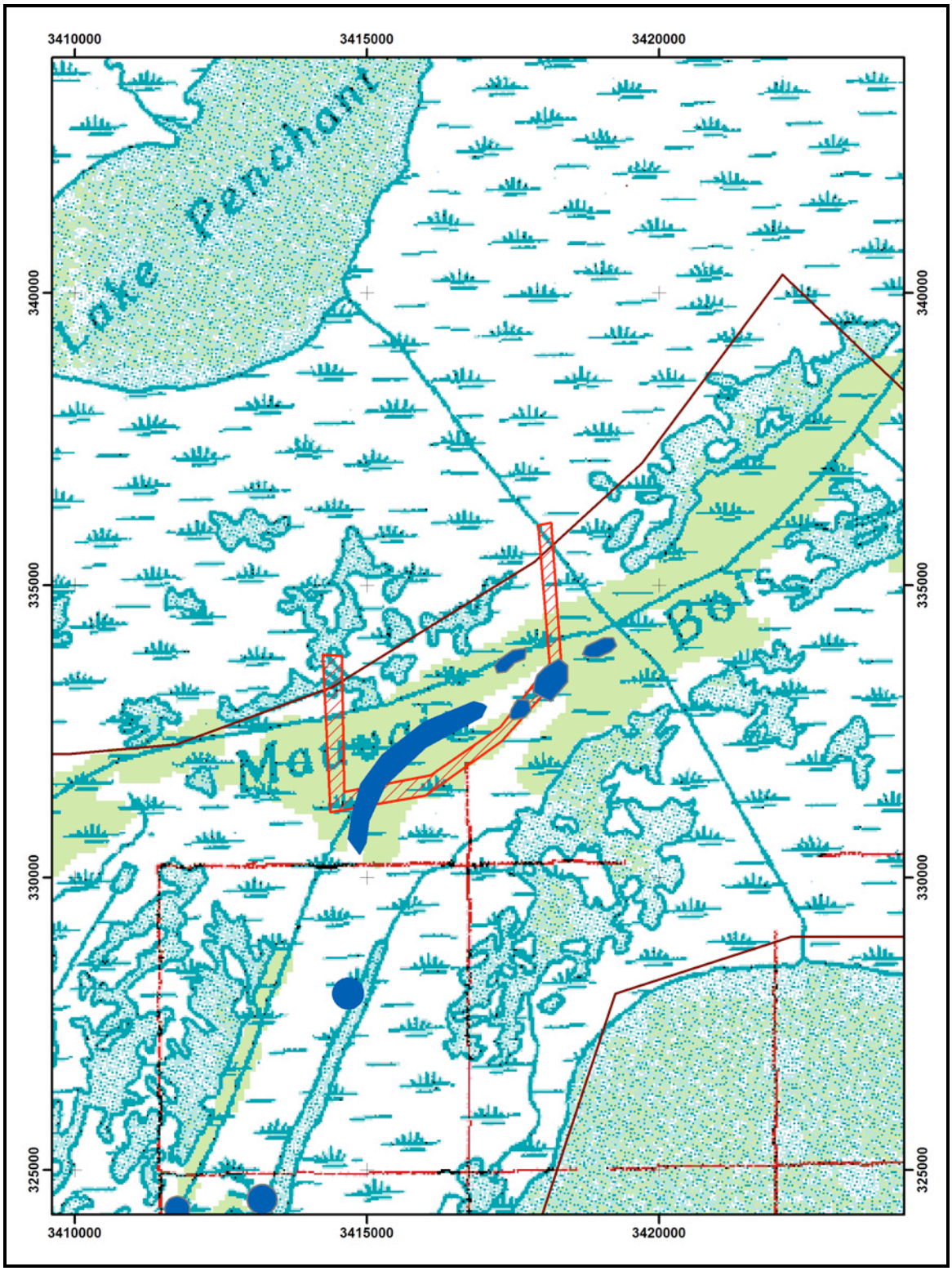

Figure 17. Location and project related extent of Survey 22-1211 and archaeological sites in the vicinity.

Report No.: 22-1226

Title: A Cultural Resources Survey of a Proposed Canal and Well Slip, Terrebonne Parish, Louisiana

Date: 1987

Author: David B. Kelly

Contractor: Coastal Environments, Inc.

Abstract:
A Level II survey of a proposed canal and well slip in Terrebonne Parish, to be excavated in the vicinity of a recorded archaeological site, 16TR205, was conducted by Coastal Environments. A total of four auger borings failed to identify indication of buried cultural deposits. As a result, the recommendation is made that the project be allowed to proceed as planned (LDA 2014b).

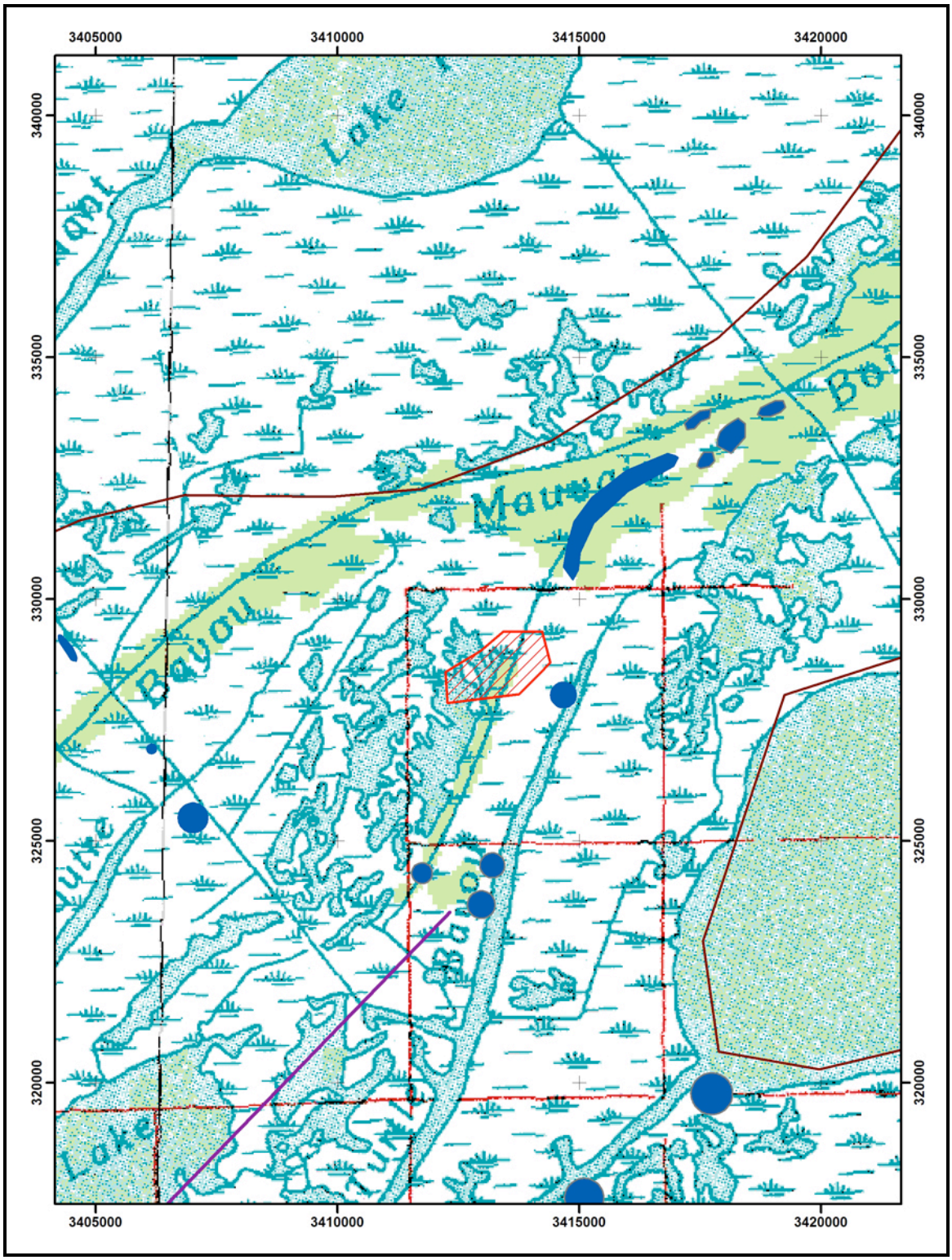

Figure 18. Location and project related extent of Survey 22-1226 and archaeological sites in the vicinity.

Report No.: 22-1482

Title: Remote Sensing Survey of the Atchafalaya Basin Main Channel, Atchafalaya Channel Training Project, Sts. Martin and Mary Parishes, Louisiana

Date: 1991

Author: Charles E. Pearson and Allen R. Saltus, Jr.

Contractor: Coastal Environments, Inc.

Abstract:
A remote sensing survey of the Atchafalaya Basin main channel was conducted by Coastal Environments in three separate areas in the Morgan City vicinity. After anomalies were identified, selected ones were dived on for verification. Three previously recorded sites 16SMY55, 56, & 58 were updated and one new site 16SMY61 was recorded. Various types of watercraft were documented and evaluated (LDA 2014b).

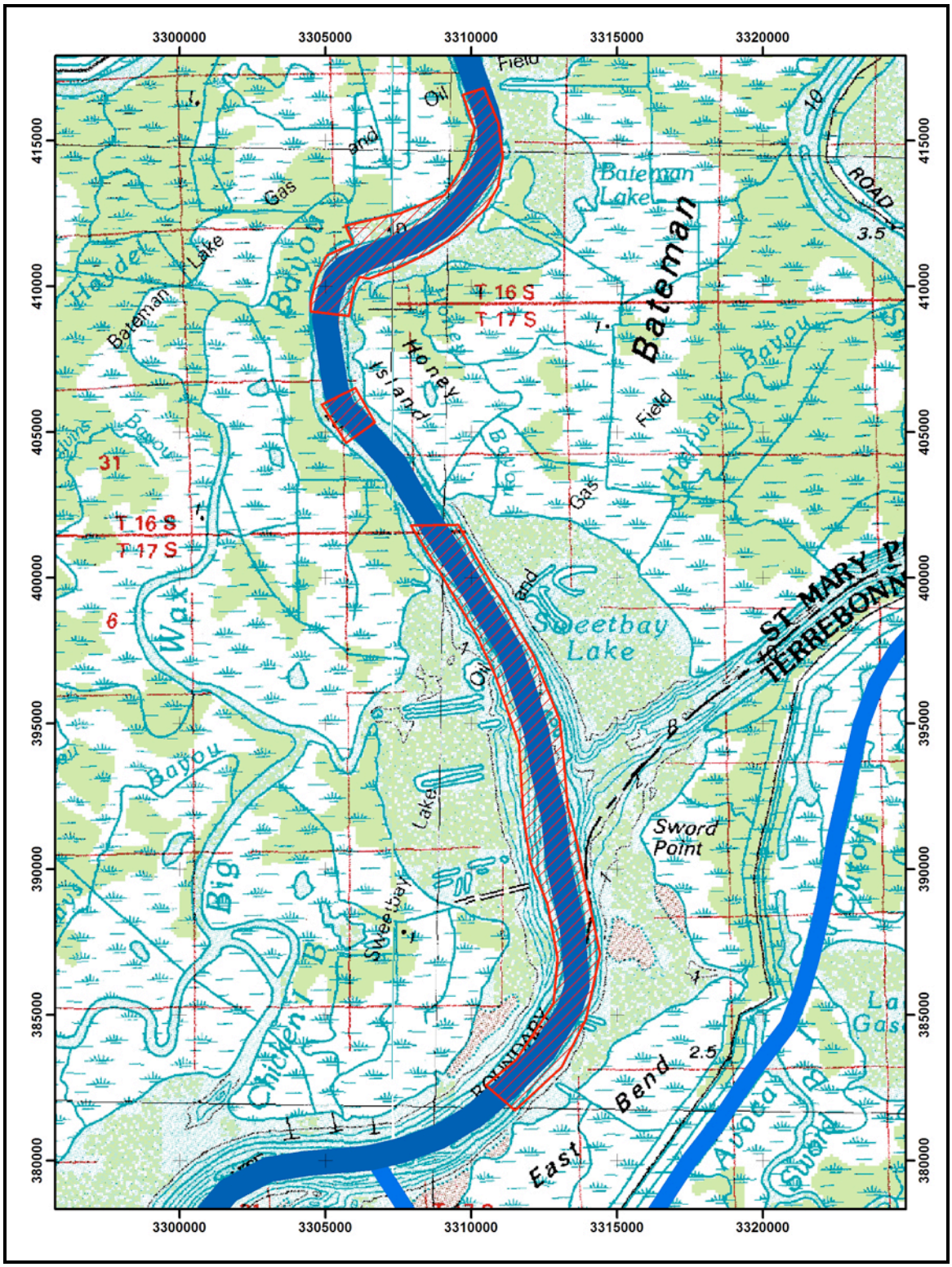

Figure 19. Location and project related extent of Survey 22-1482.

Report No.: 22-1597

Title: A Reconnaissance Survey of Derelict Boats on Bayou DuLarge, Terrebonne Parish, Louisiana

Date: 1992

Author: Michael E. Stout

Contractor: U.S. Army Corps of Engineers, New Orleans District

Abstract:
This report documents a reconnaissance survey of derelict, or abandoned, boats along a portion of Bayou Dularge, a small to medium size waterway in south central Terrebonne Parish, conducted by Michael Stout. The study was undertaken to support a proposed Corps of Engineers project, which would involve the removal of snags from the bayou. The survey identified and recorded 37 derelict boats on the waterway (16TR222 to 16TR256). Assessments of the potential historic significance of these resources were provided. Recommendations for additional survey efforts were detailed. All of the vessels appeared to relate to the seafood procurement industry. None of the vessels appeared to meet the NRHP eligibility test (LDA 2014b).

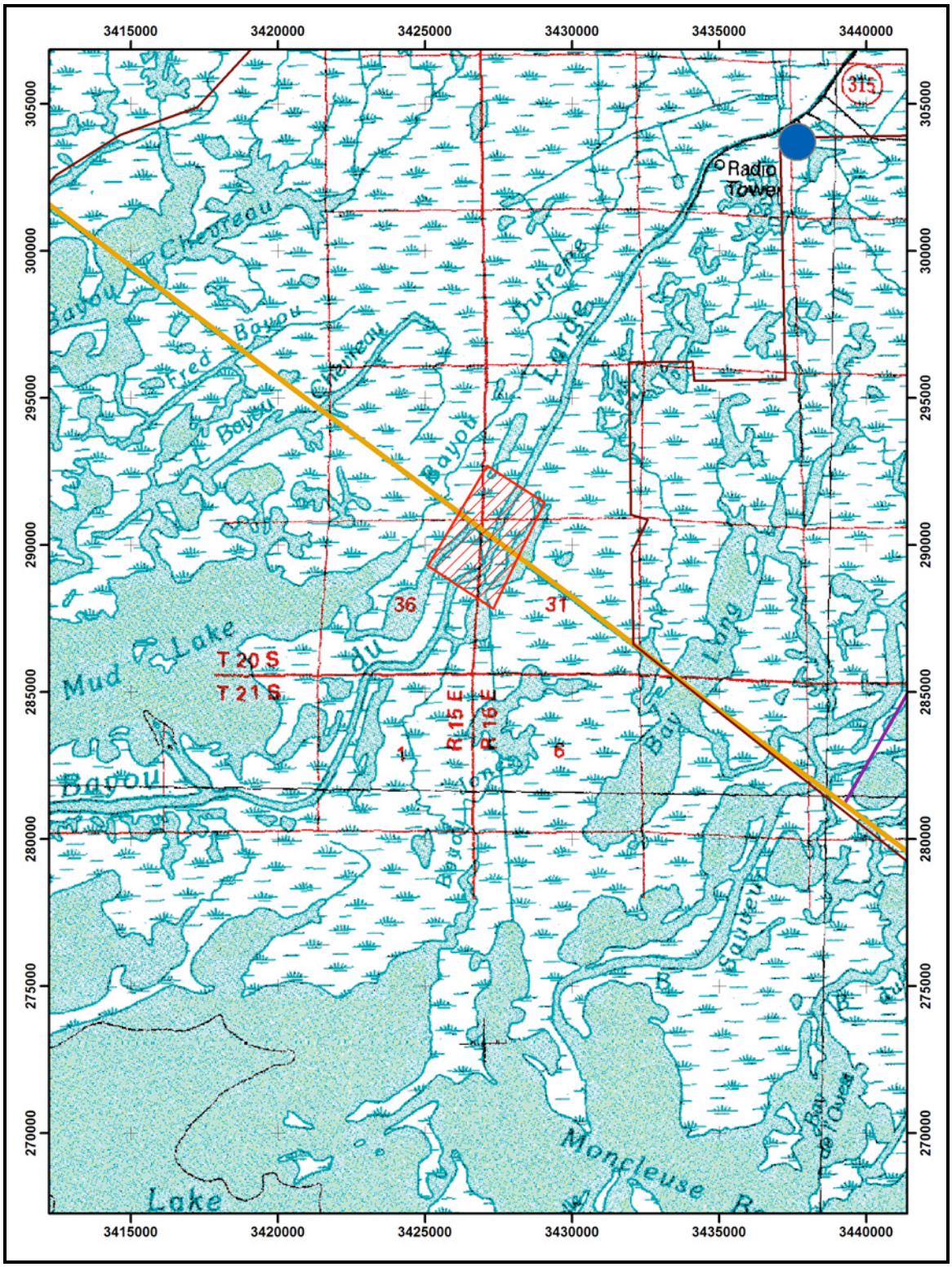

Figure 20. Location and project related extent of Survey 22-1597.

Report No.: 22-2115

Title: Cultural Resources Survey of the Brady Canal Hydrologic Restoration Area, Terrebonne Parish, Louisiana

Date: 1998

Author: Rhonda Smith and Benjamin Maygarden

Contractor: Earth Search, Inc.

Abstract:
This report presents the results of the cultural resources investigations undertaken by Earth Search, Inc. (ESI) for the Brady Canal Hydrologic Restoration Project, Terrebonne Parish, Louisiana. The study area consisted of approximately 19 mi (30 km) of bankline, nine construction locales, and three previously recorded sites (16TR46, 16TR113, and 16TR217). Investigations included survey of the project area perimeter, examination of construction locales along the perimeter, and delineation of all archeological sites located in the survey area. Two new sites (16TR295 and 16TR296) and an isolated occurrence of culturally derived shell were located during the current survey. Survey consisted of a single transect with shovel and/or auger tests at 25 m intervals. A total of approximately 250 acres were surveyed. Site definition was undertaken at 16TR46, 16TR217, 16TR295, and 16TR296. Site 16TR113 could not be relocated. Sites 16TR46 and 16TR217 are potentially eligible for nomination to the National Register of Historic Places (NRHP). Sites 16TR295 and 16TR296 are ineligible for nomination to the NRHP. No cultural resources were recorded at the construction locales. Current construction plans will not impact any archeological sites. No significant standing structures are located in the survey area. No further work is recommended at this time. If future plans will impact 16TR46 or 16TR217, further investigations are required to establish their significance and integrity (LDA 2014b).

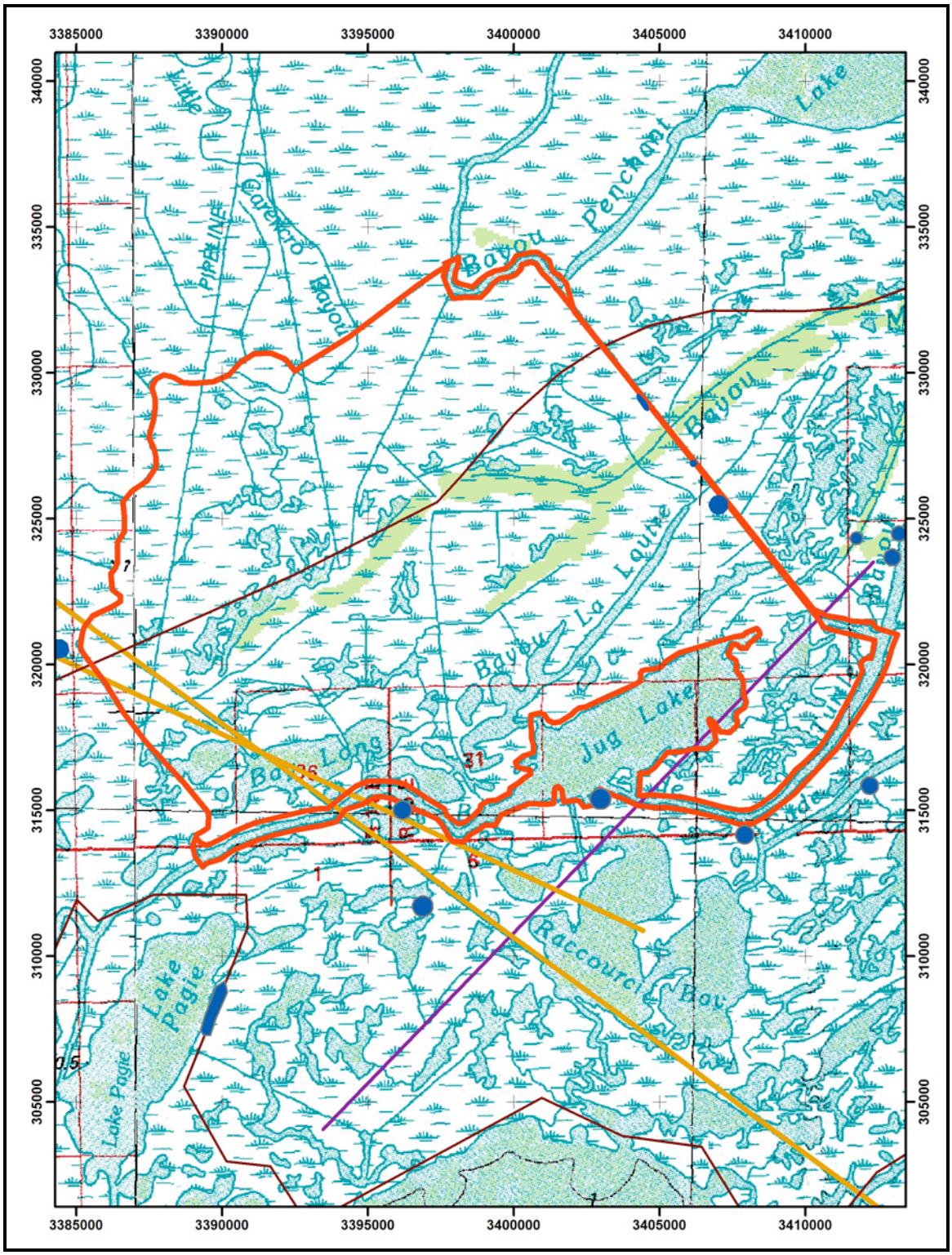

Figure 21. Location and project related extent of Survey 22-2115 and archaeological sites in the vicinity.

Report No.: 22-2133

Title: Morganza to the Gulf Feasibility Study: Cultural Resources Literature and Records Review, Terrebonne and Lafourche Parishes, Louisiana Volumes 1 and 2

Date: 2000

Author: Clifford T. Brown, Dave D. Davis, Julian Granberry, Roger Saucier, Lynn A. Berg, Christine Herman, J. Cinder Griffin Miller, Jeremy Pincoske, Susan Barrett Smith, Patrick P. Robblee, and William P. Athens

Contractor: R. Christopher Goodwin & Associates, Inc.

Abstract:
This volume presents the results of a cultural resources literature and records review for a feasibility study of two proposed levee alignments and associated water control structures in Lafourche and Terrebonne Parishes, Louisiana. This investigation was undertaken by R. Christopher Goodwin & Associates, Inc., on behalf of the U.S. Army Corps of Engineers, New Orleans District, pursuant to Contract No. DACW29-94-D-0019. The cultural resource portion of the feasibility study is a planning effort intended to assist the Corps of Engineers in carrying out its obligations under the National Historic Preservation Act (NHPA) and National Environmental Policy Act (NEPA) to take into account the effect of its undertakings upon cultural resources within the project area. Although this study initially was completed in 1997, it has been revised and reprinted in conjunction with a Phase I cultural resources survey and archeological inventory of a 405 ha (1,000 ac) sample of the levee alignment corridors (see volume II). This new edition incorporates minor changes in the proposed Morganza to the Gulf Feasibility Study levee alignment corridors. In keeping with the Scope of Work, the study reported here was conducted with the following objectives: (1) to provide an overview of regional prehistory, history, and previous cultural resource investigations; (2) to identify and describe previously recorded cultural resources sites within the project area based upon available documentation; (3) to describe the local geology and environment, especially as they relate to the identification and interpretation of cultural resources; (4) Using appropriate methodology, the development of a predictive model of culture resource site location for the project area; (5) to provide an ethnohistoric/socio-economic overview of Houma Indian communities in the project area; and (6) to create and provide a series of 1:24,000 scale maps illustrating the locations of all previously recorded cultural resources, high and low potential areas for cultural resources, and locations of Houma Indian communities identified within the ethnohistoric/socioeconomic overview. Following the Scope of

Work, this investigation also included formal consultation with the United Houma Nation; no other Native American nations were consulted. In developing the overview of regional prehistory, history, and previous cultural resource investigations, R. Christopher Goodwin & Associates, Inc., reviewed published works and available unpublished reports on the regional prehistory and history of the lower Mississippi River valley, with particular attention to the delta region, as well as archeological and cultural resources investigations in the project area and vicinity. Specific note was made of the nature and contents of previously reported archeological and historic sites in and within 500 m of the project area. State archeological site files in the Louisiana Division of Archeology and Historic Preservation were consulted to obtain further information about recorded archeological sites in and near the project area, and the records of Division's Standing Structures Survey were reviewed for information concerning houses, schools, commercial establishments, and other buildings that may have historical significance, including properties already listed on the National Register of Historic Places. In addition, efforts were made to contact avocational archeologists and collectors to identify the locations of otherwise unrecorded cultural resources. The chair and vice-chair of the United Houma Nation, the tribal entity recognized by the State of Louisiana, were contacted to aid in the preparation of the ethnohistoric profile. They also were consulted regarding their cultural resources concerns. These consultations and related correspondence led to a meeting with the tribal council and passage of a resolution concerning the consultation process. Development of a predictive model of culture resource site occurrence in the project area required an understanding of settlement patterns and subsistence and economic practices of the various cultural groups that occupied the region in the past. Equally important, however, was an appreciation of the specific geomorphic history of the area. Accordingly, it was necessary to map the surficial deltaic landforms in and around the project area, identify possible buried landforms, and estimate the probable ages of significant landforms in the area. With this information in hand, it was then necessary to apply an understanding of geomorphic processes responsible for landscape formation to create a ranking of the landscape elements as to their probability of containing archeological sites. This information was then conjoined with data about the cultural patterns of past inhabitants in designing the predictive model (LDA 2014b).

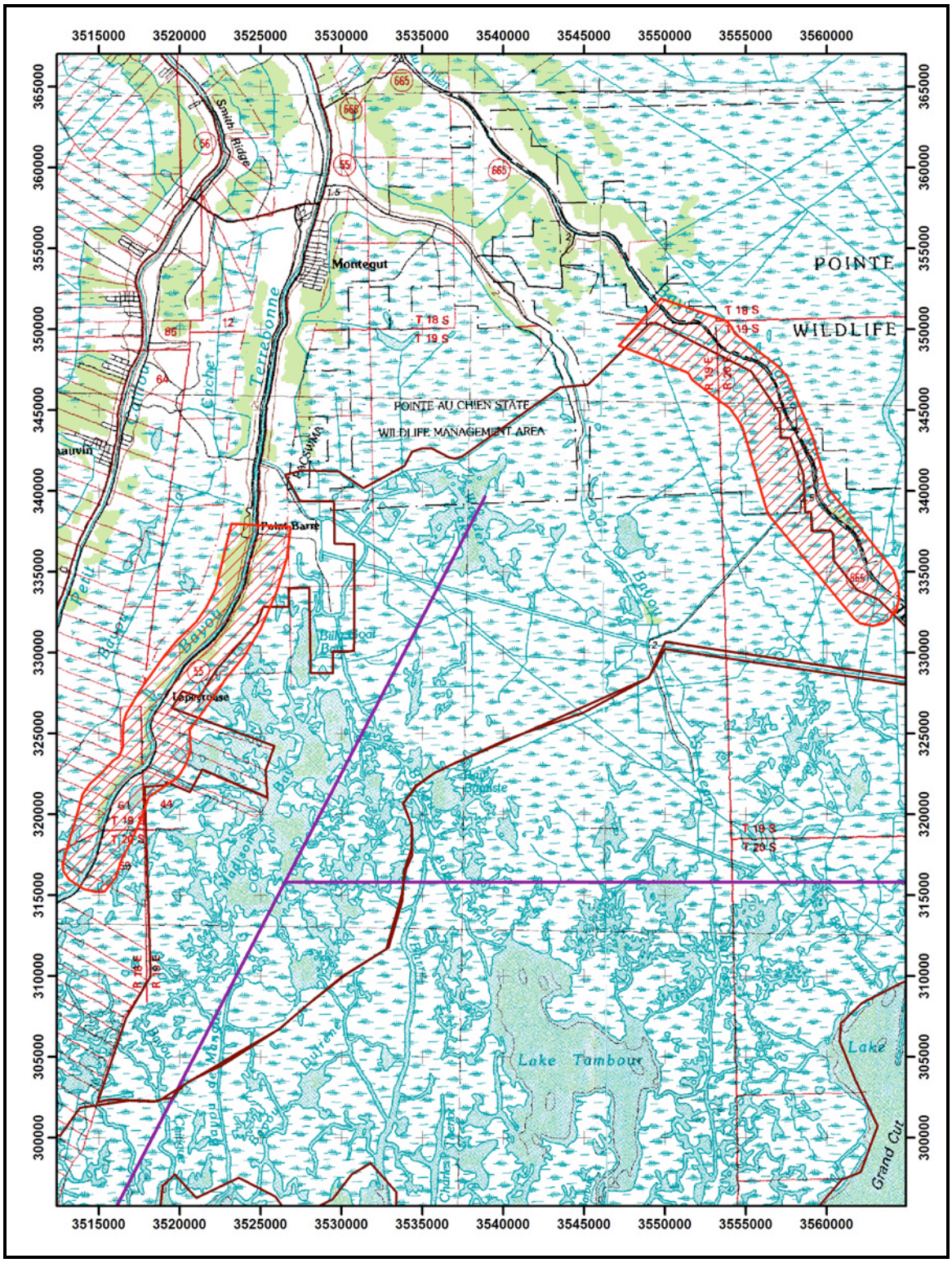

Figure 22. Location and project related extent of eastern areas of Survey 22-2133.

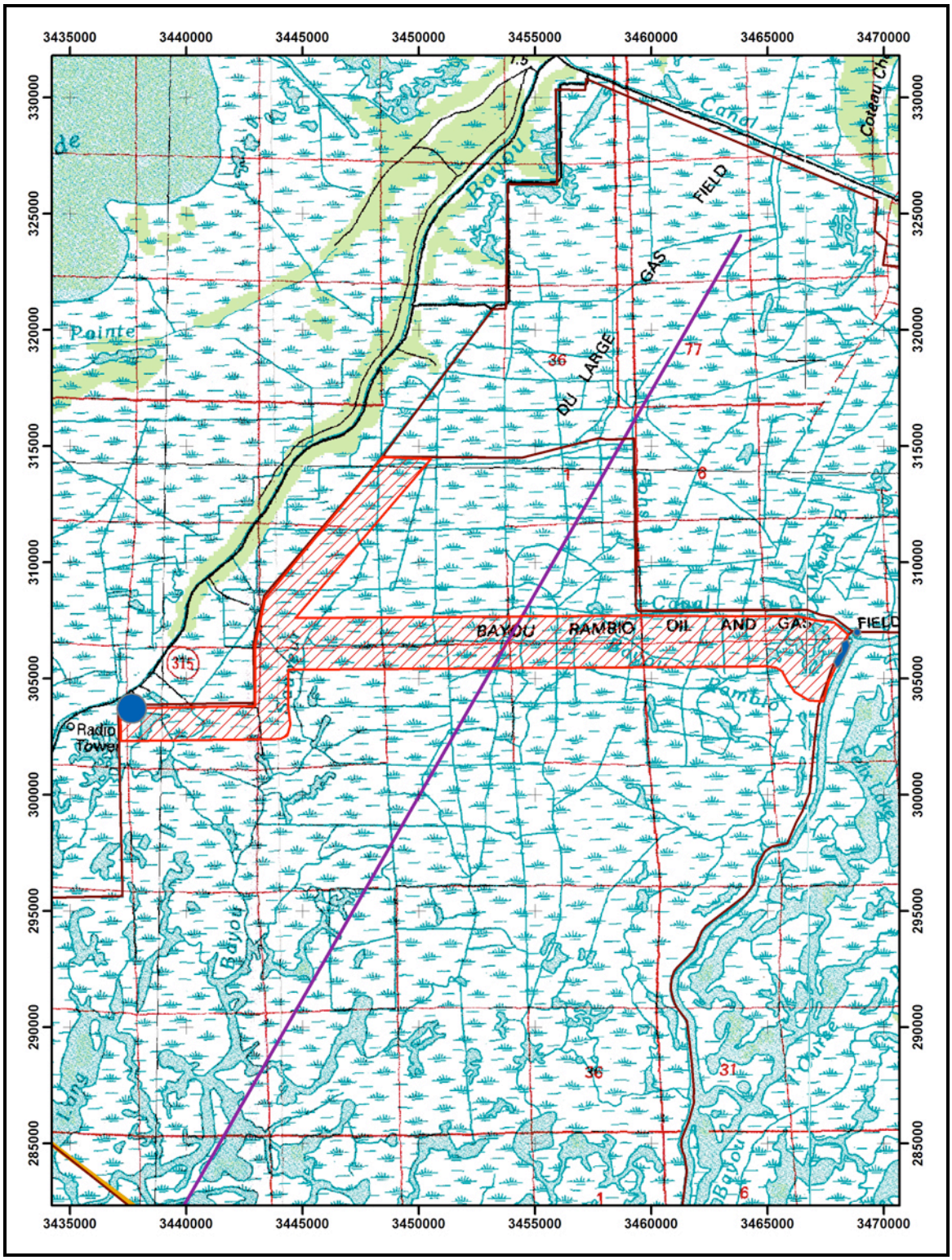

Figure 23. Location and project related extent of western areas of Survey 22-2133 and archaeological sites in the vicinity.

Report No.: 22-2250

Title: Analysis and Technical Report of Remote Sensing Data for the USS *Kinsman*

Date: 2000

Author: Allen Saltus, Jr., Benjamin Maygarden and Roger T. Saucier

Contractor: Earth Search, Inc.

Abstract:
This report deals with the results of research and analysis of remote sensing data for an area of approximately 25 acres south of Morgan City along the south bank of Bayou Boeuf at a point where it enters Berwick Bay in St. Mary Parish, Louisiana. Earth Search, Inc. (ESI), was contracted by the New Orleans District, U.S. Army Corps of Engineers (NODCOE), to conduct background research and analyze side-scan sonar, magnetometer, bathymetry, multi-beam swath sonar data for the study area, which is near to the NODCOE's maintenance dredging area in Bayou Boeuf where it enters Berwick Bay. The dredging, which has been ongoing since 1973, now appears to be very close to a possible historic shipwreck, possibly that of the USS Kinsman. Analyses revealed a total of 17 anomalies, seven of which may be associated with the Kinsman. It is recommended that Phase II investigations be undertaken on these seven anomalies to determine their nature, age, significance, and National Register eligibility (LDA 2014b).

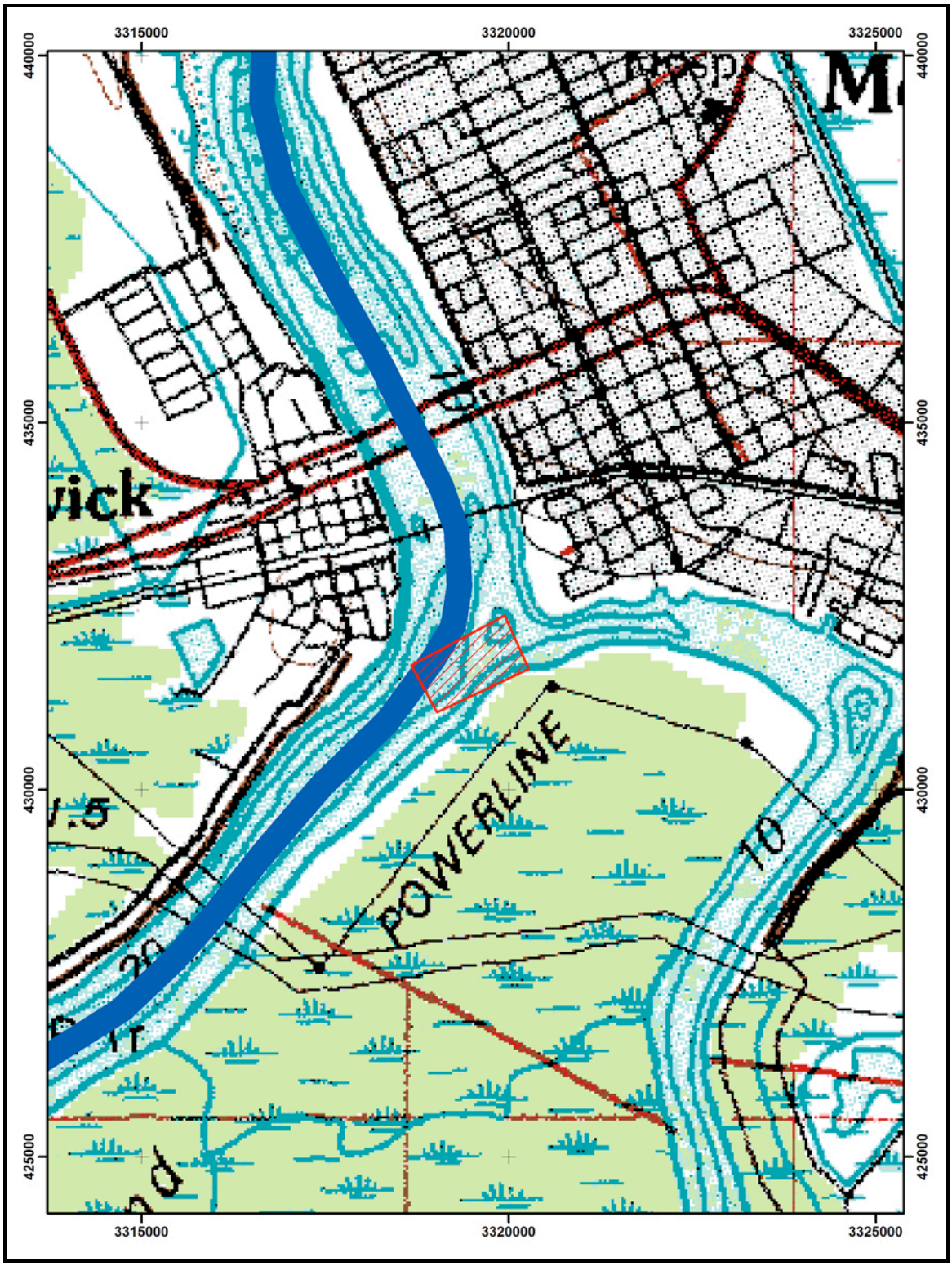

Figure 24. Location and project related extent of Survey 22-2250.

Report No.: 22-2317

Title: Evaluation and Analysis of Anomalies Possibly Associated With the U.S.S. Col. Kinsman, Atchafalaya River, Louisiana

Date: 2000

Author: Charles E. Pearson and Roland Stansbury

Contractor: Coastal Environments, Inc.

Abstract:
In November and December 1999, diving operations were conducted at the juncture of Bayou Boeuf and Berwick Bay (Atchafalaya River) adjacent to the community of Morgan City in St. Mary Parish, Louisiana. The purpose of the diving was to examine seven previously identified magnetic anomalies, some of which were thought to be associated with the United states gunboat *Kinsman* which sank in Berwick Bay in February 1863. The diving examined an area encompassing 7.2 acres. No vessel remains of any kind found during the 13 days of diving. Two of the magnetic anomaly sources proved to be modern trash and debris probably derived from recent vessel activity. The sources of the other magnetic anomalies could not be found and it is believed their sources consist of small and scattered items of modern age or are older objects buried beneath 25 feet or so of sediments that have accumulated at this location in the past 90 years (LDA 2014b).

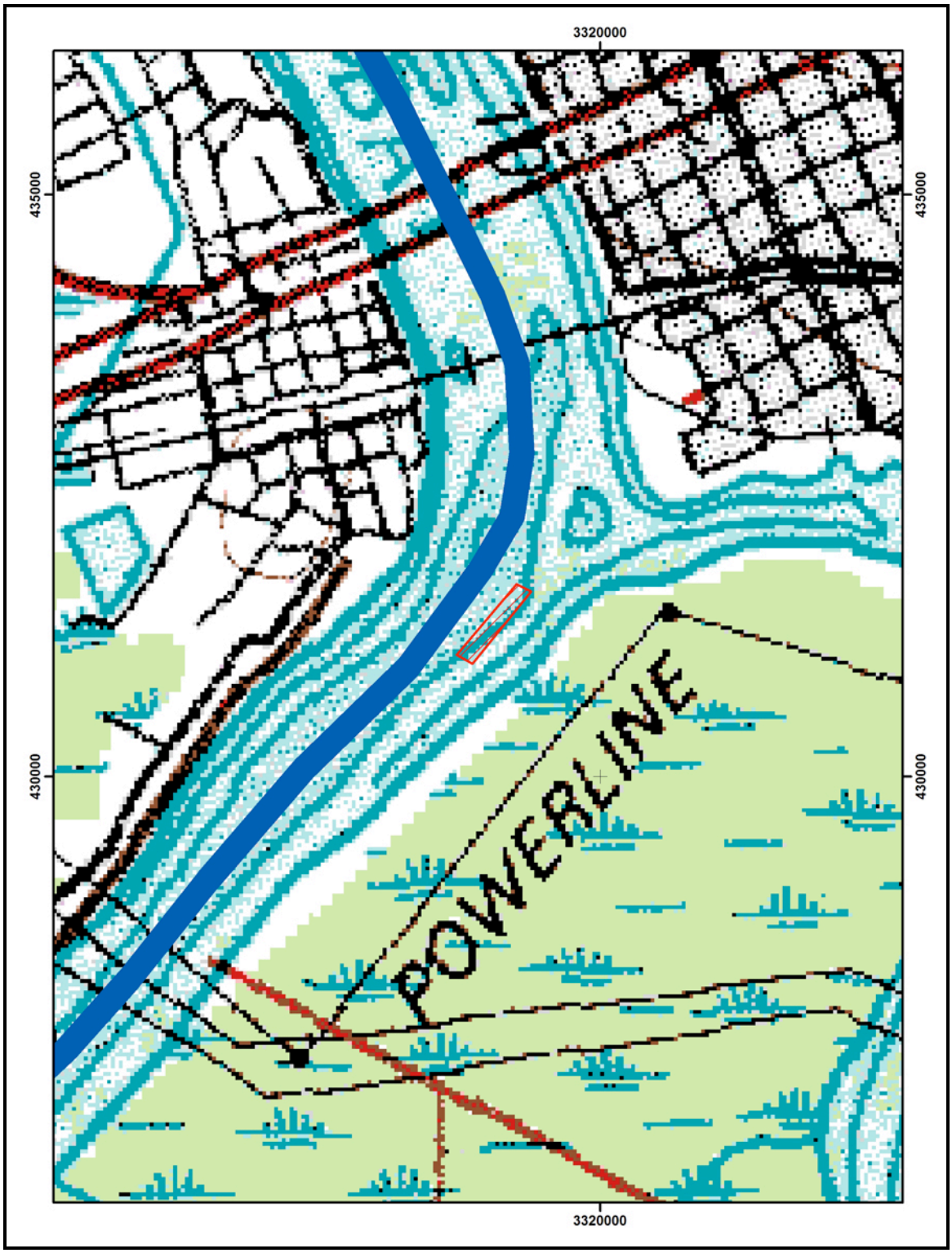

Figure 25. Location and project related extent of Survey 22-2317.

Report No.: 22-2577

Title: Phase I Cultural Resources Survey and Archeological Inventory of Four Project Areas Associated with the Proposed Discovery Market Expansion Project, Lafourche and Terrebonne Parishes, Louisiana

Date: 2003

Author: Kari Krause, Katy Coyle, Heather Backo, Jeremy Pincoske, David George and William P. Athens

Contractor: R. Christopher Goodwin & Associates, Inc.

Abstract:
This document presents the results of a Phase I cultural resources survey and archeological inventory of the proposed Discovery Market Expansion Project in Lafourche and Terrebonne Parishes, Louisiana. Fieldwork for this project was completed July 2, 2003, by R. Christopher Goodwin & Associates, Inc., on behalf of Discovery Gas Transmission LLC. The current document contains the results of a detailed examination of the proposed Areas of Potential Effect. The Areas of Potential Effect were subjected to both pedestrian survey and systematic subsurface testing where applicable. This undertaking included the examination of three pipeline segments that totaled approximately 4.16 km (2.59 mi) in length, as well as three delivery meter stations and two platforms encompassing approximately 0.79 ha (1.95 ac), and a walkway/road approximately 24.4 m (80 ft) in length, respectively. Thus, the total area surveyed measured 8.7 ha (21.2 ac) in land. Despite this intensive survey and inventory effort, no intact cultural deposits were observed, and no cultural material was recovered during survey of the proposed project items. In addition, no historic standing structures were identified within, or immediately adjacent to, the proposed Areas of Potential Effect. No additional testing of the above-mentioned project items is recommended (LDA 2014b).

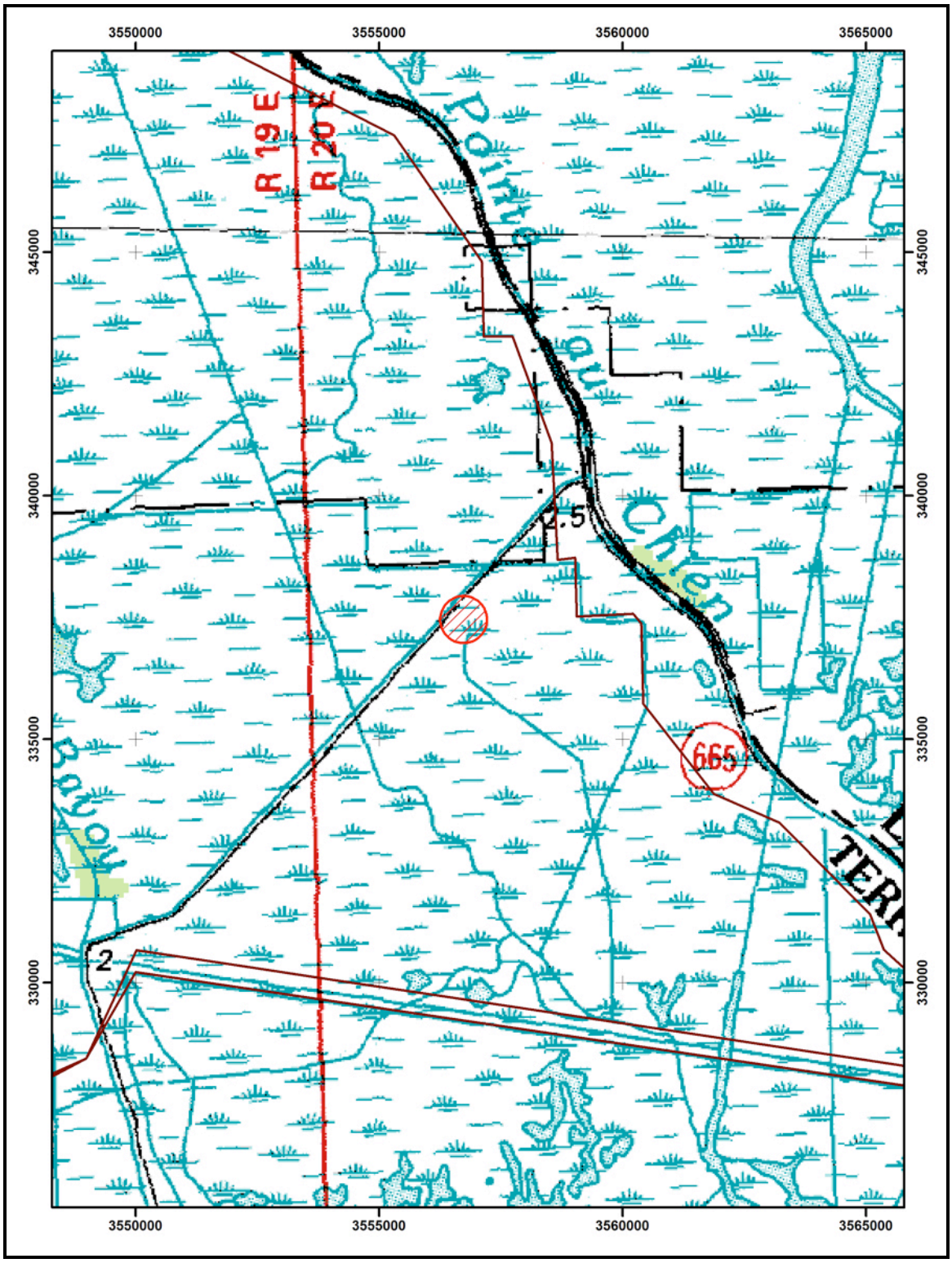

Figure 26. Location and project related extent of Survey 22-2577.

Report No.: 22-2641

Title: Houma Navigation Canal Deepening Project, Terrebonne Parish, Louisiana: Cultural Resources Literature Search, Records Review, and Research Design

Date: 2005

Author: Joanne Ryan, Richard A. Weinstein and Charles E. Pearson

Contractor: Coastal Environments, Inc.

Abstract:
From October through December of 2003, Coastal Environments, Inc. (CEI), conducted a cultural resources literature search and records review as part of a U.S. Army Corps of Engineers (COE) New Orleans District reevaluation study to determine if improvements to navigation along the Houma Navigation Canal, in Terrebonne Parish, Louisiana, are justified. These investigations are part of the planning to evaluate several alternatives to deepening the HNC from the authorized 15-foot depth to an 18 or 20-foot depth while maintaining the existing canal width. Both channel depths are being considered with a lock and without a lock in place. If the canal itself is assumed to be approximately 1000 ft (305 m) wide, the HNC encompassed roughly 4969.69 ac (2012.05 ha), including 2909.09 ac (1177.78 ha) of canal and 2060.60 ac (834.26 ha) of navigation channel. Three previously recorded archaeological sites and 13 sunk or salvaged vessels exist within the project's Area of Potential Effect (APE). In addition, seven unrecorded sites and 23 potential site loci were noted on the HNC during the project area site inspection conducted during this study. Those portions of the project area with a high probability for containing cultural resources have been defined on project plans and encompass 691.48 ac. A research design to guide future cultural resources fieldwork in the project area is presented (LDA 2014b).

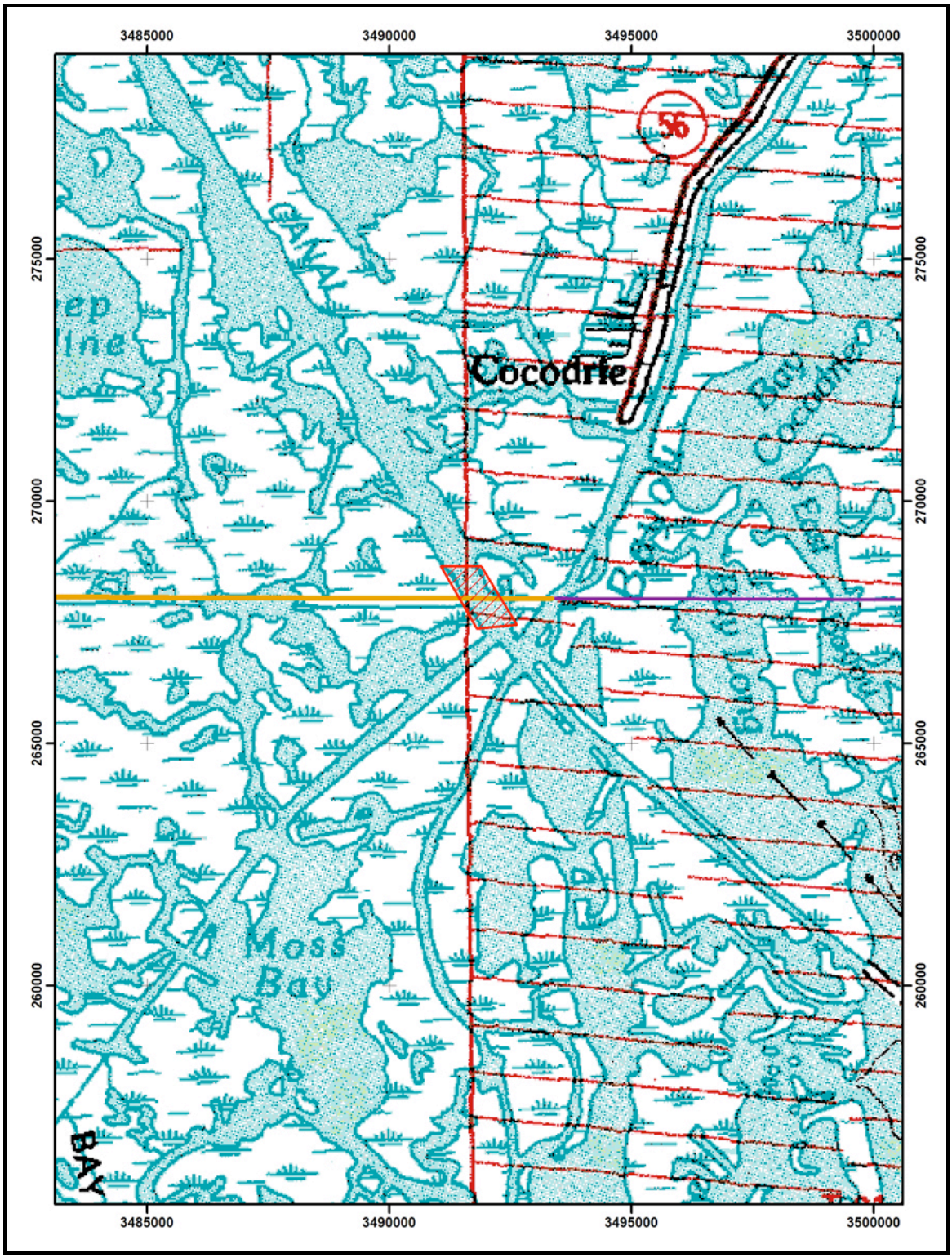

Figure 27. Location and project related extent of Survey 22-2641.

Report No.: 2817

Title: Phase I Submerged Cultural Resource Investigation Atchafalaya River Bar Channel Fluff/Fluid Mud Pilot Plan, St. Mary's Parish, Louisiana [Draft]

Date: 2006

Author: G. Anthony Randolph, Jean B. Pelletier, Samuel P. Turner, Gregg Brooks and Troy J. Nowak

Contractor: R. Christopher Goodwin & Associates, Inc.

Abstract:
This report presents results of Phase I marine archeological remote sensing survey of three related study areas located in the Gulf of Mexico, approximately ten (10) miles (16.1 km) south of the mouth of the Atchafalaya River, in St. Mary Parish, Louisiana. R. Christopher Goodwin & Associates, Inc., conducted this work on behalf of the U.S. Army Corps of Engineers New Orleans District (USACE-NOD). Field investigations were undertaken in September 2004, in support of the Atchafalaya River Bar Channel Fluff/Fluid Mud Pilot Plan project. This study was carried out to assist the U.S. Army Corps of Engineers in compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, and with 36 CFR Part 800, entitled "Protection of Historic Properties." All aspects of these investigations were completed in accordance with the Secretary of Interior's Standards and Guidelines for Archeology and Historic Preservation (Federal Register 48, No 190, 1983), and in consultation with the Louisiana Division of Archeology, Louisiana Department of Culture, Recreation, and Tourism. The three study areas for this project are composed of ten small parcels located in and adjacent to the Atchafalaya Navigation Channel, which lies approximately 10 mi (16.1 km) south of the mouth of the Atchafalaya River, in St. Mary Parish, Louisiana. The first study area is comprised of two parcels that correspond to a sediment sump (Sump) and the slopes and floor of the Atchafalaya Navigation Channel, Main Channel (MC). The Sump measures 1,600 ft by 4,000 ft (488 m by 1220 m), or 147 acres (59.5 hectares) in size. A total of 25 transects were surveyed for a total of 100,000 linear ft (30,488 linear m), or 18.9 linear mi (30.49 linear km). The slopes and floor of the Atchafalaya Navigation Channel, Main Channel (MC) survey area measured approximately 550 ft by 32,000 ft (168 m by 9756 m), or 404 acres (163.5 hectares) in size. This area was sub-divided into six survey blocks to achieve greater survey control; these blocks were designated MC-A through MC-F. Each of these survey blocks measured 550 ft by 5280 ft (168 m by 1610 m) and contained 14 transects spaced at 50 ft (15.25 m) intervals. A total of 84 transects were surveyed in MC, for a total of 443,520 linear ft (135219.5 linear m), or 84 linear mi (135.2 linear km). The second study area was

comprised of six cross channel survey blocks, designated CC-A through CC-F, oriented perpendicular to the existing navigation channel. Each of these survey blocks measured 500 ft by 1,500 ft (152.4 m by 457.3 m), or 17.2 acres (6.96 hectares) in size, and contained 13 transects spaced at 50 ft (15.25 m) intervals. A total of 78 transects were surveyed in CC, for a total of 117,000 linear ft (35,670.7 linear m), or 22.16 linear mi (35.67 linear km). A sub-bottom profiler was deployed during the cross channel portion of the Atchafalaya survey to detect any remnant river channels and natural levees that may have been sub-serially exposed in the prehistoric past. The third study area was comprised of two parcels that correspond to parallel channels, designated PCE and PCW, and located on the eastern and western side of the existing navigation channel. Each parallel channel measured 300 ft by 70,000 ft (91.5 m by 21341.5 m), or 482.1 acres (195.1 hectares) in size. These areas were sub-divided into 13 survey blocks to achieve greater survey control; these blocks were designated PCE-A through PCE-M, and PCW-A through PCW-M. Survey blocks PCE-A through PCE-L, and PCW-A through PCW-L, measured 300 ft by 5,280 ft (91.5 m by 1609.8 m) and each contained 9 transects spaced 50 ft (15.25 m) intervals. Survey blocks PCE-M and PCW-M measured 300 ft by 6,581 ft (91.5 m by 2006.4 m); each also contained 9 transects spaced at 50 ft (15.25 m) intervals. A total of 234 transects were surveyed in PCE and PCW, for a total of 1,258,938 linear ft (383,822.6 m), or 238.4 linear mi (383.8 km). The objectives of this study were to identify targets within the project area that have the potential to represent significant submerged cultural resources, and to provide management recommendations for any such resources. These objectives were net through the application of a research design that combined background archival investigations and marine archeological remote sensing survey and analysis. Background research and archival investigations indicated a moderate potential for encountering submerged historic cultural resources within the project area. This is due to the extensive history of commercial vessel traffic between New Orleans and other Gulf ports, most notably Galveston and Corpus Christi. A review of the geomorphological data for the project area indicated a low to moderate potential for submerged terrestrial sites. A review of Louisiana's archaeological site files and relevant research reports documented two archeological sites within five miles of the survey area; however, no maritime sites were reported within five miles of the proposed work area. A review of the National Oceanic and Atmospheric Administration's (NOAA) Automated Wreck and Obstruction Information System (AWOIS) revealed no mapped obstructions within the study area. This survey utilized a Trimble AG132 differential global positioning system (DGPS), a Marine Sonic recording side scan sonar, a Geometrics digitally recording marine cesium magnetometer, and Imagenex 1030F digital sub-bottom profiler, a Cetrek digital recording fathometer; and hydrographic navigational computer software. The survey was conducted with a lane spacing of 50 ft (15.25 m) to assure adequate survey coverage and data density. The survey techniques ensured that any abandoned or wrecked historic vessels

within the survey area would be detected. The marine remote sensing survey registered a total of 3134 individual magnetic anomalies, 207 individual acoustic anomalies, and 10 sub-bottom anomalies. A total of 163 target clusters were identified during remote sensing data analysis. All but one of these targets, along with the remaining magnetic and acoustic anomalies, appears to represent modern debris. Only Target 51 was identified as having potential to represent a submerged cultural resource. This target is located in Parallel Channel East, Block B, and it should be avoided during the project in lieu of further archeological investigation (LDA 2014b).

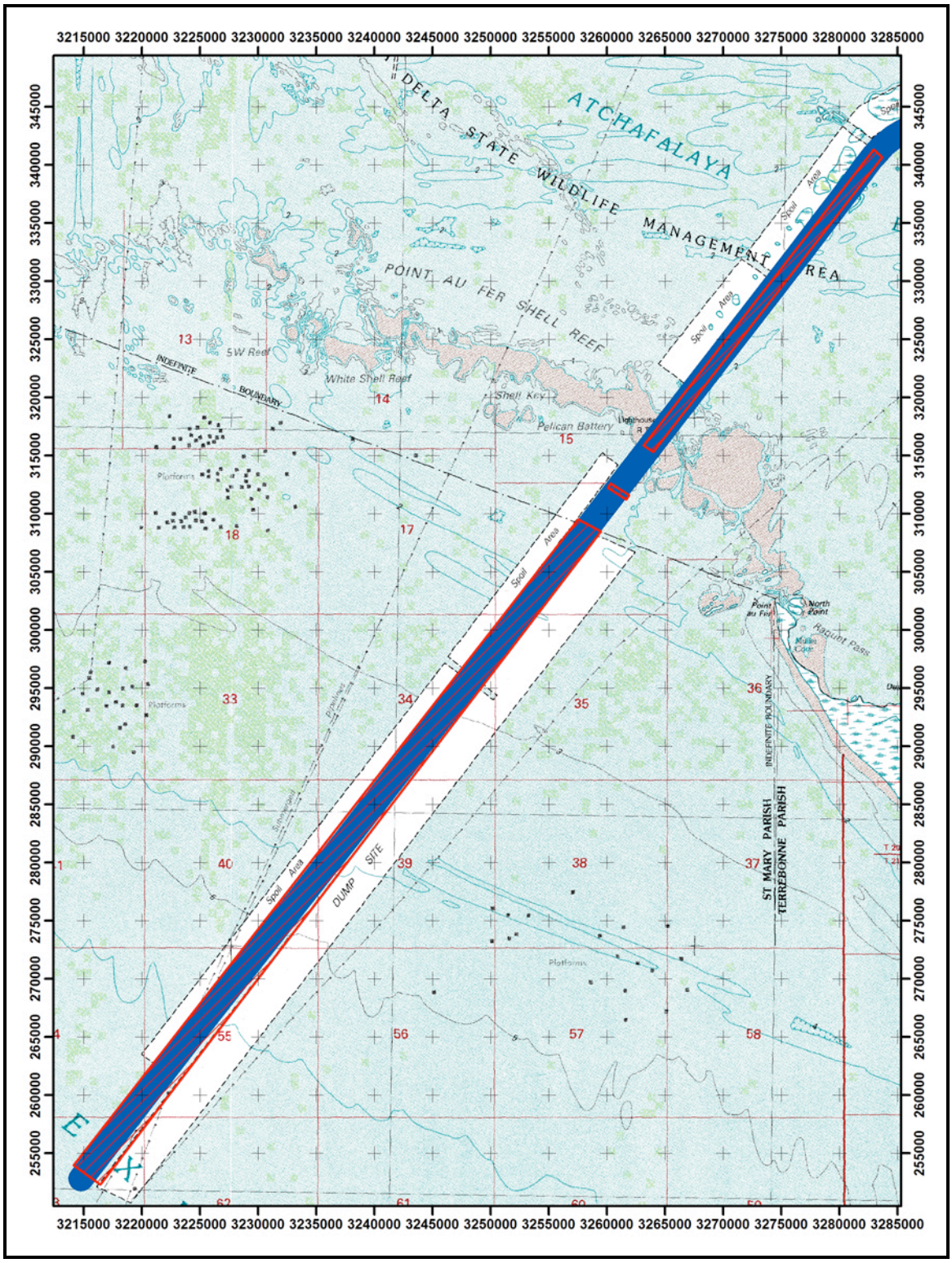

Figure 28. Location and project related extent of Survey 22-2817.

Report No.: 22-3077

Title: Phase I Cultural Resources Survey of Areas to be affected by the Houma Navigational Canal Deepening Project, Terrebonne Parish, Louisiana

Date: 2009

Author: David B. Kelley, Charles E. Pearson, and Joanne Ryan

Contractor: Coastal Environments, Inc.

Abstract:
Between October 2007 and February 2008, Coastal Environments, Inc. (CEI) conducted a cultural resources survey for the U.S. Army Corps of Engineers (COE), New Orleans District of areas to be affected by the Houma Navigation Canal (HNC) Deepening Project, in Terrebonne Parish, Louisiana. These investigations are part of the planning to evaluate several alternatives to deepening the HNC from the authorized 15-foot depth to an 18- or 23-foot depth while maintaining the existing canal width. The Area of Potential Effect (APE) for the project includes approximately 4970 acres of the canal and navigation channel, 516 acres of Bayou Grand Caillou, and 23,263 acres of dredge material disposal areas for a total of 28,749 acres. Four previously recorded archaeological sites and 12 newly recorded sites were examined during the survey. One of the previously recorded sites, 16TR72, and one of the new sites, 16TR322, are located out side of the project's APE and were not evaluated. They will not be affected by the proposed project. The remaining sites are not considered eligible for the National Register of Historic Places. Remote-sensing surveys were conducted in five areas that will be affected by the project: 1). Offshore Survey Area 1 (SPD MI. - 1.7); 2). Offshore Survey Area 2 (SPD MI. - 2.5); 3). the Isle Derniere Survey Area, 4). the Timbalier Island Survey Area, and 5). the Bayou Grand Caillou Survey Area. Two anomalies were located in each of the two Offshore Survey Areas, but none of them are considered likely to be related to cultural resources. Survey of the Isle Derniere area located five pipelines and three individual anomalies. One of the latter, M007, was related to an oil and gas well, and the other two were more likely to be associated with oil and gas exploration than shipwrecks, therefore no further work was recommended for these. Survey of the Timbalier Island area identified 32 pipelines and two individual anomalies, but neither of the latter was considered likely to represent cultural resources. Finally, survey of the Bayou Grand Caillou area recorded a great number of individual magnetic anomalies and sidescan sonar targets most of which could be related to crab traps or small objects, such as pieces of pipe or metal drums. Only two anomalies, magnetic anomaly MS04 and sidescan sonar target SSNO1, were considered to be potentially associated with cultural resources. It is recommended

that no dredging be conducted within 75 ft. of either target. If avoidance is not possible, it is recommended that each target be further examined to determine its identity and National Register eligibility. In addition to these two target locations, the area along the western bank of Bayou Grand Caillou just below Mound Bayou was considered a sensitive area relative to historic properties. A Civil War earthwork, Fort Quitman, was located in this area and studies from other waterways in south Louisiana show that old and decrepit boats are often abandoned near settlements and docking areas where they eventually deteriorated and became submerged and/or buried. The land portion of this area was not surveyed during the project, as it did not fall in a dredged material disposal area. If dredging impacts were to occur within 75 feet of the west bank of Bayou Grand Caillou, it was recommended that a pedestrian survey be conducted along the western bank line for a distance of one mile south of Mound Bayou (LDA 2014b).

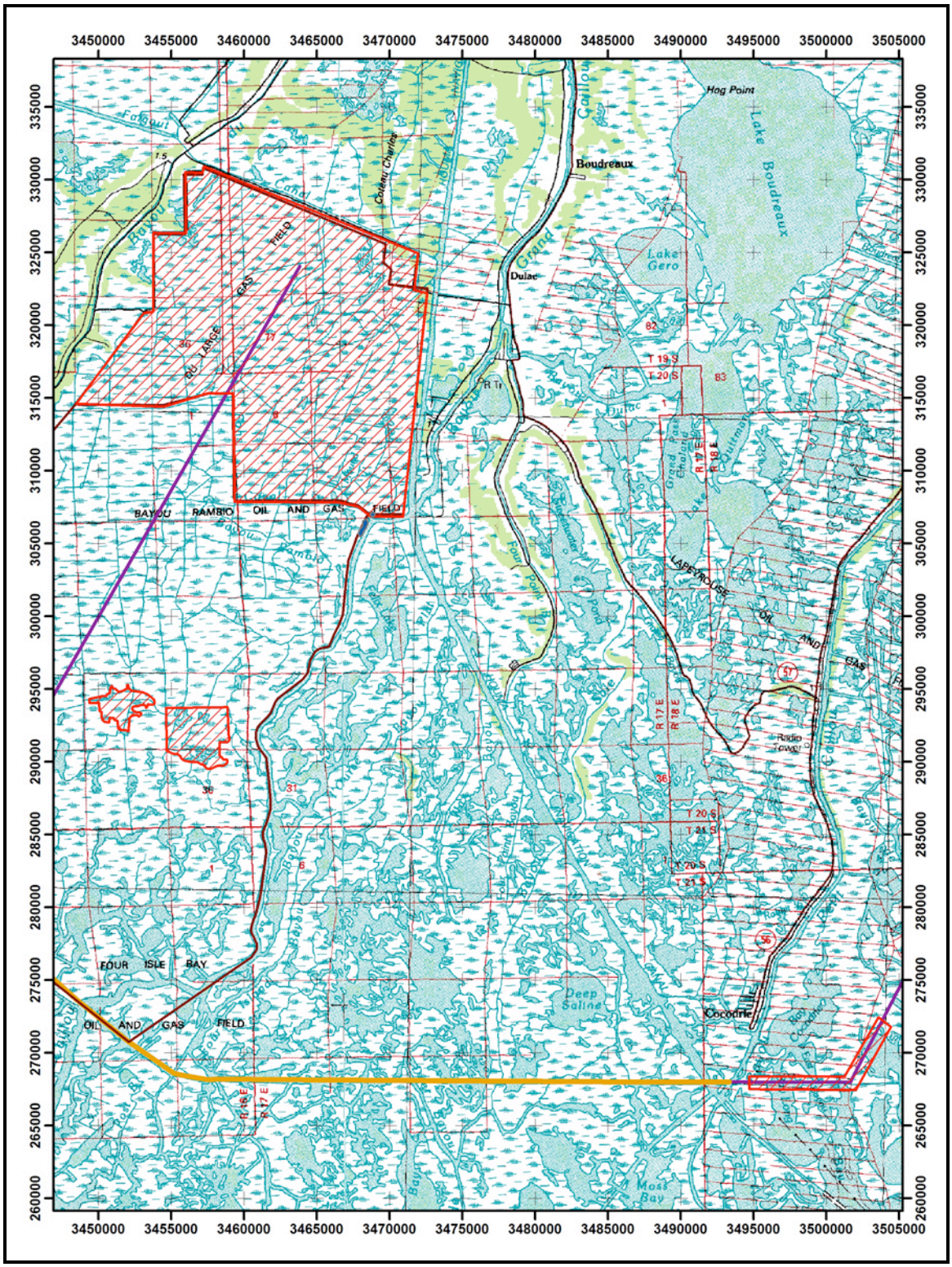

Figure 29. Location and project related extent of Survey 22-3077.

Report No.: 22-3291

Title: Phase Ia Literature Search and Records Review of Previously Recorded Cultural Resources Located within the Proposed Project Area Associated with the Morganza to the Gulf Hurricane Protection Project, Terrebonne and Lafourche Parishes, Louisiana

Date: 2011

Author: Meredith Moreno, Susan Barrett Smith, Dave D. Davis and R. Christopher Goodwin

Contractor: R. Christopher Goodwin & Associates

Abstract:
This report presents the results of Phase la cultural resource literature search and records review for previously uninvestigated locations within the proposed Morganza to the Gulf Hurricane Protection Project. This investigation was undertaken by R. Christopher Goodwin & Associates, Inc., on behalf of the U.S. Army Corps of Engineers, New Orleans District. In 2000, a predictive model was developed for proposed levee alignments of the Morganza to the Gulf project area in Terrebonne and Lafourche Parishes, Louisiana. That report (Brown et al. 2000) investigated a large portion of the proposed 2008 study area; the current report does not replicate those data. Rather, the purpose of this study is to update the research completed in 2000 in addition to conducting background research for the newly proposed levee alignments in the project vicinity. The cultural resources portion of the literature search, records review, and probability study is a planning effort designed to assist the Corps of Engineers in its carrying out its obligations under the National Historic Preservation Act of 1966, as amended (NHPA) and the National Environmental Policy Act (NEPA), to take into account the effect of its undertakings upon cultural resources within the project area. The study reported here was conducted with the following objectives: (1) to provide an overview of regional prehistory, history, and previous cultural resource investigations; (2) to identify and describe previously recorded cultural resource sites within the project area based upon available documentation; (3) to describe the local geology and environment, especially as they relate to the identification and interpretation of cultural resources; (4) to update and support the research utilized in the 2000 Morganza to the Gulf Feasibility Study (Brown et al. 2000), and to apply the predictive model of culture resource site location to the levee alignments and to new levee alignments; (5) to provide a series of maps illustrating the locations of all previously recorded cultural resources and those areas of high and low potential for containing cultural resources; and (6) to use the above mentioned data to recommend locations for Phase lb archeological survey (LDA 2014b).

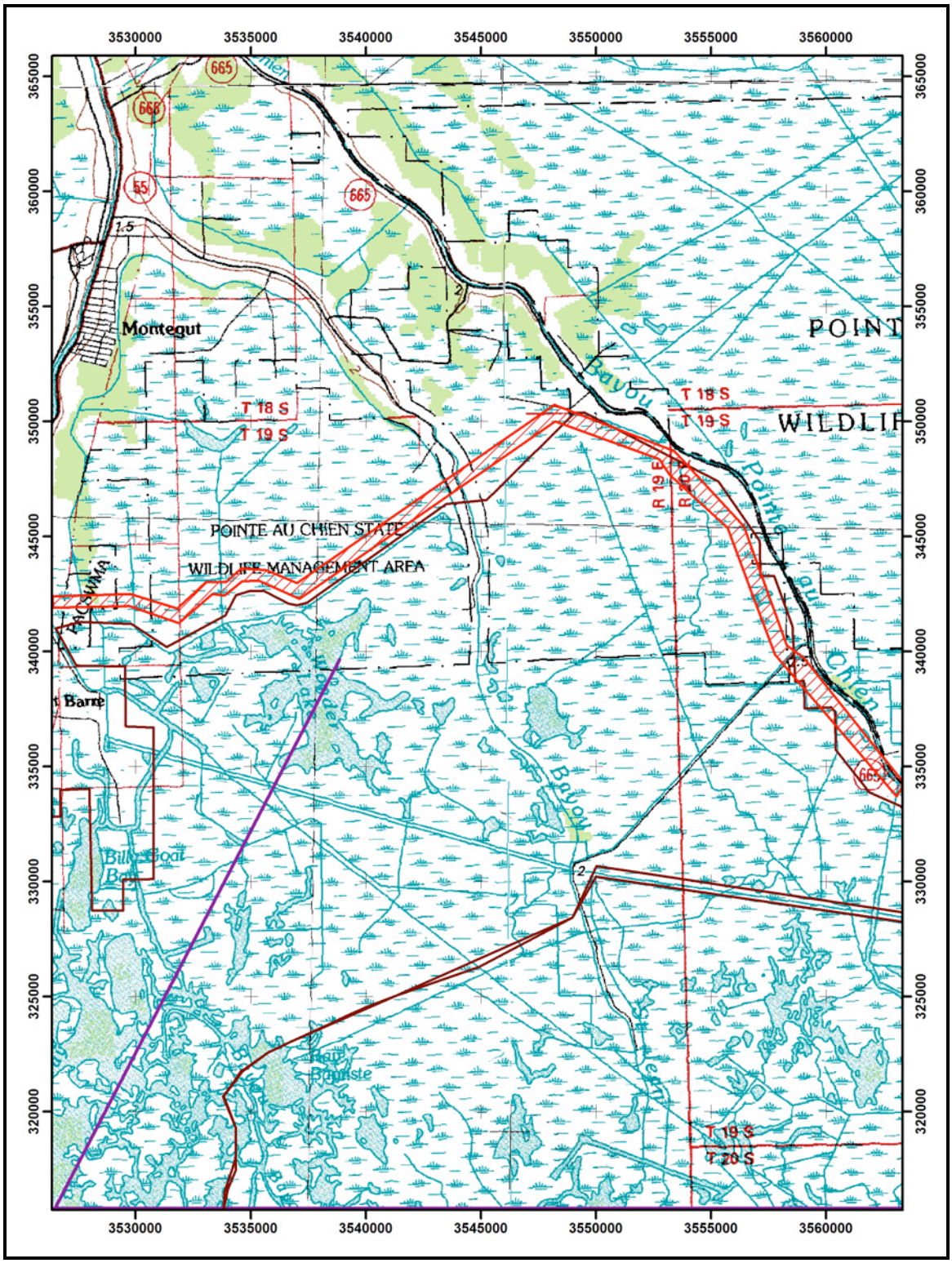

Figure 30. Location and project related extent of Survey 22-3291.

Report No.: 22-4074

Title: Phase I Cultural Resources Survey of the Proposed Terrebonne Parish Upper Dularge Flood Protection Levee Project in Terrebonne Parish, Louisiana

Date: 2012

Author: Wayne C. J. Boyko, Katherine Fodd, David Stitcher, Craig Matthews and William P. Athens

Contractor: R. Christopher Goodwin

Abstract:
This document describes the results of a Phase I cultural resources survey of the proposed Terrebonne Parish Upper Duularge Flood Protection Levee Project in Terreebonne Parish, Louisiana. The proposed levee development project corridor measured approxiimately 7.64 km (4.75 mi) in length and 61 m (200 feet) in width, and is located to the south of Theriot, Louisiana. As part of this project, appproximately 46.6 ha (liS ac) were examined for cultural resources. This investigation consisted of a Phase I cultural resources survey of the proposed levee corridor and fieldwork designed to identitY and to evaluate all cultural resources (e.g., archeological sites, historic standing structures, isolated finds, and cemeteries) situated within or immediately adjacent to the project area that might be impacted adversely as a result of planned construction activities. This research included cartographic, archival, and archeological review of data relevant to the Upper Dularge levee project area. The archeological inventory included both pedestrian reconnaissance along the entire length of the 7.64 km (4.75 mi) corridor and the excavation of 90 shovel tests. In general, the 46.6 ha (115 ac) project area was wet, with only slight variation in relief. No cultural resources were identified as a result of this archeological inventory, and no further work is recommended within the limits of the currently proposed Terrebonne Parish Upper Dularge Flood Protection Levee Project Area (LDA 2014b).

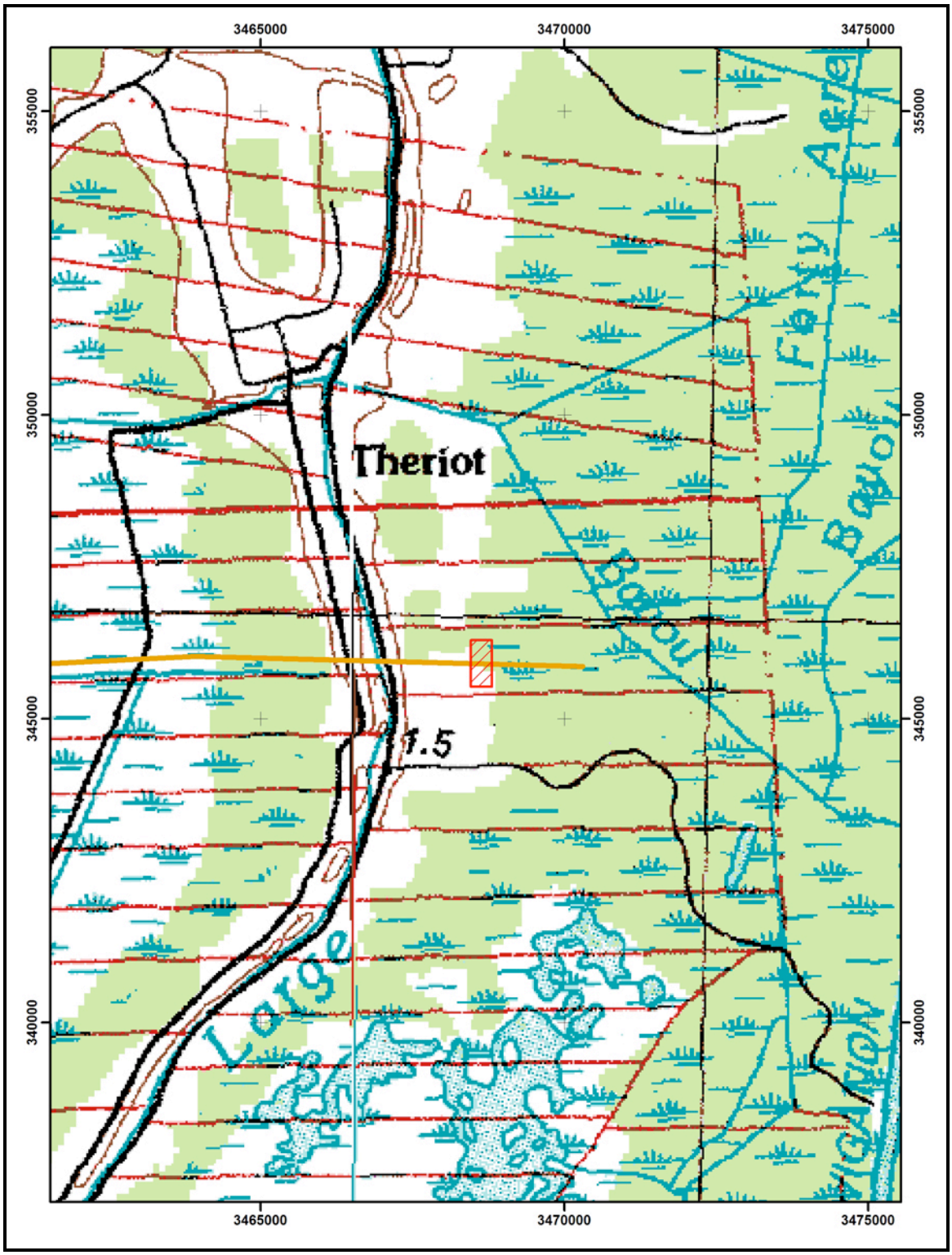

Figure 31. Location and project related extent of Survey 22-4074.

Results and Conclusions

Data from the site files of LDA indicates that to date 22 cultural resource surveys have been carried out within, or extending into, the Atchafalaya River, extant and proposed pipeline canal corridors and the four areas of marsh and ridge habitat restoration that comprise the project footprint. Six surveys have been carried out in the Atchafalaya and the offshore entrance channels. Six surveys cross extant pipeline canals that may be used for sediment transfer across Central Terrebonne Hydrologic Basin. Of the remaining surveys, have been carried out in the Bay Raccourci marsh and ridge habitat restoration area (Figure 30). Two surveys have been carried out in the Falgout Canal marsh and ridge habitat restoration area (Figure 31) and one has been carried out in the Lake Tambour marsh and ridge habitat restoration area (Figure 32). Five surveys have been carried out in the Wonder Lake area (Figure 32).

While survey work has been carried out in each of the marsh and ridge habitat restoration areas, the Falgout Canal site has the highest survey density. The Lake Tambour site has been the site of the least cultural resource survey activity. Surveys in the Bay Raccourci ridge habitat restoration area have focused on small specific areas and along canal, bayou and lake levees. The majority of cultural resource surveys in the Wonder Lake marsh and ridge habitat restoration area has occurred along rivers that border the area, bayous and canals.

In light of the rich prehistoric and historical traditions associated with the Atchafalaya and the Central Terrebonne Hydrologic Basin, both areas are considered to be high probability locations for cultural resource sites. In the "Cultural Resource Literature and Records Review for Morganza to the Gulf Feasibility Study, Terrebonne and LaFourche Parishes, Louisiana" produced in 1997 for the USACE-New Orleans District, R. Christopher Goodwin and Associates identified a number of essential considerations for predicting archaeological site distribution in a study area that included much of the Terrebonne Hydrologic Basin.

Considerations influencing archaeological site distribution and density identified in the Morganza to the Gulf study area that might be relevant for predicting sites in the Terrebonne Hydrologic Basin included:

> 1. Past settlement was almost entirely confined to natural levee deposits, with the possible exception of historic shipwrecks that will occur in distributary channel deposits; therefore archaeological sites will occur in the same areas, regardless of whether the geomorphic features can be identified based on the presently available data. For example, presently unsuspected distributary natural levees could be discovered by subsurface testing.

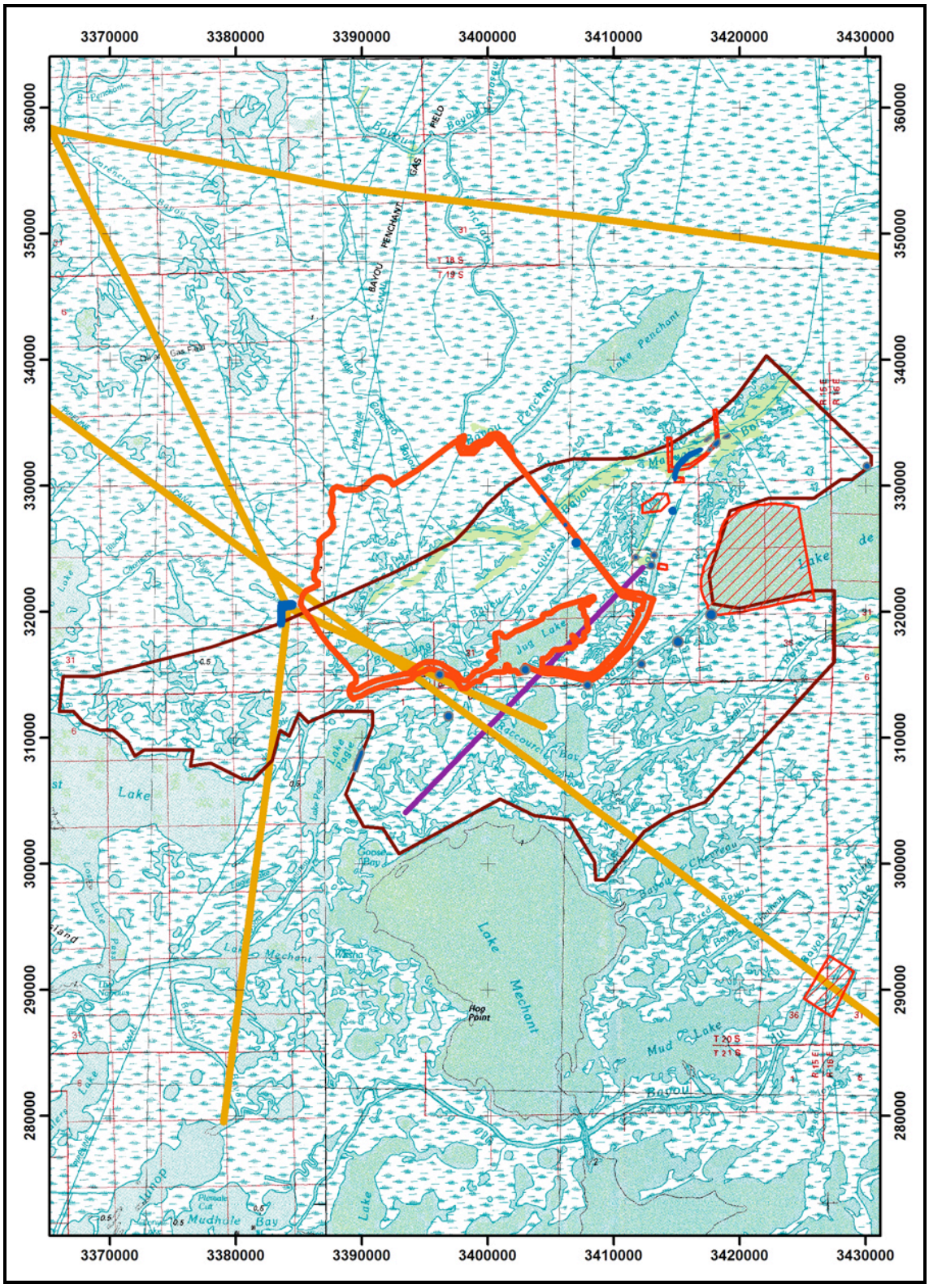

Figure 32. Bay Raccourci marsh and ridge habitat restoration area survey density and archaeological sites.

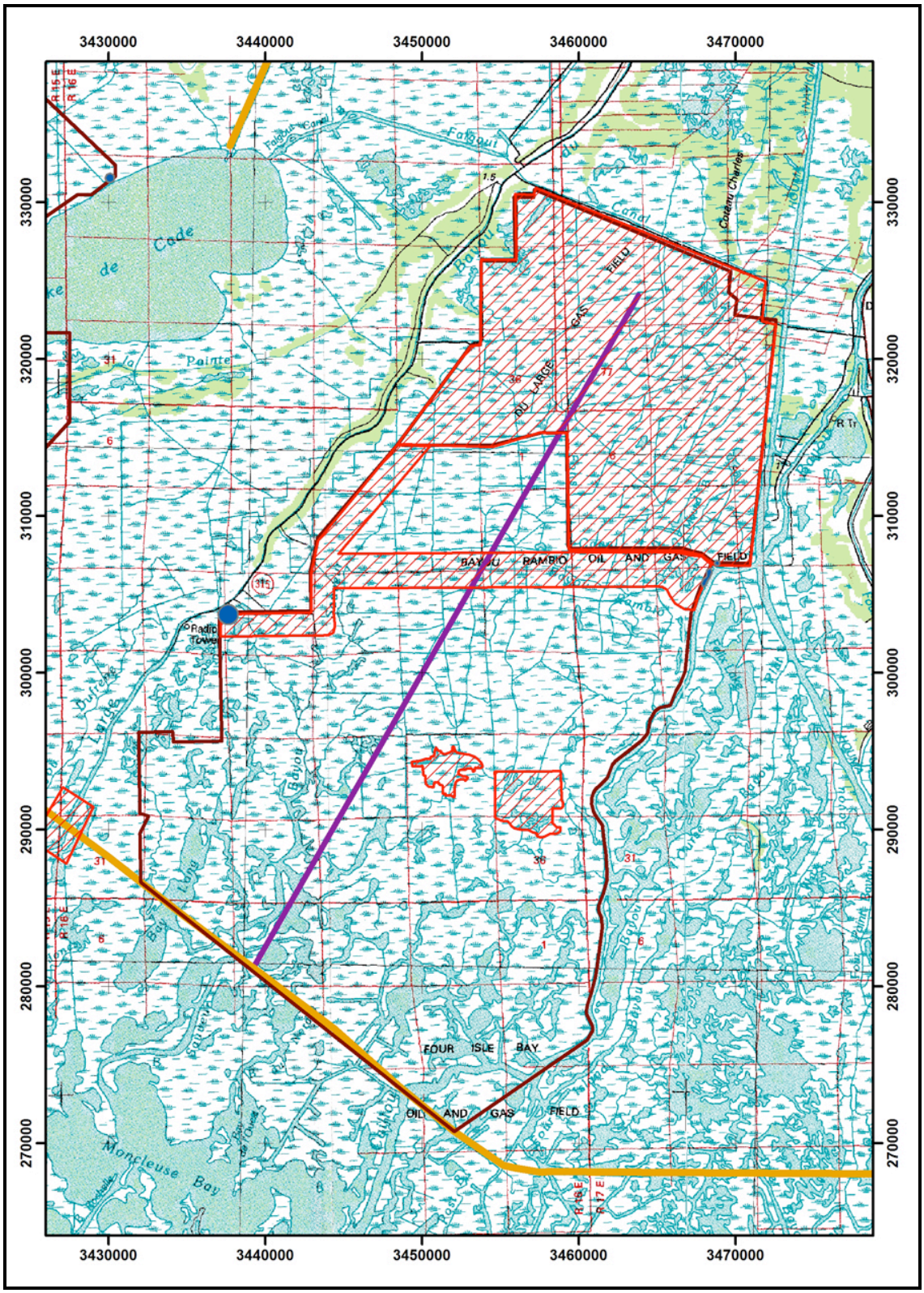

Figure 33. Falgout Canal marsh and ridge habitat restoration area survey density and archaeological sites.

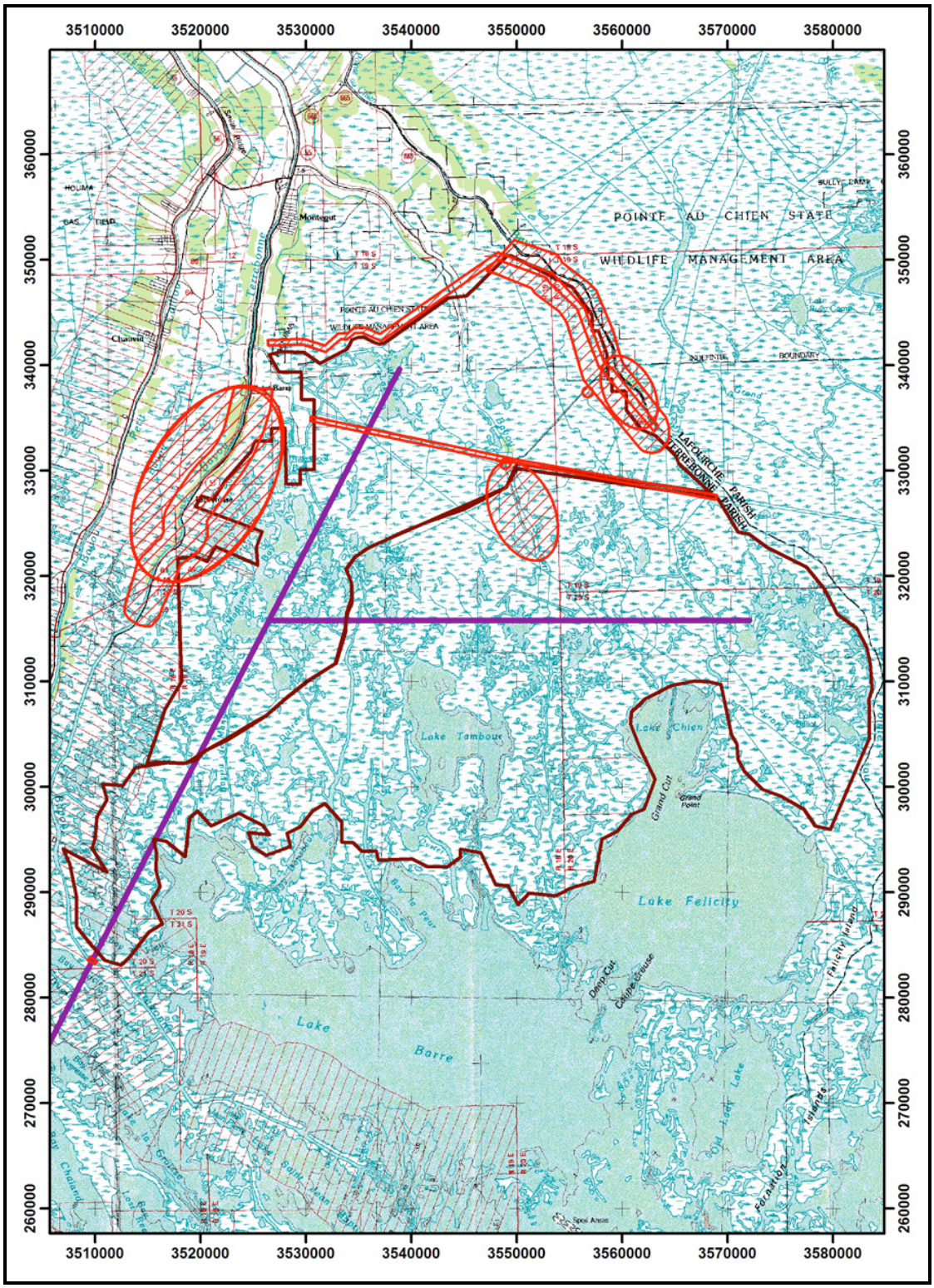

Figure 34. Lake Tambour and Wonder Lake marsh and ridge habitat restoration areas survey density.

2. Sites of all periods will occur preferentially at distributary confluences and crevasse land bridges.

3. Site types will be distributed differentially, with central places like mounds and plantations occurring preferentially at distributary confluences, and with resource procurement sites occurring preferentially on the distal flanks and extremities of distributaries. In fact mounds will be heavily over-represented in the project area, because it does not include the corresponding distal portion of the distributary system.

4. Earth middens are the most common type off site that remain to be identified in the project area. Without doubt, the inventory of extant sites is much more complete for shell middens and mounds of all kinds than earth middens. Earth middens are probably common but very poorly recognized in the project area.

5. Overall site density on natural levees in the project area can be estimated at 0.0148 sites per acre or 0.037 sites per hectare. It could be argued the densities of sites should be higher on the older as compared to the younger landforms…because of the additional time available for habitation and other activities (the study noted that site specific evidence does not always support this hypothesis).

6. Site density in interdistributary wetlands, although very low, will be greater than zero.

7. Shipwreck sand derelict vessels appear to be common in the larger distributary channels, although there may be some difficulties in determining whether a vessel is abandoned or merely decommissioned.

8. Historic plantations will exhibit nodal block and bayou block settlement patterns described by Rehder (1978), with the latter predominating; plantations will occur preferentially where there are unusual expanses of arable land.

Once Areas of Potential Effect (APE) have been established, these and other criteria can be employed to identify specific landforms having high, moderate and low potential association with archaeological and historical resources. Those data can be used to identify appropriate survey methodologies and costs.

As proposed marsh and ridge habitat restoration project activities will impact previously unsurveyed areas, plans for conducting underwater and terrestrial cultural resource surveys should be initiated as soon as specific impact areas can be identified. Clearly the uninvestigated transects for the new pipeline canals will require surveys. Where marsh and ridge habitat restoration activity will alter the extant terrestrial and underwater environment, surveys will also be required to ensure that cultural resources meeting the eligibility requirements for nomination to the National Register of Historic Places are identified, avoided or preserved in-situ. Where avoidance is not possible, archaeological investigation will be necessary to mitigate the loss of both physical remains and data through excavation and documentation.

As LDA and the SHPO are ultimately responsible for approval of survey criteria and acceptance of the reported results, contact with appropriate personnel in those offices should be made as early in project planning as possible. Close coordination will facilitate both the conduct and acceptance of Section 106 related cultural resource activity. In addition contact should also be made and maintained with Native American groups. That contact can be made through the designated Tribal Preservation Officer for each Nation with interest in the project area. Making and maintaining those contacts will facilitate carrying out state and federal cultural and historical resource identification and preservation requirements.

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Appendix E

Conceptual Pipeline Construction Cost Estimates

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 1 Submerged Pipeline

SUBMERGED WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,058,670	$5,058,670
1.02	Construction Surveys	1	L.S.	$1,264,668	$1,264,668
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	100,700	L.F.	$175	$17,622,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	28,000	L.F.	$175	$4,900,000
1.05	Crossings (pipelines, waterways, etc.)	12	L.S.	$100,000	$1,200,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	140,980	L.F.	$40	$5,639,200
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$65,910,038
				30% CONTINGENCY	$19,773,011
				TOTAL CONSTRUCTION COST	**$85,683,049**

SUBMERGED OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,058,670	$5,058,670
1.02	Construction Surveys	1	L.S.	$1,264,668	$1,264,668
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	100,700	L.F.	$175	$17,622,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	28,000	L.F.	$175	$4,900,000
1.05	Crossings (pipelines, waterways, etc.)	12	L.S.	$100,000	$1,200,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	140,980	L.F.	$40	$5,639,200
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	45	Acre	$5,000	$225,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$66,135,038
				30% CONTINGENCY	$19,840,511
				TOTAL CONSTRUCTION COST	**$85,975,549**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 1 At Grade Pipeline

AT GRADE PIPELINE WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,914,750	$5,914,750
1.02	Construction Surveys	1	L.S.	$1,478,688	$1,478,688
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	100,700	L.F.	$175	$17,622,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	28,000	L.F.	$175	$4,900,000
1.05	Crossings (pipelines, waterways, etc.)	12	L.S.	$100,000	$1,200,000
1.06	Treated Timber Piles (20 ft spacing 70 ft length)	355,000	L.F.	$40	$14,200,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$75,540,938
				30% CONTINGENCY	$22,662,281
				TOTAL CONSTRUCTION COST	$98,203,219

AT GRADE PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,914,750	$5,914,750
1.02	Construction Surveys	1	L.S.	$1,478,688	$1,478,688
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	100,700	L.F.	$175	$17,622,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	28,000	L.F.	$175	$4,900,000
1.05	Crossings (pipelines, waterways, etc.)	12	L.S.	$100,000	$1,200,000
1.06	Treated Timber Piles (20 ft spacing 70 ft length)	355,000	L.F.	$40	$14,200,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	45	Acre	$5,000	$225,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$75,765,938
				30% CONTINGENCY	$22,729,781
				TOTAL CONSTRUCTION COST	$98,495,719

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 1 Land Ridge Pipeline

LAND RIDGE PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$4,494,750	$4,494,750
1.02	Construction Surveys	1	L.S.	$1,123,688	$1,123,688
1.03	Dredging for Earthen Ridge	2,500,000	C.Y.	$6	$15,000,000
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	100,700	L.F.	$175	$17,622,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	28,000	L.F.	$175	$4,900,000
1.05	Crossings (pipelines, waterways, etc.)	12	L.S.	$100,000	$1,200,000
1.06	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.07	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.08	Easement/ROW Acquisition	470	Acre	$5,000	$2,350,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$76,915,938
				30% CONTINGENCY	$23,074,781
				TOTAL CONSTRUCTION COST	**$99,990,719**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 1 Floating Pipeline

FLOATING PIPELINE WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$8,367,500	$8,367,500
1.02	Construction Surveys	1	L.S.	$2,091,875	$2,091,875
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	100,700	L.F.	$500	$50,350,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	28,000	L.F.	$175	$4,900,000
1.05	Crossings (pipelines, waterways, etc.)	12	L.S.	$100,000	$1,200,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	150,000	L.F.	$40	$6,000,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$103,134,375
				30% CONTINGENCY	$30,940,313
				TOTAL CONSTRUCTION COST	**$134,074,688**

FLOATING PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$8,367,500	$8,367,500
1.02	Construction Surveys	1	L.S.	$2,091,875	$2,091,875
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	100,700	L.F.	$500	$50,350,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	28,000	L.F.	$175	$4,900,000
1.05	Crossings (pipelines, waterways, etc.)	12	L.S.	$100,000	$1,200,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	150,000	L.F.	$40	$6,000,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	45	Acre	$5,000	$225,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$103,359,375
				30% CONTINGENCY	$31,007,813
				TOTAL CONSTRUCTION COST	**$134,367,188**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 2 Submerged Pipeline

SUBMERGED WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$4,875,500	$4,875,500
1.02	Construction Surveys	1	L.S.	$1,218,875	$1,218,875
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	77,600	L.F.	$175	$13,580,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	50,000	L.F.	$175	$8,750,000
1.05	Crossings (pipelines, waterways, etc.)	8	L.S.	$100,000	$800,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	110,000	L.F.	$40	$4,400,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$63,849,375
				30% CONTINGENCY	$19,154,813
				TOTAL CONSTRUCTION COST	**$83,004,188**

SUBMERGED OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$4,875,500	$4,875,500
1.02	Construction Surveys	1	L.S.	$1,218,875	$1,218,875
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	77,600	L.F.	$175	$13,580,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	50,000	L.F.	$175	$8,750,000
1.05	Crossings (pipelines, waterways, etc.)	8	L.S.	$100,000	$800,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	110,000	L.F.	$40	$4,400,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	20	Acre	$5,000	$100,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$63,949,375
				30% CONTINGENCY	$19,184,813
				TOTAL CONSTRUCTION COST	**$83,134,188**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 2 At Grade Pipeline

AT GRADE PIPELINE WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,521,900	$5,521,900
1.02	Construction Surveys	1	L.S.	$1,380,475	$1,380,475
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	77,600	L.F.	$175	$13,580,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	50,000	L.F.	$175	$8,750,000
1.05	Crossings (pipelines, waterways, etc.)	8	L.S.	$100,000	$800,000
1.06	Treated Timber Piles (20 ft spacing 70 ft length)	271,600	L.F.	$40	$10,864,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$71,121,375
				30% CONTINGENCY	$21,336,413
				TOTAL CONSTRUCTION COST	$92,457,788

AT GRADE PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,521,900	$5,521,900
1.02	Construction Surveys	1	L.S.	$1,380,475	$1,380,475
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	77,600	L.F.	$175	$13,580,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	50,000	L.F.	$175	$8,750,000
1.05	Crossings (pipelines, waterways, etc.)	8	L.S.	$100,000	$800,000
1.06	Treated Timber Piles (20 ft spacing 70 ft length)	271,600	L.F.	$40	$10,864,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	45	Acre	$5,000	$225,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$71,346,375
				30% CONTINGENCY	$21,403,913
				TOTAL CONSTRUCTION COST	$92,750,288

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 2 Land Ridge Pipeline

LAND RIDGE PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$4,435,500	$4,435,500
1.02	Construction Surveys	1	L.S.	$1,108,875	$1,108,875
1.03	Dredging for Earthen Ridge	1,900,000	C.Y.	$6	$11,400,000
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	77,600	L.F.	$175	$13,580,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	50,000	L.F.	$175	$8,750,000
1.05	Crossings (pipelines, waterways, etc.)	8	L.S.	$100,000	$800,000
1.06	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.07	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.08	Easement/ROW Acquisition	360	Acre	$5,000	$1,800,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$72,099,375
				30% CONTINGENCY	$21,629,813
				TOTAL CONSTRUCTION COST	**$93,729,188**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 2 Floating Pipeline

FLOATING PIPELINE WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$6,246,500	$6,246,500
1.02	Construction Surveys	1	L.S.	$1,561,625	$1,561,625
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	77,600	L.F.	$400	$31,040,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	50,000	L.F.	$100	$5,000,000
1.05	Crossings (pipelines, waterways, etc.)	8	L.S.	$100,000	$800,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	110,000	L.F.	$40	$4,400,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$79,273,125
				30% CONTINGENCY	$23,781,938
				TOTAL CONSTRUCTION COST	**$103,055,063**

FLOATING PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$7,375,000	$7,375,000
1.02	Construction Surveys	1	L.S.	$1,843,750	$1,843,750
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	77,600	L.F.	$500	$38,800,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	50,000	L.F.	$175	$8,750,000
1.05	Crossings (pipelines, waterways, etc.)	8	L.S.	$100,000	$800,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	110,000	L.F.	$40	$4,400,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	20	Acre	$5,000	$100,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$92,293,750
				30% CONTINGENCY	$27,688,125
				TOTAL CONSTRUCTION COST	**$119,981,875**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 3 Submerged Pipeline

SUBMERGED WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,110,050	$5,110,050
1.02	Construction Surveys	1	L.S.	$1,277,513	$1,277,513
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	85,500	L.F.	$175	$14,962,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	55,000	L.F.	$175	$9,625,000
1.05	Crossings (pipelines, waterways, etc.)	5	L.S.	$100,000	$500,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	119,700	L.F.	$40	$4,788,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	15	Acre	$5,000	$75,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$66,563,063
				30% CONTINGENCY	$19,968,919
				TOTAL CONSTRUCTION COST	**$86,531,981**

SUBMERGED OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,110,050	$5,110,050
1.02	Construction Surveys	1	L.S.	$1,277,513	$1,277,513
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	85,500	L.F.	$175	$14,962,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	55,000	L.F.	$175	$9,625,000
1.05	Crossings (pipelines, waterways, etc.)	5	L.S.	$100,000	$500,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	119,700	L.F.	$40	$4,788,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	30	Acre	$5,000	$150,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$66,638,063
				30% CONTINGENCY	$19,991,419
				TOTAL CONSTRUCTION COST	**$86,629,481**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 3 At Grade Pipeline

AT GRADE PIPELINE WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,828,250	$5,828,250
1.02	Construction Surveys	1	L.S.	$1,457,063	$1,457,063
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	85,500	L.F.	$175	$14,962,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	55,000	L.F.	$175	$9,625,000
1.05	Crossings (pipelines, waterways, etc.)	5	L.S.	$100,000	$500,000
1.06	Treated Timber Piles (20 ft spacing 70 ft length)	299,250	L.F.	$40	$11,970,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	15	Acre	$5,000	$75,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$74,642,813
				30% CONTINGENCY	$22,392,844
				TOTAL CONSTRUCTION COST	$97,035,656

AT GRADE PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$5,828,250	$5,828,250
1.02	Construction Surveys	1	L.S.	$1,457,063	$1,457,063
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	85,500	L.F.	$175	$14,962,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	55,000	L.F.	$175	$9,625,000
1.05	Crossings (pipelines, waterways, etc.)	5	L.S.	$100,000	$500,000
1.06	Treated Timber Piles (20 ft spacing 70 ft length)	299,250	L.F.	$40	$11,970,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	30	Acre	$5,000	$150,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$74,717,813
				30% CONTINGENCY	$22,415,344
				TOTAL CONSTRUCTION COST	$97,133,156

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 3 Land Ridge Pipeline

LAND RIDGE PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$4,543,750	$4,543,750
1.02	Construction Surveys	1	L.S.	$1,135,938	$1,135,938
1.03	Dredging for Earthen Ridge	2,100,000	C.Y.	$6	$12,600,000
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	85,500	L.F.	$175	$14,962,500
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	50,000	L.F.	$175	$8,750,000
1.05	Crossings (pipelines, waterways, etc.)	5	L.S.	$100,000	$500,000
1.06	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.07	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.08	Easement/ROW Acquisition	400	Acre	$5,000	$2,000,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$74,717,188
				30% CONTINGENCY	$22,415,156
				TOTAL CONSTRUCTION COST	**$97,132,344**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 3 Floating Pipeline

FLOATING PIPELINE WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$6,621,300	$6,621,300
1.02	Construction Surveys	1	L.S.	$1,655,325	$1,655,325
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	85,500	L.F.	$400	$34,200,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	55,000	L.F.	$100	$5,500,000
1.05	Crossings (pipelines, waterways, etc.)	5	L.S.	$100,000	$500,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	119,700	L.F.	$40	$4,788,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	15	Acre	$5,000	$75,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$83,564,625
				30% CONTINGENCY	$25,069,388
				TOTAL CONSTRUCTION COST	$108,634,013

FLOATING PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$7,866,300	$7,866,300
1.02	Construction Surveys	1	L.S.	$1,966,575	$1,966,575
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	85,500	L.F.	$500	$42,750,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	55,000	L.F.	$175	$9,625,000
1.05	Crossings (pipelines, waterways, etc.)	5	L.S.	$100,000	$500,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	119,700	L.F.	$40	$4,788,000
1.07	Booster Pump Station (Per 5 Miles)	3	Each	$7,000,000	$21,000,000
1.08	Connection to Natural Gas Pipeline	3	Each	$75,000	$225,000
1.09	Easement/ROW Acquisition	30	Acre	$5,000	$150,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$97,870,875
				30% CONTINGENCY	$29,361,263
				TOTAL CONSTRUCTION COST	$127,232,138

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 4 Submerged Pipeline

SUBMERGED WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$2,150,300	$2,150,300
1.02	Construction Surveys	1	L.S.	$537,575	$537,575
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	38,000	L.F.	$175	$6,650,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	30,000	L.F.	$175	$5,250,000
1.05	Crossings (pipelines, waterways, etc.)	4	L.S.	$100,000	$400,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	53,200	L.F.	$40	$2,128,000
1.07	Booster Pump Station (Per 5 Miles)	1	Each	$7,000,000	$7,000,000
1.08	Connection to Natural Gas Pipeline	1	Each	$75,000	$75,000
1.09	Easement/ROW Acquisition	13	Acre	$5,000	$65,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$33,255,875
				30% CONTINGENCY	$9,976,763
				TOTAL CONSTRUCTION COST	**$43,232,638**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 4 At Grade Pipeline

AT GRADE PIPELINE WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$2,469,500	$2,469,500
1.02	Construction Surveys	1	L.S.	$617,375	$617,375
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	38,000	L.F.	$175	$6,650,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	30,000	L.F.	$175	$5,250,000
1.05	Crossings (pipelines, waterways, etc.)	4	L.S.	$100,000	$400,000
1.06	Treated Timber Piles (20 ft spacing 70 ft length)	133,000	L.F.	$40	$5,320,000
1.07	Booster Pump Station (Per 5 Miles)	1	Each	$7,000,000	$7,000,000
1.08	Connection to Natural Gas Pipeline	1	Each	$75,000	$75,000
1.09	Easement/ROW Acquisition	13	Acre	$5,000	$65,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$36,846,875
				30% CONTINGENCY	$11,054,063
				TOTAL CONSTRUCTION COST	**$47,900,938**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 4 Land Ridge Pipeline

LAND RIDGE PIPELINE OUTSIDE TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$1,937,500	$1,937,500
1.02	Construction Surveys	1	L.S.	$484,375	$484,375
1.03	Dredging for Earthen Ridge	905,000	C.Y.	$6	$5,430,000
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	38,000	L.F.	$175	$6,650,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	30,000	L.F.	$175	$5,250,000
1.05	Crossings (pipelines, waterways, etc.)	4	L.S.	$100,000	$400,000
1.06	Booster Pump Station (Per 5 Miles)	1	Each	$7,000,000	$7,000,000
1.07	Connection to Natural Gas Pipeline	1	Each	$75,000	$75,000
1.08	Easement/ROW Acquisition	175	Acre	$5,000	$875,000
1.09	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$37,101,875
				30% CONTINGENCY	$11,130,563
				TOTAL CONSTRUCTION COST	**$48,232,438**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Segment 4 Floating Pipeline

FLOATING PIPELINE WITHIN TGP ROW					
ITEM	DESCRIPTION	QUANITIY	UNIT	UNIT PRICE	TOTAL COST
1.01	Mobilization and Demobilization	1	L.S.	$3,385,300	$3,385,300
1.02	Construction Surveys	1	L.S.	$846,325	$846,325
1.03	30" to 36" Steel Pipe (3/4" Thickness, Welded Joint)	38,000	L.F.	$500	$19,000,000
1.04	30" to 36" Steel Pipe Laterals (3/4" Thickness)	30,000	L.F.	$175	$5,250,000
1.05	Crossings (pipelines, waterways, etc.)	4	L.S.	$100,000	$400,000
1.06	Treated Timber Piles (50 ft spacing 70 ft length)	53,200	L.F.	$40	$2,128,000
1.07	Booster Pump Station (Per 5 Miles)	1	Each	$7,000,000	$7,000,000
1.08	Connection to Natural Gas Pipeline	1	Each	$75,000	$75,000
1.09	Easement/ROW Acquisition	13	Acre	$5,000	$65,000
1.10	Intake Structure	1	Each	$9,000,000	$9,000,000
				SUBTOTAL	$47,149,625
				30% CONTINGENCY	$14,144,888
				TOTAL CONSTRUCTION COST	**$61,294,513**

Terrebonne Parish
Long Distance Sediment Pipeline
Conceptual Construction Cost - Marsh Creation
Containment Dikes

BAY RACCOURCI						
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**UNIT PRICE**	**Minimum**	**Maximum**
1.01	Equipment Mobilization	1	L.S.	$1,480,000	$445,000.00	$1,480,000
1.02	Const. Layout / Surveying	1	L.S.	$1,110,000	$335,000.00	$1,110,000
1.03	Marsh Creation Containment Dikes	528,146	L.F.	$35.00	$5,545,000.00	$18,485,000
				SUBTOTAL	$6,325,000	$21,075,000
				30% CONTINGENCY	$1,900,000	$6,325,000
				TOTAL CONSTRUCTION COST	**$8,225,000**	**$27,400,000**

Notes:
1 Cost shown are for estimated containment dike construction cost. Unit rate taken from recent CPRA bids.
2. Cost shown include estimated 8% for mobilization and 6% for const layout/surveying.
3. Minimum costs assumes 30% preliminary estimated length of containment dikes.
4. Bay Raccourci has increased unit rate for containment dike construction due to soil constructability issues.
5. Costs Rounded to nearest $5,000 integer.
6. Maximum costs assumes linear footage estimated on Figure 6-11.

FALGOUT CANAL						
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**UNIT PRICE**	**Minimum**	**Maximum**
1.01	Equipment Mobilization	1	L.S.	$610,000	$185,000.00	$610,000
1.02	Const. Layout / Surveying	1	L.S.	$460,000	$140,000.00	$460,000
1.03	Marsh Creation Containment Dikes	255,057	L.F.	$30.00	$2,295,000.00	$7,650,000
				SUBTOTAL	$2,620,000	$8,720,000
				30% CONTINGENCY	$785,000	$2,615,000
				TOTAL CONSTRUCTION COST	**$3,405,000**	**$11,335,000**

Notes:
1 Cost shown are for estimated containment dike construction cost. Unit rate taken from recent CPRA bids.
2. Cost shown include estimated 8% for mobilization and 6% for const layout/surveying.
3. Minimum costs assumes 30% preliminary estimated length of containment dikes.
4. Costs Rounded to nearest $5,000 integer.
5. Maximum costs assumes linear footage estimated on Figure 6-11.

WONDER LAKE						
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**UNIT PRICE**	**Minimum**	**Maximum**
1.01	Equipment Mobilization	1	L.S.	$660,000	$200,000.00	$660,000
1.02	Const. Layout / Surveying	1	L.S.	$495,000	$150,000.00	$495,000
1.03	Marsh Creation Containment Dikes	274,842	L.F.	$30.00	$2,475,000.00	$8,245,000
				SUBTOTAL	$2,825,000	$9,400,000
				30% CONTINGENCY	$850,000	$2,820,000
				TOTAL CONSTRUCTION COST	**$3,675,000**	**$12,220,000**

Notes:
1 Cost shown are for estimated containment dike construction cost. Unit rate taken from recent CPRA bids.
2. Cost shown include estimated 8% for mobilization and 6% for const layout/surveying.
3. Minimum costs assumes 30% preliminary estimated length of containment dikes.
4. Costs Rounded to nearest $5,000 integer.
5. Maximum costs assumes linear footage estimated on Figure 6-11.

LAKE TAMBOUR						
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**UNIT PRICE**	**Minimum**	**Maximum**
1.01	Equipment Mobilization	1	L.S.	$1,360,000	$410,000.00	$1,360,000
1.02	Const. Layout / Surveying	1	L.S.	$1,020,000	$305,000.00	$1,020,000
1.03	Marsh Creation Containment Dikes	485,818	L.F.	$35.00	$5,100,000.00	$17,005,000
				SUBTOTAL	$5,815,000	$19,385,000
				30% CONTINGENCY	$1,745,000	$5,815,000
				TOTAL CONSTRUCTION COST	**$7,560,000**	**$25,200,000**

Notes:
1 Cost shown are for estimated containment dike construction cost. Unit rate taken from recent CPRA bids.
2. Cost shown include estimated 8% for mobilization and 6% for const layout/surveying.
3. Minimum costs assumes 30% preliminary estimated length of containment dikes.
4. Lake Tambour have increased unit rates for containment dike construction due to soil constructability issues.
4. Costs Rounded to nearest $5,000 integer.
5. Maximum costs assumes linear footage estimated on Figure 6-11.

Appendix F

Long Distance Sediment Pipeline Feasibility Study
Ancil Taylor

Long Distance Sediment Pipeline
Feasibility Study for Terrebonne Parish
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1. Executive Summary

– Louisiana has a single primary renewable resource of sand available in the Mississippi River. This river transports sand to the Gulf of Mexico through two major outlets, the mouth of the Mississippi River and the mouth of the Atchafalaya River. The Atchafalaya River traverses Terrebonne Parish and provides a viable source of sand and sediment to restore, nourish and re-construct the valuable tracts of land in and around the parish(s), both east and west of the Atchafalaya River. This feasibility study developed an estimate of the cost of transporting sand from the Atchafalaya to points east. It includes the estimated production rates, pipeline construction cost, land creation including cost and duration. This analysis yields an estimated 8500 acres[1] created in 7 years for a total estimated cost of $570,000,000[2] or an average of about $70,000 / acre. Over 53,000,000 Cubic yards will have been transported through the pipeline in the 7 year period before some of the initial pipeline installation would need to be replaced due to wear.

2. Introduction

a. Purpose and Objective – To perform a feasibility study and brief cost analysis of transporting sediment from the Atchafalaya River to points east of the river out to a distance of roughly 30 statute miles or about 160,000 feet. This feasibility will be measured on the long distance pipeline transport.

b. Basic Assumptions - The basis of the construction is a single mobilization effort with an initial pipeline length of approximately 30,000 - 50,000 feet. Within this first installation or reach, it is assumed there will be a couple of opportunities for a year or two to create land. The dredge will work an average of 9 months / year. It is presumed the responding dredge will have sufficient capability to work without the booster(s) up to the 35,000 - 40,000 foot range and

[1] This assumes one acre of land is created for every 6500 cubic yards of material removed from the Atchafalaya River or about 4 feet of fill placed per acre. Subsidence, actual bank height or retention ratios are site specific and are not included in this study.
[2] These are 2010 dollars.

a booster will be inserted after the initial mobilization effort. This study anticipates duration of approximately 7 years to transport 50,000,000 Cubic Yards, the anticipated life of the initial pipeline installation. Progress on the alignment is assumed to continue unhampered for the duration except for the average 3 months / year for repairs, installations, etc.

c. Methodologies and Resources – This feasibility study was prepared by Ancil Taylor, Vice President of the Bean Companies, with support from the staff of The Bean Companies. Bean is a contractor based in Plaquemines Parish, Louisiana and has been involved in all aspects of the dredging and marine construction industry for over 70 years including significant restoration of coastal and near coastal areas, long distance transportation of sediment. Ancil Taylor, with over 32 years of designing, developing and constructing these types of projects is also responsible for developing and implementing State of the Art technology and science for predicting the performance of slurries in pipelines and dredge pumps. This expertise is made available to the Terrebonne Parish for assisting with this feasibility study.
d. Report Organization – This study is focused on five main areas.
    i. The primary borrow area designated for mining sediment from the Atchafalaya River,
    ii. The description of a potential pipeline route from the river to points east of the river to a location near the Houma Navigation Canal.
    iii. The pipeline design for the chosen alignment.
    iv. The method of mining and transport.
    v. The conventional fill placement equipment most appropriate for this concept.

3. Site Characterization

a. Survey – A condition survey was performed of the horseshoe area to ascertain the general bottom contour condition of the waterway. Subsequent to that survey, we requested that the

USACE send surveys of the waterway as they acquire the data. While the bottom conditions are somewhat dynamic, the general condition of the waterway and approximate depths and the proximity to the shore line and desired shore connection does not appear to vary materially. The horseshoe area in the vicinity of Horseshoe Island was chosen primarily due to its river sediment deposition characteristic and its proximity to the potential pipeline route for transport to the east. It is assumed that some 8,000,000 Cys of material will be available on an annual basis to feed the borrow area.

b. Sediment – Surface samples were gathered in the vicinity of the intended borrow area along the river. Those locations are attached along with the associated grain size data. In general, the median diameter of the sediment is about 170 μ – 210 μ with a D_{60} of roughly 180μ and a D_{10} of about 90μ indicating generally poorly graded material and a coefficient of uniformity, C_u, of about 2.0.
c. Changes to the river hydrology may be an issue that will require additional review or need to be modeled by others.

4. Pipeline – this project will involve the installation and use of a pipeline that has been specifically designed for this application. The study was focused on identifying the most efficient method of transport for the long term purpose and function. The cost associated with identifying, securing and preparing a right-of-way combined with the relatively fixed cost effort of mobilizing and installing the pipeline will vary little with the actual size of the pipeline installed. Therefore, it is reasonable to assume that maximizing the practical size of the pipe itself will yield a lower overall unit cost after you amortize the fixed installation cost over a greater quantity of cubic yards conveyed.

a. Route – the route investigated in this report is based upon the Columbia pipeline right-of-way that intersects the Atchafalaya River near Latitude 29º 32’ 18”N and Longitude 91º 15’ 19”W. [See attached map]

b. Size – the size of the pipeline diameter was determined by:
   i. Maximizing the size that could be managed by conventional amphibious equipment.
   ii. Optimizing the flow with the necessary velocity for the sediment we will be transporting. Slurry transportation horsepower requirements increase with the velocity head loss. Velocity head-loss is the most significant variable within the context of this design. Velocity head-loss increases at the rate of the square of the velocity. Therefore, minimizing and optimizing the velocity and concentration of the slurry will increase the overall transportation efficiency.
   iii. Optimizing the wear-rate of the pipeline to extend the life of the pipeline to the maximum limits. Here again, slurry velocity within the pipeline has the greatest impact on wear rates. Increased velocity increases wear rate on the pipeline. For this study, the life of the pipeline includes a management strategy of measuring and monitoring changing pipeline wall thickness and rotating the pipeline 120 degrees on two occasions after initial installation.

The result of this analysis would yield a pipe diameter of 750 – 800 mm or roughly 29.5" to 31.5".

c. The pipe wall thickness is determined by a couple of parameters as well.
   i. the minimum cost per unit of wall thickness based upon wear characteristics. Pipe can be worn to a minimum wall thickness of around 6 – 7 mm. Therefore, for ¾", .75" wall, 19 mm wall, that would yield about 12mm of usable wear life. Comparatively, for .312" wall, 8mm, commonly salvaged oil field pipe, only 2 mm of practical wear life would be available. Therefore, when you amortize the cost of the pipe, along with the installation, etc. the cost / mm of wear life drops significantly with the increase in the wall thickness.
   ii. the maximum wall thickness to which the pipe will maintain a positive buoyancy in water. Management of the pipeline will include the need to raise the pipe from

the water bottom for rotating, repairing or transporting to another location. This is accomplished by pumping air into the pipe, evacuating the water and allowing the pipe to float to the surface. If the wall thickness and corresponding weight of the pipe exceeds the displacement value of the pipeline, it will not float with air in the pipe and therefore handling of the pipeline becomes more difficult and much more expensive.

d. Installation – in almost all possible locations along the proposed alignment, it appears amphibious equipment will be necessary. The proposed pipeline will be installed either within the Columbia pipeline right-a-way by widening the floatation canal or by excavating a floatation canal adjacent to and parallel to the floatation canal. Marsh excavators will be used to excavate approximately 700,000 cubic yards of floatation canal to float and pull the constructed pipeline in place. The pipeline will be constructed from a series of deck barges with 2 welding stations per barge. Spud barges with pulling winches will be incorporated to pull the constructed pipeline into and along the floatation canal. The attendant plant will consist 2-3 material barges to haul and store random joints of pipes, 2 900 HP tugboats, a shallow draft workboat, and a crewboat.

e. Phasing – As suggested in our earlier status meeting with the parish, building the pipeline infrastructure in phases as the fill progresses to the East is the most logical. There are numerous opportunities along the length of the proposed alignment where substantial quantities of material may be placed. Assuming an average fill depth of 4 feet, and an anticipated production of 6,500,000 – 7,500,000 cubic yards / year, over 1000 acres could be created annually. This production could be performed while the next stretch of pipeline is under construction to the next area of opportunity. Attempting to build the entire length of the main trunk line to the East before actual implementation of the dredging effort delays the overall progress of the project with no real benefit or cost savings. The potential fill areas of opportunity are not a focus of this study.

f. Pipeline Wear Rates – have been calculated based upon sediment types found during this investigation. It is anticipated that roughly 4.7 million Cys can be transported through an average wear of 1 mm. Therefore, with 12 mm available, we anticipate roughly 50 – 60 million Cys could be transported through a .75" wall pipeline. This assumes the pipeline is rotated twice, 120 degrees, after initial installation. Pipeline velocity and slurry concentration are two of the greatest areas of impact to wear rate. Minimum velocity and maximum concentration maximizes wear life as well as overall transport efficiency.

5. Placement zones

a. Progression of fill sites to East will allow the closest areas of opportunity to the Atchafalaya River to be addressed first. These areas can be identified and filled concurrently to maximize the efficiency of the sand mining equipment. The potential fill areas are not identified or suggested in this study.
b. Multiple concurrent placement locations should be considered to take the greatest opportunity to utilize the high production capacity of the designed system. It is anticipated that multiple opportunities exist along the length of the main trunk line. Some of the areas may be relatively small and could be overwhelmed by the flow and capacity of the dredge if this placement location was the sole deposition area. To maximize the economy of scale available, numerous sites could be prepared and made available to receive sediment from the main line. Alternating between fills to allow time to effectively manage and shape the placement will permit the project to enjoy the cost benefits of the large scale production while still managing the fill with a lower production impact. Placement equipment is discussed in Section 7.

6. Transportation of Sediment

a. Dredge type – The removal of sediment from the Atchafalaya River may be accomplished primarily by a pipeline dredge described as a cutterhead, a dustpan or a plain suction dredge. The sediments are of such a density where significant cutter power is not necessary to dislodge the material from its in-situ state. Initiating cavitation or dilation of the sand in-situ will not be difficult as permeability is high along with the high void ratio.
    i. Cutterhead – The cutterhead dredge is the most common pipeline dredge found in this region and will likely be the responding candidate for removal of sediment from the Atchafalaya River. It will deliver the characteristics and capabilities necessary for the removal of the sediment. Dredge cuts can be established to allow for removal of 5 – 20 feet of material over a width of 250 – 600 feet, depending upon the dredge specifications. Swing anchors will be utilized to move the cutterhead in an arc roughly normal to the centerline of the cut or river alignment. Interference with traffic can be minimal and manageable.
    ii. Dustpan – The dustpan dredge is commonly used in cohesion-less granular sediments in riverine environments. The Mississippi River will be the most common location in this region for the use of a dustpan dredge. The dustpan head may vary in widths of 20 – 35 feet and will primarily work against the current, propelling itself with 2 – 3 anchor wires stretched forward into the current. Propulsion or aft wires will adjust the approach angle and attitude of the dredge into the current. The dredge will remove banks of material varying from 3 – 7 feet over the width of the dustpan head and over a length parallel to the channel alignment that may vary from approximately 1000 – 2500 feet, depending upon the dredge's flexible floating pipeline length.
    iii. Plain suction – The plain suction dredge could be a candidate for removal. It is somewhat stationary as to

positioning in the river. It may utilize a water jet around the suction mouth to enhance slurrification or mixing of the sediment prior to removal and entrance into the suction mouth. The plain suction is least capable of accommodating varying consistency or density of the bottom sediment and therefore has less control of slurry preparation and delivery.

b. **Booster(s)** – the overall length of this pipeline approaches 30 miles from one end of the study area to the other. It will be impractical due to pressure limitations to install all the necessary horsepower at the initial dredge location and therefore the strategic placement of additional horsepower along the pipe alignment will be the most favorable approach. The primary design parameter for booster placement locations apart from physical geographic limits is pressure. Incoming pressures and outgoing pressures must be predicted and locations adjusted to reduce the risk of operating outside the design pressure parameters. Geographically, locations where the alignment can be reached by water will be the most practical locations. Initial access, fuel and supplies, crew access, etc. are all much more achievable when a channel of at least 6 – 8 feet is available to the proposed booster location.

c. **Slurry Characteristics** – transportation of these sediments will be most economically performed at a velocity slightly above the settling velocity of the majority of the sediment. Optimum flows will result in a shallow sliding bed-load along the bottom of the pipeline. Sediment concentration will depend upon the horsepower installed and the pipeline length. Automatic flow or velocity control[3] will be preferred as it will deliver the optimum efficiency during the transportation phase. While sediment concentration will depend upon the exact conditions, the target concentration will be around the 25% – 35% solids by volume. This equates to roughly 1700 – 2400 cubic yards per hour.

[3] Flow control is similar to the cruise control on your car. Choose a velocity (speed) set-point and allow the computer to control the pump revolutions and horsepower to maintain the desired flow.

d. **Net Operating Hours** – The available hours for which sediment is introduced into the suction mouth must be maximized in order to deliver optimum efficiency. Designing the slurry transportation system to minimize lost time[4] associated with the pipeline or loss of equipment operability along the way is of primary importance. If this design is performed successfully and effectively implemented, an operating efficiency of 55% - 65% should be achievable depending upon the overall pipeline length and number of booster installations.

e. Overall Productivity – the obvious combination of the foregoing paragraphs would yield roughly 150,000 cubic yards to about 260,000 cubic yards per week. In general, it should be expected that this level of productivity could be achieved an average of 25 - 27 days / month or roughly 575,000 cubic yards to 1,000,000 cubic yards per month.

7. Placement Equipment

The effective design and utilization of fill equipment at the fill locations is as important as choosing the right dredge and pipeline. The ability to manage the placement of an average 1,000,000 cubic yards per month in a relatively challenging environment like the marsh of south Louisiana can be as much an art as a science. Low Ground Pressure, LGP, is an important characteristic of fill equipment. Access to placement sites can be extremely challenging and costly if not well planned in advance. Delivery of personnel and equipment on a daily basis will be necessary to ensure continued operations throughout the month.

[4] Consider the time necessary for sediment to travel from the entrance of the pipe to the exit, 30 miles away, is almost 4 hours.

This section identifies and describes some of the more conventional equipment that will be utilized within the context of this study.

a. **Dozers** 4*(D-6H LGP)
    i. This will be the most utilized piece of equipment on the fill site. At least two of these units will be working continuously around each discharge location. One unit will need to be under repair and preventive maintenance with 1 spare ready to replace a unit that fails.

b. **Front-end loaders** 2*(Cat 966) – These pieces are primarily used to transport pipes and other equipment along the placement alignment. Forks attached to the front replace the bucket for increased versatility.

c. **Marsh cranes** 2 – 4*(Cat 325c) – these units are the most costly and least reliable pieces of the fill spread, but they are the only pieces that can effectively navigate the amphibious environment often found in South Louisiana. Depending upon the specific environmental conditions and the risk to shutting down the site if one goes out of service, more than one may be necessary to minimize lost time on the fill site.

d. **Track hoe** – this equipment is preferable due to reliability and cost whenever possible. It would replace or at least supplement the marsh cranes described above. Surface conditions are more critical for use of this type of equipment.

e. **Light Plants** are used to illuminate the entire work site where people and / or equipment are active. Diesel driven generators provide power to metal halide lights on a tower.

f. **Kubotas** or similar type off-road utility vehicles provide transportation for crewmembers along and around the fill locations. These units enhance crew efficiency by facilitating transportation efficiency.

g. **Air boats** are commonly used in south Louisiana if excess noise levels can be accommodated. They facilitate transportation in amphibious environments and are cheaper to operate than a marsh buggy. Safety concerns are an issue that requires an experienced operator focused on the safety of the passengers. They are not well suited for rough water or marsh where most areas traversed are above the water surface.

h. **Shallow draft launches** (crew-boats) should provide dependable all-weather transportation for crewmembers to and from the fill site. Light supplies, spareparts and consumables are also more efficiently transported around the project site with smaller, shallower boats.

i. **Pipelines**
   i. **Shorelines** – are used on, around and in the vicinity of the placement area. They are commonly pipelines that

are worn to minimum thicknesses and therefore suitable only for low pressure applications. Connections between pipes can be done by bolted flanges as depicted here or by "telescopes" where one end of the pipe has a slightly reduced diameter that slips into the larger diameter of the adjoining pipe. The pipe lengths are generally about 40 feet. These installations are generally temporary in nature to provide greatest flexibility to the shore crew to move sand around on the fill. The head-loss associated with a shoreline installation is relatively high compared to the other types of pipe in the system therefore overall lengths of shorelines are kept at a minimum. When appropriate and if necessary, shorelines are replaced with dedicated longer sections of pipe with less resistance and friction and with thicker pipe walls to accommodate growing working pressures with increasing line lengths.

ii. **Elbows** – are also used when a change of direction is necessary. Long sweeping elbows are preferable to short radius elbows due to head-loss but can be more cumbersome to handle and expensive to fabricate.

iii. **Y-valves** – allow the fill management to direct flow quickly to different directions or split the flow if necessary. Multiple Y valves installed on a fill allow flexibility in fill placement locations.

iv. **Spreaders** are commonly used to

diffuse energy at the end of a pipeline, enhance settling of material, and protect the integrity of the foundation on which the end of the pipeline is placed.

j. **Fill offices** are necessary on or very near the fill to ensure immediate access to administrative and supervisory resources. Survey data, radios, and other management resources must be readily available to optimize decision making and communication with project management. It also provides a safe haven for crew members in extraordinarily severe weather conditions. These fill offices are most often containerized for portability and ruggedness. They are often placed on skids with a portable generator attached to provide electricity.

k. **Fuel tanks** will be a necessity for fueling all equipment on the fill. Sizes may range from 500 gallons to 8,000 gallons. They should have dual containment and be skid mounted to reduce risk of spillage into the environment.

l. **Equipment maintenance** facilities and mechanics w /spare parts will provide an opportunity to ensure optimum availability and operability of equipment to the fill site. Transportation of broken equipment is impractical from the fill site to offsite repair locations and availability of professional mechanics and repair technicians can be limited and certainly not timely. Establishing a preventive maintenance routine and ensuring proper repair and maintenance procedures will provide the necessary reliability of equipment on the fill site. This operation may involve 2 – 3 spare parts containers, depending upon the size of the spread. A semi-enclosed portable building

to protect repair facilities will also provide additional operating efficiency of the "repair shop".