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Marine Archaeological Survey For The Lavaca Bay LNG Project Off Calhoun County, Texas

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MARINE ARCHAEOLOGICAL SURVEY FOR THE LAVACA BAY LNG PROJECT OFF CALHOUN COUNTY, TEXAS

Lead Agency:
Federal Energy Regulatory Commission
Texas Antiquities Permit Number 6335

Prepared for:

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Excelerate Liquefaction Solutions I, LLC
and
Lavaca Bay Pipeline System, LLC

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ABSTRACT

HRA Gray & Pape, LLC, of Houston, Texas conducted a Phase I marine cultural resources survey for the proposed Lavaca Bay LNG project. All marine fieldwork and reporting activities were completed with reference to state law (Antiquities Code of Texas [Title 9, Chapter 191 of the Texas Natural Resources Code] and Texas State rules found in the Texas Administrative Code [Title 13, part 2, Chapters 26 and 28]) for Cultural Resources investigations. Work was completed under Texas Antiquities Permit Number 6335. The Federal Energy Regulatory Commission has been identified as the Lead Federal Agency.

The Phase I underwater archaeological investigation assessed the number, locations, cultural affiliations, components, spatial distribution, data potential, and other salient characteristics of potential submerged cultural resources within the proposed project area. The project area includes approximately 113.3 hectares (280 acres) of submerged land in Calhoun County, Texas. The investigation comprised of a comprehensive magnetic and acoustic remote sensing survey, and target analysis to determine the presence or absence of potentially significant remote sensing targets that might be affected by proposed project activity.

Marine field investigations consisted of a magnetometer, and side-scanning sonar investigation of the proposed project area in safely navigable waters. Data were collected between August 29 and 31, 2012. Survey required approximately 80-person hours to complete. Comprehensive analysis of the magnetic and acoustic data recorded for this project resulted in the identification of 251 discrete magnetic anomalies and 15 isolated acoustic targets. Of the 251 magnetic anomalies, only 8, including the previously noted M-6 and M-7, are considered to have signatures of potential significance and should be either avoided or identified prior to any seabed disturbing activities. It should be noted that previously identified magnetic anomaly M-6 is outside of the present project area. The other anomalies that should be avoided or examined are: 142, 164, 217, 221, 224, and 231. None of the acoustic targets express the characteristics of a shipwreck or articulated shipwreck material.

Additional work planned for the project included a diving/dive ground truthing phase to provide a preliminary evaluation of submerged targets. The project was placed on hold and has ultimately been cancelled before this activity could be mobilized and therefore an evaluation of the remaining submerged targets cannot be offered. This report is submitted to satisfy reporting requirements under Permit 6335. Should activities associated with a future project take place within the survey area, further marine investigation is recommended. Project records will be curated at a state-approved curation facility. Project permitting projected that the Texas Archaeological Research Laboratory would be the curation facility used, however conditions changed and the Center for Archaeological Studies will be the ultimate repository.

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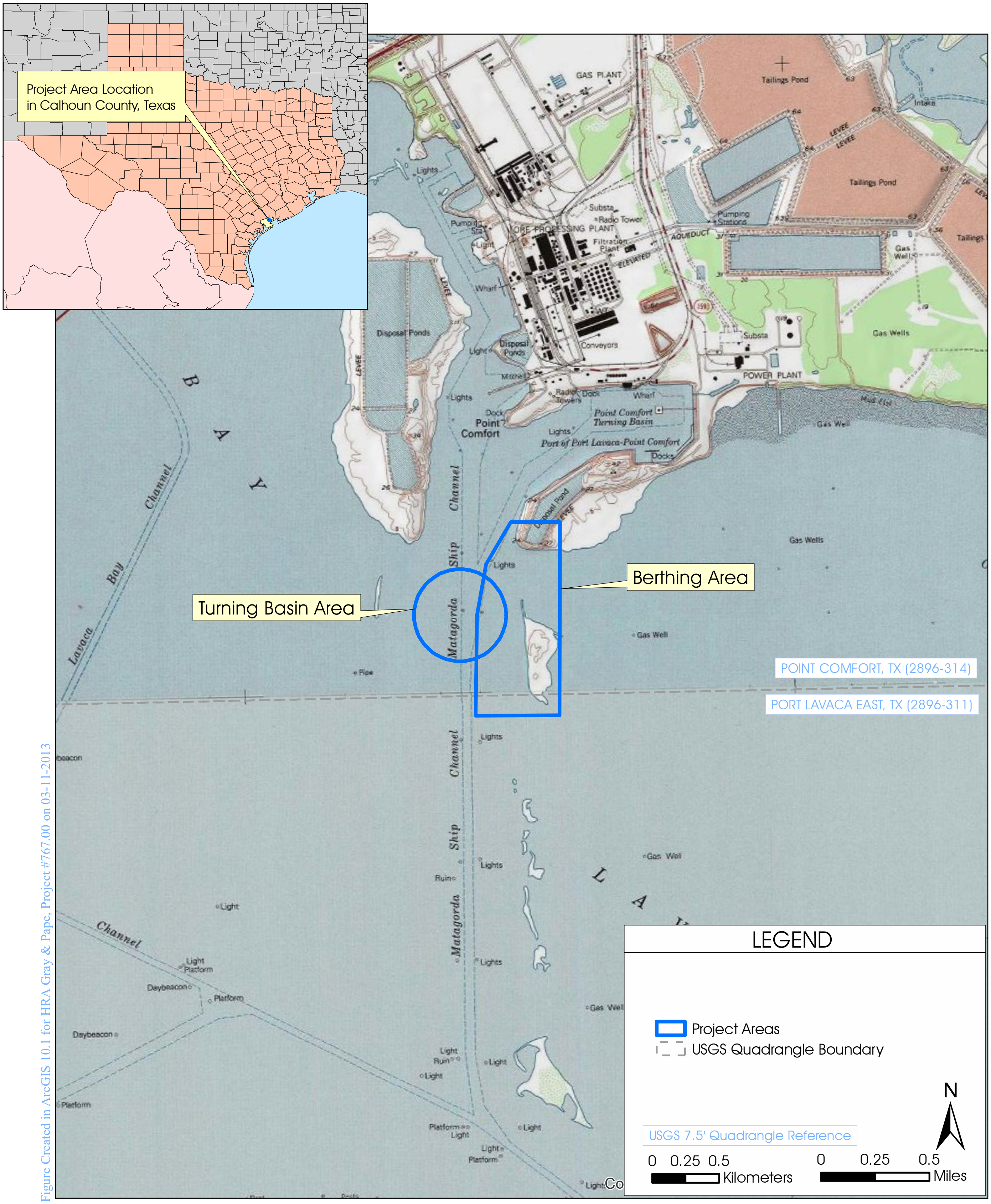
1.0 INTRODUCTION

HRA Gray & Pape, LLC. (HRA Gray & Pape), of Houston, Texas, conducted a Phase I marine cultural resources survey to examine areas associated with Excelerate Liquefaction Solutions I, LLC's and Lavaca Bay Pipeline System, LLC's (collectively referred to as ELS) proposed Lavaca Bay LNG Project. The project intended to include marine facilities consisting of floating liquefaction, storage, and offloading units (FLSOs), turning basin, berthing area, and associated infrastructure required for docking of the FLSOs, and deepening and widening of portions of the Matagorda Ship Channel. These areas are overlapping and adjacent along both sides of the north-south trending navigation channel to Point Comfort, Calhoun County, Texas (Figure 1). Proposed shore side facilities and an associated pipeline are not addressed in this report. The Lead Federal Agency for this project is the Federal Energy Regulatory Commission (FERC), as such the project is designed to meet or exceed federal requirements contained in Section 106 of the National Historic Preservation Act of 1966, as amended, and the regulations of the Advisory Council on Preservation (30 CFR part 800). As the channel which bisects the project area is operated by the Calhoun Port Authority (CPA), a political subdivision of the State of Texas, all marine archaeological and reporting activities were completed under subcontract to Tetra Tech Inc. and with reference to state law (Antiquities Code of Texas [Title 9, Chapter 191 of the Texas Natural Resources Code] and Texas State rules found in the Texas Administrative Code [Title 13, Part 2, Chapters 26 and 28]) for Cultural Resources investigations. HRA Gray & Pape has conducted cultural resources fieldwork for the project under Texas Antiquities Permit Number 6335 issued by the Texas Historical Commission (THC) on August 24, 2012.

The archaeological investigations took place in part because two potentially significant magnetic anomalies, identified as M-6 and M-7, were known to reside in the general vicinity of the proposed project, and as a result of survey, additional targets were identified. By letter dated November 12, 2012, the THC accepted a proposal to modify permit number 6335 to include diver ground truthing of several identified anomalies.

Comprehensive analysis of the magnetic and acoustic data recorded for this project resulted in the identification of 251 discrete magnetic anomalies and 15 isolated acoustic targets. Of the 251 magnetic anomalies, only 8, including the previously noted M-6 and M-7, are considered to have signatures of potential significance and should be either avoided or identified prior to any seabed disturbing activities. None of the acoustic targets express the characteristics of a shipwreck or articulated shipwreck material.

Additional work planned for the project included a diving/dive ground truthing phase to provide a preliminary evaluation of submerged targets. The project has been repeatedly delayed and ultimately has been cancelled, and mobilization for this additional effort has not taken place. HRA Gray & Pape cannot offer an evaluation of the remaining submerged targets. This report is submitted in order to satisfy reporting requirements under Permit 6335.



Project Area Location in Calhoun County, Texas

Figure 1

HRA Gray & Pape LLC.

1.1 Project Description

The project area includes approximately 113.3 hectares (280 acres) of submerged land in Calhoun County, Texas. The area examined is for the proposed Lavaca Bay LNG facility and turning basin. It is anticipated that dredging activities in the project area will create berthing areas and a turning basin for the first projected floating liquefaction facility in the United States utilizing FLSO vessel technology. The proposed berth areas will be dredged to a depth of 18.3 meters (60 feet), and the turning basin will be dredged to a depth of approximately 13.4 meters (44 feet). These areas are overlapping and adjacent along both sides of the north-south trending Matagorda Ship Channel (MSC) into Point Comfort, Calhoun County, Texas. As the channel which bisects the project area is operated by the CPA, a political subdivision of the State of Texas, marine archaeological activities were completed under the above-referenced permit.

The project area includes the northern portion of both sides of the MSC, which runs approximately 41.8 kilometers (26 miles) from the Point Comfort Turning basin in the north to the Gulf of Mexico in the southeast. The navigation channel into Port Comfort, Texas, was first constructed in the 1960s and dredged to an operating depth of 11 meters (36 feet) and a bottom width of 61 meters (200 feet). The project area is comprised of a north-south trending rectangular berth area attached to a semi-circular turning basin located approximately in the center on the western border of the rectangle. The project area's maximum dimension north-south is approximately 1,477 meters (4,845 feet) and its maximum east-west dimension is approximately 1,053 meters (3,455 feet). The turning basin is circular with a diameter of 676 meters (2,218 feet) and is centered at 13421255.5 North and 2748940.52 East. The coordinate system used during the field phase of the project was NAD 83, Texas State Plane, South Central Zone 4204 (Figure 1). The area was surveyed between August 29 and 31, 2012. Due to the shallowness of most portions of the project area, although floated at the surface, the magnetometer sensor was in close proximity to the harbor bed and therefore may exaggerate the size of the source of anomalies.

1.2 Organization of the Report

This report is organized into seven numbered chapters. Chapter 1.0 provides an overview of the project. Chapter 2.0 presents an overview of the environmental setting and geomorphology of the project area. Chapter 3.0 presents the research design and methodology developed for these investigations. Chapter 4.0 presents a discussion of the cultural context associated with the project area and provides a discussion of previous investigations as well as previously recorded terrestrial and submerged cultural resources. The results of these investigations are presented in Chapter 5.0. Chapter 6.0 presents the investigation summary and provides recommendations based on the results of field surveys. A list of all references cited is provided in Chapter 7.0. Appendix A contains all potentially significant anomalies.

1.3 Acknowledgements

Research on various aspects of this project was conducted by Project Manager James Hughey, Principal Investigator Michael Tuttle, and Marine Archaeologist Vincent Valenti. Background research included consultation of online research archives maintained by the THC and by Texas

Archeological Research Lab (TARL), resources maintained by the Soil Service Staff of the Natural Resources Conservation Service of the United States Agriculture Department (SSS NRCS USDA), and numerous marine targets datasets. Acquisition of the remote sensing data for this project was conducted by personnel from Chris Ransome Associates (CRA) of Houston, Texas. Mr. Arron Yoho, served as Senior hydrographic surveyor, and Mr. Kevin Acieri acted as the assistant surveyor. They were joined by Dr. Tuttle, maritime archaeologist from HRA Gray & Pape, who acted as the archaeological monitor and conducted the subsequent data analysis. This report was prepared by Dr. Tuttle and Mr. Hughey. Graphics were produced by Tony Scott. Jessica Bludau produced the report.

2.0 PHYSICAL SETTING OF THE PROJECT AREA

The project area lies within a strip of land known as the Coastal Prairie and Marsh physiographic province (Fenneman 1938). A discussion of the basic physiography, and soils recorded on terrestrial lands near the project area, is provided below.

2.1 Physiography and Geomorphology

The Coastal Prairie and Marsh zone runs along the coast stretching inland about 80 kilometers (50 miles). Ten major geomorphological features characterize the Coastal Prairie and Marsh zone: upland prairies, rivers, floodplains, freshwater streams, freshwater marshes, meander belt ridges, saltwater marshes, saltwater lagoons, gulf beaches, and the open gulf. Calhoun County, located on the Gulf Coast between Houston and Corpus Christi, is bordered by Victoria and Jackson counties on the north, Matagorda Island and the Gulf on the south, Refugio County on the west, and Matagorda County on the east. The area has a flat topographic relief and is poorly to moderately drained with loamy soils at the surface, which are underlain by clayey subsoils.

2.2 Soils

The soils found within the project area and in the general region are discussed briefly below. Matagorda Peninsula is made up of Galveston-Follet soils, which are nearly level to sloping, somewhat excessively drained and very poorly drained, sandy and loamy, and nonsaline and saline soils (SSS NRCS USDA 2015). The southern edge of the peninsula, known locally as Matagorda Beach, consists entirely of Beaches (Bb). This area is constantly changing due to tides and coastal winds. The dominant soil on Matagorda Peninsula is Galveston fine sand, undulating (GaB). Mustang fine sand (MuA) and Follet loam (Fe) are found along the northern edge of Matagorda Peninsula. This area supports vegetation and wildlife and serves as a natural barrier, protecting inland coastal sites from tidal storm damage. These soils are susceptible to wind erosion when vegetation is removed (Hyde 2002).

Sections of land extending from Port O’Connor to Powderhorn Lake are made up of Portalto-Roemer soils. These are nearly level to gently sloping, noncalcareous, well drained and somewhat poorly drained sandy soils of the low coastal uplands (SSS NRCS USDA 2015). Haplaquents, loamy (HA) soil is associated with coastal waters in this area, and inland waterways are generally associated with Placedo clay (Pc) soil. Portalto-Roemer complex (Pr) and Galveston complex, undulating (Gc) account for a majority of the soils, with some Veston soils, low (Vs) scattered throughout (SSS NRCS USDA 2015).

Areas extending from Powderhorn Lake to Magnolia Beach and the Keller and Carancahua Bay areas are made up of Livia-Francitas soils, which are nearly level to gently sloping, noncalcareous, poorly drained loamy and clayey soils of the low coastal uplands. The coastal beaches in the Powderhorn Lake area are Psamments, gravelly (PS), and the beaches along the lake are mostly Haplaquents, loamy (HA) with some areas of Placedo clay (Pc), Rahal fine sand, gently undulating (Ra), Matagorda very fine sandy loam (Ma), Livia clay loam, 0 to 1 percent slopes (Lv), and Livia silt loam (Lo) are found scattered throughout the remaining area. The beaches of the Keller and Carancahua Bay areas include a variety of soils, such as Haplaquents, loamy (HA), Psamments, gravelly (PS), Placedo clay (Pc), Livia silt loam (Lo), Dianola-Portalto complex (Dp), Livia clay loam, 2 to 5 percent slopes, eroded (Lx), Livia clay loam, 0 to 1 percent slopes (Lv), Bayucos soils (BA), and Dacosta-Contee complex, 0 to 1 percent slopes (Dc), Lake Charles clay, 0 to 1 percent slopes (La), Francitas clay (Fr), and Edna very fine sandy loam, low (En) make up the majority of the remaining soils, with Livia clay loam, 0 to 1 percent slopes (Lv), Livia silt loam (Lo), Francitas clay (Fr), Te, Bayucos soils (BA), Harris clay (Hr), Placedo clay (Pc), and Dacosta clay loam, saline (Da) scattered throughout. Directly west of Huisache Creek is an existing industrial waste area (SSS NRCS USDA 2015).

Portions of Magnolia Beach to the northern edge of Lavaca Bay contain Lake Charles soils. Lake Charles soils are nearly level to sloping, noncalcareous, somewhat poorly drained clayey soils of the uplands. Most of the soils in this area are Francitas clay (Fr) and Lake Charles clay, 0 to 1 percent slopes (La), with some Dacosta clay loam, saline (Da), Veston soils (Ve)/ Velasco clay, frequently flooded, Livia silt loam (Lo), Livia clay loam, 0 to 1 percent slopes (Lv), Matagorda very fine sandy loam (Ma), Dacosta-Contee complex, 0 to 1 percent slopes (Dc), Midland clay loam (Mb), Edna very fine sandy loam (Ed), and Midland clay loam, low (Mc) scattered throughout. The beaches are generally Placedo clay (Pc), Haplaquents, loamy (HA), Livia clay loam, 2 to 5 percent slopes, eroded (Lx), Livia clay loam, 0 to 1 percent slopes (Lv), and Livia silt loam (Lo) (SSS NRCS USDA 2015).

Scattered in areas near the project are Dacosta-Midland-Contee soils. These soils are nearly level to gently sloping, calcareous and noncalcareous, somewhat poorly drained and poorly drained loamy soils of the uplands. Soils found near the coast include Mustang fine sand (Mu), Lake Charles clay, 0 to 1 percent slopes (La), Placedo clay (Pc), and Lake Charles complex, 3 to 8 percent slopes (Lc). Scattered inland are Terferner very fine sandy loam (Te), Dacosta-Contee complex, 0 to 1 percent slopes (Dc), and Midland clay loam, low (Mc). Islands within this area have similar soils, with Ijam clay (Ic) along the coast (SSS NRCS USDA 2015).

Telferner-Edna soils are found scattered throughout the northern area. These soils are nearly level, nonclacareous, somewhat poorly drained and poorly drained loamy soils of the uplands. Soils along the beach in this area are Livia clay loam, 0 to 1 percent slopes (Lv), Haplaquents, loamy (HA), and Midland clay loam (Mb). Terferner very fine sandy loam (Te), Francitas clay (Fr), and Livia clay loam, 0 to 1 percent slopes (Lv) are found scattered inland (Mowery and Bower 1978).

The present coastline of the Texas Gulf Coast, while relatively stable since the past approximately 3,000 years, has varied significantly in the past. Towards the end of the Pleistocene era 20,000 years ago, global temperatures rose, and sea levels rapidly began to rise. By 8,000 B.C., shorelines worldwide had progressed inland, with the flooding of the valleys of major streams along the Texas coast, such as the Trinity, Lavaca, Guadalupe, Aransas, and Nueces Rivers (Ricklis 2005). As a result, the earliest forms of the modern coastal bays found in Texas were created. Once sea levels reached their current depths, continuing wave action and longshore drift deposited sand and shell hash parallel to the mainland, forming the modern chain of barrier islands, such as Galveston Island and Bolivar Peninsula along the upper Texas coast, and similarly affected the morphology of Matagorda Bay, Matagorda Island, Aransas, and Corpus Christi further south. Based partially on geological estimates of past sea level activity, it seems that the major periods of human occupation along the bayshores corresponded with periods of relatively stable sea level (Ricklis 2005).

2.3 Climate

Proximity to the Gulf of Mexico tends to influence the temperature, rainfall, and relative humidity of the region. Winds usually trend from the southeast or east, except during winter months when high-pressure systems can bring in polar air from the north. Average temperatures in the summer can reach well into the 30s° Celsius, (90s° Fahrenheit), and are often accompanied by equally high humidity. Although winter temperatures can reach into the low single digits Celsius (30s° Fahrenheit), below freezing temperatures usually occur on only a few days out of every year and are typically restricted to the early morning hours. Rainfall is variable through the year with the direst month being April with an average of 6.6 centimeters (2.6 inches) of precipitation and September being the wettest with 14.7 centimeters (5.8 inches) of precipitation. Precipitation comes in both thunderstorms and trace amounts. Hurricanes are known to visit the region on occasion.

3.0 METHODOLOGY

3.1 Site File and Literature Review

Prior to field investigations, desktop activities were conducted that included a state site file search. Consulting the online THC Atlas database and resulted in a listing of all recorded terrestrial and marine archaeological sites and National Register of Historic Places (NRHP) properties within approximately 8 kilometers (5 miles) of the project APE. The site file research was used as a basis for developing a historic context and to gather information about past cultural resource survey activities near the project area. Background historical research incorporated material and data gathered during previous archaeological investigations and primary and secondary historical sources. The historical research aided in identifying potential types of marine resources that may have been deposited near the project area and determining the nature and extent of subsequent activities that may have removed or disturbed such resources. Data sources available for background research include historic maps and aerial photographs, primary and secondary shipwreck lists, primary historical accounts, newspapers, the Automated Wreck and Obstruction Information System (AWOIS) and online THC Atlas databases, and county and thematic histories. Information gleaned from these sources aided in developing a list of potential resources as well as identifying resources that may be expected to be located within the project area.

3.2 Field Methods

The underwater survey employed a variety of remote sensing technologies deployed from a survey vessel to examine the Bay bed and locate anomalies and acoustic targets on or buried in submerged sediments that might be affected by project activities.

3.2.1 Underwater Archaeological Survey

Positioning is considered a critical aspect of marine remote sensing projects. There are few landmarks on the water to use for orientational reference. To recreate or relocate survey targets, accurate positioning is critical. A discussion of equipment, techniques, and analysis of data collected during the survey is provided below.

Remote Sensing Investigation

Acquisition of the remote sensing data for this project was conducted by personnel from CRA of Houston, Texas. Mr. Arron Yoho, served as Senior hydrographic surveyor, and Mr. Kevin Acieri acted as the assistant surveyor. They were joined by Dr. Michael Tuttle, maritime archaeologist from HRA Gray & Pape, to act as the archaeological observer. The survey was conducted aboard a 5.8-meter (19-foot) center console survey vessel. Each piece of remote sensing equipment was run individually for proper acquisition of the data as well as safe navigation, due to the environmental factors encountered on site. CRA used state of the art technology to collect the remote sensing data to be used for both hazard and archaeological analysis.

Horizontal positioning for the hydrographic survey work was achieved using a differential Global Positioning System (DGPS) positioning system based on the use of Trimble model SPS 461 12 channel GPS receiver which offers an accuracy of less than 1 meter (3 feet). Data from the horizontal positioning system were integrated into a laptop PC utilizing Hypack® navigation software which allows real-time calculation of the boat's position and gives helmsman guidance information with respect to pre-programed survey lines. Pre-programed survey lines were run over all safely navigable areas of the project area, shallow areas to the east could not be run (Figure 2). Survey line spacing was established at 20-meter (65.6-foot) intervals in accordance with the Texas Administrative Code (Title 13, Part 2).

Remote sensing equipment utilized for this project included an Odom Echotrac MKIII digital survey fathometer used to collect depth measurements for this project. To create an image of the harbor floor, a digital dual frequency side scan sonar system was used. The side scan sonar provides a near photograph-type image of the harbor bed on which features, and objects can clearly be seen and mapped. CRA used the new Edgetech 4125 system operating at 400 and 1250 kHz. This system takes coordinates from the positioning system to locate the side scan data in real time. Processing of field data takes place in "SonarWizMap" software. To locate iron and ferrous objects that may be on or buried beneath the harbor floor, CRA utilized a Marine Magnetics SeaSpy marine magnetometer which is the latest generation equipment with very low noise and high sensitivity. The towed sensor is interfaced to a computer system that records the data digitally, together with position information directly from the GPS receiver. Data were collected at a rate of 2 readings every second. Due to the shallowness of most portions of the project area, although floated at the surface, the sensor was in close proximity to the harbor bed and therefore may exaggerate the size of the source of anomalies.

The remote sensing phase of the project area took place between August 29 and August 31, 2012. The data were collected, edited, and analyzed by CRA for their various purposes. After their review, the data were forwarded to HRA Gray & Pape for detailed archaeological analysis.

Remote Sensing Interpretation

The magnetometer and side scan sonar are the basic tools of marine archaeology. The magnetometer can indicate metal objects, which are some of the main components of shipwrecks, while the side scan can create a near photographic image of the sea bed that allows for detailed analysis of recorded objects. Unfortunately, the analysis and interpretation of remote sensing data is a process that is not 100% accurate in identifying a target source. While a physical examination is the only way to positively identify the source of a remote sensing target, in most cases it is economically unfeasible to examine every recorded anomaly. Therefore, a rational method has to be used to discriminate the likelihood that a magnetic anomaly source or side scan sonar image represents a potentially significant cultural resource. Numerous factors should be considered while conducting remote sensing interpretation. The factors that make up the basis for remote sensing interpretation are just as important as quality data acquisition. Magnetometer data presents several properties which can be used for analysis. One characteristic examined is magnetic amplitude, or the deviation recorded from background readings. The change from background may be either positive or negative or both. If the

Figure Removed from Public Distribution Copy

Map Showing Project Limits, Planned Track Lines,
and Acreage of Surveyed Areas

HRA Gray & Pape, LLC

Figure 2

amplitude change is only in a single direction it is known as a monopole if it has a single positive and negative change it is a dipole. If the anomaly source has more than two opposing peaks it is complex. Another significant characteristic for analysis is the anomaly's duration, how long does it occur in the record. Again, an anomaly is a local event and the closer the sensor is to its source the greater the amplitude recorded. This local field, the recorded duration, will increase from and die out to background readings where the sensor no longer detects it. Another attribute of an anomaly that has been receiving more attention in analysis lately is its orientation, the way the poles of the anomaly are oriented relative to the earth's magnetic field. During the present field research, it must be noted that the sensor was in relative proximity to the harbor bed, in many cases less than 1.5 meters (5 feet). Magnetic deviation recorded is, in part, a function of distance between the sensor and magnetic source material, for example, the closer the sensor to the material, the larger the reading. With the sensor so close to the obvious resting place of any metallic materials, the amplitude changes representing anomalies will be greatly exaggerated than if the sensor was at a more typical survey distance of 6 to 9 meters (20 to 30 feet) from the sea bed.

Effective analysis of magnetic remote sensing data depends on quality data collection, knowledge of the environment from which the data are collected, and experience with examining anomaly sources. Through the years several authors have created models to aid in interpreting remote sensing data, especially magnetometer data. Garrison et al. (1989) created a model based on selected ship wrecks in the Northern Gulf of Mexico. The authors suggest a magnetic signature for the vessel remains they examined would cover an area of between 10,000 and 50,000 meters squared (107,639 and 538, 195 square feet). That converts to an area between approximately 99.6 by 99.6 meters (327 by 327 feet) and 223 by 223 meters (733 by 733 feet) or put in another way 1 to 5 hectares (2.47 to 12.35 acres). These are rather large areas and do not appear to be representative of smaller, wooden vessels that would be of great interest to historians and archaeologists. History has indicated that this model, although a good early start as a baseline for analysis, could be refined.

Later, Pearson et al. (1991), considering the earlier work, developed a new model to suggest the presence of shipwrecks based on magnetic amplitude and duration. Threshold data for potential shipwreck sites were set at 50-gamma total magnetic deflection from background with a linear duration of greater than 24 meters (80 feet). Notice the duration is greatly decreased and a minimum element of magnetic deflection is introduced. In addition to these quantitative limits, Pearson with Hudson (1990) have argued for a qualitative assessment of remote sensing data as well. The environmental context in which an anomaly is located is an important factor in its analysis and interpretation. The Lavaca Bay LNG Project area environment consists of a highly-modified harbor that was constructed by dredging in the 1960s and has been maintained on a regular schedule since then. Today evidence of anti-erosion control features containing metal and newly created land structures partially surround the project area. Additionally, there was little historic shipping in the immediate vicinity as the important local ports were on the other side of the bay. These environmental and cultural factors were taken into consideration while conducting an analysis of the project anomaly data. Although there was little historic shipping in the project area, hurricanes are another feature of the Texas coast and they have been known to displace vessels from traditional shipping lanes. So a recognition of the possibility for historic wreck sites must be considered as well.

After decades of use Pearson has recently revised his 50gamma/80-foot model for anomaly identification. He has kept his gamma deflection the same at 50 but shortened the duration from 80 to 65 feet. He has been employing this model since at least 2014 (Linden and Pearson 2014; Haley and Pearson 2015; Pearson 2015).

A third model, which has been more recently developed, does not rely exclusively on a specific magnetic deflection or area of coverage but on the very essence of the Earth's magnetic field and the orientation characteristics of a recorded magnetic anomaly. In order to increase the efficiency of magnetic analysis as, "Only a tiny fraction of seafloor magnetic anomalies are associated with shipwrecks," Gearhart (2011) has created a model for identifying shipwreck sites based, in part, on the principles of magnetic orientation. Using 29 known shipwreck sites comprising a varied selection of vessel types exhibiting a wide range of horizontal dimensions and magnetic amplitudes, the basis of other magnetic interpretive models, Gearhart highlights the orientation of the anomaly itself. One unique magnetic characteristic of all known shipwrecks in the sample presented is the magnetic orientation of the anomaly over all shipwreck sites, the negative component of a dipolar anomaly unfailingly resides to the geographic north. Additionally, it is recognized that the magnetic deviation of the graphically represented signature did not vary greater than 26° from magnetic north. In addition to orientation, Gearhart indicates that an anomaly representing a shipwreck site should be located on two parallel and adjacent survey transects not exceeding 20 meters (66 feet) and have an area of coverage 1,580 meters squared (0.4 acres, 39.7 meters by 39.7 meters) as represented on a 5-gamma contour map (Gearhart 2011:101). Thus, a dipolar anomaly with a positive gamma deflection to the north is not consistent with known shipwreck sites and therefore should not be considered a potential shipwreck.

Several models have been created and refined to aid in the interpretation of magnetic data based on quantitative data relative to aid in the identification of potentially significant shipwreck sites. Another important aspect of remote sensing data interpretation is the context in which a survey was conducted, as argued by Pearson and Hudson (1990). It is important to understand and consider the environmental variables that may contribute to the archaeological record; from debris deposition through to various seabed/shore line modifying activities as well as construction. A study conducted in a similar environmental context as the present investigation, shallows surrounding a long-used dredge spoil deposition area, located over 400 magnetic anomalies. The source of these was considered to represent pipes or pipelines and sources similar to observed shore debris. Although many of the recorded anomalies and anomaly clusters exceeded the 50-gamma/80-foot duration criteria used to determine potential significance, the overriding imperative for determining significance was environmental context. "In all, given the associated side scan targets and the work history of the area, all targets were considered to be non-significant in nature and no further work is recommended" (Lydecker and Tuttle 2000:39).

A study in a context very different from the present research, Boston Harbor, examined 67 previously identified remote sensing targets. The historic importance of the water body to American history cannot be discounted. The examination found approximately 15% of the initially identified materials were mobilized and could not be recreated; the sources for the remaining targets were identified. The materials examined spanned the gamut from metal debris, pipes, and chain to fishing gear and several watercrafts. Four barges, one modern vessel and the remains of a potentially significant wooden hulled shipwreck were observed. In the context of a harbor that has had historic traffic and is still actively used today only one potentially historic site was located (Tuttle 2004). Locating one potentially significant site indicates the rarity and difficulty of distinguishing remote sensing data as significant archaeological sites. However, it also indicates the necessity to examine anomalies in the proper context to protect the rare sites that are indicated in the record.

Interpreting the context of an archaeologically surveyed area relative to remote sensing analysis is the grayest of the evaluation criteria. There are no base line numbers or qualitative assessments to be referred to or consulted. Experience and in some respects common sense are required to make a subjective evaluation based upon the variables pertaining to the environment worked in. The only way to know the source of every magnetic anomaly or side scan image is to have a complete examination either by an archaeological diver or remotely operated vehicle. “Hands-on inspection of every buried anomaly source may not be an economic possibility, so researchers must trust their interpretive abilities” (Gearhart 2011: 91). In the context of the present research, the environmental and historic considerations will be one of the factors considered while interpreting for potential significance of the sources of magnetic anomalies.

For the present investigation in a highly-modified environment, three main filters will be used to determine the potential significance of a recorded magnetic anomaly. The filters are a combination of the Pearson model, which takes into consideration amplitude and horizontal measurements of a recorded anomaly. With a nod to Pearson anomalies that did not meet minimum deflection and duration were not considered potentially significant. The Gearhart model was then imposed to filter out more anomalies, and any anomaly that contained a positive magnetic deflection to magnetic north were removed from consideration of potential significance. Additionally, any anomalies that did not exhibit itself on two parallel adjacent survey transects and smaller than 1,580 meters (.04 acres or 39.7 meters by 39.7 meters) as represented on a magnetic contour map at 5 gamma intervals are also most likely not representative of a shipwreck site and should not be considered potentially significant. The final filter was based upon the environmental context of the project area, any anomaly directly associated with obvious shore structures, debris, piping or the recently created and regularly maintained navigation channel were removed from consideration of significance.

Side scan sonar data present a different form of result for analysis, a near photographic presentation of an area examined is created based on reflected sound. Sonar images capture only what is above or on the seabed, and in some cases, can discriminate between various densities of sea bed. However, any buried material that does not affect the surface of the seabed in any way cannot be discerned. In some ways, the analysis of side scan sonar data is relatively easy, one sees what is observable. Interpreting the nuances of side scan sonar records is another matter. Characteristics of an acoustic target to be scrutinized in a sonar image are spatial extent, association or configuration, location, and the environmental context. Shipwrecks are generally easy to discern as are other large articulated cultural features. Additionally, many natural features, rock outcrops, oyster reefs, sunken logs, and even schooling fish create images that can be identified in the data. The difference between a log and a length of pipe are a bit harder to make based solely upon side scan data, but in conjunction with other remote sensing technologies and knowledge of the local environment may aid in making an interpretive determination of the created images.

4.0 CULTURAL SETTING

4.1 Prehistoric Period

Most larger coastal archaeological sites consist of sandy shell middens that may contain high lithic material counts and moderate amounts of pottery. These are typically located near water sources. These sites are generally considered base camps and there is a notable absence of satellite activity areas.

Projectile point types, along with ceramics on the coastal margin, are the most distinctive artifacts associated with archaeological sites in southeast Texas. The various types serve as hallmarks of the cultural periods of the region. These types range from the Clovis and Folsom points found in the Early Paleoindian period, to the stemmed points of the Archaic, to the dart points of Late Archaic/Early Ceramic, and finally to the arrow points of the Late Prehistoric circa (ca.) A.D. 500 or 600. The projectile point technologies found in the region were influenced by adjacent regions, including the Southern Plains, Southeast Woodlands, Louisiana, and north, central, and south Texas.

Many of the sites located near the current project area are documented as ephemeral prehistoric scatters or midden sites containing primarily Rangia or oyster shell, which often also contain fish otoliths. Locally defined cultural units include the Archaic Aransas Phase and the Ceramic Period Rockport Phase. The Aransas complex has been identified based on a suite of tools indicative of a lifestyle based on marine resources (Campbell 1958; Corbin 1974). Material culture recovered from Archaic sites within the south Texas region includes shell artifacts such as conch columella gouges, adzes, and awls. Stone projectile points recovered from Archaic sites in the region include Abasolo, Palmillas, Ensor, Refugio, and Tortugas types. Documented ceramics near the project consist of Coastal Rockport Complex wares, and bone tempered sherds suggesting a "Toyah Phase" affiliation.

The Late Prehistoric continues from the end of the Archaic period to the historic period ushered in by the Spanish Missions and Anglo-American settlers. During the Late Prehistoric stage in south Texas, two cultural complexes appear to have existed. The first complex, located further east on the coast, is characterized by ceramics that appear similar to the Goose Creek ceramics found farther north (Ricklis 1996; 2004). The second and later complex has been called the Rockport complex, and has been associated with the Karankawa groups (Newcomb 1961; Ricklis 2004). Although archeological evidence suggests the Karankawas migrated to the Texas Gulf Coast from the Caribbean in the early 1400s, it is unknown exactly how early these Indians roamed the Texas Gulf Coast area. Their occupation of the region ended not long after European contact.

4.2 Historic Period

With the discovery of the New World by Columbus in 1492, the Spanish conducted numerous other voyages of exploration along the American continents during the early sixteenth century. Parry indicates that the Spanish had three general stages of growth in the New World: the island stage, the Mexican stage, and the Isthmian or Peruvian stage. After the Caribbean Islands were exploited of their easy wealth, Cortes' conquest of Mexico 1519-1521 encouraged the settlement and exploration of the continent proper. From 1522 the average size and number of ships sailing from Spain to the Americas steadily increased (Parry 1966). It was during this period when the Texas coast was initially examined, and at a high cost.

The earliest Spanish examinations along the west Gulf Coast was that of Alonso Alvarez de Pineda, which was initiated in 1518. From Florida to Mexico, via the Mississippi and the coast of modern day Texas, new discoveries were made. Unfortunately, the natives of the region were hostile and many of the explorers were killed and all but one ship lost; however, the Gulf of Mexico was successfully mapped (Morison 1974; Johnson 2002). The next voyage to the region was that of Panfilo Narvaez in 1527-1528. Like that of Pineda this exploration ended in tragedy, which was slightly self-imposed. Narvaez sailed to Florida with five vessels and several hundred soldiers, sailors, and colonists. Dismissing his vessels, he and 260 of his men landed and attempted to venture around parts of the Gulf and meet the ships at a prearranged point. All did not go as planned, the natives were hostile, the ships never reestablished contact, and somewhere near the Mississippi River new vessels were constructed in an attempt to return to Mexico. Only four adventurers survived the expedition to make their way to safety. One of the survivors was named Alvar Nunez Cabeza de Vaca, who left an account of this 8-year misadventure on the Texas coast and interior (Morison 1974; Johnson 2002).

Another failed Spanish mission that may have encountered Matagorda Bay was that of the famed Hernando de Soto. Like Narvaez, de Soto landed in Florida and during 1539 began his adventures to the north and west. After encountering the Mississippi River in 1541 and exploring further west along the larger tributaries, De Soto died in 1542. Luis de Moscoso Alvarado took command, built several vessels during the spring of 1543, sailed down the Mississippi to the Gulf of Mexico and followed the coast to the Panuco River, in Spanish held territory. It is conjectured that they may have entered Matagorda and Corpus Christi Bays along the coast of Texas for water and provisions, however, little was made of the discoveries (Morison 1974; Johnson 2002).

With the confines of the Gulf of Mexico known and mapped by the mid sixteenth century, the region was not the focus of intensive exploration. During the later sixteenth and early seventeenth centuries while the Spanish were consolidating and exploiting their New World empire, focusing on the mineral wealth of Mexico and South America, other European nations began to send explorers and adventurers to claim lands unoccupied by the Spanish. Most of the lands claimed by other European nations were in North America well removed from Spanish habitations and active opposition. The Frenchman Rene Robert Cavalier, commonly known as La Salle, ranged throughout the continent and eventually claimed the Mississippi River system for his king in 1682.

During a return voyage to establish a French outpost at the mouth of the Mississippi, through a navigation error or other seventeenth century technological failure, La Salle ultimately landed on the Texas coast in the region of Matagorda Bay in 1685. Unfortunately, one of his three vessels, *L'Aimable,* wrecked at Pass Cavallo, the entrance to the bay. The other two vessels, *La Belle* and *Le Joly* made it safely into the bay. The captain of the *Le Joly* had orders to carry supplies for the expedition and once his task was complete left for France taking several of the would-be colonists with him. La Salle was left with one ship, 180 people and little idea of where he was. A camp, called Fort St Louis was made at the head of Lavaca Bay on the banks of Garcitas Creek. After several misadventures, including the loss of *La Belle*, La Salle decided to march with a small group of survivors to Canada so that a rescue mission could be organized, but he was murdered by his disgruntled men in March of 1687 (Bruseth and Turner 2006). La Salle's was an early failed attempt by Europeans to colonize Texas.

At Fort St. Louis, La Salle had left hardly more than 20 persons with the crippled Gabriel Minime, Sieur de Barbier, in charge. They consisted of women and children, the physically handicapped, and those who for one reason or another had incurred La Salle's disfavor. The Indians, learning of La Salle's death and the disunity among the French, attacked the settlement by surprise around Christmas 1688, sparing only the children (Weddle 2011).

The Spanish, jealous of their possessions and not wanting the French to establish a base, sent out an expedition to find and eliminate the threat that La Salle posed once they heard of it from a sailor, Denis Thomas, who jumped ship from the voyage and was ultimately captured while a buccaneering. The Spanish found the wreck of La Salle's *La Belle* in early April of 1687 but did not locate Fort St. Louis. It was a couple of years later when the Spanish became aware of the ultimate demise of the French at Fort St Louis. Another expedition to the east Texas region was informed by the local Karankawa Indians that all the French were killed, and as proof the natives had many war trophies in the material possessions of the dead (Bruseth and Turner 2006). The wreck of *La Belle* is highly significant for its historical value and is listed among several early wrecks in the northern Gulf of Mexico region that have been archaeologically examined (Borgens 2011).

4.2.1 Civil War

During the American Civil War, the Union placed a naval blockade, quickly to be labeled the Anaconda Plan, almost immediately upon the seceding southern states. Unprepared for the war the north could not establish an effective blockade immediately, but over time resources were developed and employed to strangle southern trade. The Confederate government did not have a well-developed naval or merchant marine infrastructure at the beginning of the conflict, nor did it have the resources to develop one. However southern blockade runners had great success at the beginning of the war getting through the porous Union effort. Later in the war, when the Federal forces were more effective, and the laws of supply and demand were intensified, blockade running was a financial boon for successful ventures. As the Union Anaconda Plan began to be affective along the Atlantic coast of the Confederacy the coast of Texas became more appealing to those who wished to move cotton out and various military and luxury goods into the Confederacy.

Texas, geographically at the western end of the Confederacy, was at the margins of strategic thinking, as the Mississippi River and the Atlantic Coast regions were initially focused upon. However, this did not inhibit the natives of the region from attempting to protect their shores and repel northern attacks and occupations. Although the port of Galveston and the Sabine Pass to the north were the sight of several major operations throughout the war, Matagorda Bay was also the scene of some belligerent activity. During the first months of the war *The Star of the West*, famous in part for being fired upon by the Confederates in Charleston Harbor in January of 1861, was on another Federal mission to help evacuate northern soldiers from Texas. *The Star of the West,* chartered to carry Union baggage and supplies out of Texas, was captured in the waters of Matagorda Bay off Indianola by a small number of troops from Galveston using the vessel *General Rusk* on the 17th of April (Scharf 1996).

Matagorda Bay was entered by Federal gunboats as there were no real Confederate naval assets to stop them. Union vessels bombarded Indianola which was also briefly occupied and looted in the autumn of 1862. Just days later, Lavaca, a hub of military activity at the western edge of the Confederacy containing a Confederate arsenal and small-arms factory, was bombarded. Hosting several garrisons at various occasions throughout the war and having an active artillery battery, Union forces soon retired from the town. Late the next year, 1863, Union troops returned to occupy both towns. About six months later, in June of 1864, Federal troops evacuated the Matagorda Bay area (Texas State Historical Association [TSHA] 2012a; TSHA 2012b). In addition to being the scene of minor naval engagements, other activities such as blockade running and commerce raiding took place in and from Matagorda Bay.

The Confederates used the tactic of commerce raiding throughout the war as they did not have the ability to produce naval vessels in quantity or quality to match the output of the North. Therefore, they tried to destroy northern commerce as they could not challenge the Union Navy. Near the end of the war, February of 1865, the Confederate privateer *Anna Dale* was waiting in Pass Cavallo for the remainder of her crew before she tried to slip the blockade to wreak havoc on Union shipping. Federal crews attempted to cut out the *Anna Dale* before she could make a cruise but ended up burning her when she grounded (Porter 1998). Thus, naval actions and maritime stratagems, although not central to the conflict, can be seen to have played out in Lavaca and Matagorda Bays from the beginning through to the end of the war.

4.2.2 Post-Civil War

After the Civil War, the bayside communities of Lavaca and Indianola rebuilt their infrastructure that was destroyed during the conflict. Railroads were rebuilt by both communities with service into the interior of the state to complement their shipping facilities. Competition between the two communities as a regional transportation hub appeared to favor Indianola. Unfortunately, the low-lying region was devastated by a hurricane in 1875 and again by the hurricane and fire of 1886. These tragedies devastated Indianola and the town was soon abandoned and Lavaca, to the north, began to prosper in its stead. Lavaca became the county seat in November of 1886, the next year railroad service to Victoria and to the interior was reestablished and an era of growth began, and the town began to be known with the prefix Port (TSHA 2012a; TSHA 2012b).

4.2.3 Twentieth Century

Transportation developments changed the face of Port Lavaca. Cattle shipments, once a primary industry, were lost out to the railroad’s expanding network. However, the railroad also created new opportunities. From the interior came a new commodity, tourists, people that would spend their resources enjoying the attractions of the bay. The bay also became a place of work as the federal government began waterway improvement projects such as dredging. In 1910, a channel was completed from Port Lavaca all the way to Pass Cavallo, the inlet at the Gulf of Mexico.

Three years later the Gulf Intra Coastal Waterway was completed giving Port Lavaca a protected water link to a major deep-water port to the north, Galveston. Fishing, in particular shrimping, became a leading industry for the region. Port Lavaca became a national leader in seafood shipments during the 1920s. This growth contributed to further expansions in the local infrastructure that affected the bay. A causeway was completed between Port Lavaca and Point Comfort in the 1930s. Additionally, gas and oil were discovered in the region during this period. Harbor improvements were also completed adding to an infrastructure that would attract business (TSHA 2012a; TSHA 2012b).

In the post-World War II era, large companies such as Alcoa, Union Carbide, Du Pont, and others established industrial facilities in the nearby communities. In 1953, residents two miles east of Port Lavaca, across Lavaca Bay, voted to become the county's third incorporated city, Point Comfort. By the early 1960s, the town was a mini industrial center supported by large aluminum plant and chemical industries. With the growing economic base, the need for access to better shipping infrastructure in the form of a deep navigation channel through Lavaca and Matagorda Bays to the Gulf of Mexico was recognized. Although hurricane Carla caused a large amount of damage in 1961, which ultimately lead to the causeway, a major transportation feature, being abandoned the region persevered. In 1963, the Port of Port Lavaca-Point Comfort was designated a port of entry for customs purposes. Two years later the deep-water channel from Point Comfort, with a side channel to Port Lavaca, known as the MSC was completed (TSHA 2012a; TSHA 2012c).

As can be seen from the earliest days of days of Spanish exploration, through to the era of the Texas Republic and Civil War of the nineteenth century into the twentieth century the waterways of Matagorda and Lavaca Bays have been utilized, and even depended upon for transportation, communication, industry, and fishing. This robust utilization of the resource indicates that there may be resources of historic significance located beneath its waters. This is most strikingly illustrated by the recently located and removed seventeenth century ship *La Belle,* associated with La Salle's exploration and settlement activities in Matagorda and Lavaca Bay region. However most of the historic activity took place along the western boundaries of the bays, while much of the development has taken place in the modern era.

4.3 Matagorda Bay Communities

Four cities in Calhoun County stand out today as being historically significant, or as containing historically significant sites; these include Port Lavaca, Indianola, Olivia, and Linnville. A brief discussion of relevant historic period activities and of each city is provided below.

4.3.1 Port Lavaca

The modern city of Port Lavaca, originally known as Lavaca, is in the north central part of the county on the west coast of Lavaca Bay. The town was founded in the aftermath of the Linville raid of 1840, during which Comanche raiders attacked Victoria and Linnville. In the Republic period, Lavaca was the busiest port in the region and later, during the Civil War, it would house a large Confederate arsenal and small-arms factory. Among the city's historic points of interest are a historic lighthouse, hotels, churches, and cemeteries. Several of these resources have been identified by state historical markers and are located with the project's study area.

The Half Moon Reef Lighthouse was constructed in 1858 and was originally located in Matagorda Bay, at the southern tip of Half Moon reef. The beacon served as an aid to ships trading in Port Lavaca and the nearby town of Indianola. During the Civil War, the light was disabled by Confederate troops in an attempt to disrupt federal efforts to capture southern blockade-runners. The lighthouse was restored to full operation in 1868 and remained in service until 1943 when it was moved to Point Comfort. It was relocated to Port Lavaca in 1979.

The Beach Hotel, constructed in 1904, has been a part of the Port Lavaca landscape for generations. At the time of its construction, the hotel was the tallest building in town and tourists from inland cities often rode special excursion trains to Port Lavaca to enjoy the recreational opportunities along the coast and to stay in the hotel.

Historic churches within the study area include the First Baptist Church of Port Lavaca and the Saint Joseph Baptist Church. The First Baptist Church of Port Lavaca was organized in 1854 as the Lavaca Baptist Church. This congregation developed from area missionary efforts that began in the 1830s. Despite early hardships such as the Civil War, hurricanes, and a yellow fever epidemic, the Baptists continued their worship services and in 1913 were chartered by the state as the First Baptist Church of Port Lavaca. Active in the formation of several area congregations, the church has played an active role in the development of the town. The Saint Joseph Baptist Church began as the Free Will Baptist Church in the town of Indianola in 1872. Three years later, a devastating hurricane struck the Texas Gulf Coast, inflicting major damage on Indianola. The congregation repaired their church, but in 1886 another hurricane completely destroyed the town. In 1898, the congregation purchased a warehouse in Port Lavaca and converted it for use as a house of worship. The name of the church was changed about 1900 to Saint Joseph Baptist Church. The original warehouse/church structure was replaced by a new building in 1984, and the church continues to serve the Port Lavaca community today.

Two historic cemeteries exist in Port Lavaca, the Ranger Cemetery and the Port Lavaca Cemetery. The oldest known grave in the Ranger Cemetery is that of Major H. Oram Watts, the customs collector at Linnville and casualty of the Comanche raid on that settlement in 1840. Other burials include Margaret Peyton Lytle, wife of James T. Lytle, the "poet" of the Texas Rangers. When an epidemic broke out during the Civil War (1861-65), a nearby house was used as a hospital. At least 10 federal soldiers were among victims buried here. Members of the five families who owned the site are also interred in Ranger Cemetery. The Port Lavaca Cemetery was in use in the 1840s, with several mass graves dating from an 1849 cholera epidemic. Pioneer families and their descendants, as well as prominent state, county, and city officials, are also interred in the community graveyard. At least one participant in the Battle of San Jacinto is buried here. Graves of both Union and Confederate soldiers may be found in the Port Lavaca Cemetery, which has been enlarged through various land transactions over the years to cover eight city blocks.

4.3.2 Indianola

This former port figured prominently in local history for almost 175 years. Following Pineda’s exploration of the coast in 1519, the first major development resulted from La Salle’s establishment of a settlement at this location in 1685. The first half of the nineteenth century saw the emergence of Indianola as a primary point of entry for colonists entering the region including Germans led by Prince Carl of Solms-Braunfels. By the time of its destruction in 1875, Indianola was a major seaport. During the Civil War, Indianola was an objective of Federal blockading vessels and eventually fell to Federal forces on December 23, 1863. Two days later Lavaca was occupied, and the entire Matagorda-Lavaca Bay area remained in Federal control until 1864. After the war, while at the peak of its prosperity, Indianola was struck by the hurricane of 1875. The town was severely damaged but was rebuilt on a smaller scale. In 1886, the town was struck by a second hurricane. The storm damage and resulting fire led to the abandonment of the site in 1887.

Three cemeteries served Indianola during the nineteenth century, the Old Town Cemetery, the Indianola Cemetery, and the Zimmerman Cemetery. The oldest existing grave marker in the Old Town Cemetery, the marker of James Chilton Allan, bears a date of 1851. Some of Calhoun County's earliest settlers, who came in the first wave of German immigration to Texas in the 1840s, are buried here along with Angelina Eberly, heroine of the Texas Archives War. The Indianola Cemetery reflects many of the hardships encountered by nineteenth century residents of Indianola. The oldest existing grave marker in the Indianola Cemetery is that of a child, William Woodward, who died in 1852 after cholera and yellow fever epidemics swept through Indianola. Victims of the 1875 and 1886 hurricanes are also buried here. The oldest marked grave in the Zimmerman Cemetery is dated 1852, and citizens of both Indianola and Magnolia Beach are buried there.

4.3.3 Olivia

The town of Olivia was established in 1892 for Swedish immigrants from the Midwest. The first public building in Olivia was a one-room schoolhouse where children were taught during the day and parents attended classes at night to learn English. The Eden Lutheran Church held services in the schoolhouse until 1910, when a sanctuary was built. Businesses included a hotel, doctor's office, grocery store, blacksmith shop, and cotton gin.

When the Olivia townsite was laid out, land was set aside for the Olivia Cemetery. Both Swedes and non-Swedes are buried here; the oldest marked grave is that of Christina B. Cavallin, who died in 1897.

4.3.4 Linnville

An early Texas port named for John Joseph Linn, a pioneer merchant from Victoria who located his warehouse here in 1831. It was one of the most important ports of entry during the early period of the Republic of Texas. The Federalist armies of Mexico used Linnville as an ordinance arsenal and depot during their attempt to defeat Centralist forces under the command of Antonio López de Santa Anna. These hostilities would give rise to the Linnville Raid of 1840. Linnville was eventually abandoned, as Port Lavaca grew in prominence, and much of the townsite is now covered by Lavaca Bay (TSHA 2015).

4.4 Navigation History

Relatively shallow Texas coast harbors coupled with sediment-fouled river mouths meant that, historically, shipbuilding in Texas was a relatively limited enterprise. The shipyards that did exist tended to focus on building small boats for fishing and river navigation. While steamboats ran routes around the coast and up the rivers, these ships were constructed at many locations along the east coast but not in Texas. An example of Texas coastal ship building includes an 1845 ship designed for commerce on the Colorado River which sailed from Matagorda.

Just before and after World War I, shipbuilding began to grow into a large industry due to the growing need for merchant ships. As a result, Texas ship builders opened several shipbuilding and ship-repair yards in the Beaumont-Orange, Houston, Galveston Bay, and Corpus Christi areas utilizing local yellow pine. A fleet of 14 wooden barkentines and schooners were produced during the course of the war. After World War I the shipbuilding industry across America suffered the effects of the Great Depression and other problems (Peebles 2013).

Wooden fishing boats and smaller transport vessels were the first European-style vessels in the Bays of eastern Texas. These early days saw the first use of iron, at first as a covering and later as the entire frame and structure. Civil War blockade runners used iron cladding for protection from warships enforcing the blockade. Steamships and sailing ships were common into the early 1900s. By the time of the Spanish-American War large warships were powered by steam powering screw propellers. With World War II diesel engines became the most common power for ships. Oil tankers became common with the discovery of the Spindletop oil fields in the early 1900s. The first oil tankers were sailing ships, but these were soon replaced by steam ships. Modern freighters, barges, tankers, and towboats have dominated Texas shipping since the 1940s (Peebles 2013).

4.4.1 The Project Area

Local waterways have been used for transportation, communication, industry, fishing, and war from the earliest days of days of Spanish exploration, through to the era of the Texas Republic, Civil War of the nineteenth century, and into the twentieth century. This long-term use has obvious implications for the discovery of shipwrecks and other submerged cultural resources in and around Matagorda Bay.

However, a series of topographic maps of the project area indicate the radical changes to the physical environment. The 1952 Point Comfort topographical map indicates the project area is mostly shallow, with depth soundings ranging in between 0.3 and 1.8 meters (1 and 6 feet). The navigation channel to Point Comfort resides well to the west of the project area and it has a reported depth of 2.7 meters (9 feet). Mitchell Point is the only land feature near the proposed project area (Figure 3). Post-World War II, the area began to be modified for heavy industry and the present navigation channel was planned and dredged in the 1950s and 1960s to a working depth of 11 meters (36 feet). Dredging a navigation channel and dredge spoil

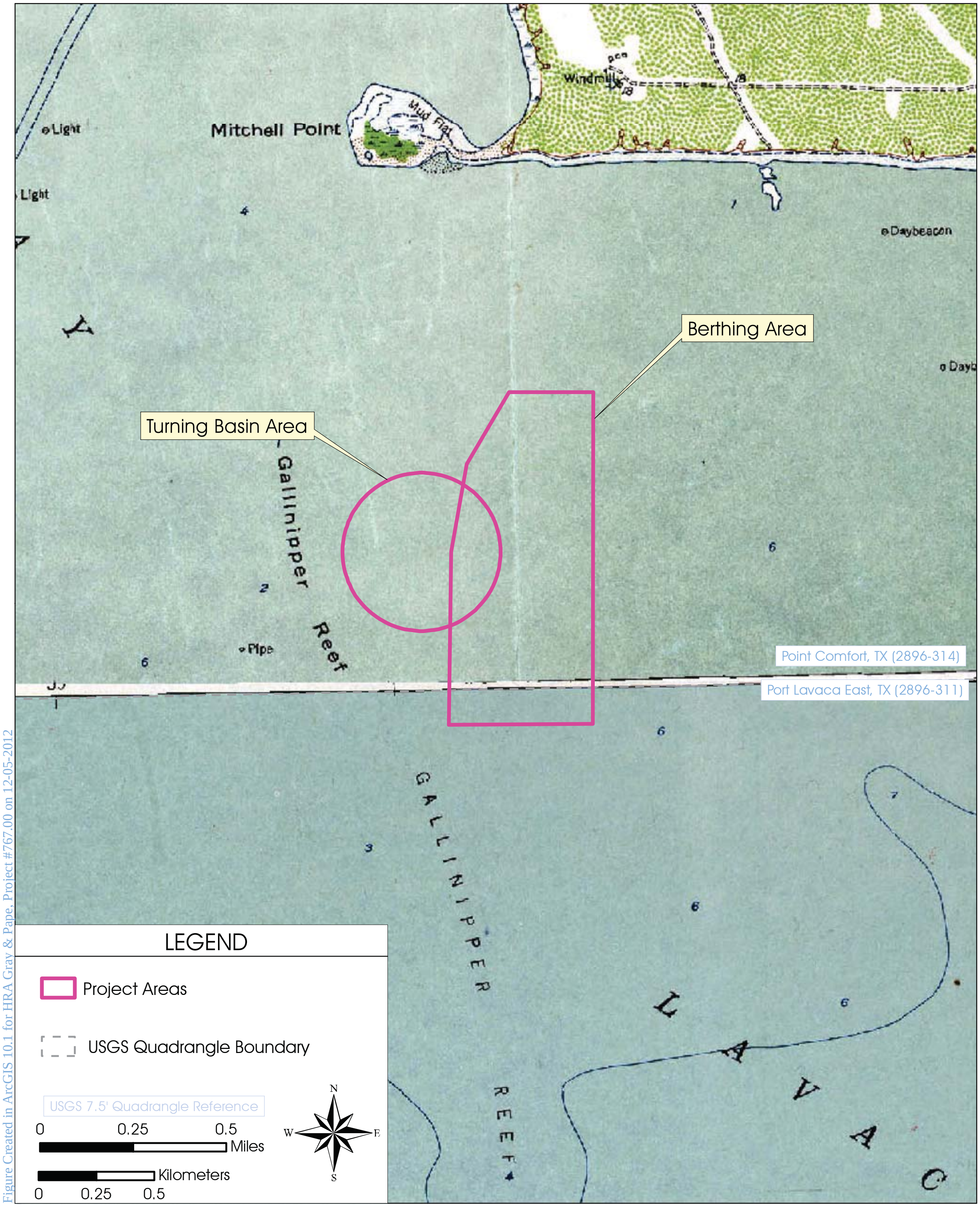


Figure Created in ArcGIS 10.1 for HRA Gray & Pape, Project #767.00 on 12-05-2012

Project Overlaid on a 1952 Topographic Map Showing Shallow Soundings and Lack of Land Masses to the Northwest and East of the Project Area

HRA Gray & Pape LLC.

Figure 3

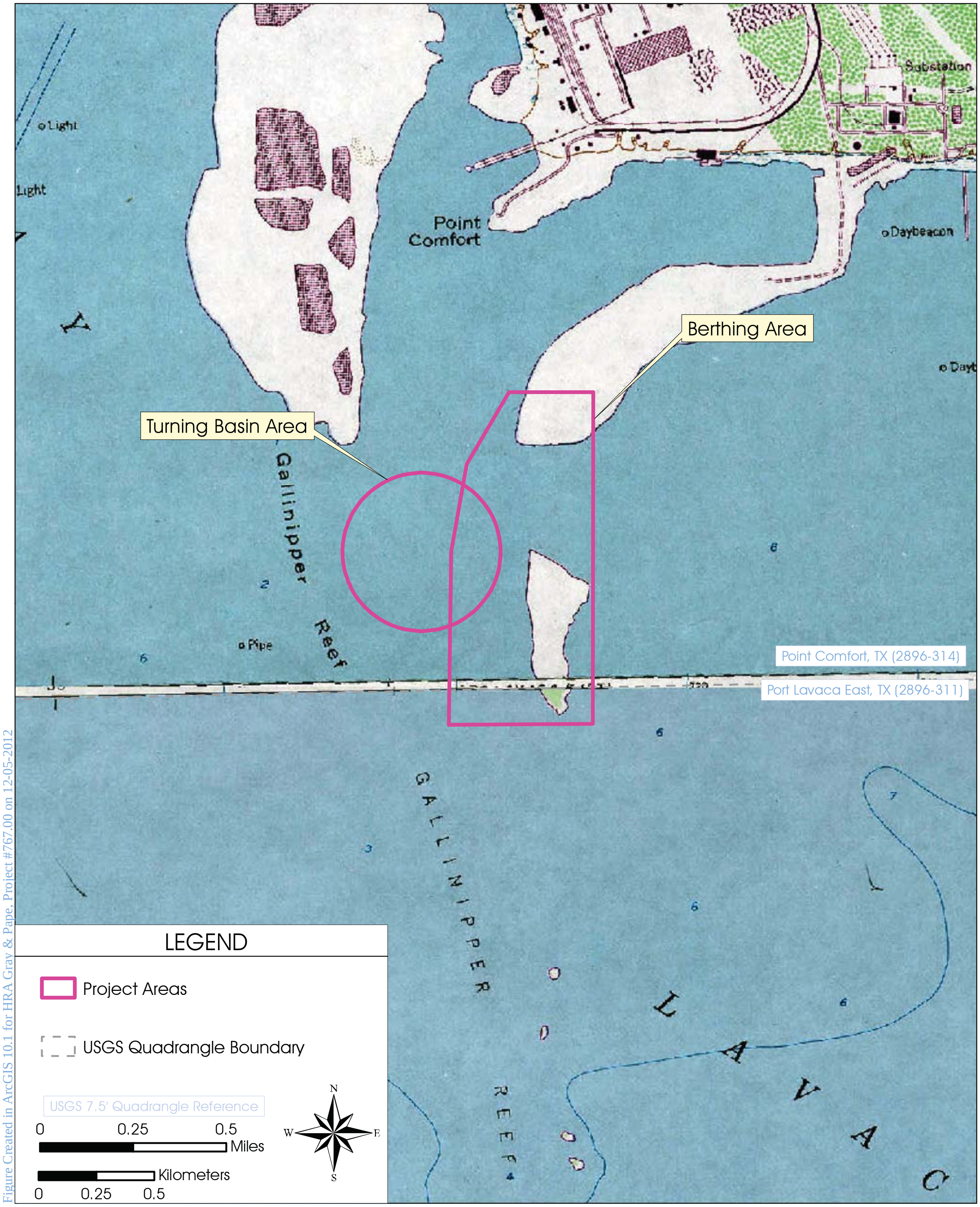
deposition created new physical features on the landscape. It is apparent by the 1973 topographic representation that the physical environment has been radically changed. Note the new spoil island to the west of Point Comfort and the new island and peninsula to the east of Gallinipper Reef (Figure 4). Additionally, the old navigation channel resides well to the west of the project area beyond the newly created spoil island. By 1995, the land to the north of the project area was developed by various industrial enterprises serviced by the dredged MSC. Additionally, the old navigation channel no longer connects to Point Comfort, but is diverted north under a causeway into Upper Lavaca Bay (Figure 5).

The MSC serves as the navigation artery for the Port of Port Lavaca-Point Comfort and empties into the Gulf of Mexico after traversing through Matagorda Bay. The 42-kilometer (26-mile) long MSC has been maintained but not widened or deepened since its first construction parameters were set in the 1960s, which are set at 11 meters (36 feet) deep and 61 meters (200 feet) wide at the base of the channel. Recently, the United States Army Corps of Engineers (USACE) approved the concept of widening to a 122-meter (400-foot) bottom width and deepening the channel to a 13-meter (44-foot) operating depth. ELS plans include deepening the channel to this new depth and widening is currently estimated to measure approximately 91 meters (300 feet).

A review of The National Oceanic and Atmospheric Administration (NOAA) and its predecessor agency's navigation charts in the region of the project area indicate drastic changes in site bathymetry. Figure 6 from a 1958 navigation chart entitled *Matagorda Bay and Approaches* indicates that the channel is "Being dredged" and that the water depth, correlated to mean low water, to the east of the channel, where spoil was to be deposited, was generally in the 1.8-meter (6-foot) range. By the ninth edition of the navigation chart, in 1967, the navigation channel is complete to a depth of 11 meters (36 feet) in an otherwise area of shallows and the area immediately to the east has changed with spoil pile land or shallows in the range of 0.6 to 1.2 meters (2 to 4 feet), indicating that the natural surface of the bay was covered by spoil (Figure 7). One feature of note represented on the chart is the "Platform" icon located to the west of where the channel Ys. The latest iteration of the navigation chart, the 32nd edition entitled *Matagorda Bay* and renumbered 11317, corrected to 2009, indicates the same general conditions found 40 years earlier (Figure 8). Some of the spoil islands appear to have eroded and the depths to the east range from 0.6 to 1.5 meters (1 to 5 feet). The platform located at the Y in the earlier chart is now listed as a ruin. The navigation charts, presenting a chronological illustration of the underwater surface of the project area, indicate that the harbor bed to the east of the dredged navigation channel consists of several feet of spoil.

4.5 Previous Investigations

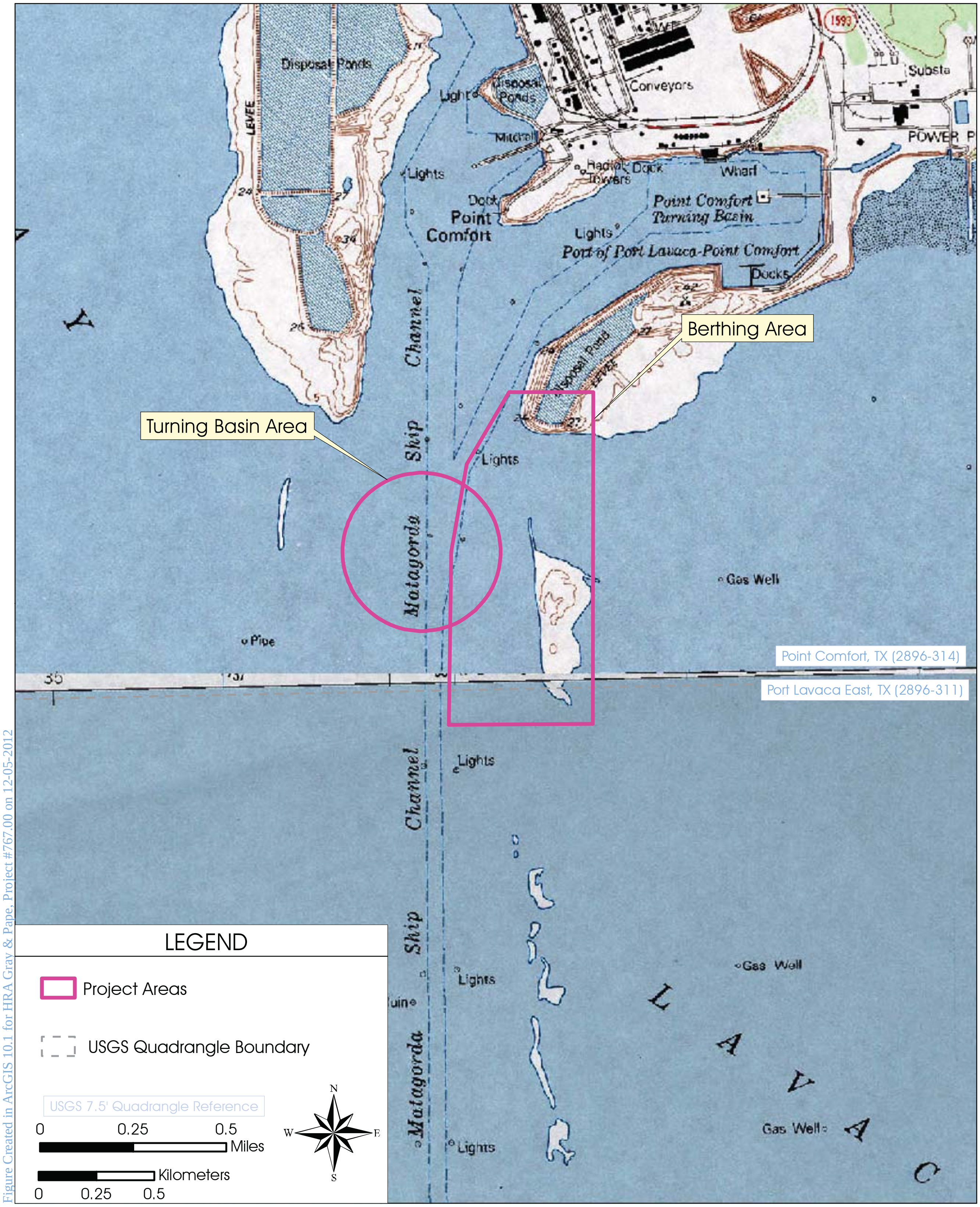
Previous marine investigations have included numerous surveys conducted in advance of petroleum and navigation enhancement projects. Ahead of the planned expansion of SH 35, the Lavaca Bay Causeway, Espey, Huston & Associates Inc., under contract to the Texas Department of Transportation conducted a remote sensing survey along the northwest side of the existing highway. The survey collected magnetometer, side-scan sonar, and bathymetric



Project Area Overlaid on a 1973 Topographic Map Showing a Newly Created Island to the West and a Peninsula and Small Island to the East

Figure 4

HRA Gray & Pape LLC.



Project Area Overlaid on a 1995 Topographic Map Showing Industrial Development in Point Comfort as well as the Dredged Matagorda Ship Channel

Figure 5

HRA Gray & Pape LLC.

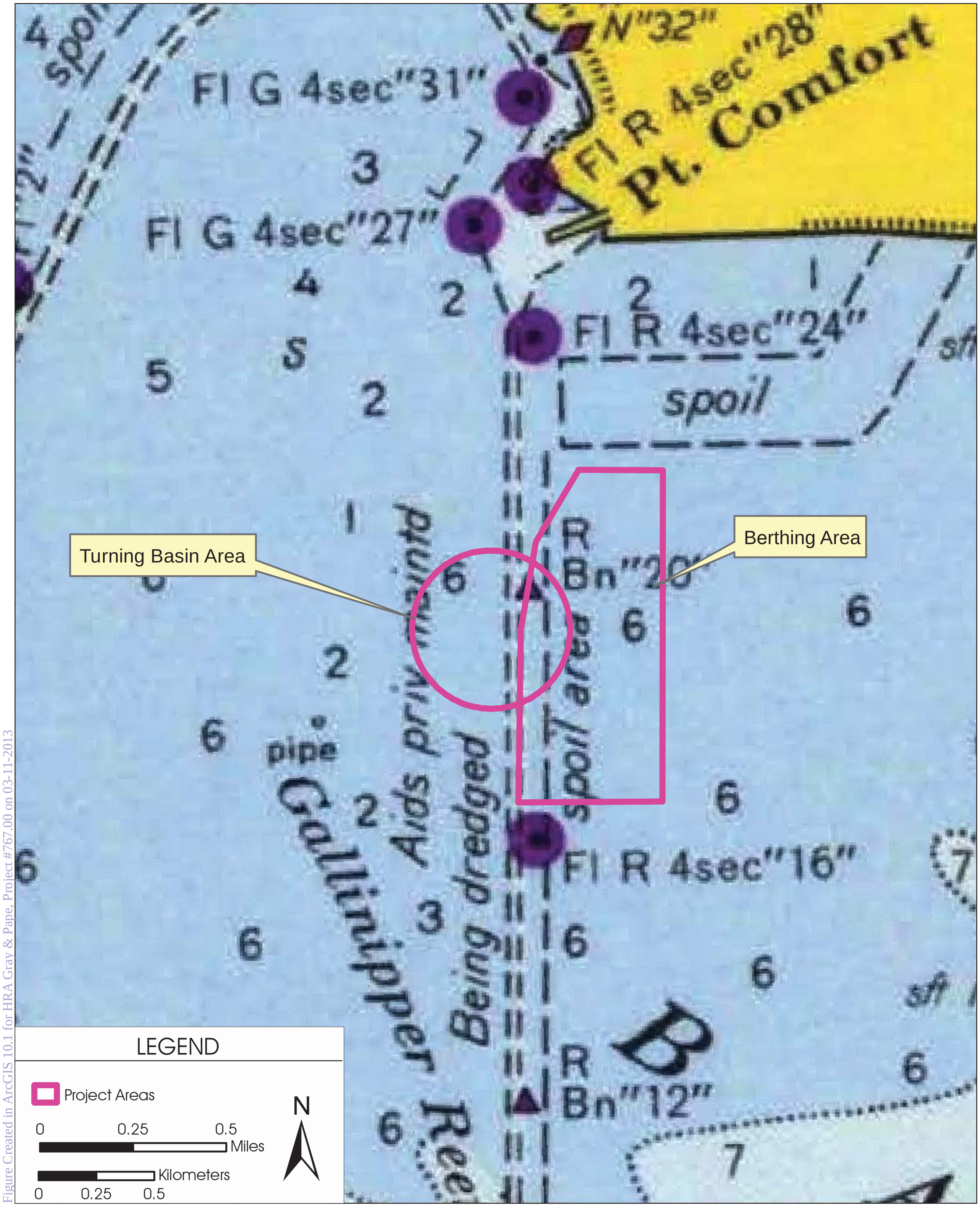
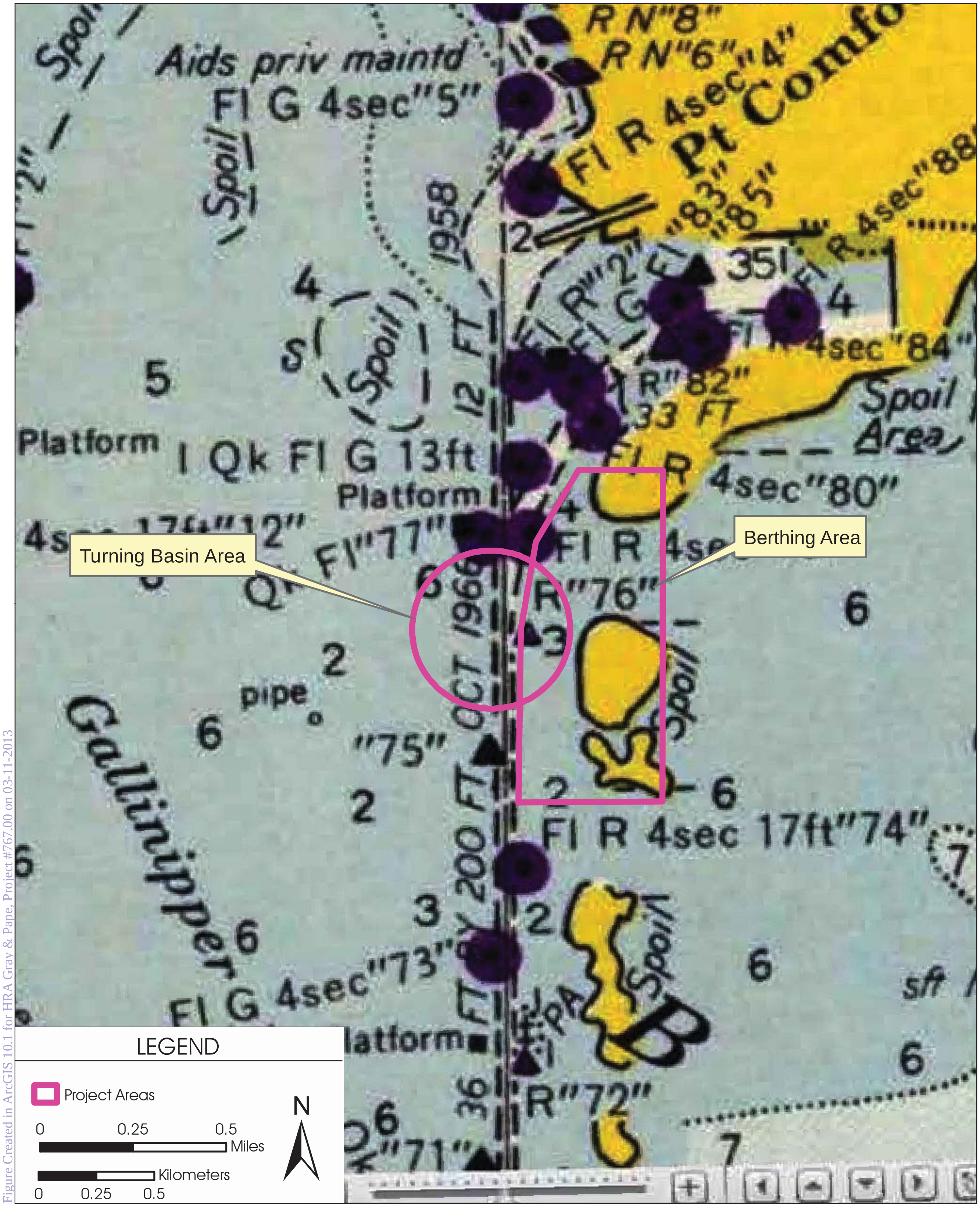


Figure Created in ArcGIS 10.1 for HRA Gray & Pape, Project #767.00 on 03-11-2013

Project Area Overlaid On 1958 United States Coast And Geodetic Survey Navigation Chart 1284
Showing Navigation Channel Under Construction

HRA Gray & Pape LLC.

Figure 6



Project Area Overlaid On 1967 United Stares Coast And Geodetic Survey Navigation Chart 1284 Showing New Navigation Channel And Shallows And Spoil Islands Immediately To The East

Figure 7

HRA Gray & Pape LLC.

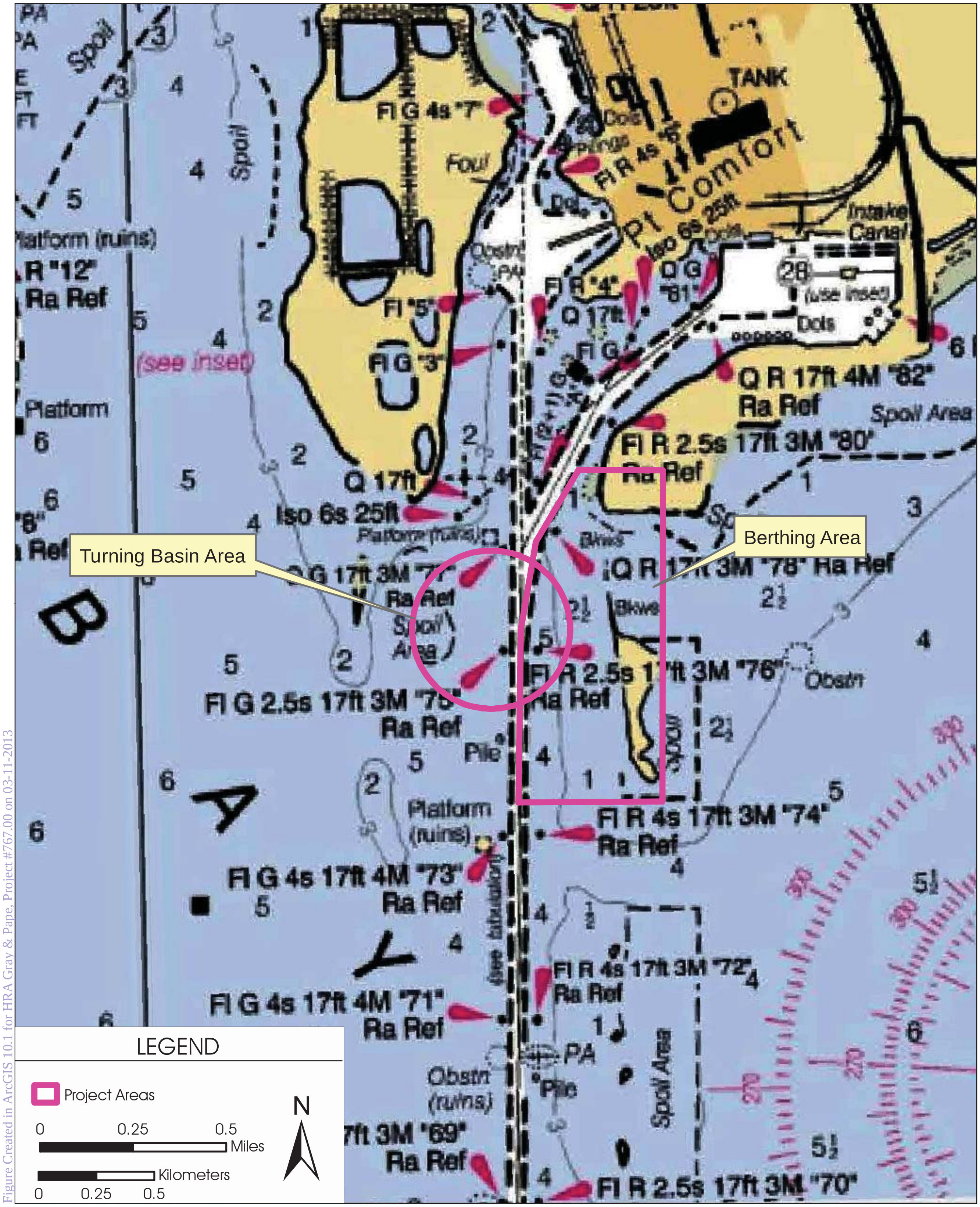


Figure Created in ArcGIS 10.1 for HRA Gray & Pape, Project #767.00 on 03-11-2013

Project Area Overlaid On 2009 NOAA Navigation Chart 11317 Showing New Navigation Channel And Shallows And Spoil Islands Immediately To The East

Figure 8

HRA Gray & Pape LLC.

data over a 37-hectare (92-acre) area. Historic research of the area was also conducted. The purpose of the project was to investigate the area for potentially significant submerged cultural resources (Schmidt and Gearhart 1998).

A 2005 survey of areas in Lavaca Bay surrounding Point Comfort was conducted by NCS Subsea Inc., and the data assessed by PBS&J (Figure 1). The survey examined 355.11 hectares (828.07 acres) and no cultural resources consistent with submerged shipwreck sites were identified (Borgens and Gearhart 2006).

In 2006, PBS&J was contracted by URS Corporation on behalf of the Calhoun County Navigation District to conduct a marine survey as part of a proposed plan to widen and deepen the MSC. The survey was conducted using both magnetometer and side scan-sonar along the length of the MSC as well as in several locations around Matagorda Bay and Lavaca Bay proposed for dredge material placement. A total of 39 targets were identified with the magnetometer of which five had an associated sonar target (Borgens et al. 2007). In regard to the Lavaca Bay LNG Project, targets M6 and M7 are both identified within the project study area.

A brief mention should be made of the *La Belle* shipwreck. Although the wreck site is well outside the project area, its historical importance to the region warrants a mention here. It had long been known that La Salle's ill-fated mission had lost two ships in the vicinity of Matagorda Bay; *L'Aimable*, near Pass Cavallo and *La Belle* along the Matagorda Peninsula. In 1978, the first magnetometer survey was conducted in high probability areas in both locations by both boat and helicopter. However, limits in positioning technology limited the results (Bruseth and Turner 2005). In 1995, a new survey was conducted making use of improved GPS technology. Thirty-nine targets were identified, including what turned out to be the remains of *La Belle* (Arnold 1996). Difficult diving conditions and the historical importance of the wreck resulted in the decision to excavate within a coffer dam. A treasure trove of artifacts was recovered: cannon, firearms, pottery, class, as well as nearly half of the ship's hull (Bruseth and Turner 2005). More recent research indicates that approximately one third the hull remains were recovered (Carrell 2017).

5.0 PROJECT FINDINGS

5.1 Site File and Literature Review

Research included a review of historical and archaeological records held in state archives, governmental web sites, navigation charts and electronic data bases, libraries, and secondary sources. An examination of the THC Atlas and the AWOIS databases indicates that 19 historic markers, 9 shipwrecks, and 36 archaeological sites have been reported or recorded within the area surrounding the project area (Tables 1, 2, and 3). In addition, the AWOIS database indicates that approximately 155 marine obstruction or unknown anomalies are located within the area around the proposed project APE.

Coordinates provided during archival research suggest that certain historic markers or archaeological sites might not be accurately plotted. Future work should include a site visit to ground truth accuracy of these records.

Table 1. Historical Markers in the Area.

Marker Number	Site Name	Site Type	Quadrangle	Temporal Affiliation	NRHP Eligibility	Potential Effect
#345	Beach Hotel	Hotel	Port Lavaca East	1904	Unknown	No
#627	Calhoun County Jail	Jail	Kamey	1896-	Unknown	No
#1101	Cox's Point	Town site	Point Comfort	1836-1840	Unknown	Yes
#1246	First United Methodist Church of Port Lavaca	Church	Kamey		Unknown	No
#1249	First Presbyterian Church of Port Lavaca	Church	Kamey		Unknown	No
#1667	First Baptist Church of Port Lavaca	Church	Kamey	1854-present	Unknown	No
#2332	Half Moon Reed Lighthouse	Lighthouse	Port Comfort	1858-present	Unknown	Unknown
#2642	Indianola	Town site	Keller Bay	1844-1875	Unknown	Yes
#2643	Indianola Cemetery	Cemetery	Port Lavaca East	1852-	Unknown	No
#2746	Jefferson Beaumont	Grave marker	Port Lavaca West	1801-1865	Unknown	No
#3051	Lavaca Lodge No. 36, A.F & A.M.	Lodge	Kamey	1848- present?	Unknown	No
#3091	Site of the Town of Linnville	Town site	Port Lavaca East	? -1840	Unknown	No
#3508	Angelina Bell Peyton Eberly	Marker	Port Lavaca East	ca. 1800-1860	Unknown	Unknown
#3521	Mount Sinai Baptist Church	Church	Kamey	1870-present	Unknown	No
#3825	Old Town Cemetery	Cemetery	Port Lavaca East	1851-	Unknown	Yes
#3855	Olivia	Community	Olivia	1892-	Unknown	No

Marker Number	Site Name	Site Type	Quadrangle	Temporal Affiliation	NRHP Eligibility	Potential Effect
#3856	Olivia Cemetery	Cemetery	Olivia	1897-	Unknown	No
#4077	Port Lavaca Cemetery	Cemetery	Port Lavaca East	1840-	Unknown	No
#4197	Ranger Cemetery	Cemetery	Port Lavaca East	1840s-1941	Unknown	No
#4243	Rene Robert Cavelier, Sieur de La Salle	Marker	Port Lavaca East	1643-1687	Unknown	Yes
#4454	Saint Joseph Baptist Church	Church	Port Lavaca East	1898-present	Yes	Unknown
#4518	San Antonio & Mexican Railroad	Railroad	Kamey	1850-1930s	Unknown	No
#4938	Site of the Town of Indianola	Town site	Keller Bay	1844-1886	Unknown	Yes
#5952	Zimmerman Cemetery	Cemetery	Port Lavaca East	1858-	Unknown	No
#12430	Salem Lutheran Church	Church	Kamey	1967-	Unknown	No
#12778	Our Lady of the Gulf Catholic Church	Church	Kamey	1854-	Unknown	No
#13171	Alice O. Wilkins School	School	Point Comfort	1937-1965	Unknown	No

Table 2. Identified Shipwrecks - AWOIS Databases

Record	Vessel Name	Chart	Registered Archaeological Site	Year Sunk
8	Gram Kirk	11319	No	Unknown
2501	Fina V	11317	No	1976
5313	Mary Ethel	11317	No	Unknown
5349	Dredge No. 9	11317	No	1975
5363	Bildot	11317	No	1960
5443	Grand Prize	11319	No	1972
5472	Vivian	11319	No	1991
5509	Cheetah	11319	No	1987
5510	Jolly Roger	11319	No	1987

Table 3. Reported Shipwrecks - THC Archaeological Atlas

Record	Vessel Name	Quad	State Antiquities Landmarks	Year Sunk
48	Buffalo Bill	Keller Bay	Yes	1886
52	Star of the South	Keller Bay	Yes	1875
53	Shellfish	Keller Bay	Yes	1875
54	Royinia	Keller Bay	Yes	1875
55	Delmore	Keller Bay	Yes	1875
58	Emory	Keller Bay	Yes	1875

Record	Vessel Name	Quad	State Antiquities Landmarks	Year Sunk
60	Flounder	Keller Bay	Yes	1875
61	Tidal Wave	Keller Bay	Yes	1875
62	Phoenix	Keller Bay	Yes	1875
63	Commodore Morbitt	Keller Bay	Yes	1875
64	Edith Belle Nason Dover	Keller Bay	Yes	1875
71	Perseverance*	Port Lavaca East	Yes	1856
81	Emeline	Port O'Connor	Yes	1836
91	Cora Bickford	Keller Bay	Yes	1875
280	Democrat	Keller Bay	Yes	1875
539	Eclipse	Keller Bay	Yes	1886
991	Prouty	Keller Bay	Yes	1866
993	Caroline	Keller Bay	Yes	1886
995	Annetta	Keller Bay	Yes	1886
1001	William & Mary	Point Comfort	Yes	1851
1002	William Penn	Port Lavaca East	Yes	1851
1003	Commercial	Port Lavaca East	Yes	1851
1470	Maggie	Keller Bay	Yes	1875
1796	Agnes Grey	Keller Bay	Yes	1875
1975	Agnes	Keller Bay	Yes	1875
2378	Alice	Keller Bay	No	1886

*Perseverance is in the process of receiving a trinomial as a recorded archaeological site

Table 4. Previously Recorded Archaeological Sites

Site Number	Site Name	Site Type	Quadrangle	Size (unit varies)	Temporal Affiliation	NRHP Eligibility	Potential Effect
41CL11	Mrs. Kate Wedia Ranch		Port Lavaca East			Unknown	Unknown
41CL12	Cox Point Site	Shell Midden	Point Comfort		Mid Archaic, Late "Neo-American" & Historic Era	Unknown	No
41CL14	Indianola		Keller Bay			Unknown	Unknown
41CL18		Shell Midden	Port Lavaca East	45 meters long		Unknown	No
41CL19		Shell Midden	Port Lavaca East	8 meters along beach		Unknown	No
41CL20		Undetermined	Port Lavaca East	11 meters long		Unknown	Yes
41CL21		Shell Midden	Keller Bay	200 meters		Yes	Yes
41CL22		Shell Midden	Keller Bay	110 meters x unknown	Unknown	Unknown	Yes
41CL23		Secondary Deposit	Olivia		Unknown	Unknown	Unknown
41CL24		Shell Midden	Olivia	160 meters x 210 meters	Unknown	Unknown	Yes
41CL25		Shell Midden	Point Comfort		"Pottery horizon"	Unknown	Yes

Site Number	Site Name	Site Type	Quadrangle	Size (unit varies)	Temporal Affiliation	NRHP Eligibility	Potential Effect
41CL26		Unknown	Point Comfort	160 meters long	"Pottery horizon"	Unknown	No
41CL27		Shell Midden Campsite	Point Comfort		"Pottery horizon"	Yes	No
41CL28	GLO 1st and 2nd	Shell Midden Campsite	Point Comfort	122 meters long	Unknown	Unknown	No
41CL29	GLO 3rd	Aboriginal Occupation	Point Comfort	100 yards		Yes	No
41CL30	GLO 4th and 5th	Open Campsite	Point Comfort	200yards NS x 30 meters EW	Unknown	Unknown	No
41CL31	GLO 6th and 7th	Shell Midden Campsite	Point Comfort	0.5-kilometer NS x 30 meters EW N	Neo-American	Unknown	Unknown
41CL32		Campsite	Point Comfort	375 yards long		Unknown	No
41CL33		Aboriginal Campsite	Port Lavaca East	305 meters NS x 15 meters EW	Unknown	Unknown	No
41CL34		Shell Midden	Port Lavaca East	Several Acres	Unknown	Yes	No
41CL35		Shell Middens?	Port Lavaca East	200 yards NS x 15 meters EW	Unknown	Yes	No
41CL36	Cecil Calhoun's #39 on Hwy Dept map	Shell Midden Campsite Disturbed by Historic Burial	Port Lavaca East		Unknown	Unknown	No
41CL37		Shell Middens	Port Lavaca East	0.8 kilometers NS to EW	Unknown	Unknown	No
41CL38		Cemetery	Port Lavaca East	122 meters x 46 meters	19th century German and Anglo-American	Unknown	No
41CL39		Town site	Port Lavaca East	Unknown	19th century German-American 1844-1850	Yes	Unknown
41CL40		Secondary Deposit	Keller Bay		Unknown	Unknown	Yes
41CL41	Cecil Calhoun's #16 on Hwy Dept map	Shell Midden Campsite	Keller Bay		Unknown	Unknown	Yes
41CL42			Keller Bay	500 yards EW	Unknown	Unknown	Yes
41CL43		Historic House	Keller Bay	Unknown	Historic/Unknown	Unknown	Yes
41CL44			Keller Bay	213 meters long	Unknown	Unknown	Yes
41CL52		Cemetery	Port O'Connor	Unknown	Mid-Late 19th Century Anglo American	Unknown	Unknown
41CL53		Campsite	Port O'Connor	Unknown	Archaic	Unknown	Unknown
41CL54		Campsite	Port O'Connor	Unknown	Archaic	No	No
41CL71	Decros Point Light Station-	Twin Lighthouses	Decros Point, Port O'Connor	Unknown	Historic 1872-1875	Yes	No

Site Number	Site Name	Site Type	Quadrangle	Size (unit varies)	Temporal Affiliation	NRHP Eligibility	Potential Effect
	W & E Shoal Light						
41CL72		Shell Midden	Port Lavaca East	Unknown	Prehistoric, Early Archaic, Modern	Unknown	No
41CL87	No Information		Port O'Connor			Unknown	Yes
41CL88	No Information					Unknown	No
41MG40		Shipwreck	Decros Point	Unknown	Historic – Anglo American	No	no

Table 1 lists the historic markers found within the area, and provides information regarding the subject of the marker, temporal information, and the National Register status of the subject. None appear to be currently listed on the National Register. St. Joseph Baptist Church (Marker 4454) has been recommended as eligible. The status of the remainder is unknown.

Tables 2 and 3 provide a listing of all reported or recorded shipwrecks in the area, chart or quad information, and the year that the vessel was reported sunk, if known, from the AWOIS Databases and the THC Atlas. Most AWOIS listings appear to have been sunk between 1960 and the early 1990s. None of these appear to be registered marine archaeological sites. The THC Marine Archaeology Program shipwreck database, featured in the THC's Archaeological Sites Atlas lists close to 2,000 historic vessels dating from 1552. Currently there are 133 shipwrecks recorded as archaeological shipwreck sites.

Table 4 provides a listing of all recorded archaeological sites within the area. This table also provides information concerning each resource's temporal affiliation, known dimensions, and National Register eligibility status. The majority of the terrestrial sites are prehistoric shell middens of unspecified cultural affiliation. Historic sites in the area tend to be composed of homesteads, historic deposits associated with town sites, or are potentially associated with coastal structures. Cemeteries are also recorded within the area. None of these resources are currently listed on the National Register, however, seven have been recommended as eligible for listing. The National Register status of the majority of the remaining resources is unknown.

5.2 Geophysical Survey

Magnetometer and side scan sonar were recorded in the entire project area, except where shallow water depth prevented safe navigation and survey. Additionally, due to the shallowness of most portions of the project area, although floated at the surface, the magnetometer sensor was in close proximity to the harbor bed, generally less than 1-3 meters (1-10 feet). Therefore, the size of magnetic anomalies may be considered exaggerated, when compared to a normal towing height of circa 6 meters (20 feet) above a seabed. The data collected during survey were analyzed to determine any existing hazards/obstructions on the seabed and document any magnetic anomalies or side scan targets that could represent historic shipwrecks or other submerged cultural resources.

While conducting the fieldwork for the present project it was obvious that both the surficial and underwater landscapes have been greatly altered by the creation of the navigation channel and dredge spoil deposition areas. The observations on site affirm the changes represented in the topographic maps and navigation charts in a very direct manner.

Plate 1 shows a view from the eastern extent of the navigable portions of the project area to the north. To the east of the barrier were mud flats that were exposed at low tide and could not be surveyed. To the north the dredge spoil pile can be seen rising from the water to an estimated height of 9 meters (30 feet) (Plate 1). Bordering the navigable portions of the project concrete rubble with associated rebar was placed at the base of the spoil pile (Plate 2). Conversations with Mickey Sappington of G&W Engineers noted that the material was most likely placed around 2000, during some construction activity (Mickey Sappington, personal communication 2012).

The inclusion of iron rebar in this riprap introduces ferrous materials which are detected by the main remote sensing device, the magnetometer. There were other potential sources of magnetic contamination in the project area that are also evidence of the continued maintenance dredging of the navigation channel. Sitting at the water/land interface is metal piping that extends into the dredge spoil deposition area (Plate 3). The features that have been briefly discussed reside at the eastern and northern portions of the workable project area. To the northwest is an island created by dredge spoil. Around the perimeter of the island at water level are a series of concrete erosion mats held together by wire cables (Plate 4). Conversations with Mickey Sappington of G&W Engineers noted that the matting was placed in 2003 and is held in place with wire rope, a potential source of magnetic anomalies (Mickey Sappington, personal communication 2012). Observation of these materials within and next to the project area indicates that the physical environment is likely polluted by similar materials, especially in close proximity to these features. Conversations with dredge operators and the USACE personnel indicate that the project area was heavily modified and is continually being maintained. Personnel at Orion Marine Group, located in Port Lavaca, indicated that the MSC, in the area of Point Comfort, is maintained on a more or less regular schedule of between two to three years. It was also noted that material found within or next to the channel could easily be wire cable or other incidental dredging materials. Incidentally, Orion recently was awarded a contract for maintenance dredging of the MSC by the USACE. This casual conversation led to contact with the USACE Corpus Christi Area and ultimately USACE personnel at the Galveston District Operations Division. Conversations with operations manager Ms. Alicia Rea confirmed that the USACE regularly, at 2-year intervals, conducts maintenance dredging at the northern end of the MSC near Port Comfort. This regular maintenance, which has taken place for decades, is to ensure that a minimum depth for commercial traffic is maintained. Ms. Rea also indicated a contract for maintenance dredging of the MSC had been recently let (Alicia Rea, personal communication 2013). Mickey Sappington of G&W Engineering noted that dredgers who encountered wire rope, a common material found in a marine environment, would cut it and let it fall back into the water, and that debris in an active harbor should be expected (Mickey Sappington, personal communication, 2012). Any anomaly source located within the dredged navigation channel should be considered suspect due to the recent nature of the channel and the regular dredge maintenance activities conducted there. These underlying factors, relative to the

Plate 1. North running fabric erosion barrier leading to concrete and rebar shore protection at the base of a dredge spoil deposition area.

Plate 2. Detail of the concrete and rebar shore line protection material. Note inclusion of metal rebar, a material which will create magnetic anomalies.

Plate 3. Detail of dredge spoil pipe line to move dredged materials into spoil containment area.

Plate 4. Detail of concrete erosion matts attached by wire cable. The metal in the cable is a source for magnetic anomalies.

environmental context of the project area, are important issues to consider during the interpretive analysis of the remote sensing data collected during the project. Additionally, previous research in the project area, (Borgens et al. 2007), indicated 2 potentially significant cultural properties, identified as magnetic targets M-6 and M-7, which were located in the area and require further investigation if they could not be avoided by project activities.

The findings from the present report differ in number of anomalies identified as potentially significant resources from earlier draft and revised interim reports dated December 14, 2012 and April 5, 2013. Eighteen anomalies located that were listed as having characteristics that may be associated with potential shipwreck sites, and 13 of them were within the project area and were recommended for diver ground truthing if they could not be avoided by project activities. Those findings were concurred with by the THC at that time.

The present report alters the number of anomalies to be avoided downward from 13 to 8, which includes previously noted magnetic anomaly M-6 that is outside the present project area. Although no physical examination of the anomalies has taken place for the revision, newer interpretive methods have been employed and emphasized relative to the previously examined data. During the original analysis, the interpretation was heavily dependent on the Pearson et al.'s (1991) interpretive model, which is reliant on magnetic deflection from background and duration, the previously noted 50 gamma/80-foot criteria, see above. A rather new interpretive model had recently been put forward just before the survey was conducted, that uses anomaly orientation and spatial parameters to determine potential shipwreck sites (Gearhart 2011). The author having used the Pearson model for years was heavily reliant on it for the original interpretation in the earlier iterations of the report. However, since becoming more familiar with the Gearhart model, applying it and seeing it employed and standing up to professional critique over the intervening years, the author now has more confidence in deploying it to aid in refining anomalies that may be potentially significant submerged materials, such as shipwreck sites. The present report's interpretation now minimizes the Pearson model and then employs characteristics from the Gearhart model to further eliminate non-significant anomalies. Utilizing the 26˚deviation from magnetic North and knowing the Port Lavaca region of Matagorda Bay had a magnetic variation from true north of approximately 4˚ 15' and 3˚ 30' East between 2009 and 2014, wrecks conforming to the Gearhart method should have a magnetic deflection ranging between approximately 338˚ to 30˚ (NOAA 2009, NOAA 2014). Adding a conservative measure for unknowns of 15˚ to either side would create an arc from approximately 323˚ to 45˚. This approximates closely with Gearhart's suggestion of using an arc of ± 45˚ from magnetic north to determine potential shipwreck sites (Gearhart 2011).

The project area is in a highly modified and maintained environment. Evidence of dredging, construction, island building, dredge spoil containment and other features of the site suggest that most if not all the anomalies identified during this survey are most likely modern debris. Using well developed and strong interpretive tools that are available and accepted in the archaeological community assists in conserving resources and limiting diver exposure to anomaly source testing that are most likely not significant. It is due to these multiple reasons that additional analysis was taken with the interpretive tools now available that the number of anomalies has been reduced from earlier iterations of the project report.

5.2.1 Magnetometer

Inspection of the remote sensing records collected for the Lavaca Bay LNG Project indicates that there are 251 magnetic anomalies and 15 side scan sonar targets in the project area. Of these remote sensing indications, six locations appear to have associated magnetic and acoustic signatures. None of the side scan sonar images appear to have area of coverage, linearity, complex shaping, above seabed signature, or other features that would indicate that they represent potentially significant cultural resources. The 251 discrete magnetic anomalies located in the 62.6 hectare (155 acres) surveyed for the present project resulted in a density of 1.6 anomalies per acre, a high rate by any measure (Figure 9). Well over 240 of the anomalies, when examined, fall below the 2 common measurements noted above, Pearson's 50 gamma/80 foot and Gearhart's magnetic orientation and spatial criteria, to be considered potentially significant, and are most likely modern debris.

There are 7 anomalies, including the previously mentioned magnetic anomaly M-7 identified by the THC, that meet or exceed both criteria and reside within the current project area. Previously noted anomaly M-6 lies to the north of the project area (Table 5). Anomaly is the sequential number of the anomaly as identified during analysis. Easting is the east coordinate. Northing is the north coordinate. Type relates to magnetic signature, M for monopole, D for Dipole, C for complex. Gamma Deviation indicates the positive and/or negative deflection from background. Duration is the linear extent of the anomaly as detected on a survey track line. Depth is the approximate corrected depth to Mean Low Water. The magnetic contours are presented on a color scale where red represents positive and blue represents negative. The contour interval is 10 gamma. All anomalies considered potentially significant in Figure 9, cannot be accurately presented due to the scale and are individually represented in Appendix A.

Several anomalies are found at the eastern edge or in at the northeastern portion of the project area near newly created land forms created by dredge spoil. Additional anomalies are located within the dredged and regularly maintained navigation channel. Both these areas heavily mitigate against the anomaly source being potentially significant. Changes in the land forms in these areas due to dredging and spoil deposition have been demonstrated through a review of historic topographical maps and navigation charts.

As was shown in Plates 1 through 4, there are obvious sources of metallic contamination and pollution, pipe, and rebar along the eastern edge of the examined area. As can be seen in Figure 9 there is a high concentration of anomalies in the northeast portion of the surveyed area, which correlates nicely with the metal debris observed along the shore line. For those anomalies

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Magnetic Contour Data and Avoidance Buffers
of Potentially Significant Anomalies

HRA Gray & Pape, LLC

Figure 9

Table 5. Magnetic anomalies which exceed the 50 gamma/80-foot magnetic orientation and spatial criteria.

Anomaly	Eastings	Northings	Type	Gamma deviation	Duration (feet)	Depth	Associated along or in nav channel
142	2749425	13421933	D	+223/-34	130'	24	Yes
164	2748902	13422192	D	+88/-44	82'	8	Yes
197/ Target M-7	2748576	13421662	D	+532/-32	152'	5	No
217	2748307	13421759	D	+334/-33	145'	5	No
221	2748182	13420402	D	+391/-113	110'	5	No
224	2748202	13421758	D	+365/-253	105'	5	No
231	2747986	13420943	C	-290/+240	122'	5	No
M-6	2749049	13423566	D	+777/-1088	150'	30	Yes

located within or on the edge of the navigation channel, they could only be deposited after the initial cuts of the channel in the 1960s. Thus, it is highly unlikely that they are historically deposited materials. The signature for anomaly M-7 was relocated in very close proximity to where it was reported during a previous survey conducted in 2006 (Borgens et al. 2007). The earlier reported coordinates were 2748584 East and 13421677 North. The present examination placed the anomaly at 2748576 East and 13421662 North. The small difference in coordinates, 2.1 meters (7 feet) on the easting and 4.5 meters (15 feet) on the northing, can be accounted for in many ways. The earth's magnetic field is continually changing; thus, the anomaly signature is continually changing as a result. The 6 years between surveys adds to this element of time. The points through which a sensor moves through space and detects an anomaly cannot be perfectly recreated. It would be highly unlikely that 2 surveys 6 years apart collected data at the same data collection points in the same orientation, running the same survey lines at the same speed during the same state of tide. That stated it is relatively easy to recreate the general location of a large anomaly such as M-7 that is located in the same place. Another possible explanation for the slight change in the coordinates of the anomaly representation is that the source material was moved or shifted. It is possible that during the 6 years between the two surveys the anomaly source material was mobilized by activities of one of the three scheduled biennial maintenance dredging operations.

Additionally, while conducting the survey shrimp draggers and private boats were seen transiting the area. Natural phenomena such as hurricanes can also mobilize shallow water materials as well. Between August 2007 and September 2011 several tropical storms and hurricanes made landfall in Texas.

The signature for anomaly M-6 was relocated in very close proximity to where it was reported during a previous survey conducted in 2006 (Borgens et al. 2007). The earlier reported coordinates were 2749062 East and 13423520 North. The present examination placed the anomaly at 2749049 East and 13423566 North. The small difference in coordinates, 4 meters (13 feet) on the easting and 14 meters (46 feet) on the northing, can be accounted for in many ways. The earth's magnetic field is continually changing; thus, the anomaly signature is continually changing as a result. The 6 years between surveys adds to this element of time. The points through which a sensor moves through space and detects an anomaly cannot be perfectly recreated. It would be highly unlikely that 2 surveys 6 years apart collected data at the same data collection points in the same orientation, running the same survey lines at the same speed during the same state of tide. That stated it is relatively easy to recreate the general location of a large anomaly such as M-6 that is located in the same area. Another possible explanation for the slight change in the coordinates of the anomaly representation is that the source material was moved or shifted. It is possible that during the 6 years between the two surveys the anomaly source material was mobilized by activities of one of the three scheduled biennial maintenance dredging operations. Anomaly M-6 resides at the bottom of the dredged navigation channel in approximately 9 meters (30 feet) of water. The anomaly source could not have been in its present place prior to the construction of the navigation channel in the 1950s and 1960s and therefore reduces the chance that its source may be considered potentially significant.

There are no obvious sources, shoreline indications, or depth variation for the other anomalies located away from the eastern and northern portions of the survey area, or the previously noted M-7 to exclude them from being considered potentially significant cultural resources. However, the environmental context in which they are located would suggest that most are all debris of similar origin.

5.2.2 Side Scan Sonar

Side scan sonar data for the harbor bed in the Lavaca Bay LNG project area in general was flat and unremarkable, with the major exception of having a navigation channel dredged down the middle of it. The sonar data were only collected in safely navigable areas, the navigation channel and the areas to the west of the channel. Areas to the east could not be fully covered due to the placement of dredge spoil and shallows. Dredge scars along the slope of the channel are the most prominent feature of the record (Figure 10). An examination of the side scan sonar records indicates that there are 15 isolated targets that had some spatial extent or objects elevated off the harbor bed (Table 6). None of the acoustic targets express the characteristics of a shipwreck. In general, they are single, non-articulated items. The small circular objects seen in Figure 10 may represent fender tires that were lost from harbor tugs, which were active in the project area.

Table 6. Side Scan Sonar targets.

Side Scan Target	Eastings	Northings	Comments	Potentially Significant
1	2748534	13422166	Circular object, 1.5 meters (5 feet) in diameter, approximate height 2 feet	NO
2	2748445	13422155	Object, 1.5 meters (5 feet) wide, approximate height 0.6 meters (2 feet)	NO
3	3748437	13422102	Object, 1.5 meters (5 feet) wide, approximate height 0.6 meters (2 feet)	NO
4	2748312	13422034	Circular object, 1 meter (3.5 feet) in diameter, approximate height 0.6 meters (2 feet), possible tire	NO
5	2748045	13421595	Object, 8.5 meters (28 feet) long, no relief	NO
6	2748266	13421757	Object, 7 meters (23 feet) long, approximate height 0.5 meters (1.5 feet)	NO
7	2478387	13421765	Object, 1.2 meters (4 feet) in diameter, no relief	NO
8	2748659	13421578	Two circular objects, each 1.5 meters (5 feet) in diameter, approximate height 0.6 meters (2 feet)	NO

Side Scan Target	Eastings	Northings	Comments	Potentially Significant
9	2748881	13421030	Two objects, approximate height 0.6 meters (2 feet) each	NO
10	2749405	13421098	Object, 3.4 meters (11 feet) long, no relief	NO
11	2749380	13421015	Object, approximate height 0.3 meters (1 foot)	NO
12	2748840	13420680	Circular object, 1.2 meters (4 feet) diameter, approximate height meters (2 feet), possible tire	NO
13	2748808	13420674	Object, approximate height 0.6 meters (2 feet)	NO
14	2748739	13420476	Object, approximate height 0.5 meters (1.5 feet)	NO
15	2748574	13420248	Object, 1.8 meters (6 feet) wide, approximate height 0.5 meters (1.5 feet)	NO

As noted there were 6 side scan sonar images that were located in proximity to magnetic anomalies (Table 7). The coincidence of a side scan sonar target and magnetic anomaly in close association suggest that they may be related. However, none of the sonar targets or accompanying anomalies met criteria for potential significance. Proximity for considering potential relation of an anomaly to a target was based on the distance of the survey transect spacing. If a side scan sonar target was further than 10 meters (33 feet), half the transect spacing away from an anomaly source, they were not considered to be associated. If a target was greater than half the distance, theoretically it would reside closer to the adjacent parallel survey transect and magnetic indications should be observed there if the side scan sonar target was the source of the anomaly.

Table 7. Side scan sonar targets with potential magnetometer association.

Side Scan Target	Eastings	Northings	Possible Associated Anomaly	Eastings	Northings	Type	Deviation	Duration (feet)
2	2748445	13422155	Anomaly 208	2748442	13422143	M	15	23'
4	2748312	13422034	Anomaly 218	2748314	13422013	M	-11	38'
6	2748266	13421757	Anomaly 220	2748256	13421748	C	+481/-188	211'
7	2478387	13421765	Anomaly 211	2748391	13421774	D	-888/+67	202'
8	2748659	13421578	Anomaly 188	2748644	13421566	D	+29/5	61'
9	2748881	13421030	Anomaly 161	2748905	13421016	D	-27/+10	58'

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Side Scan Sonar Mosaic of the Safely Navigable Portions
of the Project Areas

HRA Gray & Pape, LLC

Figure 10

6.0 CONCLUSIONS AND RECOMMENDATIONS

The archaeological investigation documented in this report took place in part because two magnetic anomalies of interest, identified previously as M-6 and M-7, were known to reside in the general vicinity of the proposed project. As a result of the present survey, several additional targets were identified. Following completion of the initial survey effort, the THC accepted a proposal to modify permit number 6335 to include diver ground truthing of several identified anomalies.

Although work planned for the project included a diver ground-truthing phase to provide a preliminary evaluation of submerged targets the project was delayed and ultimately cancelled. Mobilization for this additional effort has not taken place. Since the project is unlikely to continue in the near future, this report is submitted in order to satisfy reporting requirements under Permit 6335. The survey located 251 magnetic anomalies and 15 side scan sonar targets. A vast majority of these are most likely modern debris.

Eight magnetic anomalies, including M-6 and M-7, were recorded during the conduct of the fieldwork for this project with quantitative characteristics, minimum 50-gamma deflection from back ground, 80-foot duration, and a magnetic orientation with the negative pole to the north, located on at least two survey transects and had a coverage equal to 1,580 m^2 to the 5-gamma contour indicating that they may represent potentially significant cultural resources. The survey was conducted in relatively shallow waters, generally 1.5 meters (5 feet) or less, navigation channel excepted, and many of the anomalies may be exaggerated due to close proximity of the sensor to the harbor bed and potential anomaly sources. Additionally, the environmental context in which the anomalies reside, radically altered and in parts regularly maintained and modified landscape, suggests a high proportion of modern debris as anomaly sources. Anomaly M-6, identified by the THC for its potential importance, resides outside of the proposed project area, and within the modern navigation channel. Anomaly M-6 was mapped along with a 50-meter (164-foot) avoidance margin, as required per TAC Title 13 Part 2, Chapter 26 and 28, Rule 28.2 and Rule 28.6 I(1)(A)(i) and was intended to be avoided by project activities. Additionally, it resides within the modern navigation channel at a depth of 9 meters (30 feet). Although residing in a modern dredged navigation channel, which receives biennial maintenance dredging, might suggest the likelihood of modern debris as the source for anomaly M-6, direct evidence to the source of the anomaly was not elucidated during the present survey. Therefore, the possibility that the source could be historic materials, as it meets the criteria for potentially significant resources, and was previously identified as such, Gray & Pape does not consider that there is sufficient evidence to suggest a change in its previous designation.

Two anomalies (142, 164) located within the project area are also located within the dredged and regularly maintained, modern navigation channel. Due to the recent nature of the feature, as indicated by historic topographical maps and navigation charts, and its regularly scheduled maintenance, these anomalies are most likely not potentially significant, as they could not have reached their present position prior to the channel's construction in the 1950s and 1960s and the biennial maintenance which would have over the years destroyed the context of any intact materials. Additionally, verbal accounts of maintenance dredging crews redepositing materials, such as wire rope, encountered during their operations would appear to the most likely cause of these anomalies.

The remaining anomalies (197(M-7), 217, 221, 224, and 231) that were located within the project's APE would not have been avoided by planned project activities. Of the remaining anomalies, including previously identified M-7, there are no observable or obvious magnetic sources, but considering the environment they are most likely modern debris as well. There were no side scan sonar indications that exhibited features, with or without associated magnetic anomalies that met the minimum criteria to be considered potentially significant to aid in their identification. Although, not correlated with survey data, ruins of a navigation platform, seen on Navigation Chart 11317, may be the source of some remote sensing data it they were mobilized north.

That said there is always the possibility of locating a submerged shipwreck site in a marine environment with remote sensing technologies. The NOAA maintained AWOIS database lists an obstruction, AWOIS Number 4897, and the Texas archives lists a shipwreck, Number 1240, less than 1.6 kilometers (1 mile) south of the project area. Anomaly M-7 is located within the project area and cannot be avoided and therefore may require examination prior to any future activities that will disturb the area. The sources of the other anomalies, noted above, have not been positively identified through remote sensing technologies alone. Although the cultural and environmental context of the project area would indicate that a vast majority of the anomalies may be modern debris, the source could also be historic artifacts displaced by hurricane or wave actions that are associated with nearby settlements including Indianola, Indian Point, and other towns. Impacts from future planned projects may require further examination to establish whether they represent actual cultural materials of significance. As such, anomalies 142, 164, 197/M-7, 217, 221, 224, and 231 should be either avoided or identified prior to any seabed disturbing activities. Previously noted anomaly M-6 lies outside the present project area, and should also be avoided as per its original designation.

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APPENDIX A:
Potentially Significant Anomalies

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