MARINE ARCHAEOLOGY ASSESSMENT IN SUPPORT OF THE BLUEWATER SPM PROJECT, NUECES AND ARANSAS COUNTIES, TEXAS AND ADJOINING FEDERAL WATERS

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Principal Investigator:
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July 2019
MARINE ARCHAEOLOGY ASSESSMENT IN SUPPORT OF
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Texas Antiquities Permit No. 8672

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Abstract

BOB Hydrographics, LLC conducted a marine archaeological assessment for portions of the Bluewater SPM Project proposed in Nueces and Aransas counties and adjoining federal waters. These archaeological investigations were sponsored by Lloyd Engineering, Inc. on behalf of Bluewater Texas Terminal, LLC. The marine portion of this project comprises two segments: Offshore and Inshore. The Inshore project corridor parallels the Aransas Ship Channel from the community of Aransas Pass to Harbor Island, crossing portions of State Mineral Lease Tracts 309, 310, 313, 314 in Corpus Christi Bay, and then crosses beneath the Lydia Ann Channel to San Jose Island, including a portion of Tract 306 in Aransas Bay. The Offshore project corridor crosses portions of State Mineral Lease Tracts 693, 694, 695 (same as MI-695), 721, 836, 837, 838, 839, 844, 845, 846, 847, 848, 849, 850, and 851 on the Gulf side of San Jose Island, and then crosses portions of Federal Lease Blocks MI-695, MI-696, MI-697, MI-698, and MI-699.

The marine Area of Potential Effect (APE) is a 2,000-foot-wide corridor, offshore of San Jose Island, and a 1,000-foot-wide corridor, inshore of San Jose Island. Both Inshore and Offshore APEs are centered on the construction right-of-way and include the proposed lay barge anchorage. The APE totals 7,174 acres, including 3,079 acres in federal waters and 4,095 acres in state waters. The APE in state waters totals 288 acres Inshore and 3,807 acres Offshore in the Gulf of Mexico. Water depth ranges from 2-30 feet (ft) Inshore and from 0-92 ft Offshore. The Project proposes construction of a Deepwater Port (DWP) with two single point mooring (SPM) buoys and associated pipelines. The DWP would be located 17.3 miles offshore of San Jose Island in approximately 89.5 ft of water. The DWP would allow simultaneous loading of two Very Large Crude Carrier tankers with domestic crude oil via two 30-inch sub-marine pipelines. Pipes will be directionally drilled beneath all shorelines and Inshore waterways. Offshore pipes will be buried by a jetting sled to a depth of 6-7 ft below the seafloor with 36 inches of cover. The sled will discharge sediment back into the trench to facilitate backfilling. Subsea pipes will be separated by 10-15 ft, horizontally, within a proposed 75-ft-wide construction right-of-way. Offshore pipes will be installed from a conventional pipelay barge with an 8-point anchor system (using 4 at a time). Inshore pipes will be directionally drilled beneath all bay waters.

The purpose of this study was to assess the potential for submerged archaeological sites in the APE; however, no artifacts were collected during the survey. Submerged archaeological sites, in this context, might be historic sites, such as sunken or abandoned watercraft; or drowned terrestrial prehistoric sites dating to the late Pleistocene or Early Holocene when the APE was last above sea level. A review of the cultural background determined that 11 marine archaeological investigations have been conducted within 3 miles of this project. At least, 95 wrecks have been reported within 3 miles of the APE.

Geophysical survey was completed by Naismith Marine Services, Inc. from January 4 through April 19, 2019 under Texas Antiquities Permit 8672. A variety of equipment was used to conduct the marine survey, depending on water depths, including multi- and single-beam echo sounders, a sub-bottom profiler, side-scan sonar, and a magnetometer. Archaeologists monitored the acquisition of all data in state waters.

Analysis of geophysical survey results from this investigation discovered three significant targets, including one in federal waters (Anomaly 1), and two in state waters (anomalies 2 and 3). All three targets are potentially eligible for the National Register of Historic Places and are recommended for avoidance. The
two targets in state waters also may be eligible as State Antiquities Landmarks. Anomaly 2, is confirmed as a shipwreck by sonar imagery and is designated as an archaeological site, 41AS119. No potential historic sites were discovered by the Inshore survey. There is low potential for the presence of intact prehistoric sites in the Offshore APE. The top of the Beaumont Formation is exposed at the seafloor between the 31-ft and 46-ft isobaths and is buried by Holocene sediments to varying depths beneath the remainder of the survey corridor. This former land surface had little protection from wave energy during sea-level rise and is still actively eroding along portions of the APE where exposed. The Texas Historical Commission did not require sub-bottom data in the bay, so areas of high potential for submerged prehistoric sites were not mapped there.

This study was completed in compliance with Section 106 of the National Historic Preservation Act (Public Law 89-665; 16 U.S.C. 470) and the Antiquities Code of Texas (Texas Natural Resource Code, Title 9, Chapter 191). The minimum reporting and survey requirements for marine archaeological studies conducted under a Texas Antiquities Permit are mandated by The Texas Administrative Code, Title 13, Part 2, Chapters 26 and 28, respectively. The petroleum industry is regulated in federal waters, beyond 9 nautical miles offshore, by the Bureau of Ocean Energy Management (BOEM), an agency of the United States Department of the Interior. This study also complies with archaeological requirements published by BOEM in their Notice to Lessees 2005-G07. Archaeological project records are curated at the Center for Archeological Study at Texas State University in San Marcos.
I. Introduction

BOB Hydrographics, LLC (BOB) conducted a marine archaeological assessment for portions of the Bluewater SPM Project (the Project) proposed in Nueces and Aransas counties and adjoining federal waters (Figure 1). Lloyd Engineering, Inc. contracted with BOB, on behalf of Bluewater Texas Terminal, LLC, for an archaeological assessment of marine geophysical data acquired under a separate contract by Naismith Marine Services, Inc. Cultural resources investigations were required because construction activities might affect historic cultural resources resting on or embedded in the seafloor. The results reported in this document will support an application by Bluewater Texas Terminal, LLC for a Deepwater Port (DWP) License to construct, own, and operate the Project pursuant to the Deepwater Port Act of 1974, as amended, and in accordance with the United States (US) Coast Guard (USCG) and the Maritime Administration’s implementing regulations. This study also supports a separate permit application to the US Army Corps of Engineers (USACE) for authorization under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act.

The Project would allow loading of Very Large Crude Carriers at a DWP, to be located approximately 17.3 miles offshore of San Jose Island. The DWP would include two single point mooring (SPM) buoy systems able to accommodate simultaneous mooring of two tankers. The DWP would be supplied with domestic crude oil from the existing Midway Terminal, located south of Taft, in San Patricio County, via 56.5 miles of new pipeline infrastructure and a booster station on Harbor Island. The Project would have capacity to load up to 80,000 barrels of crude oil per hour and would be capable of filling 16 Very Large Crude Carriers per month.

The Project comprises three segments: Offshore, Inshore, and Onshore. The Offshore segment is located seaward of the mean high tide line separating San Jose Island from the Gulf of Mexico. The Inshore segment is located between the western margin of Redfish Bay and the Gulf of Mexico. The Onshore segment extends from the western shore of Redfish Bay to the existing Midway Terminal south of Taft, Texas. Terrestrial cultural resources are not addressed in this report, including the entire Onshore segment and island portions of the Inshore segment.

The Offshore segment includes approximately 27.13 miles of pipeline corridor and the DWP footprint. Two 30-inch-diameter crude oil pipelines will be installed within a proposed 75-foot-wide construction right-of-way (ROW). A conventional pipelay barge will use a jetting sled to install the pipes 6-7 feet (ft) below the seafloor and 10-15 ft apart. Sediment will discharge into the trench behind the sled to facilitate burial of the pipes with 36 inches of cover. The barge will anchor with an 8-point mooring system, using 4 anchors at a time. The Offshore pipe would be installed beneath the beach and surf zone by horizontal directional drilling. The exit point will be approximately 3,500 ft seaward of San Jose Island.
**Figure 1**

Project Component Map

- **Inshore Pipeline**
- **Offshore Pipeline**
- **Onshore Pipeline**
- **SPM 1 and Proposed Safety Zones**
- **SPM 2 and Proposed Safety Zones**
- **Navigational Fairways and Anchorage Areas**

**Map Details**

- Coordinate System: NAD 1983 2011
- StatePlane Texas South FIPS 4205
- Ft US
- Projection: Lambert Conformal Conic
- Datum: NAD 1983 2011
- Units: Foot US

**Project Location**

Bluewater SPM Project
Bluewater Texas Terminal, LLC

Date: Mar 28, 2019
The DWP would consist of two SPM buoy systems separated by 1.7 miles and connected by two 30-inch-diameter pipelines. The SPM buoy systems each would consist of a pipeline end manifold, catenary anchor leg mooring system, mooring hawser, sub-marine hoses, and floating hoses for the transfer of crude oil from the SPM buoy system to moored vessels. The pipeline end manifolds would be anchored to the seabed by 4-6 pneumatically-driven, 18-inch-diameter piles.

The Inshore (bay and island) segment includes 7.2 miles of pipeline corridor, crossing the bay to the Gulf of Mexico, and a 19-acre booster pump station on Harbor Island. Two 30-inch-diameter crude oil pipelines would be installed within a 75-ft-wide construction ROW. The Inshore pipe alignment parallels Highway 361 and the Aransas Ship Channel, in Nueces County, from the town of Aransas Pass [unless otherwise stated, the phrase “Aransas Pass” in this report refers to the pass between the Gulf of Mexico and Corpus Christi Bay, not to the town of the same name] to the booster station on Harbor Island and then crosses to San Jose Island where it joins the Offshore segment. The Inshore pipeline would cross three navigable waterways including the Gulf Intracoastal Waterway, the Aransas Ship Channel, and the Lydia Ann Channel. No subsea trenching is proposed along the Inshore segment. The Inshore pipe would be installed to a depth of 6 ft using trench and bury methods along terrestrial sections and by horizontal directional drill beneath all shorelines and waterways. All directional drilling entry/exit points will be on land. Navigable portions of the Inshore Project are addressed in this report at the sponsor’s request; however, no seafloor disturbances are proposed in the bay.

Geophysical survey was completed by Naismith Marine Services, Inc. over multiple deployments between January 4, 2019 and April 19, 2019. Survey in state waters was monitored by BOB under Texas Antiquities Permit 8672. A variety of vessels and equipment were used to conduct the marine survey, depending on water depths, including multi- and single-beam echo sounders, a sub-bottom profiler, side-scan sonars, and a magnetometer. Archaeologists monitored the acquisition of all data in state waters. The Principal Investigator was present for greater than 25-percent of days when acquisition occurred in state waters and was solely responsible for archaeological data analysis and report preparation. The archaeological monitoring effort was assisted by Ed Baxter, RPA, of Edward Baxter Consulting.

The Area of Potential Effect (APE) is 2,000 ft wide Offshore and 1,000 ft wide Inshore. The APE corridor is centered on the construction ROW and includes the proposed lay barge anchorage. The APE totals 7,174 acres, including 3,079 acres in federal waters and 4,095 acres in state waters. The APE in state waters totals 288 acres Inshore and 3,807 acres Offshore in the Gulf of Mexico. The APE coincides with the scope of other environmental studies in support of Maritime Administration and USACE permit applications. The Offshore Survey spans portions of 5 Federal Lease Blocks (MI-695, MI-696, MI-697, MI-698, and MI-699) in the Matagorda Island Lease Area, and 16 State Mineral Lease Tracts (693, 694, 695 [same as MI-695], 721, 836, 837, 838, 839, 844, 845, 846, 847, 848, 849, 850, and 851). The Inshore Survey includes portions of 5 State Mineral Lease Tracts (Tracts 309, 310, 313, 314 in Corpus Christi Bay and Tract 306 in Aransas Bay). Water depth ranges from 2-30 ft Inshore and from 0-92 ft Offshore.

The purpose of this study was to assess the potential for submerged archaeological sites in the APE; however, no artifacts were collected during the survey. Submerged archaeological sites, in this context, might be historic sites, such as sunken or abandoned watercraft; or drowned terrestrial prehistoric sites dating to the late Pleistocene or Early Holocene when the APE was last above sea level. Submerged historic
remains may be eligible for nomination to the National Register of Historic Places (NRHP) or as State Antiquities Landmarks. A review of the cultural background determined that 11 marine archaeological investigations have been conducted within 3 miles of this project. At least, 95 wrecks have been reported within 3 miles of the APE.

Analysis of geophysical survey results from this investigation discovered three significant targets, including one in federal waters (Anomaly 1), and two in state waters (anomalies 2 and 3). All three targets are potentially eligible for the National Register of Historic Places and are recommended for avoidance. The two targets in state waters also may be eligible as State Antiquities Landmarks. Anomaly 2, is confirmed as a shipwreck by sonar imagery and is designated as an archaeological site, 41AS1119. No potential historic sites were discovered by the Inshore survey. There is low potential for the presence of intact prehistoric sites in the Offshore APE. The top of the Beaumont Formation is exposed at the seafloor between the 31-ft and 46-ft isobaths and is buried by Holocene sediments to varying depths beneath the remainder of the survey corridor. This former land surface had little protection from wave energy during sea-level rise and is still actively eroding along portions of the APE where exposed. No sub-bottom data was required in the bay, so areas having potential for submerged prehistoric sites were not mapped there.

This study was completed in compliance with Section 106 of the National Historic Preservation Act (Public Law 89-665; 16 U.S.C. 470), requiring that the lead agency consider the effects of projects upon historic resources, if those projects receive either permits or funding from the federal government. This study complies also with the Antiquities Code of Texas (Texas Natural Resource Code, Title 9, Chapter 191), which provides for the protection of cultural resources on state lands. Submerged portions of the APE are publicly owned by the state of Texas out to 9 nautical miles beyond the beach; therefore, Texas Antiquities Permit 8672 was obtained prior to beginning fieldwork. Title 13, Part 2, Chapters 26 and 28 of The Texas Administrative Code mandates the minimum reporting and survey requirements, respectively, for marine archaeological studies conducted under Texas Antiquities Permits. The petroleum industry is regulated in federal waters, beyond 9 nautical miles offshore, by the Bureau of Ocean Energy Management (BOEM), an agency of the US Department of the Interior. This study complies with archaeological requirements published by BOEM in Notice to Lessees 2005-G07, which is available on their website. Archaeological project records are curated at the Center for Archeological Study at Texas State University in San Marcos.

This report is organized into six sections that provide context for interpreting the survey results and includes maps of magnetic contours and side-scan sonar imagery. Section II relies upon a combination of published literature and data collected by this survey to summarize the physical environment of the APE. Section III summarizes the relevant cultural background within a 3-mile radius of the APE, including relevant prehistory, maritime history, previous archaeological investigations, and the potential for intact archaeological sites. Section IV summarizes methods for conducting the geophysical survey and for processing and analyzing the geophysical data. Section V presents an archaeological assessment of the geophysical data and provides recommendations specific to archaeological findings within the APE. Bibliographic references cited in the text are included as Section VI.
An Offshore Geophysical Survey Report was prepared separately from this document by Geo-Marine Technology, Inc (GMT) on behalf of Naismith Marine Services, Inc. Their hazard report (GMT 2019) will be submitted to BOEM separately; however, their text and reduced-size map sheets are included here as Appendix A. Relevant information from the Offshore shallow hazard report has been incorporated into this document as necessary to comply with BOEM archaeological reporting standards. Appendix B contains Naismith Marine’s Inshore Survey Report. Appendix C contains a roster of field personnel and a summary of survey equipment and procedures. Appendix D illustrates results of the side-scan sonar survey overlaid by locations of sonar contacts and magnetic anomalies. Results of the magnetometer survey are contoured in Appendix E. Close-up screen captures of each sonar contact are included in Appendix F. A copy of the Texas Antiquities Permit 8672 and Texas Historical Commission (THC) correspondence is included as Appendix G.

II. Physical Environment

The Offshore APE is located in the Gulf of Mexico adjacent Aransas County. The corridor extends 27.1 miles diagonally from the beach of San Jose Island to the proposed DWP 17.3 miles from the island. Offshore depths range from 0 ft at the beach to about 92 ft (below North American Vertical Datum, 1988) at the DWP. Offshore bathymetry is illustrated in Appendix A, Charts 1-4). The Inshore APE parallels Highway 361, in Nueces County, from the town of Aransas Pass to the booster station on Harbor Island and then crosses to San Jose Island where it joins the Offshore segment. Inshore depths range from 2-30 ft.

Geologic Setting

Geomorphology of the APE was influenced by sea level changes during and after the Pleistocene Epoch. Continental glaciers held back significant amounts of water from the sea during the Wisconsin Glaciation, at the end of the Late Pleistocene, resulting in a much lower sea level than exists today. Geologists have charted the timing and magnitude of sea level rise (e.g. Figure 2; reproduced from Weise, et al. 1980, Figure 16; after Fisher, et al. 1973). Sea level has risen more than 300 ft since the last glacial low stand, about 22,000 to 20,000 years ago.

Archaeologists are interested in geologic unconformities marking recent inundation of dry lands by rising seas. The timing of the most recent low-stand sea level overlaps the period of earliest known human habitation in North America. Fresh surface water and ecological diversity of coastal streams, marshes and estuaries during this period likely would have attracted human populations. One geologic unconformity is of particular significance to archaeologists along the Texas Coast and the adjoining continental shelf. It marks the divide between the top of the Late Pleistocene-aged, Beaumont Formation and the base of Holocene-aged sediments.

The Beaumont Formation consists of hard and soft clay layers, intermixed with sandy strata, deposited in a delta plain environment along the Texas Coast during the previous interglacial high-stand sea level (Marine Isotope Stage 5), between 120,000 and 80,000 BP. Beaumont Formation exposures along Powderhorn Lake and Matagorda Bay have been dated between 72,000 and 83,000 BP by optical luminescence (Paine, et al. 2018: 11). Clays in the Beaumont Formation that were exposed to subaerial conditions became desiccated and hardened, increasing their resistance to erosion. Intervening layers are
more easily eroded. The desiccated hard clay layers may be as thin as a few inches; however, they are highly reflective to seismic energy, making this unconformity a prominent horizon in acoustic sub-bottom profiles. The Beaumont Formation is older than any known human evidence in the Western Hemisphere, thus its upper surface forms the hypothetical lower limit of strata likely to contain archaeological materials, except where the formation has been dissected by streams post-dating the entry of humans into the region. Distributary channels dissecting the Beaumont surface, on the other hand, are presumed to be about the same age as the surrounding materials; therefore, they would predate human habitation of the region.

![Figure 2: Holocene Sea Level Curves by Various Authors](image)

Reproduced from Weise, et al. (1980, Figure 16; after Fisher, et al. 1973)

Sea level fell during the early-Wisconsin Glaciation, exposing the entire APE to subaerial conditions. Then during the mid-Wisconsin interglacial period (Marine Isotope Stage 3), seas rose again. The maximum height of the mid-Wisconsin shoreline was between the modern 45-ft and 50-ft isobaths (GMT 2019:4-5). West of the mid-Wisconsin, high-stand shoreline, the top of the Beaumont Formation was exposed in the survey corridor from before the arrival of humans in the region until the most recent, Holocene transgression. Seaward of the mid-Wisconsin, high-stand shoreline, the Beaumont Formation presumably was eroded by waves and currents during transgression, and then was capped by marine sediments. During the late-Wisconsin glaciation, the shoreline retreated to near the shoulder of the continental shelf.
The entire survey corridor remained available to human use throughout the late-Wisconsin period until rising sea level gradually flooded the APE between about 10,000 and 3,500 years ago (Figure 2).

As sea level rose during the Holocene, a layer of sediment known as the Texas Mud Blanket covered large portions of the central and southern Texas continental shelf seaward of the mid-Wisconsin shoreline referenced above. Much of the Texas Mud Blanket material originated in the Colorado and Brazos river basins, although sediment from as far as the Mississippi River has been documented (Weight, Anderson and Fernandez, 2011). GMT (ibid.) state that the survey corridor crosses an inter-deltaic section of the Texas Mud Blanket, dominated by shoreface processes (Rodriguez, et al. 2001; cited in GMT 2019).

**Cultural Background**

**Prehistory**

The chronology of early human migration into and across the New World continues to be debated and refined. Two cultural stages, the Paleo-Indian and Archaic periods, coincided with the period of rising sea level in South Texas prior to about 3,500 years ago. The earliest definitive evidence for humans in the New World is from the Paleo-Indian Stage, coinciding roughly with the end of the late-Wisconsin Glaciation (at the end of the Pleistocene Epoch). The Paleo-Indian Stage was classically defined by the presence of finely crafted, lanceolate projectile points and by a substantial reliance on megafauna for subsistence. Paleo-Indian sites have been documented in South Texas from 11,000-8,000 years ago, although some evidence suggests a much earlier arrival in the New World. Waters and Stafford (2014) suggest that the earliest projectile points diagnostic of the Paleo-Indian Period, the Clovis complex of fluted-blade technology, likely evolved in the New World long after migrants had already spread throughout both North and South America. The idea of a pre-Clovis migration to North America from central Asia, possibly as early as 16,000 BP, is supported by genetic evidence and correlates with an apparent decline in megafauna populations beginning shortly after that time.

Paleo-Indian artifacts have been reported from several south Texas sites. A Clovis point base was found by A.E. Anderson at Laguna Atascosa National Wildlife Refuge during the early 20th century (Anderson 1932). W.A. Price later reported mammoth bones eroding in the same vicinity (Suhm, et al. 1954: 118, 121). Lithic artifacts have been reported at Falcon Reservoir in association with extinct megafauna (Cason 1952: 243; Kreiger n.d.: 18). A Paleo-Indian component was identified at the Perdida Site, in Starr County, containing Plainview, Meserve, Angostura, Scottsbluff, and Clovis projectile points (Weir 1956: 59-78; Newton 1968). North of Corpus Christi, in Bee County, Clovis and Folsom points have been documented in association with mammoth, mastodon, horse, bison, and glyptodon bones at the Buckner Ranch Site (Sellards 1940: 1627:1657). Many Paleo-Indian points also are known from San Miguel Creek in Atascosa and McMullen counties (Hester 1968: 147-162).

The Archaic Period in South Texas dates from about 8,000-1,000 years ago. It is unclear whether the cultural traditions or adaptations of the Archaic were substantially different from the preceding Paleo-Indian Period. Both relied on hunting and gathering for subsistence. The most noticeable, and often cited, differences are the absence of Pleistocene mega-fauna, due to extinction, and changes in projectile point
styles during the Archaic. Archaic sites appear to demonstrate a more diversified subsistence economy focused on a larger number of smaller species (Story 1985). The diversification of economies may have been driven by continued warming of the climate following the Late Pleistocene. Holocene warming peaked during the climatic optimum roughly 7,000-4,000 years ago (e.g., Nordt, et al. 2002). Sea levels had risen to near modern levels by the end of the climatic optimum.

Stright (1990) summarized inundated sites discovered along the Gulf of Mexico coast at depths up to 59 ft below Mean Sea Level. For example, artifacts from all Paleo-Indian traditions with the exception of Folsom have been found along a 22-mile stretch of McFaddin Beach near Sabine Pass, Texas (Long 1977; cited in Stright 1990). The collection includes 14 Clovis Points. Faunal material recovered includes a wide variety of Pleistocene species, such as mammoth, mastodon, saber-toothed cat, bear, giant armadillo, bison, tapir and horse. An elephant tusk from the site yielded a radiocarbon date of 11,100 +/- 750 BP. The former Pleistocene land surface at McFaddin Beach, known regionally as the Beaumont Clay Formation, is about 5 ft below sea level at that site.

Many inundated sites have been discovered as a result of dredging. For example, human remains and artifacts were recovered from the Texas City Channel in Galveston Bay (Aten and Good 1985). This site, situated near the ancestral Trinity River Valley, contained 4,000 bone specimens from Pleistocene species, such as horse and tapir, including 42 bones that appeared to have been modified, and a variety of lithics interpreted as stone tools. Evidence of Pleistocene megafauna has also been discovered by dredging at Padre Island, although a cultural connection has not been demonstrated. The molar of an extinct elephant (species unknown) was recovered on Padre Island near Port Mansfield by a local resident in the late 1980s. The tooth was dredged from the Mansfield Cut (Gearhart, personal communication).

Few attempts have been made to actively seek intact, buried, archaeological deposits on the continental shelf. Nevertheless, one such effort by Coastal Environments, Inc. (1986) located two suspected, prehistoric sites in vibacore samples collected near Sabine Pass at depths of 54 and 59 ft below Mean Sea Level. One site contained rangia (sp.) shell deposited in a sub-aerial environment. The shell was radiocarbon dated to 8,055 +/- 90 BP, consistent with sea-level curves in Figure 2. Burned fish bones, difficult to explain from a non-archaeological context, were found at both sites (Stright 1990). Carbonized seeds and vegetal material were recovered from one location. Pollen analyses demonstrated that both deposits had formed subaerially; however, the core sample sizes were too small to allow a definitive determination of cultural origin for the shell deposits.

Potential for Submerged Prehistoric Sites

There is no doubt that humans lived along Gulf of Mexico coastlines that have long-since been submerged by rising seas. The timing of the most recent sea level transgression (Late Pleistocene through most of the Holocene) includes the postulated pre-Clovis culture, the entire Paleo-Indian Period, and most of the Archaic Period. Many sites are presumed destroyed by wave energy during the process of inundation. The most likely locations for submerged sites to remain preserved are along streams that were above sea level during the period of human habitation in North America. Sources of fresh water may have attracted humans, and burial of cultural sites in alluvial deposits might have afforded protection from wave energy as rising seas inundated the land. As river valleys flooded to become estuaries, deltaic sediments may
have accumulated on top of already sealed deposits, providing further protection by the time those sites were exposed to the open Gulf of Mexico. The search for intact sites on the submerged continental shelf focuses on remnants of flooded and buried stream channels, which often are recognizable on acoustic sub-bottom profiles.

The Beaumont Formation, is exposed in the survey corridor from the 31-ft to 46-ft isobath (GMT 2019). A buried Pleistocene/Holocene unconformity (top of the Beaumont Formation) was interpreted from acoustic sub-bottom profiles seaward of the 46-ft isobath (GMT 2019) and ranging in depth from 46 to about 105 ft (0-35 ft below the seafloor). The Beaumont Formation is capped, seaward of the 46-ft isobar, by under-consolidated layers of Holocene sand and mud, deposited in a marine environment during the most recent transgression.

The Beaumont Formation is incised by numerous, relict, distributary channels out to the 65-ft isobath, where the former land surface is buried beneath 35 ft of Holocene sediments (GMT 2019). Seaward of the 70-ft isobath, sub-bottom penetration was limited to about 40 ft and could no longer image the top of the Beaumont Formation. Evidence for distributary channels continues across the area where the Beaumont Formation is exposed at the seafloor. Bathymetry over the Beaumont exposure has a hummocky relief, and the side-scan sonar shows irregular patches of variable reflectivity, consistent with laterally discontinuous sediments expected of the Beaumont Formation (GMT 2019). Low spots are believed to correlate with distributary channel fill, while localized high spots are believed to be remnants of desiccated clay. These channels were incised prior to the earliest known evidence for humans in the region; however, they were exposed above sea level during the Paleo-Indian Period and roughly the first half of the Archaic Period before being flooded by rising seas and filled in their upper levels with estuarine sediments during the Holocene. Any sites associated with this unconformity would have had little protection from wave energy during sea-level rise and are presumed to have been destroyed by waves and currents, in the same manner that such erosion continues where the Beaumont Formation is presently exposed.

**Maritime History**

Exploration of the Texas Coast began in 1519, when a Spaniard named Alonso Alvarez de Pineda led an expedition, on behalf of the governor of Jamaica, to map lands bordering the Gulf of Mexico. Pineda’s map of the Gulf of Mexico shows inlets along the Texas Coast; however, there is no evidence that he entered or explored their shores (Weddle 1985; Chipman and Joseph 2010: 25). Pineda demonstrated there is no shortcut to Asia through the Gulf of Mexico. His logs also helped to identify the fastest sailing route between Vera Cruz and Havana (Chipman 1992: 24-26).

The first Europeans known to explore the Texas Coast inland were survivors from the shipwrecked Pánfilo de Narváez expedition of 1527. Álvar Núñez Cabeza de Vaca and 80 other Spaniards sailed on makeshift rafts to what many believe was Galveston Island. Those who survived the first winter were enslaved by Native Americans. Only four men returned to tell their stories of wandering from tribe to tribe through what is now Texas and northern Mexico to the Pacific Coast, eventually reaching Mexico City after eight years. Cabeza de Vaca published his story in 1542 upon returning to Spain (e.g., Cabeza de Vaca 2013).
The Spanish silver fleet, sailing out of Vera Cruz, conducted steady trade with Havana for about 250 years, until 1790. Their ships typically followed either a northern route, paralleling the coast, or crossed the central Gulf of Mexico. Seasonal changes in wind and current patterns determined their choice of routes (Lugo-Fernandez et al. 2007). The northern route occasionally imperiled Spanish flotillas when storms pushed them toward the coast.

In 1554 a fleet of three Spanish ships wrecked on the Texas Coast near the Port Mansfield Channel, about 90 miles south of Port Aransas. The loss of the ships, *Santa María de Yciar, San Esteban*, and *Espíritu Santo*, led in the short term to an intensive 2-month salvage effort by García de Escalante Alvarado to recover their valuable cargos (McDonald and Arnold 1979). The loss of nearly 300 crew and passengers (only 32 people returned to Vera Cruz), including women and children, prompted longer range plans for more detailed explorations of the Gulf Coast. Guido de Lavazares was chosen to lead an expedition of three ships with orders to explore the entire coast from Rio de las Palmas to the Florida Keys. Lavazares arrived on the Texas Coast in the fall of 1558 at the latitude of present-day Kingsville (Chipman and Joseph 2010: 48). From that point, he followed the coast, stopping in what is believed to be Matagorda Bay, where he formally claimed the region as a Spanish possession (Chipman 1992:48-49 and Weddle 1991:100-103). A second expedition by Gonzalo Gayon followed the Gulf Coast in the opposite direction, from Florida to Texas, within a year or two of Lavazares.

Spain did little to explore or develop settlements along the Texas Coast until their claims were challenged by other nations. Their population and trade centers were located far to the south in Mexico. Instead, they focused on inland explorations and establishment of missions to Christianize the natives. But then, in 1685, René Robert Cavelier, Sieur de La Salle arrived in Matagorda Bay with 300 colonists. By the time Spain heard talk of a French colony in the heart of their territory, La Salle’s Fort St. Louis was already doomed to failure, through a series of unfortunate events. The expedition lost one of three ships upon their arrival. A second ship returned to France with a group of colonists. While La Salle was attempting to find the Mississippi River with an overland expedition, their last ship, *La Belle*, grounded during a storm and was lost in Matagorda Bay. La Salle was murdered by his own men, and having no way to return to Europe, those remaining at Fort St. Louis eventually perished (Weddle 1991).

Rumors of the French incursion quickly reached Madrid. Spain mounted an intensive exploration of the Texas Coast to find and rout out the unwelcome intruders while simultaneously charting their own, relatively unknown, possessions there. Weddle (1991:68) summarized the effect of La Salle’s arrival on the Spanish royal court as inspiring “the most intense coastal reconnaissance ever made in the Gulf of Mexico. In five coastal voyages spanning three years, there were few rivers and bays that had not been examined.” One such voyage explored the area of Aransas Pass. Martín de Rivas and Pedro de Iriarte sailed north from Veracruz in 1686, reaching Aransas Pass in March of 1687. They named the pass Rio de San Joseph, charted its depths, and spent several days exploring the surrounding area (Weddle 1991). The abandoned remains of Fort St. Louis eventually were discovered by Alonso de León in 1689, upstream from Lavaca Bay on Garcitas Creek.

In 1764, Jose de Escandon was ordered by the viceroy of New Spain, Joaquín de Montserrat, marqués de Cruillas, to investigate rumors of English settlement on islands of the Texas Coast, not far from the mouth of
the Nueces River. Escandon reported about the shoreline from Tampico to the Trinity River, based largely on testimony of a seaman, Joseph Garabito, who had made many trips up and down the coast. He reported that no English were found and that there was no place along that stretch of coast suitable for the English to establish a settlement (Bolton 1915: 104).

Shortly thereafter, in 1766, Diego Ortiz Parrilla was commissioned to explore the islands of the lower Texas Coast, and in particular what is now known as Padre Island. Parrilla was unable to personally explore the coast above the Nueces River, due to flooding from a hurricane, so he diverted inland to La Bahía del Espíritu Santo (Goliad) where he recorded extensive testimony regarding that portion of the coast between Nueces and the Trinity River. The soldiers of La Bahía interviewed by Parrilla had extensive knowledge of the coast between Matagorda Bay and the Nueces River, having made frequent trips to investigate wrecked vessels and pursue mission Indians (Bolton 1915: 104-106).

Copano Bay was one of the earliest maritime destinations inside of Aransas Pass. Its origin as a place of commerce may be linked to the relative ease of overland travel between Copano Bay and Spanish settlements at San Antonio (Presidio San Antonio de Béxar in 1716) and Goliad (Presidio La Bahía in 1749). Huson points out that Copano was the “nearest port and had no great river or stream between it and the settlements at San Antonio, or Rosario and La Bahía Mission, required to be crossed in carting between this port and either town. There is no question that this port was regularly used to supply Bexar and La Bahía” (Huson 1935: 6). The Port of Copano was officially opened for trade in 1785 with a collector of customs located at Goliad. Huson goes on to say that “the Mission of Nuestra Senora del Refugio was established [in 1793] to protect this port from pirates and smugglers” (ibid.).

Perhaps not surprisingly, when the Mexican army came ashore at the onset of the Texas Revolution, the chosen landing site was El Copano. General Cos landed on September 20, 1835 with 400 soldiers. From there he marched through Refugio to Goliad and then on to Béxar (Huson 1935: 24). Fortunately for the Texan colonists, Santa Anna had not acted on General Almonte’s suggestion to fortify the entrance to Copano Bay. Seizing on this oversight, General Houston ordered that the port be protected as a point of entry for military supplies and provisions to support Burleson’s army and the Texan garrison at Goliad. In 1835, Copano was designated as a port of entry for the Republic of Texas. A community of shellcrete houses developed around the landing beginning about 1840, and the town did a thriving export business in cotton, hides and tallow.

The first settlement at what is now Corpus Christi was founded as a trading post in 1839 by Henry Kinney and William Aubrey (Long 2010). The first town to be organized at the site was Grayson, shown on Hunt and Randel’s (1839) chart and mentioned by Folsom (1842: 204) as “a town recently laid off on the south side of Corpus Christi Bay.” By 1845, when General Zachary Taylor’s army landed there during the Mexican American War, the town had become known as Corpus Christi. Aransas Pass and Corpus Christi were used extensively during the war to land troops and supplies bound overland for Mexico. Taylor’s troops and supplies were lightered to shallow-draft steamers near Aransas Pass for transport across the bay to Corpus Christi. Lightering presumably took place at a “U.S. Depot,” charted in 1846 on the bay side of St. Joseph (San Jose) Island, about 3 miles up the Lydia Ann Channel from Aransas Pass (Figure 3). The circuitous route between Aransas Pass and Corpus Christi Bay (Figure 3) followed Lydia Ann Channel northward from Aransas Pass, then turned westward through Corpus Christi Bayou, then southwestward to McGloins Bluff.
(Ingleside). The portion of channel connecting Corpus Christi Bayou to Ransome Point was deepened by dredging in 1874 and became known as the Morris and Cummings Cut (Figure 4; Alperin 1977: 126).

Figure 3: Route from Aransas Pass to Corpus Christi Bay (Corps of Engineers 1846)

Figure 4: Inshore APE on USCGS (1887) Chart

Other early bay settlements, dependent largely upon trade through Aransas Pass, included the original town of Aransas, charted by Hunt and Randel (1839) on Live Oak Point (present site of Fulton and Rockport; see also Folsom 1842: 204); Lamar, at the entrance to Copano Bay opposite Live Oak Point; and a later version of Aransas on St. Joseph’s (San Jose) Island (Marcy 1855). Marcy indicated channels and soundings leading
from Aransas Pass to each town, as well as wagon roads leading to various points inland. All of the above bay shore communities were accessed by sea primarily through Aransas Pass and to a lesser extent through Corpus Christi Pass, and Cedar Bayou, also known as Espíritu Santo Inlet (Hunt and Randel 1839). Marcy did not chart soundings for Cedar Bayou, as he did for the other two inlets, suggesting it was of less commercial importance.

Corpus Christi Pass, on the south end of Mustang Island, remained open from before 1839 (Hunt and Randel 1839) through at least 1934 (USCGS 1935). It was never a naturally deep pass; however, one branch of the pass, known as Packery Channel, became important to the local beef packing industry following the Civil War. A county map shows two structures on the south side of Corpus Christi Pass labeled “Factory” and “Kings” in 1869 (Blucher 1869). Attempts to dredge Packery Channel in 1890 and again in 1938 and 1940 were only briefly successful (Alexander et al. 1950; cited in USACE 2003a: 3-77).

C.W. Howell proposed closing Corpus Christi Pass in a USACE annual report (Howell 1879: 930; cited in USACE 2003a: 3-77). Howell believed that cutting off tidal flow through Corpus Christi Pass might increase flows through both Aransas Pass and Laguna Madre, south of Corpus Christi Bay. Laguna Madre was an important route for the local beef packers to access salt production in Baffin Bay, referred to by Blucher (1869) as “Salt Lagoon.” Funding was never allocated for Howell’s planned closure of the inlet; however, it closed through natural processes by the mid-twentieth century.

Morgan Line steamboats began regular runs between New Orleans and the Texas Coast following the Civil War. This trade was subsidized by contracts with the federal government to deliver mail. Morgan negotiated four-year contracts in 1867 for service three times per week between New Orleans, Galveston and Indianola (in Matagorda Bay) and for a coastal route between Galveston, Matagorda, Aransas Bay, and Brazos Santiago. The route between Matagorda and Aransas Bay would have passed through the Offshore APE. By 1875, Morgan Line steamships were running weekly, from June to October, and twice-weekly, from October to June, between Brashier, Louisiana (Morgan City) and Rockport, by way of Aransas Pass. The Morgan Line offered the only regular steamship service along the Texas Coast. Morgan Line steamers averaged one trip through Aransas Pass every 10 days over a period of five years, from 1871 through 1876 (Hoyt 1990: 9-16). While important to the regional economy, the Morgan steamship visits represented less than half of offshore maritime trade (measured in vessel transits) through Aransas Pass. Over the period from 1866-1877, ships crossed the bar at Aransas Pass 1,880 times, averaging 1 arrival and 1 departure every 4-5 days (Kuehne 1973: cited in Hoyt 1990: Appendix A).

Hoyt (1990: Appendix B) itemized imports and exports through Aransas Pass for a short part of the 1880’s. His research provides a snapshot of the quantity and variety of commerce through the pass at that time. Cattle products greatly dominated exports, including: tinned beef, hides (wet and dry), tallow, bones, blood, hair, shin bones, horns, knuckles, hoofs, neat’s-foot oil, and a small number of live cattle. Also exported was a large quantity of wool, and lesser quantities of jute fiber, fish and turtles, cotton, hemp, lead, merchandise, sheep, horses, hogs, and ore. Imports were dominated by general merchandise, lumber, and shingles. Other items imported included: steel rails, coal oil, coal, fire brick, cedar piles, salt, sheep, and a small number of calves, and hogs.
The bar at Aransas Pass became so shallow in 1878 that steamships could not enter the harbor. Federal involvement with navigation improvements in Corpus Christi Bay began with passage of the Rivers and Harbors Act of 1878. The following year, funds were authorized for deepening the outer bar channel at Aransas Pass, which was completed in 1885. The first direct channel between Aransas Pass and Corpus Christi, the Turtle Cove Channel, was dredged to a depth of 8.5 ft by 1909. Completion of the Turtle Cove Channel bypassed the Morris and Cummings Cut, so commercial traffic through the Inshore survey area would have decreased significantly after this time. By 1919 the current stone jetties at Aransas Pass had been completed, which aided efforts to maintain the Aransas Pass Channel (Alperin 1977: 129-132) and removed the safety concerns associated with shifting sand bars at the harbor entrance. In 1922 the Turtle Cove Channel was renamed the Corpus Christi Ship Channel. The channel has been deepened and widened multiple times since then to accommodate larger ships.

Improvements to channels coincided with steady advancements in the safety of ships during the first half of the twentieth century. Sailing vessels were being replaced rapidly by safer, machine-powered vessels. By 1910, sailing ships comprised less than half of annual losses of US merchant vessels for the first time, and by the end of World War II, only 2-percent of nationwide losses were sailing ships. This is significant, because sailing ships were at a higher risk of running aground than machine-powered vessels. At the same time that machinery was replacing wind power, more durable metal hulls gradually were replacing wooden hulls, a trend which had accelerated by the turn of the century. Nevertheless, at least 93 percent of all US merchant vessels lost through the end of World War II were made of wood (Gearhart 2011a).

Natural gas was discovered in Nueces County in 1922. Oil production began in Aransas County in 1936, and 13 wells were producing there by 1946. Production in the area increased dramatically in the 1950s when offshore drilling became routine (Pratt, et al. 1997). Offshore drilling was stimulated by settlement of the Tidelands controversy in 1953, solidifying Texas ownership of mineral resources within 9 nautical miles of its Gulf of Mexico shorelines (Long 2016, 2019).

**Potential for Historic Shipwrecks**

Europeans have navigated the Texas Coast, including the Offshore APE, for the past 500 years. Visits increased after 1685 as Spain and France competed for possession of the region. Europeans probably made regular trips through Aransas Pass by the mid-1700’s to supply the mission and presidio at Goliad by way of Copano Bay. The Port of Copano was officially opened in 1785 along with a Customs House at Goliad. By 1839 traffic through Aransas Pass was visiting other coastal communities including Lamar, Aransas, and Kinney’s Trading Post at Grayson (soon renamed Corpus Christi). The volume of trade through Aransas Pass would have steadily grown from then onward. The Inshore APE was crossed for commercial navigation through the Morris and Cummings Cut until at least 1909 when the Turtle Cove Channel was completed. The Turtle Cove Channel, later renamed the Corpus Christi Ship Channel, provided a direct channel between Aransas Pass and Corpus Christi. The Offshore APE would have been intentionally crossed by ships transiting between Aransas Pass and more northerly ports, including Galveston and Indianola. Both areas have potential for wrecks driven ashore by storms. Traffic crossing the Offshore APE near Aransas Pass often risked the additional hazard of shallow sand bars, strong currents, and rough seas.
At least 95 shipwrecks have been reported within a 3-mile radius of the APE (Table 1) by one or more of the sources listed below. Positions reported in historical accounts are often imprecise; however, archaeologists have verified the locations of at least 5 of the wrecks listed in Table 1. Sources consulted for Table 1 include the THC’s Texas Archaeological Sites Atlas (Atlas); the NOAA Automated Wreck and Obstruction Information System (AWOIS) database; a shipwreck database compiled by PBS&J; a BOEM GIS database; and historic maps from the Texas Historical Overlay (Foster, et al. 2006). The THC Atlas contains reports of shipwrecks from historic records. The AWOIS database is maintained by NOAA to support the charting of coastal areas. AWOIS tends to report recent shipwrecks; however, some historic wrecks are included. Positions for wrecks in AWOIS are usually more accurate than those from historic records, although positions pre-dating the era of satellite position systems can vary considerably from actual locations. A group of archaeologists, including this author, assembled the PBS&J database, in part, based on information gathered from charts, historical reports, THC files, and AWOIS. The PBS&J database focuses primarily on well-documented commercial wrecks postdating 1850. BOEM maintains a GIS database for offshore areas showing historic wrecks, USCG hazards to navigation, and net hangs reported by trawl fishermen.

Factors Affecting Vessel Loss
Factors contributing to the loss of watercraft vary depending on environmental conditions. Historic government statistics, summarized by Gearhart, et al. (1990: Volume IV, 59-61), categorized vessel casualties, including most accidents and incidents resulting in injury or loss of property, and reported the value of losses incurred. A total loss was reported if the hull could not be saved. These statistics do not reflect the degree to which cargo and vessels were salvaged. Types of casualties included foundering, stranding, collision and other (including fires, boiler explosions, injuries, and mechanical failures, etc.).

Foundering was the primary mechanism of vessel loss in navigable waters. The Annual List of Merchant Vessels of the United States (US Department of the Treasury 1906-1946) defined foundering as leaking or capsizing of vessels. Foundering accounted for about 6 percent of historic vessel losses. Despite its low rate of occurrence, recovery from foundering was less likely than from any other type of casualty. Fifty-four percent of all foundered vessels were reported as totally lost.

Stranding was the primary mechanism of loss in shoal waters and was, by far, the most common type of shipwreck during the historic period. Stranding (or grounding) accounted for 64 percent of total losses reported by the US Lifesaving Service for the period 1876 through 1914 (Gearhart, et al. 1990: Volume IV, 59-61). Stranding occurred where the water was too shallow for navigation, including shorelines, harbor bars and reefs. Forty-six percent of stranding events resulted in a total loss. Severe weather accounted for 55 percent of total losses reported by the US Lifesaving Service from 1876 through 1914. Almost half of all losses from foundering were caused by weather, compared with two thirds of losses from stranding. Mariners had short warning of approaching storms prior to modern weather forecasting. The Texas Coast can experience hazardous weather conditions throughout much of the year. Hurricane season lasts from late June through October. Hurricane-force winds can devastate ships caught unprepared. During the winter, severe cold fronts, or Northers, with winds exceeding 50 miles per hour and dangerous waves can affect the Texas Coast.
<table>
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<th>AWOS No.</th>
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<td></td>
<td></td>
<td></td>
<td>1955</td>
</tr>
<tr>
<td>Jimbo</td>
<td>1031</td>
<td>576</td>
<td>4177</td>
<td>Passenger vessel; USCG #73</td>
<td>1965</td>
</tr>
<tr>
<td>John Worthington</td>
<td>1032</td>
<td>580</td>
<td>5020</td>
<td>Oil tanker; moved in 1945 from original location</td>
<td>1944</td>
</tr>
<tr>
<td>L’Éclair</td>
<td>1272</td>
<td></td>
<td></td>
<td>Merchant sailing ship</td>
<td>1866</td>
</tr>
<tr>
<td>Lake Austin</td>
<td>992</td>
<td></td>
<td></td>
<td>scow schooner barge</td>
<td>1903</td>
</tr>
<tr>
<td>Libbie Shearn</td>
<td>343</td>
<td>1258</td>
<td></td>
<td>Merchant sailing ship</td>
<td>1911</td>
</tr>
<tr>
<td>Liberia C.</td>
<td>1941</td>
<td></td>
<td></td>
<td></td>
<td>1964</td>
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<tr>
<td>L’Éclair</td>
<td>860</td>
<td></td>
<td></td>
<td>Trawler; BOEM #1250; USCG #5796</td>
<td>1954</td>
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<tr>
<td>Lionel Hodgson</td>
<td>2281</td>
<td>4191</td>
<td></td>
<td>Fishing vessel; BOEM 112; USCG #946</td>
<td>1977</td>
</tr>
<tr>
<td>Little Saran</td>
<td>2282</td>
<td></td>
<td></td>
<td></td>
<td>1959</td>
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<tr>
<td>Louisa</td>
<td>659</td>
<td>584</td>
<td></td>
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<td>1865</td>
</tr>
<tr>
<td>Margie B</td>
<td>-</td>
<td>4186</td>
<td></td>
<td>Pleasure craft; BOEM #12243; USCG #4459</td>
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<tr>
<td>Mary (41NU252)</td>
<td>104</td>
<td>1281</td>
<td>4175</td>
<td>Steam-sail</td>
<td>1876</td>
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<tr>
<td>Mary Agnes</td>
<td>2483</td>
<td></td>
<td></td>
<td>Schooner</td>
<td>1865</td>
</tr>
<tr>
<td>Mary Agnes</td>
<td>655</td>
<td>586</td>
<td></td>
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<td>1862</td>
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<tr>
<td>Mary E. Lynch</td>
<td>609</td>
<td>1283</td>
<td></td>
<td>Merchant sailing ship</td>
<td>1902</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Merchant sailing ship</td>
<td>1870</td>
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<tr>
<td>Mary Lorena</td>
<td>1422</td>
<td>1288</td>
<td></td>
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<tr>
<td>Mattie</td>
<td>653</td>
<td>589</td>
<td></td>
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<td>1873</td>
</tr>
<tr>
<td>Mert</td>
<td>2287</td>
<td></td>
<td></td>
<td></td>
<td>1970</td>
</tr>
<tr>
<td>Miss Aransas</td>
<td>2292</td>
<td>-</td>
<td></td>
<td></td>
<td>1974</td>
</tr>
<tr>
<td>Moon Glow</td>
<td>151</td>
<td>5014</td>
<td></td>
<td>Fishing vessel</td>
<td>1967</td>
</tr>
<tr>
<td>Mox Nix</td>
<td>-</td>
<td></td>
<td></td>
<td>USCG #1697</td>
<td>-</td>
</tr>
<tr>
<td>Nieuwe Market</td>
<td>-</td>
<td></td>
<td></td>
<td>Fishing vessel; BOEM #133</td>
<td>1973</td>
</tr>
<tr>
<td>O’Jennings Gill</td>
<td>1386</td>
<td></td>
<td></td>
<td>Merchant sailing ship</td>
<td>1887</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>423</td>
<td>593</td>
<td></td>
<td>Merchant steam-sail</td>
<td>1868</td>
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<td>Name of Vessel</td>
<td>THC No.</td>
<td>PBS&amp;J No.</td>
<td>AWOIS No.</td>
<td>Description</td>
<td>Date Lost</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------</td>
<td>-----------</td>
<td>-----------</td>
<td>---------------------------------------</td>
<td>-----------</td>
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<tr>
<td>Powhatton</td>
<td>2311</td>
<td></td>
<td></td>
<td>Unknown; BOEM 110</td>
<td>1969</td>
</tr>
<tr>
<td>Princess Pat</td>
<td>1943</td>
<td></td>
<td></td>
<td></td>
<td>1958</td>
</tr>
<tr>
<td>Ramyrez</td>
<td>1049</td>
<td>1337</td>
<td></td>
<td>Brig</td>
<td>1881</td>
</tr>
<tr>
<td>Reindeer</td>
<td>1449</td>
<td></td>
<td></td>
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<td>1870</td>
</tr>
<tr>
<td>Ring Dove</td>
<td>2187</td>
<td></td>
<td></td>
<td></td>
<td>1919</td>
</tr>
<tr>
<td>Rowena Burgman</td>
<td>452</td>
<td></td>
<td></td>
<td></td>
<td>1960</td>
</tr>
<tr>
<td>San Jacinto</td>
<td>469</td>
<td></td>
<td></td>
<td></td>
<td>1960</td>
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<td>Sea Bird</td>
<td>1450</td>
<td></td>
<td></td>
<td>Merchant sailing ship</td>
<td>1870</td>
</tr>
<tr>
<td>Silas</td>
<td>1417</td>
<td></td>
<td></td>
<td>Merchant sailing ship</td>
<td>1902</td>
</tr>
<tr>
<td>Syndi Lee</td>
<td>-</td>
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<td></td>
<td>42-ft fishing vessel</td>
<td>-</td>
</tr>
<tr>
<td>Surprise</td>
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<td></td>
<td></td>
<td>Merchant sailing ship</td>
<td>1871</td>
</tr>
<tr>
<td>Taasinge</td>
<td>2334</td>
<td></td>
<td></td>
<td></td>
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<td>1412</td>
<td>1374</td>
<td></td>
<td>Merchant sailing ship</td>
<td>1882</td>
</tr>
<tr>
<td>Tramp</td>
<td>2186</td>
<td></td>
<td></td>
<td></td>
<td>1919</td>
</tr>
<tr>
<td>Two Marys</td>
<td>1411</td>
<td>1385</td>
<td></td>
<td>Merchant sailing ship</td>
<td>1882</td>
</tr>
<tr>
<td>Umpire</td>
<td>512</td>
<td>603</td>
<td></td>
<td>Merchant steam-sail</td>
<td>1852</td>
</tr>
<tr>
<td>Unknown</td>
<td>113</td>
<td>605</td>
<td></td>
<td>Sailing ship</td>
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</tr>
<tr>
<td>Unknown (41NU264)</td>
<td>513</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Unknown</td>
<td>1019</td>
<td>606</td>
<td></td>
<td></td>
<td>-</td>
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<tr>
<td>Unknown</td>
<td>1024</td>
<td></td>
<td></td>
<td>(possible duplicate of AWOIS #4190)</td>
<td>1954</td>
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<tr>
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<td>4190</td>
<td></td>
<td>(possible duplicate of #1024)</td>
<td>1974</td>
</tr>
<tr>
<td>Unknown</td>
<td>1027</td>
<td></td>
<td></td>
<td></td>
<td>Pre-1974</td>
</tr>
<tr>
<td>Unknown</td>
<td>1030</td>
<td></td>
<td></td>
<td></td>
<td>Pre-1972</td>
</tr>
<tr>
<td>Unknown</td>
<td>1047</td>
<td>608</td>
<td></td>
<td></td>
<td>Pre-1935</td>
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<tr>
<td>Unknown</td>
<td>1056</td>
<td>610</td>
<td></td>
<td></td>
<td>1853</td>
</tr>
<tr>
<td>Unknown</td>
<td>1223</td>
<td>10439</td>
<td></td>
<td></td>
<td>1977</td>
</tr>
<tr>
<td>Unknown</td>
<td>1224</td>
<td>5047</td>
<td></td>
<td>Ribs bare at MHW when reported; no longer visible by 1971</td>
<td>Pre-1948</td>
</tr>
<tr>
<td>Unknown</td>
<td>1225</td>
<td>5051</td>
<td></td>
<td>Visible wreck when reported; no longer visible by 1971</td>
<td>Pre-1948</td>
</tr>
<tr>
<td>Unknown</td>
<td>1228</td>
<td></td>
<td></td>
<td></td>
<td>1977</td>
</tr>
<tr>
<td>Unknown</td>
<td>1229</td>
<td></td>
<td></td>
<td></td>
<td>Pre-1971</td>
</tr>
<tr>
<td>Unknown</td>
<td>1528</td>
<td></td>
<td></td>
<td></td>
<td>1884-1900</td>
</tr>
<tr>
<td>Unknown</td>
<td>1534</td>
<td>617</td>
<td></td>
<td></td>
<td>Pre-1966</td>
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<tr>
<td>Unknown</td>
<td>1535</td>
<td>618</td>
<td></td>
<td></td>
<td>Pre-1966</td>
</tr>
<tr>
<td>Unknown</td>
<td>1536</td>
<td>619</td>
<td></td>
<td></td>
<td>1971</td>
</tr>
<tr>
<td>Unknown</td>
<td>1537</td>
<td>620</td>
<td></td>
<td></td>
<td>1970</td>
</tr>
<tr>
<td>Unknown</td>
<td>-</td>
<td>4172</td>
<td></td>
<td>Airboat</td>
<td>1984</td>
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<tr>
<td>Unknown</td>
<td>-</td>
<td>13346</td>
<td></td>
<td>18-ft fishing vessel</td>
<td>2001</td>
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<tr>
<td>Unknown</td>
<td>-</td>
<td>5018</td>
<td></td>
<td>Oil barge</td>
<td>1932</td>
</tr>
<tr>
<td>Unknown</td>
<td>-</td>
<td>10428</td>
<td></td>
<td>15-ft fishing vessel</td>
<td>1918</td>
</tr>
<tr>
<td>Unknown</td>
<td>-</td>
<td>5967</td>
<td></td>
<td>Visible wreck</td>
<td>1971</td>
</tr>
<tr>
<td>Unknown</td>
<td>-</td>
<td>10429</td>
<td></td>
<td>Area foul with visible and partially submerged wrecks</td>
<td>Pre-1990</td>
</tr>
<tr>
<td>Utina (41NU292)</td>
<td>-</td>
<td>604</td>
<td>11022</td>
<td>WWI EFC Steamer; converted to barge</td>
<td>1920</td>
</tr>
<tr>
<td>Vilco 22</td>
<td>-</td>
<td>8877</td>
<td></td>
<td>Fishing vessel; BOEM #1030; USCG #5007</td>
<td>1992</td>
</tr>
<tr>
<td>William Bagley (USA)</td>
<td>1045</td>
<td>635</td>
<td></td>
<td>Merchant steam-sail</td>
<td>1863</td>
</tr>
</tbody>
</table>

Factors Affecting Vessel Preservation

Preservation of sunken watercraft depends mainly upon their composition and the extent of their burial in the seafloor. Vessels may become partially buried soon after sinking due to the combined effects of storm-induced current scour, liquefaction of sediments, and their weight pressing down on a waterlogged substrate. Ships made of metal are equally susceptible to burial as wooden hulls, but metal hulls remain exposed much longer than wooden ones in saline waters along the Texas Coast. Exposed wooden components tend to disintegrate quickly where wood-boring organisms thrive. Biological organisms and
water saturation weaken the wood, which is then more easily disarticulated and laid flat or removed by fishing trawlers and storm waves. Burial promotes long-term preservation of wood by creating an oxygen-deprived environment, which limits biological activity. Given a sufficient quantity of weakly-consolidated sediment, a significant portion of a hull might become preserved in this manner.

Iron corrodes five times faster in seawater than when buried on land. Iron artifacts tend to become concreted when calcium carbonate from the seawater cements adjacent materials, such as rock and sand, or even other artifacts, to the iron object. Prolonged oxidation can leach out most or all iron mineral, leaving only a carbonate mold of the original artifact (Hamilton 1998). Iron and steel hulls, nevertheless, can survive seawater exposure for well over a century.

Previous Investigations
There are 11 marine archaeological surveys reported within 3 miles of the APE (Table 2). Most of those investigations were sponsored by the USACE in connection with harbor improvement projects. The earliest project in the vicinity was an investigation of the steamship Mary, Site 41NU252, which sank in Aransas Pass in 1876. Espey, Huston & Associates, Inc. conducted a remote-sensing survey and archaeological dive investigations under Texas Antiquities Permit No. 858, on behalf of the USACE, to assess the site’s condition and historic potential. Their field study and subsequent historical research concluded that the wreck is eligible for the NRHP (Hoyt 1990).

Table 2: Previous Marine Investigations Within 3 Miles of the APE

<table>
<thead>
<tr>
<th>Antiquities Permit</th>
<th>Principal Investigator</th>
<th>Investigating Firm</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>858</td>
<td>Steven Hoyt</td>
<td>Espey, Huston &amp; Associates, Inc.</td>
<td>Hoyt 1990</td>
</tr>
<tr>
<td>1543</td>
<td>Charles Pearson</td>
<td>Coastal Environments, Inc.</td>
<td>Pearson and Simmons 1994</td>
</tr>
<tr>
<td></td>
<td>Allen Saltus</td>
<td>Eric G. Ryals, Inc.</td>
<td>Saltus and El D’Arragi 2003a</td>
</tr>
<tr>
<td>7014</td>
<td>Layne Hedrick</td>
<td>PBS&amp;J</td>
<td>Hedrick 2001</td>
</tr>
</tbody>
</table>

The USACE sponsored a remote-sensing survey and diver assessment along three segments of the Corpus Christi Ship Channel in 1991. The work was performed by Coastal Environments, Inc., and Panamerican Consultants, Inc., under Texas Antiquities Permit No. 1008 (James and Pearson 1991). Their survey discovered 130 geophysical targets, 11 of which were recommended for diving. Five targets were investigated by divers. Four targets proved to be modern debris. The fifth target, near the end of the south jetty remained unidentified but was believed potentially significant. Further investigations were recommended for that target, as well as the six targets that were not visited by divers, in the event that any of them would be affected by dredging.
Coastal Environments, Inc. conducted remote-sensing and diver investigations on 7 geophysical targets recommended by James and Pearson (1991) for further study. With one exception, these were targets that had not been previously assessed. Their study also included data recovery on the steamship *Mary*, which had been recommended by Hoyt (1990) as eligible for the NRHP. This work was sponsored by the USACE and performed under Texas Antiquities Permit No. 1261 (Pearson, et al. 1995). Six of the targets were determined to lack historic significance. A seventh target, near the end of the south jetty, was revisited and was recorded as archaeological site 41NU264. The wreckage was suspected to be remains of a World War I-era steamer, named *Utina*, that wrecked on the end of the south jetty in 1920. *Utina* was built by the Emergency Fleet Corporation as a freighter but had been converted to a barge before it wrecked.

Coastal Environments, Inc. performed a marine remote-sensing survey in 1994 along a 45-mile segment of the Gulf Intracoastal Waterway between San Antonio Bay and Aransas Pass (Pearson and Simmons 1994). The study was conducted on behalf of the USACE, Galveston District in support of maintenance dredging operations. A total of 31 geophysical targets of interest were recorded by their survey, including the remains of two modern iron barges, associated with shell dredging activities. None of the targets in the corridor were recommended for avoidance. The remains of a World War II tanker, the *John Worthington*, were discovered just outside their project ROW but will not be affected by maintenance dredging.

Four overlapping pipeline projects were surveyed for the offshore oil and gas industry by Eric G. Ryals, Inc. (Saltus and D’Arragi 2003a, 2003b, 2005a, 2005b). The surveys were not conducted under Texas Antiquities Permits; thus, no reports are available on the THC Atlas. The projects were reviewed by BOEM.

PBS&J completed an extensive study of the Corpus Christi and La Quinta Ship Channels from 2000-2001 on behalf of the USACE (Enright, et al. 2003). Marine remote-sensing and archeological diving investigated areas potentially affected by expansion of both federal navigation channels. Geophysical survey of 5,610 acres discovered 13 potentially significant anomalies, which were further investigated by divers. One target was determined to be a historic shipwreck, believed to be the *Dayton* (designated 41NU291) a steamboat that sank as a result of a boiler explosion in 1845. A second intact shipwreck was discovered at the end of the south jetty, very near Site 41NU264, reported by Pearson, et al. (1995) as possibly the associated with *Utina*. The newly discovered site, designated 41NU292, has a largely intact hull. Its dimensions and position are consistent with those reported for *Utina*. The authors concluded that 41NU292 is, indeed, *Utina* and speculated that 41NU264 may be superstructure from *Utina* that was swept overboard by a storm.

In 2001, PBS&J completed a 294-acre geophysical investigation of a 3.5-mile corridor centered on Corpus Christi Bayou and the historic Morris and Cummings Cut in the northern half of Redfish Bay (Hedrick 2001). The study was conducted on behalf of Cabot Oil in connection with three USACE permit applications for proposed well pads and pipeline routes. Marine remote-sensing investigations included the collection and assessment of magnetic, side-scan sonar, and bathymetric data along 19 miles of survey transects.
Naismith Marine Services conducted geophysical survey of 62 acres proposed as a mooring facility along the eastern side of Lydia Ann Channel. Coastal Environments, Inc. participated in the survey and assessed the data to determine whether any significant historic properties would be affected by the piling installation (Pearson 2015). The survey recorded only one side-scan sonar target of interest, bearing resemblance to a small boat. The target was examined by divers and by probing and determined to be a bottom feature produced by barges pushing into the channel bottom. No significant cultural resources were recommended for avoidance.

III. Research Design

Survey Methods

The purpose of the survey was to map geophysical anomalies that might indicate the presence of historically-significant, submerged archaeological sites. Submerged archaeological sites, in this context, might be historic sites, such as sunken or abandoned watercraft; or drowned terrestrial prehistoric sites dating to the late Pleistocene or Early Holocene when the APE was last above sea level. The primary instrument for locating areas with potential for preservation of drowned prehistoric sites is the acoustic sub-bottom profiler. The search for submerged prehistoric sites focuses on the use of sub-bottom profiling to discover geomorphic features, such as buried stream channels, that tend to be associated with prehistoric sites on land. Stream dissections of ancient land surfaces, known as paleo-channels, are considered areas of heightened potential for preservation of submerged, prehistoric archaeological remains.

The primary instrument for locating submerged watercraft in buried contexts is the magnetometer. Exposed shipwrecks are most easily recognized in side-scan sonar imagery; however, historic wrecks in Texas bays and shallow areas in the Gulf of Mexico are more often buried. Vessels predating World War II tend to be constructed of wood, which quickly deteriorates when exposed to wood-loving organisms, common to warm saline environments. Nevertheless, buried wooden hulls can retain a high level of artifact preservation and historic integrity. Wrecks exposed above the mudline for more than a few years tend to be constructed of materials other than wood.

Geophysical survey of the APE was designed to meet or exceed the following minimum standards of the THC for archaeological survey of state-owned submerged lands (Texas Administrative Code, Title 13, Part 2, Chapter 28, Rule 28.6): 1) the survey must be conducted under a Texas Antiquities Permit issued by the THC; 2) the survey line interval cannot exceed 20 meters (30 meters when greater than 3 nautical miles offshore); 3) bottom-disturbing activities must be avoided within 50 meters of potentially significant targets (150 meters when more than 3 nautical miles offshore); 3) the survey area must extend beyond the limits of bottom-disturbing activities by the width of the avoidance margin; 4) survey instrumentation must include a marine magnetometer, a high-resolution side-scan sonar, and a recording fathometer all of which must record data digitally to electronic storage media; 5) survey instrumentation should be interfaced with a positioning system having accuracy comparable or better than a differential GPS receiver; 6) the magnetometer must be towed within 6 meters of the marine bed and should sample at least once per second; 7) the side-scan sonar should operate at a minimum frequency of 300 kilo-Hertz.
(kHz); 8) the positioning system should sample at least once per second; and 9) no artifact collection is permitted. This study also meets or exceeds archaeological survey requirements published by BOEM in Notice to Lessees 2005-G07.

A 2,000-ft-wide corridor, centered on the ROW and including the proposed lay barge anchorage, was surveyed Offshore. A 1,000-ft-wide corridor was surveyed Inshore. The APE totals 7,174 acres, including 3,079 acres in federal waters and 4,095 acres in state waters. The portion of the APE in state waters totals 288 acres Inshore and 3,807 acres Offshore in the Gulf of Mexico. The Offshore Survey spans portions of 5 Federal Lease Blocks (MI-695, MI-696, MI-697, MI-698, and MI-699) in the Matagorda Island Lease Area, and 16 State Mineral Lease Tracts (693, 694, 695 [same as MI-695], 721, 836, 837, 838, 839, 844, 845, 846, 847, 848, 849, 850, and 851). The Inshore Survey includes portions of 5 State Mineral Lease Tracts (Tracts 309, 310, 313, 314 in Corpus Christi Bay and Tract 306 in Aransas Bay). Water depth ranges from 2-30 ft Inshore and from 0-92 ft Offshore.

Geophysical survey of submerged areas was completed by Naismith Marine Services, Inc. Appendices A and B contain their survey reports for Offshore and Inshore areas, respectively. Appendix C contains a roster of field personnel and a summary of survey equipment and procedures. The archaeological field crew, responsible for monitoring all data acquisitions in state waters, included Robert Gearhart (Principal Investigator) and Ed Baxter, RPA of Edward Baxter Consulting.

A variety of vessels and equipment were used to conduct the marine survey, depending on the water depths. Navigable Inshore areas and the surf approach, from 6-20 ft deep, were surveyed from a 26-ft Glacier Bay catamaran and a 21-ft Dory. Offshore data was acquired from a 65x19.5-ft trawler, Peggy Ann (Appendix A, Figure 3.1), in waters greater than 20 ft deep.

Vector data, including sensor positions, bathymetry and magnetometer, were logged in Hypack navigation software. Raster data, including side-scan sonar and sub-bottom profiles, were logged in Edgetech’s Discover software. Geographic positions were acquired using a Trimble Model R8, RTK, GPS. Single-beam bathymetry data were acquired using a Teledyne-Odom Echotrac CVM recording fathometer equipped with a 200-kHz transducer. Multi-beam bathymetry data were acquired in federal waters using an Odom MB2 system operating at 200 kHz. Sound velocity profiles were used to calibrate the echo sounders.

A Geometrics 882 magnetometer, equipped with an altimeter and depth sensor was towed within 20 ft of the seafloor. The sensor was towed a minimum of 100 ft behind the Offshore survey vessel to minimize interference. The layback distance was adjusted for different ranges of water depth to keep the sensor close to the seafloor. Archaeologists monitored altimeter readings to ensure the sensor height was no greater than 20 ft. The magnetometer was towed on the sea surface Inshore.

Side-scan sonar data was acquired Offshore, beyond the surf zone, using an Edgetech 4200 system operating at a minimum frequency of 400 kHz. A smaller, Edgetech 4125 system was used for portions of the Inshore survey. Geographic positions were embedded in the digital sonar data as it was recorded.
Sonar range was adjusted to ensure sufficient overlap with adjacent swaths. Chesapeake SonarWiz software was used to combine sonar data from each transect into a composite sonar mosaic. Sub-bottom profiles were recorded Offshore (only), in waters greater than about 20 ft deep, using an EdgeTech 3100 system operating an SB-424 towfish at a frequency range of 4-24 kHz. Sub-bottom data was charted and analyzed by GMT and is reported in Appendix A.

**Interpretation of Magnetometer Data**

Low-frequency fluctuations in magnetic data caused, for example, by diurnal passage of the sun or by geologic gradients were removed, prior to contouring, using a filter algorithm. The algorithm treats short-term fluctuations, exceeding a selected threshold amplitude (0.5 nanoTesla [nT]), as anomalous values. The result is a dataset in which abnormally high and low magnetic amplitudes (anomalies) are centered around zero (representing the ambient level). All amplitude shifts, smaller than the threshold value, are reduced to near zero and are treated as ambient background. This process removes low frequency data, leaving potentially significant anomalies intact, and allows a visual representation of anomaly polarity.

Magnetometer data illustrated in this report have been thinned to a 1-second interval between data points. Diurnally-corrected magnetometer data was contoured using Blue Marble’s Global Mapper® software (Version 17.2) at a 5-nT contour interval. Magnetic amplitudes between +5 nT and −5 nT are considered insignificant. Contour maps omit the 0-nT contour level to prevent a cluttered appearance. Positive amplitude is indicated by red contours, and negative amplitude is drawn as blue contours.

Most magnetic anomalies in marine environments are caused by relatively small pieces of ferromagnetic debris, which tends to concentrate near high-traffic areas, marine disposal areas, industrial developments, petroleum wells, and pipelines. The frequency of ferromagnetic debris far outnumbers shipwrecks, necessitating some means for distinguishing between the two when conducting archaeological assessments. The method used here is based primarily upon a study by Gearhart (2011b) that compared shipwreck and debris anomalies. Gearhart has analyzed magnetic data from a large and diverse collection of anomaly sources, including 39 verified shipwrecks (Gearhart 2011b, 2016) and many debris sources with the goal of characterizing differences between these two categories of magnetic sources. Shipwrecks in his dataset represent a broad spectrum of material compositions, construction styles, ages, and archaeological contexts. Their hulls include construction from wood, iron, steel, and concrete. Their propulsion systems range from sail to steam-driven paddlewheels and propellers, and from oil and diesel screws to towed or pushed barges. They range in age from the mid-16th to the mid-20th century. They have been found in diverse depositional environments including harbor entrances, surf zones, beaches, marsh, oyster reefs, open bay waters, and the Gulf of Mexico. And this assortment of watercraft found their way to the seafloor in various ways including stranding on beaches, foundering at sea, by fire, by explosions (both accidental and intentional), and by abandonment. Some were partially demolished or salvaged after wrecking. Others remain largely untouched since the day they sank. Yet despite their many differences, they share common characteristics, which form the basis for this interpretative method.

**Amplitude**

Anomaly amplitude correlates poorly with horizontal dimensions of a magnetic source, because amplitude depends greatly upon the mass of the source and the distance between the magnetometer and the
source. Small sources can produce large amplitude when measured at close range. Shipwreck anomalies from Gearhart (2011b) have average peak-to-peak amplitudes of 270 nT for wood-hulled sailing vessels (n=6); 5,020 nT for wood-hulled machine-powered vessels (n=7); and 10,386 nT for iron- and steel-hulled vessels (n=12). Magnetic debris can produce amplitudes virtually anywhere within that same range, thus amplitude is of little use for differentiating shipwrecks from debris.

**Complexity**

Archaeologists frequently have described shipwreck anomalies as appearing “multicomponent” or “complex”, while anomalies having simple, monopolar or dipolar shapes often were attributed to debris. Garrison, et al. (1989: II, 223) summarized several common methods for prioritizing anomalies with a focus on complexity. Shipwreck anomalies were characterized as having: multiple peaks of differing magnitudes spread over an area greater than 10,000 square meters (2.5 acres); gentle gradients; and a linear association with anomalies on adjacent transects. A typical debris anomaly was characterized as having a single peak covering an area of less than 10,000 square meters, a steep gradient, and no alignment of anomalies on adjacent lines.

Some early observations of complexity in wreck anomalies pre-dated computer contouring software. One or more peaks were observed on each transect crossing a single anomaly, but the spatial relationships between those peaks were not apparent. This problem was compounded by the lower accuracy of positioning systems prior to GPS. Thus, even a simple dipole might appear more complex than it really was. Earlier magnetometer technology also might have contributed to the perception of complexity. Proton precession systems tended to produce false noise spikes in the presence of high magnetic gradients, which could be interpreted as complex patterns of amplitude peaks where none existed.

The collection of 39 anomalies from verified shipwrecks reported by Gearhart (2011b and 2016) indicate, contrary to earlier models, that shipwreck anomalies (in mid-northern latitudes) tend to be dominated by a single main dipole, oriented approximately in line with magnetic north (Figure 5, for example; also see “Orientation” below). In fact, most debris anomalies also tend toward simple, dipolar shapes, while some shipwreck anomalies have more than two amplitude peaks. The concept of complexity is insufficient, by itself, to differentiate shipwrecks from debris anomalies; although, this fact does not lessen the need to correct any remaining misconceptions that shipwreck anomalies are typically complex and debris anomalies are not. The truth is more complicated than that simple dichotomy.

Many wreck anomalies also have secondary amplitude peaks, in addition to their main, north-south-aligned dipole. Secondary peaks typically have lower amplitude than the main dipole and cover a smaller area than the main dipole peaks in all examples known to this author. Secondary peaks can be caused in two ways. The combined mass of the wreck either induces secondary peaks, or they are directly associated with individual ferromagnetic sources in a debris field.
Figure 5
Example of a Verified Shipwreck Anomaly
Site 41CL92
Secondary peaks can be induced by the magnetic field lines emanating from wreckage. In mid-northern latitudes, a smaller peak sometimes occurs immediately north or south of, and in line with, the main dipole (e.g., peaks labelled “A” in Figures 6, 7, and 8). Amplitude peaks of this nature are not necessarily located over an anomaly source and may not indicate the presence of widely-scattered wreckage. Rather they seem to be induced by a source of relatively high mass, such as a ferrous hull. In such cases, magnetic lines-of-force can loop so far to the north and/or south of a source that, respectively, they reinforce or diminish (i.e., are anomalous to) earth’s field. The result is a small positive peak to the north and, occasionally, a smaller negative peak to the south of the main dipole. They will always have polarity opposite the adjoining peak of the main dipole. Such peaks are fairly symmetrical about an anomaly’s north-south axis and will not overlap its main dipole. The inflection point between an induced secondary peak and the main dipole occurs where the anomaly’s lines of magnetic force are perpendicular to earth’s lines of force.

Other secondary peaks may be directly caused by relatively large, individual magnetic sources within or near a hull or debris field. If such a mass is sufficiently large, its anomaly might not be completely cancelled by neighboring sources, allowing it to stand out. A similar effect may be observed if a magnetometer passes sufficiently close to a complex source, such as a shipwreck, so that some large-mass sources, are individually expressed against the background of the main dipole field. Such debris-centric, secondary peaks should have random orientations and positions, with respect to the main dipole, since they are directly caused by randomly-positioned objects within a debris field. They may overlie and disrupt the symmetry of the primary north-south dipole (e.g., peaks labelled “B” in Figures 6 and 8).

**Horizontal Dimensions**

Anomaly width, or duration as preferred by some, is a common and valid measure used by archaeologists for discriminating potential shipwreck anomalies from those believed more likely caused by debris. For example, Linden and Pearson (2014) would consider an anomaly significant if it has amplitude of at least 50 nT and a width of 65 ft or more. The horizontal dimensions of shipwreck and debris anomalies overlap considerably, especially when considering wrecks with wooden hulls, thus width alone is not particularly useful for discriminating between the two. There is a 15-fold difference in width between the smallest wood-hulled sailing ship and the largest steel tanker, so large wrecks tend to be obvious. Unfortunately, small, wooden watercraft, even many steamboats, tend to have anomalies no wider than many debris anomalies.
Small shipwreck anomalies cannot be distinguished from debris anomalies based on size alone. All wooden-sailing-ship anomalies and all but one wooden-steamboat anomaly known to this author are smaller than 10,000 square meters, Garrison, et al.’s (1989: II, 223) minimum suggested size for typical shipwreck anomalies. Site 41CL92 (Figure 5), for example, covers an area of only 1,580 square meters (0.4 acres) out to the 5-nT contour. Small, wooden, and generally historic, shipwrecks are the most difficult sites to detect precisely because their anomalies overlap in size with many debris anomalies.

The smallest wreck, although not the smallest anomaly, in Gearhart’s anomaly dataset, Mag-13 (Figure 9), is a wooden hull buried 2-10 ft below the seafloor. The hull measures roughly 35 x 13 ft, based on diver probes (Gearhart 2016). The Mag-13 anomaly measures 197 x 164 ft (60 x 50 m) across. Site 41CL92 (Figure 5), although having larger site dimensions, has the smallest verified wreck anomaly known to this author, measuring 176 x 155 ft (53.6 x 47.2 m) to the 5-nT contour. Divers identified Site 41CL92 as an early 19th-century sailing vessel containing a large collection of concreted artifacts, iron bar stock, and pig iron ballast but with no hull remaining (Borgens 2004). Its debris field measures 52 x 23 ft (15.9 x 7 m) across.

The 41CL92 anomaly is smaller than the Mag-13 anomaly, even though the 41CL92 site dimensions are larger. Its smaller magnetic footprint might be due to its disarticulated nature, whereas the Mag-13 site appears to have an intact hull. The higher entropy of a disarticulated wreck, in theory, should result in a lower peak amplitude and a smaller magnetic footprint, all other things being equal, than if the same wreck were an intact hull. Unfortunately, the original hull dimensions of 41CL92 are unknown. Although it represents the smallest anomaly known to date for a disarticulated wooden wreck, smaller examples likely exist. A realistic lower limit for the dimensions of a significant anomaly remains open for debate.

The smallest likely size of historic commercial watercraft in the Gulf Coast trade can be determined through research. For example, the average size of wooden sailing vessels registered in the Port of New Orleans during the period 1804-1820 was 71 x 21 ft (21.6 x 6.4 m) (based on Works Progress [1941] as summarized in Ford et al. 2008: 54-71). The smallest vessel registered in New Orleans during the same period was the schooner Tickler, which measured only 29 x 10 ft (8.8 x 3.0 m) (Works Progress Administration 1941: 127), roughly 81 percent the size of the Mag-13 hull.

It seems reasonable, based on comparison with the Mag-13 wreck, that an intact wooden vessel as small as Tickler might have an anomaly measuring as much as 81 percent smaller than the Mag-13 anomaly, that is to say 160 x 133 ft (48.8 x 40.5 m) across, or an average diameter of 147 ft. The 41CL92 anomaly,
the smallest verified wreck anomaly known to this author, measures 92 percent smaller than the Mag-13 wreck anomaly, possibly because the site is disarticulated. To be conservative, the hypothetical anomaly size for *Tickler*, likewise, has been adjusted downward by 92 percent, yielding an estimate of 147 x 122 ft (44.8 x 37.2 m), or an average diameter of 135 ft (41.1 m). This author, therefore, will consider dipoles potentially significant if they align with magnetic north and have a minimum horizontal dimension of at least 135 ft (41.1 m), which is 81 percent smaller than the 41CL92 anomaly.

**Orientation**

Shipwreck anomalies (e.g., Figures 5, 6, 8, and 9) consistently share a common orientation with respect to earth’s magnetic field, despite the great diversity of wrecks described above. All wreck anomalies observed by this author, to date, are oriented with their primary negative pole situated north of their positive pole. The local direction of magnetic north agrees, on average, within +/- 10 degrees of the dipole alignment for 29 verified wreck anomalies, reported in Gearhart (2011b). The maximum reported difference between dipole alignment and magnetic north direction was 26 degrees. A similar orientation is expected of all wrecks, as well as all other complex anomaly sources, in mid-latitudes of the northern hemisphere; however, the orientation of anomalies over simple debris sources is not limited.

![Figure 8: 41CH372 Anomaly (steel hull), 5-nT contour interval](image-url)
Shipwrecks, and other complex sources, have anomalies closely aligned to the direction of magnetic north. This phenomenon is believed due to the random orientations of many individual magnetic components that make up each complex source, including shipwrecks. The magnetic field of each component interacts with that of its neighbors. The overlapping portions of fields that oppose one another in direction tend to cancel, while lines of force that run in the same general direction reinforce each other. Since a small portion of each field is aligned with (induced by) earth’s local field, the net result of all these interactions is that more reinforcement occurs in the direction of magnetic north than in any other direction, resulting in a north-aligned anomaly. A simple debris source, on the other hand, is a solitary object on the seabed. By definition, there are no nearby sources affecting its magnetic field, thus the alignment of its anomaly is determined not by earth’s magnetic field direction but by the object’s orientation on the seabed. Hence debris anomalies can be oriented along any point of the compass.

Figure 9: Mag-13 Wreck Anomaly (wooden hull) 5-nT contour interval (Gearhart 2016: 46)

Orientation can differentiate magnetic anomalies caused by most simple debris sources from anomalies caused by complex sources, including shipwrecks, and has potential to eliminate close to 80 percent of debris anomalies from further archaeological concern. Roughly 20 percent of simple debris sources have northerly orientations like those observed over complex sources. Absent a sonar target, there is no
reliable method known, short of physically probing an anomaly, to differentiate that 20 percent of debris having northerly orientations from complex sources, including potential buried shipwrecks.

Anomalies can be eliminated from consideration as potential shipwrecks by demonstrating that their orientations differ substantially from the direction of magnetic north. It seems unlikely that a shipwreck could have a magnetic anomaly that is not aligned closely with magnetic north, as this would require a large percentage of the wreck’s many ferromagnetic components, by chance, to have the same magnetic moment. On the other hand, the anomaly of a simple debris source should align with earth’s magnetic field only when its magnetic moment, as determined by the source’s orientation on the seafloor, closely aligns with magnetic north.

The interpretation of magnetic anomalies based on orientation requires comparing unidentified magnetic anomalies, contoured at a 5-nT interval, to the anomaly of a small, verified wreck anomaly, such as 41CL92, shown in Figure 5. One must ensure that the reference anomaly is contoured, oriented and scaled using the same parameters as the survey data to which it is compared. Anomalies having a polar orientation similar to that of 41CL92 should be considered possible shipwrecks unless contradicted by other information, such as reliable evidence of an abandoned petroleum well nearby, as anomalies over steel well casings often closely resemble shipwreck anomalies. Information regarding petroleum infrastructure is available on the Texas Railroad Commission Public GIS Viewer to rule out association with wells.

**Significance Criteria**

BOB’s minimum criteria for archaeological assessment of magnetic anomalies (in mid-latitudes of the northern hemisphere) requires that a significant anomaly, surveyed at 20-meter intervals, be consistent with the following conditions: a) it must have at least one dipole, oriented with its negative pole north of its positive pole; b) it should be at least 135 ft (41.1 m) across (to the +/− 5-nT contour); and c) it should appear on a minimum of 2 transects. If survey lines are spaced at 10-meter intervals, a significant anomaly should meet all of the above conditions and d) should appear on at least 4 transects. An anomaly’s shape usually is not obvious if data is from a single survey transect; thus, additional criteria have been designed to avoid missing significant targets. If survey lines are spaced at 30-meter intervals, a significant anomaly e) may be limited to a single transect; and f) may appear as a monopole, provided the transect follows a predominantly east-west heading. Exceptions may be made in either direction, at the Principal Investigator’s discretion, based on mitigating circumstances or professional judgment. Resemblance to verified shipwreck anomalies, including the 39 reported by Gearhart (2011a, 2016), should be an important factor in such judgments when close-order survey has been conducted.

**IV. Results**

BOB Hydrographics, LLC conducted an archaeological assessment of all magnetometer and side-scan sonar data acquired by surveys of the Offshore and Inshore Areas. Only geophysical targets believed to be potentially associated with submerged archaeological sites are singled out for further discussion and illustration in the body of this report. A mosaic image of side-scan sonar data is illustrated in Appendix D. Archaeological assessment of the magnetometer survey is based on contoured data presented in
Appendix E. Detailed views of all sonar contacts from this project are included as Appendix F. Interpretation of seafloor geology was performed by GMT (2019), on behalf of Naismith, and is reproduced in this report as Appendix A. Appendix A includes GMT’s charts of bathymetry, seabed features, Holocene isopachs, shallow geologic features, and a sub-bottom profile of the entire offshore centerline (GMT’s appendices are not reproduced in Appendix A). The archaeological context of shallow geology, below, is based on GMT’s interpretation of sub-bottom profiles acquired by the Offshore survey.

**Side-Scan Sonar Targets**

Side-scan sonar data is illustrated as a mosaic in Appendix D. A total of 175 contacts were interpreted from the sonar data (Appendix F), including 140 Inshore and 35 Offshore. Their locations are overlaid in Appendices D and E. By far the greatest concentration of sonar contacts are along the Inshore channel crossings. Inshore areas will not be affected by this project, since pipes will be directionally drilled from dry land beneath all crossings. Nevertheless, the sonar data was examined for potential evidence of historic sites. The majority of Inshore targets are undoubtedly debris associated with construction and deterioration of bridges and breakwaters over many decades, although a few areas of interest are worth noting.

A linear cluster of 33 sonar contacts (Appendix F: contacts C-102 through C-137; except C-110, C-121 and C-126) is associated with a strong magnetic anomaly, which crosses the entire survey corridor along the deepest portion of the Lydia Ann Channel. The targets range in depth from 26-28 ft. Many of the individual contacts in this cluster are large objects with at least one dimension in the 10-ft to 30-ft size range. These structures are interpreted as possible remains of a collapsed bulkhead, based on a combination of their sizes and a curious alignment of the pattern with the channel margin as charted in 1934 chart (Figure 10; shaded ellipse on the right). Another group of sonar contacts (Appendix F: contacts C-93 through C-99) may be associated with a former bulkhead along the Aransas Pass Channel where pilings were charted in 1934 (Figure 10; shaded ellipse on the left).

The majority of Offshore sonar contacts are small, unidentified debris clustered around petroleum infrastructure, including both abandoned wells and existing pipelines. Offshore sonar data included two potentially significant targets (Appendix F: contacts S2-0101 and C-143). Contact S2-0101 (Figure 11) is believed to be, at least, part of a wreck and may potentially be of historic age (older than 50 years). Contact C-143 (Figure 12) is clearly a wreck, designated Site 41AS119, and is believed to be of historic age.

**Magnetic Anomalies**

Magnetic anomalies greater than +/- 5 nT are illustrated as contours in Appendix E. Inshore areas are shown on Sheets 1-4. Offshore state waters are included in Sheets 5-23. Offshore federal waters are shown in Sheets 23-38. Survey transects are overlaid on pre-planned lines. Information regarding petroleum infrastructure was obtained from the Texas Railroad Commission’s Public GIS Viewer. Seven unidentified anomalies, designated Anomalies 1-7, met criteria for significance. Three of those targets, Anomalies 1-3, were retained as significant following the close-order survey.

**Petroleum Infrastructure**

Three wells and two pipelines correlate with magnetic anomalies mapped by the geophysical survey. One well lies about 70 ft outside of the survey corridor in Block 721, but is close enough for the magnetometer.
A natural gas pipeline, operated by the Crescent Pipeline Partnership, crosses the survey corridor along a north-south alignment in Block 721 (Appendix E, Sheet 10). A second pipeline, belonging to XTO Offshore, crosses the survey corridor in Block 837 (Appendix E, Sheet 13). A well, classified as a "dry hole" by the Texas Railroad Commission, is associated with a large magnetic anomaly in Block 693, indicating the presence of steel casing in the well (Appendix E, Sheet 17). An Apache platform was abandoned and removed from Block 696 in 2012 near the northern edge of the survey corridor (Appendix E, Sheet 27). Six wells were directionally drilled from the platform over its service life; although, only surface locations can be expected to show up in a magnetometer survey. A patch of material, observed on sonar records over this location, was interpreted by GMT (2019) as a possible tar mound.

Figure 10: Possible Sources of Sonar Contacts (in filled ellipses; USCGS 1934)

Figure 11: Anomaly 1 Sonar Target (Contact S2-0101)
Anomalies Meeting Significance Criteria

Seven unidentified magnetic anomalies initially met the significance criteria defined in Section III above. These are designated Anomaly 1 through Anomaly 7. Close-order survey was performed on 10-meter transect intervals on all 7 anomalies to improve their resolution. Following close-order survey, three targets, Anomalies 1-3, were recommended for archaeological avoidance. Additional research confirmed that Anomaly 4 is caused by an abandoned well. Anomalies 5-7 were judged, on closer examination, to lack significance. Each of these anomalies is illustrated below alongside the Site 41CL92 anomaly (see Figure 5), the smallest verified wreck anomaly known to this author. The two anomalies in each comparison are shown at the same scale (except Anomalies 2 and 4 as labelled) and orientation.

Anomaly 1 (Figure 13; Appendix E, Sheet 26) is interpreted as a possible wreck, partially exposed, based largely on its sonar target (Contact S2-0101 in Figure 11 and Appendix F). The magnetic anomaly lacks a broad negative pole on its northern side, as would be expected for a complex source, such as a wreck, yet the sonar image strongly suggests a complex source comprised of many individual components. The sonar target measures 31 x 36 ft and 2.2 ft above the seafloor, so if it is a wreck, it may have additional structure buried beneath the mudline. A group of much smaller targets extends northeastward of Contact S2-0101. Taken as a group, this debris field is about 130 ft long. The seafloor in this area consists of weakly-consolidated Holocene sediments, at least 35 ft thick, so partial burial of wreckage would be expected. Scour caused by strong, surging currents beneath large storm waves, would facilitate burial of structures at this water depth. While the magnetic data is not entirely supportive, Anomaly 1 is considered a potential wreck site that should be avoided.
The fishing vessel, *Captain Charles Griffin*, sank in 1986 about 0.3 miles from this target (Table 1). The accuracy of its charted position is uncertain; however, that boat, or displaced superstructure such as mast and/or outriggers, should be considered a possible candidate to explain this target. The captain of the survey vessel for this project, a long-time resident and local shrimp fisherman, reported that this target is a known shrimping hang to be avoided when trawling. He is of the opinion that this target might be the remains of a shrimp trawler lost by his uncle in this approximate area. It’s unclear to this author whether his uncle’s boat and the *Captain Charles Griffin* are the same vessel.

Anomaly 2 (Figure 14; Appendix E, Sheet 5) is associated with a sunken watercraft, designated as Site 41AS119 (Appendix I), which is exposed above the seafloor and was observed on sonar imagery (Figure 12). Its position correlates closely with THC Wreck 1528, an unidentified wreck charted on the 1900 edition of USCGS Chart 209. Wreck 1528 predates February 1900 and postdates the 1884 edition of the same chart. THC Wreck 1528 is considered the most likely candidate to explain Anomaly 2 and Contact C-143. Portions of this wreck, visible on sonar imagery, measure 136 ft long and 34 ft wide. One end appears to be broken, so the actual length was probably slightly longer. This wreck is believed to be of historic age and should be avoided. Fortunately, it is located along a section of the project alignment where pipes will be directionally drilled, so no negative effects are anticipated.

Anomaly 3 (Figure 15; Appendix E, Sheet 5) closely resembles the 41CL92 anomaly and is interpreted as a potential historic shipwreck. The anomaly is associated with two small sonar contacts, C-141 and C-142 (Appendix F). Neither sonar contact would be of interest if not associated with this anomaly. Their appearance does not contribute to identifying the source of Anomaly 3, but their presence suggests that the source might be, at least, partially exposed on the seafloor. Anomaly 3 also correlates closely with THC Wreck 1528.

Anomaly 4 (Figure 16; Appendix E, Sheet 17) was suspected of being an abandoned petroleum well prior to conducting a close-order survey; however, there was no corroborating evidence to prove the case. Well anomalies appear similar to anomalies over iron- and steel-hulled wrecks, so close-order survey was conducted to provide additional evidence before making a final recommendation. Additional research discovered a record of a well having been drilled and abandoned at the location shown in Figure 16, so Anomaly 4 has been removed from further consideration.

Anomaly 5 (Figure 17; Appendix E, Sheet 18) was initially observed on two transects as a relatively narrow dipole; however, the orientation of the dipole and the lack of data between the poles left open a possibility that the anomaly might be larger and could actually resemble the 41CL92 reference anomaly. Close-order data revealed just the opposite case. The two poles now appear almost completely disassociated. Anomaly 5 does not closely resemble any verified wreck anomalies and has been removed from further consideration.

Anomaly 6 (Figure 18; Appendix E, Sheet 35) and Anomaly 7 (Figure 19; Appendix E, Sheet 36) are somewhat similar to one another, but neither closely resembles verified wreck anomalies. Both anomalies are quite asymmetrical in comparison with verified wreck anomalies, which tend to have simpler, more symmetrical dipoles, similar to the 41CL92 anomaly. These two anomalies are more likely caused by a
small number of discrete magnetic sources, perhaps only two or three, randomly lying close to one another. Neither anomaly is considered significant and both are removed from further consideration.

**Shallow Geology**

The Beaumont Formation, a Pleistocene layer of sediments predating about 80,000 BP, was observed beneath most of the survey corridor and presumably occurs below the entire survey area. GMT (2019) interpreted a broad exposure of the Beaumont Formation at the seafloor, extending from 31 ft deep at the base of the San Jose Island shoreface, to 46 ft deep at the start of Holocene marine deposits associated with the TMB. The Beaumont Formation extends shoreward of this exposure beneath San Jose Island, although it quickly disappeared from sub-bottom profiles beneath shoreface sand deposits. Side-scan sonar shoreward of the 31-ft isobath shows uniform reflectivity associated with shoreface sand deposits leading up to San Jose Island.

The Beaumont continues seaward from the 46-ft isobath as a buried Pleistocene/Holocene unconformity (top of the Beaumont Formation) out to, at least, the 65-ft isobath where its buried 35 ft below the seafloor. The Beaumont is capped, seaward of the 46-ft isobar, by under-consolidated layers of Holocene sand and mud, deposited in a marine environment during the most recent transgression. Seaward of the 70-ft isobath, sub-bottom penetration was limited to about 40 ft and could no longer image the top of the Beaumont Formation.

The top of the Beaumont Formation, where it could be seen, is incised by numerous, relict, distributary channels. These occur both where the formation is exposed and where it is buried by up to 35 ft of Holocene marine deposits. Bathymetry over the Beaumont exposure has a hummocky relief, varying in depth over relatively short distances by up to 2 ft. Higher areas are interpreted as remnants of a resistant clay layer that was desiccated and hardened by exposure to subaerial conditions during a Pleistocene period of lower sea level. Low-lying areas are interpreted as less-consolidated fill within the distributary channels. Side-scan sonar of the Beaumont exposure shows irregular patches of variable reflectivity, consistent with laterally discontinuous sediments (GMT 2019). Shades of darker and lighter sonar returns are due to combinations of sediment consolidation, grain size, and the angle of seafloor slope relative to the arrival direction of the sonar’s acoustic pulses. Remnants of seasonal sand migration may contribute to the acoustic contrast by filling low-relief areas where finer-grained channel fill is more highly eroded.

These channels were incised when the Beaumont geologic unit was formed, prior to about 80,000 years ago, and well before the earliest known evidence for humans in the region. Nevertheless, the top of the Beaumont Formation, including remnants of the most recent channels, was exposed above sea level during the Paleo-Indian Period and roughly the first half of the Archaic Period before being flooded by rising seas. Channel remnants would have filled with estuarine sediments and/or reworked Beaumont Formation materials during the Holocene rise of sea level. Any archaeological sites once associated with this unconformity would have had little protection from wave energy during sea-level rise and are presumed to have been destroyed by waves and currents, in the same manner that active erosion between the 31-ft and 46-ft isobaths continues to reshape the top of the Beaumont Formation today.
Figure 14: Anomaly 2 (5-nT contour interval)
Figure 15: Anomaly 3 (5-nT contour interval)
Recommendations

Three geophysical targets are recommended for avoidance. These include: Sonar Contact S2-0101/Anomaly 1 (figures 11 and 13; Appendix E, Sheet 26), Anomaly 2/Sonar Contact C-143/Anomaly 2 (figures 12 and 14; Appendix E, Sheet 5), and Anomaly 3 (Figure 15; Appendix E, Sheet 5). Anomaly 1 is located in Federal waters, thus if historically significant might qualify for the NRHP. Anomalies 2 and 3 are both in Texas waters, thus might meet criteria for State Antiquities Landmark and/or NRHP eligibility. Anomaly 1 will not be directly affected by pipeline trenching but could be disturbed by anchorage of pipe laying vessels. Anomalies 2 and 3 will not be directly affected by pipeline construction, because the pipes will be directionally drilled, at least, 39-42 ft beneath the seafloor where they pass these two anomalies.

BOB recommends cultural resource clearance for the APE, except for avoidance buffers around Anomalies 1-3. The avoidance buffers extend outward 150 meters (492 ft) beyond the cluster of sonar contacts associated with Anomaly 1; 50 meters (164 ft) beyond the margins of Sonar Contact C-143, associated with Anomaly 2; and 50 meters (164 ft) beyond the -5-nT and +5-nT contours of Anomaly 3. Disturbance of the seafloor must be avoided within these avoidance buffers. Seafloor disturbances include, but are not limited to, dredging, trenching, anchoring, dragging anchor chains, laying pipe on the seafloor, use of barge spuds, and pile driving.

There is low potential for the presence of intact prehistoric sites in the Offshore APE. Remnants of Pleistocene-aged distributary channels, associated with deltaic conditions that created the Beaumont Formation, were exposed above sea level throughout most, perhaps all, of the survey corridor during the Paleo-Indian Period and for roughly the first half of the Archaic Period. The area was available for extended human use; however, any archaeological sites once associated with the top of the Beaumont Formation would have had little protection from wave energy during sea-level rise. Such sites, if ever present, are presumed to have been destroyed by waves and currents, in a similar manner as ongoing erosion affects the Beaumont exposure between the 31-ft and 46-ft isobaths. The energy of waves and wave-induced currents in this area is high during the winter season and is particularly severe during tropical storms. No archaeological investigation or avoidance of these deposits, for the purpose of protecting potential prehistoric sites, is recommended.

If shipwreck remains, or other potentially historic or archaeological materials, are discovered anywhere in the APE during construction, work should be halted immediately, and steps taken to ensure that the site is not disturbed. In state waters less than 3 nautical miles offshore, work must be halted within 50 meters (164 ft) of the find. In state waters greater than 3 nautical miles offshore, work must be halted within 150 meters (492 ft) of the find. Notify the State Marine Archaeologist at the THC immediately for further direction concerning the discovery. In federal waters, work must cease within 305 meters (1,000 ft) of the find. Contact BOEM’s Regional Supervisor of Leasing and Environment within 48 hours of the discovery for further instructions concerning the find.
V. References Cited


Corps of Engineers. 1846. *Map from Corpus Christi to Matagorda Bays, Texas*. Compiled under the direction of Captain Mansfield, Corps Engineers; delivered to Brig. Gen’l Zachary Taylor with Capt. Mansfield’s letter of 19th April 1846. Map image courtesy of The National Archives.


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Appendix A: Offshore Geophysical Survey Report
This is to certify that: The Geo-Marine Technology report referenced as OFFSHORE GEOPHYSICAL SURVEY REPORT

Entitled: Survey Report: Bluewater SPM Project

Dated: 4/9/2019

Has been checked and approved to meet the Geo-Marine Technology, Inc. standards designated for this publication, which has been revised according to the following schedule:

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Chief Surveyor and Principal
Naismith Marine Services

Job No.: 0_AransasOffshore_Naismith
Issue: Survey Report

Date: April 9, 2019
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1. INTRODUCTION

1.1. PROJECT OVERVIEW

Lloyd Engineering, Inc. (Lloyd) contracted Naismith Marine Services (Naismith) to organize and conduct a geophysical survey for offshore project components associated with the Bluewater SPM Project located in the Gulf of Mexico, adjacent to Aransas County, Texas. The proposed offshore pipeline infrastructure will extend eastward from the San Jose Island shoreline to a deepwater port approximately 25.5 mi to the east (Figure 1-1). Water depths for the project range from zero at the shore landing to 92 ft in the surveyed SPM area.

Survey operations commenced on January 4, 2019, and concluded on February 27, 2019. Naismith divided the corridor of the proposed route into discrete Sections, and shipped the data for each Section to Geo-Marine Technology, Inc. (GMT) as they were completed. Naismith contracted GMT to process and interpret the geophysical data, and to prepare the required report and charts. The information and results of surveys conducted for project components located west of San Jose Island are provided under a separate cover. The archaeological resource evaluation was performed by Robert Gearhart, and will be provided under a separate cover as well.

Figure 1-1  Location Map

The proposed route is shown in red, and the survey corridor in white. Source image: Zoom Earth for March 12, 2019.

Ten charts accompany this report. Although the coordinate system used for this report is State Plane Texas South Central NAD27 (Feet), the associated charts are plotted in State Plane Texas South Central NAD83 (Feet) for use in planning and engineering. Because BOEMR requires all coordinates in NAD27, the charting will need to be re-projected for BOEMR submission.
1.2. KEY PERSONNEL

Jim Naismith (RPLS, LSLS) and Seth Gambill were in technical charge of the survey. Mr. Naismith and Mr. Gambill specified all survey equipment, setup the survey lines, established shore-based control, and setup survey procedures and QA/QC processes specific to this survey project in advance of the start of surveying.

The survey vessel was rigged by Seth Gambill and Jake Pruiett. The field survey personnel included Jake Pruiett, Vincent Magni and Quintin Dobrenski. The boat captains for all surveys were Bo Reiter and Billie Reiter. Bob Gearhart and Ed Baxter provided oversight for cultural resource requirements imposed by the Texas Historical Commission. Jake Pruiett was the head field surveyor for the project, and was responsible for deployment, quality checks and ensuring proper functioning of field survey equipment.

All multibeam data were checked and processed by Jim Naismith. All side-scan sonar, magnetometer and single-beam echosounder data were checked by Seth Gambill. All single-beam echosounder data was processed by Seth Gambill.

John Rietman (PG/CPG) oversaw GMT’s data processing and interpretation; Steve Dodd, Josh Anderson and Denise Lockridge performed data processing; Beau Pallister (PG/CPG) and Eric Lavering (PG) collaborated on certain phases of interpretation, mapping and charting; and Matt Zunker (PG/CPG) coordinated the reporting.

1.3. REPORT PURPOSE

The purpose of the survey was to locate and identify potentially hazardous features and processes by ascertaining the bathymetric and geologic characteristics of the seabed within the corridor of the proposed pipeline route. These characteristics were recorded with geophysical systems (i.e. bathymetric echosounders, side-scan sonar, subbottom profiler, and magnetometer). This report summarizes survey operations, details data quality and processing, presents fully integrated interpretations of the survey data, and highlights potential hazards to the proposed pipeline route.
2. REGIONAL CONTEXT

The proposed route traverses the continental shelf off the coast of Texas on a course that strikes generally eastward from the coastline of San Jose Island. This region is home to unique physiographic features, geologic processes, and human impacts.

2.1. PHYSIOGRAPHY

2.1.1. Geography

San Jose Island, Harbor Island and Mustang Island are segments of a series of barrier islands that fringes the western boundary of the Gulf of Mexico from Galveston Bay, Texas to Laguna Tamiahua, Mexico. The origin of these islands is uncertain, but in the present day they protect the mainland coast from storms, and provide numerous habitats for coastal wildlife. The survey corridor for the proposed pipeline starts in Aransas County at the southern end of San Jose Island, approximately 1 mi to the north of the Aransas Pass segment of the Gulf Deep Water Access channel (Figure 2-1). Following an initial bend to the northeast, the survey corridor traverses the Texas Shelf on an eastward bearing for 25.5 mi before terminating at a water depth of approximately 92 ft.

Figure 2-1  Regional Geography

This image depicts the principal geographic features near the Aransas Pipeline Project.

2.1.2. Oceanography

Surface and bottom currents diverge throughout the year, but both trend generally westward (Berryhill and Trippet, 1981). While bottom currents tend to move at 0.1 kts year round, the speed of surface currents is variable. During the winter months, these currents generally flow to the WSW at 0.1-0.3 kts, and bottom currents flow to the SSW. Surface currents shift westward during the spring, and increase
to 0.2-0.3 kts, while bottom currents shift to the southwest. During the summer, surface currents shift to the WNW, and slow to 0.1-0.3 kts, and bottom currents shift westward. Finally, during the fall, surface currents shift to the southwest, and increase to 0.2-0.3 kts, while bottom currents shift to the WSW.

2.2. **GEOLOGY**

2.2.1 **Tectonic Setting**

The evolution of the Gulf of Mexico basin began with the breakup of Pangaea during Triassic-Jurassic time (210-163 Ma). Large tensional grabens emerged in the intracontinental rift zones, which ultimately delineated the boundaries of the North America, South America, and Africa tectonic plates. The Gulf basin emerged near the triple junction of these plates. Although it initially accumulated terrigenous and volcanic sediments, seawater from the Panthalassa Ocean (now the Pacific) eventually flooded in from the west. Subduction of the Cocos plate against the North American plate eventually gave rise to the spine of Central America, which effectively blocked the Pacific seaway to the west even as the Atlantic Ocean opened to the east.

Structurally, the Texas Shelf is offset by a series of shore-parallel fault zones. The survey corridor crosses the Frio Fault Zone in the west, and the Lunker Fault Zone near its eastern terminus (Ajiboye and Nagihara, 2012). Both of these zones are systems of late-Oligocene growth faults that tap the Oligocene Frio Formation, a well-known reservoir of oil and gas (Swanson, Karlsen and Valentine, 2013). Many of the well and platform locations reported in this area are along or seaward of the Lunker Fault Zone (see Section 2.3.3). None of these relict fault trends extend up anywhere near the seabed.

Quaternary faulting is extensive along the Texas shelf as sediments deposited on the shelf and coastal plain gradually subside into the Gulf basin. These faults are mostly growth faults, some of which extend up far enough to offset the seabed forming escarpments (scarps), indicating they have been recently active. The part of the shelf that the route traverses has a number of these faults, all offsetting Quaternary strata and oriented in a shore-parallel (NE-SW) direction (Trippet and Berryhill, 1981).

2.2.1 **Marine Geology**

Glacial cycles during the Pleistocene resulted in a number of periods where the sea level rose and fell. The Texas coastal plain and much of the Texas shelf received sediment from various rivers. During a eustatic highstand prior to the Wisconsinan Glacial Episode (75-11 kA), rivers deposited a complex mixture of sand and clay across a broad delta that presently comprises the Texas Coastal Plain. As sea level fell during the early Wisconsinan period, this plain spread out across the Texas shelf where it became the Beaumont Formation (Fm). The clays within this deposit were occasionally desiccated and hardened by exposure to air, and then subsequently buried as sandy deposits spread across their surface, resulting in the complex mixture of hard and soft clay and sand that characterizes the Beaumont Fm.

When sea level began to rise at the close of the early Wisconsinan, channels which were cut into the Beaumont Fm began to flood and fill in with estuarine sediment. Eventually the rising sea flooded the outer Texas shelf, and late-Pleistocene marine sediments were deposited across the outer shelf.
mid-Wisconsinan sea level did not rise to the levels we have today. In the part of the Texas shelf where the survey corridor crosses, the mid Wisconsinan (Stage 3) shoreline stood along between what is presently the 45-ft and 50-ft isobaths (15-17 m). Shoreward of this, the Beaumont Fm remained exposed.

Sea level again dropped in response to the late Wisconsinan glaciations. The shoreline retreated out to near the present-day shelf break. Shoreward of this low stand shoreline, erosion of the Beaumont Fm and younger shelf sediments continued. Eventually the climate warmed resulting in glacial retreat and subsequent sea level rise. As sea level rose, a thick layer of sediment called the Texas Mud Blanket (TMB) covers the central and southern portions of the Texas continental shelf, between the deltas of the Rio Grande and Colorado rivers. Deposition of this blanket commenced after the Last Glacial Maximum (LGM) within a broad and shallow structural depression between the Marine Isotope Stage 3 (MIS 3) shoreline and a series of reefs that began growing around 21.5 kA (Weight, Anderson and Fernandez, 2011).

The melting ice sheet raised sea level and began to flood the Texas shelf around 20 kA, filling the deepest parts of the TMB depocenter with terrestrial and lagoonal deposits by 17 kA (Weight et al., 2011). Sea levels rose an average of 7 mm/yr over the following 8,000 years, but the majority of sediment accumulation during this period was restricted to the deltas of the Colorado and Brazos rivers, especially during the early Holocene epoch (12-9 kA). Around 9 kA, weathering of these deltas began to dramatically increase sediment accumulation across the TMB. This activity all but ceased by 7.5 kA, when the Texas climate entered a period of extremely dry and arid conditions that persisted for more than three millennia. This Climatic Optimum concluded around 4 kA, and it was followed by a period of rapid sediment accumulation that has persisted to the present day. Almost 60% of the volume of the TMB has been deposited in the past 3.5 kA, sourced locally from the Colorado and Brazos rivers, and distantly from Mississippi sediments brought in by westward currents (Weight et al, 2011).

The survey corridor traverses an inter-deltaic section of the TMB, dominated by shoreface processes (Rodriguez, Fasseli and Anderson, 2001). Silt and clay accumulate here at an average rate of less than 5.0 mm/yr (Weight et al, 1981). The sand on the shoreface of San Jose Island is likely transient, being worked into offshore bars during the winter, and into beach berms during the summer. These relatively coarse sediments likely onlap or grade seaward into silt and mud.

2.3. HUMAN IMPACTS

2.3.1. Maritime Boundaries

Although the U.S. is not a signatory to the United Nations Convention on the Law of the Sea (UNCLOS), President Reagan established a 200 nautical mile (Nm) exclusive economic zone (EEZ) and a 12-Nm Territorial Sea. The survey corridor crosses the 12-Nm boundary near its eastern terminus (Figure 2-2).

2.3.2. Lease Blocks

The survey corridor traverses several offshore lease blocks, all within the Matagorda Island Planning Area (Figure 2-2). Most of these blocks are administered by the State of Texas, but jurisdiction transfers to the Bureau of Ocean Energy Management (BOEM) along the Three Marine League Line. The lease...
blocks landward of this line were delineated by the Texas Land Survey (TLS), and the Outer Continental Shelf (OCS) blocks to the east were delineated by the National OCS Oil and Gas Leasing Program.

The proposed route does not cross any active lease blocks at the time of this report. The blocks that are crossed are listed in Table 2-1.

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Table 2-1  Lease Block Crossings

The locations of the State and Federal Lease Blocks are shown in Figure 2-2

Figure 2-2  Regional Delimited Areas

This image depicts known delimited areas in the vicinity of the survey corridor, as keyed to the legend at left. Pipelines that cross the survey corridor are highlighted in purple.
2.3.3. Oil and Gas Infrastructure

Numerous wells have been reported in the vicinity of the survey corridor, but only seven of them are inside it (Figure 2-2). One well is located in Block 693, and is classified as a "dry hole" by the Texas Railroad Commission (RRC). Another well lies just 200 ft outside the survey corridor in Block 721, and this is close enough for the magnetometer to detect it. Six wells were drilled in a cluster at the Apache MI 696 A1 platform. This platform was abandoned and removed in 2012. The abandoned platform site in Block 696 lies along the northern edge of the survey corridor. The platform has been removed; however, a patch of material that appears to be a tar mound is present at the abandoned site (see Section 5).

One pipeline is charted as approaching the abandoned Apache MI 696 A1 platform site from the north, formerly part of a Southern Natural Gas Company pipeline system. This pipeline does not pass into the survey corridor, but two others pass through Section 5. The westernmost pipeline is the active Crescent Pipeline Partnership Natural Gas pipeline, and the planned centerline crosses it in Block 721, at the coordinate X=2663458, Y=28096 (Lat 27.894582°; Long -96.946387°). The easternmost pipeline is the inactive XTO Offshore pipeline, and the planned centerline crosses it in Block 837, at the coordinate X=2663458, Y=28096 (Lat 27.894581°; Long -96.946387°). These features produce clear anomalies in the magnetometer data (see Section 5).
3. SURVEY DETAILS

3.1. VESSEL

The vessel used for this survey was the F/V Peggy Ann; a converted outrigger trawler that is 65 ft long, and 19.5 ft abeam (Figure 3-1).

![Figure 3-1 F/V Peggy Ann](image)

3.2. INSTRUMENTATION

The survey systems were selected in accordance with the technical specifications for the survey of the Bluewater SPM pipeline corridor (Table 3-1).

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<td>RTK GPS</td>
<td>Trimble R8</td>
<td>Accuracy is ±1 cm + 1 ppm TBL (horizontal) and ±2 cm + 2 ppm TBL (vertical)</td>
<td>Mounted atop a starboard mast amidships.</td>
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<tr>
<td>SBAS DGPS</td>
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<tr>
<td>Motion Reference Unit (MRU)</td>
<td>Teledyne DMS-05</td>
<td>Dynamic roll and pitch accuracy 0.03-0.05° RMS; heave accuracy is ±5 cm or 5%.</td>
<td>Mounted directly along the starboard mast in front of the GPS.</td>
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<td>Multibeam Echosounder (MBE)</td>
<td>Odom MB2</td>
<td>200-kHz signal</td>
<td>Mounted directly below the GPS.</td>
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<tr>
<td>Single-Beam Echosounder (SBE)</td>
<td>Odom Echotrac CVM</td>
<td>200-kHz signal</td>
<td>Mounted directly below the GPS.</td>
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<tr>
<td>Side Scan Sonar (SSS)</td>
<td>EdgeTech 4200</td>
<td>100/400-kHz signal, slant-range set to 50 m/channel</td>
<td>Towed aft of the vessel from a sheave mounted on the starboard outrigger.</td>
</tr>
<tr>
<td>Subbottom Profiler (SBP)</td>
<td>EdgeTech 3100-P (in) SB-424</td>
<td>4-24 kHz CHIRP signal</td>
<td>Towed aft of the vessel from the sheave mounted on the port outrigger.</td>
</tr>
<tr>
<td>Magnetometer (Mag)</td>
<td>Geometrics 882</td>
<td>Cesium-beam sensor recording at 1 Hz</td>
<td>Towed aft of the vessel from a point on the starboard stern.</td>
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Table 3-1 Survey Systems

This table summarizes the instrumentation for the Bluewater SPM pipeline survey.
3.3. **Layout**

As shown in the vessel diagram, the subbottom profiler (SBP) towfish and side-scan sonar (SSS) towfish were towed from blocks on the vessel outriggers (Figure 3-2). The magnetometer (Mag) was towed from a block on the aft deck of the vessel. The positions of all towfish were referenced to the primary navigation GPS system, which was mounted on a mast on the starboard side of the vessel. The Motion Reference Unit (MRU) was mounted on the mast, in line with, and directly in front of the primary navigation GPS. The heading GPS units were mounted directly fore and aft of the primary navigation GPS. The echosounders - multibeam (MBE) in Federal waters, and single-beam (SBE) in State waters - were mounted directly below the primary navigation GPS.

![Vessel Layout Diagram](image)

*Figure 3-2  Vessel Layout Diagram

This image details the layout and offsets of the instruments used in this survey.*

3.4. **Positioning**

A Trimble R8 RTK GPS receiver mounted atop a starboard mast amidships was used for positioning. Network-based RTK corrections were within 8 mi of shore, but RTK GPS corrections were not feasible or the furthest offshore portions of the survey, so SBAS differential GPS corrections were used there instead. The stated accuracy of the Trimble RTK GPS system is ± 1 cm + 1 ppm total baseline length for horizontal positions, and ± 2 cm + 2 ppm total baseline length for vertical positions. The estimated accuracy for the survey is ± 0.1 m (10 cm). The horizontal accuracy of the SBAS differential GPS corrections are typically sub-meter. The GPS data were logged into Hypack navigation software which calculated sensor positions and provided position data to the various data loggers. Other instrumentation used for the survey include a Teledyne DMS-05 motion sensor, Hemisphere Vector VS131 gyro, and a Castaway CTD sound velocity profiler.
3.5. OPERATIONS

Water depths within the offshore portion of the survey area range from about 20-92 ft. As water depths became shallower, cable-out measurements were adjusted. Cable-out measurements were noted in the survey log files. The cable-out measurements for the SBP, SSS and Mag towfish were kept as consistent as possible to maintain the correct towfish altitude.

All surveying was conducted during relatively calm wind and wave periods. Swell size during all survey trips was less than 3.0 ft. Wind speed during all survey trips was less than 15 kts. The survey followed “Other General Surveys and Studies (Coastal Engineering Surveys)” specifications according to USACOE manual No. 1110-2-1003. All equipment was calibrated and bench-tested prior to survey activities. Offset measurements were taken during initial vessel rigging, and then checked a second time after completion of rigging. The altimeter and fathometer on the Mag were checked against manual leadline measurements in a protected portion of the Corpus Christi Ship Channel prior to initial survey deployment. The MBE and SBE were also checked against manual leadline measurements prior to the initial survey deployment. RTK GPS checks were run on two project control points prior to commencement of survey activities, and SBAS differential GPS checks were also made to the project control points.

Survey data that did not meet the required specification for accuracy and quality were re-run. The only areas that had to be re-surveyed were the survey lines where the Mag altimeter showed an altitude of more than 20 ft from the seafloor. These areas were re-surveyed after completion of the initial Mag survey.
4. SURVEY DATA

4.1. BATHYMETRIC ECHOSOUNDERS

Bathymetric data were collected with a multibeam echosounder (MBE) in Section 0, and a single-beam echosounder (SBE) in Sections 1-6 (Figure 4-1). During acquisition, RTK tides were checked against tides at the nearest NOAA tide gauges at Port Aransas and Bob Hall to ensure accuracy and consistency within the inshore portions of the survey corridor. In the offshore portions of the survey corridor where RTK tides were not available, draft measurements of the echosounders and manual tides from the NOAA tide gauges were used to correct the bathymetric data to the survey datum. Data overlapping the survey sections were checked against each other to ensure a good match between the datasets.

Sound velocity profiles were collected during survey operations and used for post-processing the bathymetric data. Both the MBE and SBE data sets were collected in TX83SC ft, and reduced to MLLW. The MBE data were logged and processed using Hypack’s Hysweep software, and then output at a bin spacing of 5 ft. The SBE data were collected along route-parallel lines spaced at approximately 100 ft in Sections 1-4, and approximately 65 ft in Sections 5 and 6. Crosslines were intermittently run to check the consistency of both the MBE and SBE.

The MBE and SBE data were treated independently in post-processing, but both sets of XYZ data were gridded with a 5-ft bin spacing that preserved the seabed features visible in the raw data. The MBE and SBE GRD files were then merged and inverted, to change the positive bathymetric depths into negative elevation values. These TX83SC ft GRD files were also exported in TX27SC ft coordinates, for a total of two files. Bathymetric contours were then output at an interval of 1 ft, as shown on Charts 1-4.
3.1. **SIDE SCAN SONAR**

The depth of the SSS towfish was adjusted to maintain a towfish altitude of 10-20% of the sonar slant range per channel within each survey Section. Cable changes were not made within any Section. The slant range was set to 50 m/channel. Towfish altitude averaged 7 m above the seabed. The dual-frequency SSS data were recorded to XTF and proprietary JSF formats. Sonar coverage in Sections 0 through 4 is approximately 300%, and coverage is approximately 400% in Sections 5 and 6; this coverage far exceeds BOEMR requirements (Figure 4-2).

High-frequency data were imported to SonarWiz 7, and layback values were applied to each line in order to more accurately represent the position of the side-scan towfish. Each line was then bottom-tracked and slant-range corrected. Custom gain settings were then applied to the data to aid in seabed mapping and sonar contact detection. Each data file was analyzed for sonar contacts and anomalous seafloor features, particularly in areas of magnetic anomalies. These features were mapped, and then exported to attributed SHP files and a Sonar Contact Report (see Appendix A). Finally, SSS mosaics were created and imported to AutoCAD for sediment boundary mapping.

![Figure 4-2 Side Scan Sonar Coverage](image)

*This image depicts the coverage areas of the SSS data.*

4.2. **SUBBOTTOM PROFILER**

Wherever possible, the amount of cable for the SBP was set to the corresponding water depth for each Section in order to maintain an altitude of 10-15 msec above the seabed. The cable helped to decouple vessel motions from the towfish, thus reducing vessel heave. SBP data were acquired along all tracklines throughout the survey, and the record length was set to 88 msec (~220 ft). EdgeTech Discover software recorded the SBP data in both SGY and EdgeTech-native JSF formats.
Penetration varied depending on the sediment types encountered. To the east in water depths exceeding 50 ft, penetration increased from 35 ft at the west end of Section 4 to a little over 40 ft in Section 0. Penetration for the most part is limited by a horizon interpreted to mark the top of the Pleistocene (Beaumont Fm) sediments. Locally increased penetration occurs where paleochannel fill material propagated the SBP signal more readily. Where the Beaumont Fm is exposed on the seabed (Sections 5 and 6), penetration is limited to approximately 10 ft atop localized highs, and to 15 ft in intervening swales.

Post-processing of the SBP data began by importing the JSF files into SonarWiz. Once loaded, the seafloor was bottom-tracked and then aligned to a bathymetric grid to remove residual heave artefacts and towfish altitude changes. This process resulted in seafloor-corrected SBP data that can be more accurately interpreted. The adjusted files were then converted to SGY format, and imported along with their corresponding seafloor horizons to Kingdom Suite for interpretation.

The SBP records were then analyzed for acoustic characteristics and/or changes in the pattern of acoustic impedance that reveal key characteristics of the seafloor and the subsurface geology. Representative subsurface features were mapped, and the depth(s) to horizon(s) of acoustic impedance change were calculated (in two-way travel time) wherever possible. The base of unconsolidated (Holocene) deposits was picked as a seismic horizon (Horizon A). Seismic travel times were converted to feet using an industry-standard velocity of 5,000 ft/second for sound travelling through saturated sediments. These values are represented as contours on Charts 5-8.

Figure 4-3 Subbottom Profiler Coverage
This image depicts the coverage of the SBP data.
4.3. **Magnetometer**

The Model 882 Mag uses a cesium-beam sensor to measure total field at a high sensitivity. For this survey, the sensor altitude was generally held at 12-16 ft, and readings were taken at 1/10th second intervals at 0.001-gamma (on nT) resolution and 0.02-gamma sensitivity. Background noise levels were generally less than 0.3 gammas. Total field, sensor depth, sensor altitude, towfish gyro, and signal strength values were read from the towfish, and logged into the Hypack RAW files. In total, 386 lines of Mag data were collected and interpreted for this project (Figure 4-4). The magnetometer data coverage and quality meets or exceeds BOEMR specifications.

The magnetometer data files were imported to SonarWiz 7 for post-processing and analysis. The data quality is excellent (e.g. Figure 4-5), and allows for positioning within about 20 ft. Cable-out and layback adjustments were made to precisely position the sensor, and the altitude readings were manually edited to remove data spikes. Once positioned, each line was independently analyzed for magnetic anomalies. Although anomalies of lesser magnitude than 3 gammas (or nT) are visible in the data set, 3 gammas was considered the minimum threshold for mapping. Once mapped, the anomalies were output to a BOEMR-standard data table, and an attributed SHP file (see Appendix B).

All magnetic anomalies were checked against the SSS data to see if any of the anomalies had associated sonar contacts. The avoidance radius varies based on the anomaly intensity, whether it is definitely correlated to a sonar contact (narrowing down the source location,) and whether the anomaly correlates to a known structure, such as a well or pipeline. An anomaly with intensities less than 10 gammas was given an avoidance of 10 ft; these anomalies probably indicate small pieces of debris with
little or no significance. Anomalies of more than 10 gamma were given an avoidance of 50 ft. Known source anomalies were given no avoidance. The archaeological assessment may modify these avoidance criteria.

Figure 4-5 Magnetometer Data Example

*This image depicts the magnetometer data from Line S5-028_1023.*
5. SURVEY RESULTS

This section describes the physical conditions within the surveyed corridor as interpreted from the fully post-processed survey data.

5.1. BATHYMETRY

The proposed route enters the survey corridor approximately 3,200 ft from the shore of San Jose Island on an eastward bearing. The water depth here is approximately 19 ft, and the seafloor descends evenly over the following 2,260 ft to the 30-ft isobath. Here, the smooth lower shoreface transitions to a seafloor with a conspicuous network of irregular ridges and swales (Figure 5-1; Chart 1). The relief of these features is generally less than 2 ft, and their flanks are generally less than 1 degree (°).

![Bathymetric Features](image)

*Figure 5-1  Bathymetric Features*

The upper image depicts the bathymetry within the survey corridor, color-coded to the scale at right (in feet). The lower image shows the depths and slopes along the proposed route.
The survey corridor passes over this terrain on a sigmoidal, northeastward path for approximately 7 mi before resuming its eastward bearing near the 46-ft isobath (Figure 5-1; Chart 2). Here, the seafloor becomes generally featureless and, except for subtle slope breaks near the 53-ft and 77-ft isobaths, descends at a steady slope of less than 0.2° for the remainder of the survey corridor (Charts 3 and 4).

5.2. **Seabed Classification**

Physical differences in the seabed within a survey corridor commonly produce differences in the sonar reflectivity exhibited by SSS sonograms (e.g. Figure 5-2). Such differences typically indicate relative changes in sediment grain size, consolidation and/or seafloor roughness. The following interpretations reflect integrated analyses of the SSS, SBP, SBE/MBE and magnetometer data within the known geologic context of the survey area (refer to Section 2).
The SSS coverage begins approximately 1 mi from the landing point. For the first 3,000 ft or so, the SSS mosaic exhibits even reflectivity, but this reflectivity becomes conspicuously variegated thereafter for the remainder of the survey corridor. Along Sections 5 and 6 of the survey corridor - that is, from 31-46 ft of water depth - isolated patches of high and low reflectivity mire a moderately reflective seabed (Figure 5-3; Charts 1 and 2). These patches generally correlate with bathymetric highs and lows, where highly reflective patches tend to lie along lower slopes that face east and northeast, and low-reflectivity patches lie within depression floors; the reflectivity of the topographic highs between these patches is generally moderate and even.

Approximately 43,000 ft along the planned centerline, these topographic features become subtle, and align on a northeastern trend. The variegated reflectivity within the topographic lows also aligns, but in curvilinear striations, reminiscent of wood grain. This pattern becomes increasingly streaky over the following 10,000 ft or so as the topographic ridges and valleys give way to a featureless seafloor.
Seaward of the 55-ft isobath, only low- and high-reflectivity streaks remain, and these cross the survey corridor on a southwest bearing that shifts steadily clockwise with increasing depth (Charts 3 and 4). These streaks likely reveal slight changes in grain-size, and may reflect seasonal sand migration.

5.3. **Man-Made Features**

The SSS data reveal 32 sonar contacts, as shown in Figure 5-4 and further detailed in Appendix A. The majority of these contacts are clustered around known locations of present or former marine installations, such as wells and pipelines, and generally comprise anthropogenic debris (Charts 1-3). Of note is a grouping of sonar contacts that sits within a depression along the northern margin of the survey corridor, [position redacted]. The largest of these contacts [position redacted] has a width and length of nearly 40 ft, and a height of approximately 2.2 ft (Figure 5-5a). Although it has been classified as debris, this contact may be the remains of a shipwreck or some other structure that has been reworked and scattered by the prevailing currents. Visible pieces of this scattered debris have been mapped individually (e.g. S2-0108, S2-0109, S2-0110 and S2-0118).

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**Figure 5-4  Seabed Features**

*This figure depicts seabed features, as keyed to the legend at left. The locations of the inset images at bottom are shown with rectangles in the main image.*
The SSS data also recorded an anomalous patch of highly reflective, coalesced, low-relief mounds at Lat: 27.886241; Long: -96.744200; some 980 ft north of the planned centerline (Figure 5-5b; Chart 3). This location correlates with that of Platform MI696 1A, which was removed in July of 2012. The patch appears spread out over the seabed, covering an area of 10,900 ft$^2$ (130 ft x 100 ft). Its reflective character is similar to tar seeps ensonified in the Santa Barbara Channel off Coal Oil Point, California. This feature may also represent a tar mound, though the exact material could be more mud than tar.

![Possible shipwreck and associated debris](image1)

**Figure 5-5** Notable Seabed Targets

*The possible shipwreck (a) is located approximately 8,200 ft due west of the mound (b), which is located at the former site of Platform MI696 1A, in MI Block 696.*

The SBP data do not traverse directly over the center of the tar mound in Section 2 (Figure 5-5b), but they reveal some interesting features nonetheless (Figure 5-6). The acoustic wipeout below the mound indicates gas is likely present in a subsurface gas chimney. The faint parabola that appears in the water column may indicate an active gas seep, though fish cannot be ruled out as a possible source. Lines S2-001 and S2-003 indicate that the tar may be 2.5 ft thick in the north and 1.0 ft thick in the south. It may be several feet thicker in the center, because the tar mound is centered in a partially infilled (buried) depression, whose base is about 5 ft beneath the present-day seabed at the former platform site. The SBP and bathymetric data indicate that this depression extends about 500 ft southward.

![SBP Line S2-001](image2)

**Figure 5-6** SBP Line S2-001

*This line traverses the northern edges of the tar mound at the former site of Platform MI696 1A, in MI Block 696, as shown in Figure 5-5b.*
The cause of this depression is unknown, but one plausible explanation is that prior to its removal in 2012, the platform structure may have deflected surface currents down to the seabed that removed sediment and transported it elsewhere. Another possibility may involve an eruption, where perhaps gas built up enough pressure to blow a crater in the seabed. The upwarping of the normally horizontal marine strata supports this idea (Figure 5-6). In any case, once the platform was removed, the depression began infilling with sediment, but the source of that sediment is not clear. If the sediment is sandy, current-transport seems an unlikely mechanism, because trawler scars surround the site at an offset distance of 1000 ft, and any bottom currents with sufficient competence to transport sandy sediments would likely obliterate such surficial features. It is possible that the sediment may have come from depth, transported up the well bore to the surface, and possibly high into the water column. Such migration is the most likely source of the tar and/or mud that comprises the mound.

In total, twenty (20) of the sonar contacts plausibly correlate with recorded magnetic anomalies, but there are 582 magnetic anomalies in the survey corridor that are greater than 3 gammas (or nanoteslas [nT]) in intensity (see Appendix B). As with the sonar contacts, most of these anomalies are concentrated around locations of known marine infrastructure (Figure 5-4; Charts 1-3). Each crossing of the SBP data was scrutinized closely for parabolic reflections that could help pinpoint the pipeline locations and estimate their depth of burial, but the data resolved no such features.

Of all the survey systems, only the magnetometer detected the pipelines. The SSS data lack any traces of pipelines or installation scars, such as burial trenches or lay barge anchor scars. The XTO Pipeline was found to lie very close to the position reported by the Texas General Land Office (Figure 5-4; Chart 1). The reported location (Texas General Land Office) for the Crescent Pipeline, however, should be considered inaccurate (Chart 1). Along the northern edge of the survey corridor, this pipeline was found 87 ft to the west of its reported location; near the planned centerline, it lies 5 ft to the east; and to the south of this crossing, it deviates as much as 623 ft to the west of its reported position. Finally, a N-S trend of anomalies clearly marks the location of the abandoned well at Lat: 27.890883; Long: -96.893935 (see Figure 2-2; Chart 2).

## 5.4. Shallow Geology

The westernmost extent of the data coverage ends on the shoreface slope in about 19 ft of water. The SBP signal may have penetrated this sand deposit, but no continuous reflectors are evident, indicating the shore sand is essentially undifferentiated. Near the toe of the shoreface slope, the SBP signal penetrated the sand about 3 ft to reflect off the top of the Beaumont Fm sediment (Figure 5-7; Charts 5 and 9). The Beaumont Fm outcrops the seabed where the planned centerline descends into a depression at the 32-ft isobath. On the east side of the depression is a semicircular, 2 ft-high mound that may be an offshore sand bar remnant. East of this mound, the strata of the Beaumont Fm are exposed at the seabed. As mentioned in the geologic background (see Section 2), the Beaumont Fm formed in a delta plain environment, and consists of hard and soft clay layers intermixed with sand layers. The desiccated hard clay layers may be very thin in places; maybe only a few inches thick. Relict distributary paleochannels incised and re-incised this deposit, making a laterally discontinuous sediment package.
Figure 5-7    SBP Profile of Exposed Beaumont Fm

This image depicts the transition from the shoreface sand to the exposed Beaumont Fm.

The Beaumont Fm is exposed on the seabed from the shoreface toe to the east end of Section 5 (Charts 6 and 9). The base of the Holocene sediments was determined from analyzing stratigraphic relationships in the SBP records and comparing them to published measurements (Berryhill and Trippet, 1981), but there does not appear to be any measurable Holocene sediments overlying this Pleistocene-aged deposit. The SSS records reveal a confused mottled appearance that is consistent with exposed highly variable Beaumont Fm sediments.

Figure 5-8    Raw SSS Record Showing Collapse Features

Note the sharp edges of the depressions.

In some places, the SSS revealed blocks of material on the seabed that have been dropped a few inches (similar to karst collapse). These collapse features are widespread throughout Sections 5 and 6 wherever the Beaumont Fm is exposed. Some blocks appear to be just a couple feet across, while others may be as much as 75 ft across. What is evident from the SSS data is that the edges of these features are very sharp and the amount of down-dropping is inches (Figure 5-8). This suggests that the
collapses are likely very recent events. Combine these features with the total lack of Holocene sediment and the fact that scars and burial trenches are absent along the two pipelines that transect Section 5, and one could conclude that the topography of Sections 5 and 6 was shaped by a recent event; perhaps as recent as Hurricane Harvey, which may have produced currents up to 5 kts (James Naismith, personal communication).

Holocene sediments become measurable at the western end of Section 4 (Charts 6 and 9). Horizon A, which rises to the seabed at this location, lies at the base of a transgressive sequence. Although extensive paleochanneling is evident immediately beneath Horizon A, it cannot be determined whether these channels date to the early Holocene or are part of the Beaumont Fm (Figure 5-9). For much of Sections 3 and 4, the paleochanneling is complex with several generations incising one another. The extent of the channels beneath Horizon A as well as their possible thalwegs and depth from the seabed are mapped on Charts 6 and 7.

To the east, Horizon A is overlain by low-amplitude reflections about 5-6 ft thick (Chart 9). This layer is interpreted as probable transgressive sand that pinches out to the west. The sand is overlain by layered sediments of relatively high amplitude that are interpreted to represent a deposit of sandy mud.

The surficial sandy mud is believed to be soft or very soft, and the sand content likely decreases towards the east. Given that the bulk of the Holocene sediments has been deposited in only the last few thousand years, it is assumed that they are under-consolidated muds with varying concentrations of sand. Geotechnical sampling will ultimately confirm or refute this inference. Isopach contours depicting the thickness of the Holocene sediments overlying Horizon A are presented on Charts 5 through 8.

The following figures (Figure 5-10, Figure 5-11, Figure 5-12) depict the sub-seabed features for Sections 3, 2, and 1 respectively. The uppermost mud strata become increasingly layered in an east direction, though the thickness of the mud increases only slightly from about 15 ft - at the west end of Section 3 - to 20 ft at the eastern end of Section 1 (Charts 9 and 10). The underlying sand increases in thickness from nil - at the west end of Section 3 - to 20 ft at the east end of Section 1.
Figure 5-10  SBP Profile of Section 3
This image depicts a vertically exaggerated profile of the centerline through Section 3.

Figure 5-11  SBP Profile of Section 2
This image depicts a vertically exaggerated profile of the centerline through Section 2.

Figure 5-12  SBP Profile of Section 1
This image depicts a vertically exaggerated profile of the centerline through Section 1.
Paleochanneling tends to become more sporadic in an easterly direction as well until evidence of channeling terminates west of a normal fault near the middle of Section 2 (Charts 8 and 10).

The normal faults mapped in Sections 2 and 1 are growth faults that extend up into the Holocene-aged sand and mud layers (Charts 7, 8 and 10). Horizon A is offset about 1.5 ft for both of these recently active faults. None of the faults offset strata shallower than 5 ft beneath the seabed; however, there is a small down warp in the seabed above the easternmost fault in Section 1. Faulting is not evident in Section 0 (SPM area).

The only indication for gas in the SBP profiles occurs at the previously-mentioned abandoned platform site in Section 2, where a gas chimney appears beneath the tar mound. Several pockmarks are mapped in Section 1 (Chart 4); however, the SBP data show no indication of gassy strata or shallow-amplitude anomalies near any of the pockmarks. It is possible that the pockmarks have formed from fluid expulsion (water escaping through the seabed).
6. CONCLUSIONS AND RECOMMENDATIONS

Based on the geophysical survey data and published information, several conclusions regarding the geologic conditions and potential hazards are included here.

1. Water depths range from 19 ft at the shoreline to 92 ft in the SPM area to the east (Section 0). The steepest slopes occur along the faces of mounds of exposed Pleistocene strata (Beaumont Fm) in Sections 5 and 6. The gradients along the slopes of these mounds do not exceed 1.5°.

2. There is evidence that storm-driven currents may have removed Holocene sediment cover from the seabed in Sections 5 and 6. The exposed Beaumont Fm sediment may be highly variable, with consistencies ranging from soft to hard for clays, and loose to dense for sand. Widespread collapse depressions are present through the exposed Pleistocene sediments in Sections 5 and 6. These depressions may have formed from recent storms affecting the seabed (via either wave energy or storm-driven currents). We strongly recommend that soil borings be acquired in several locations along the route in Sections 5 and 6 to help understand the nature of the complex dynamic features in this area.

3. Offshore pipeline burial should be sufficiently deep throughout Sections 5 and 6 to withstand seasonal and storm erosion of the seabed out to a water depth of at least 46 ft. The bathymetric results from this survey are sufficient to use as a baseline to compare against any future post-storm surveys and inspections.

4. The abandoned (and removed) Apache Platform A1 site in Block 696 shows evidence that wells drilled at the site may be actively leaking tar/mud material. The US Coast Guard and BOEMR should be notified of this potential problem.

5. While the exposed Pleistocene sediments in Sections 5 and 6 may pose problems for pipeline burial, the under-consolidated Holocene sediments that persist east through Section 0 (SPM) should be easy to excavate.

6. Sonar Contact S2-101 should be avoided by at least 500 ft by all pipe-lay operations. This contact may be a shipwreck.

7. Sonar Contact S0-102 is an object of unknown source or impact, and should be avoided until its nature can be better defined. Other SSS contacts should be avoided if possible, as their potential impacts are uncertain.

8. Magnetic anomalies indicate ferrous objects are present in the survey corridor. Few sonar contacts correlate with these anomalies, so their sources are likely buried. Because so little is known about them, we recommend avoidance for anomalies over 10 gammas. Smaller anomalies are likely minor pieces of debris.

9. The surveyed pipeline locations should be considered accurate, and may be used for planning purposes.
10. Given the extremely high sedimentation rate during the last 3,500 years, the seabed sediment to the east of the exposed Beaumont Fm (Sec 5) is likely under-consolidated mud down to a depth defined by the Wisconsinan unconformity.

11. Two faults extend up into the Holocene strata, indicating they have likely moved in the last 10,000 years and as such should be considered active. The uppermost extents of these faults are deeper than 5 ft beneath the seabed, though the easternmost fault has downwarped the seabed slightly. Fault movement is likely gradual, and future movements are possible.
7. REFERENCES CITED

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Berryhill, H.L. Jr. and A.R. Trippet

Rodriguez, A.B., M.L. Fasseli, and J.B. Anderson

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Weight, W.R., J.B. Anderson, and R. Fernandez

Zoom Earth
2019 Satellite imagery. Retrieved March, 2019 from: https://zoom.earth/#0,0,3z,sat,pm,2019-03-12
Matchline Chart 1 / Chart 5
Matchline Chart 3 / Chart 7

Survey Vessel: S/V Peggy Ann
Survey Dates: January-February, 2019

DATE
DESCRIPTION
DRAWN BY
CHECKED BY
APPROVED

BATHYMETRY AND SEABED FEATURES MAP
BLUEWATER SPM PROJECT
ARANSAS COUNTY, TEXAS

Interpreted By: Geo-Marine Technology, Inc.
Archaeological Assessment: Robert Gearhart
Prepared For: Lloyd Engineering, Inc., Bellaire, Texas
Surveyed By: Naismith Marine Services, Rockport, Texas

TRUE SCALE 1: 11997.875562 (At Mid-Latitude of Chart)

NATURAL SCALE   1 : 12000 (1"=1000')

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GEODETIC PARAMETERS
Horizontal Datum
Datum: NAD 83
Projection: State Plane Coordinate System
Zone: Texas South Central (FIPS 4204)
Units: U.S. Survey Feet

Vertical Datum
Datum: MLLW

LEGEND
Proposed Pipeline Route
Bathymetry Contour (contour interval = 1 foot)
Magnetic Anomaly (with anomaly ID)
Side Scan Sonar Contact (with ID)
Pockmark
Area of Low Sonar Reflectivity
Area of Medium Sonar Reflectivity
Area of High Sonar Reflectivity
Area of Very High Sonar Reflectivity
Route Crossing (see table below)

SIDE SCAN SONAR CONTACTS

SIDE SCAN SONAR CONTACTS

SURVEY / GENERAL NOTES
Survey Vessel
S/V Peggy Ann
Positioning System
GPS - Trimble R8
Multibeam Bathymetry:
Teledyne Odom MB2
Single Beam Bathymetry:
Teledyne Odom CV Series (200kHz)
Side Scan Sonar:
Edgetech Model 4200 Dual Frequency (100kHz-500kHz)
Subbottom Profiler:
Edgetech Model 3100 with SB-424 CHIRP (4kHz-24kHz)
Magnetometer:
Geometrics G882

Preliminary Issue
March 26, 2019
JR

ROUTE CROSSING LIST
Revision 1
March 28, 2019
JR

LOCATION MAP
Coastline (from digital database)
Reported Structure or Platform
Reported Well
Reported Shipwreck
Surveyed Pipeline Location
Reported Pipeline Location
Lease Block Boundary
Federal-State Boundary
8g Line

ROUTE CROSSING LIST

Geologic Parameters

LOCATION MAP

BATHYMETRY AND SEABED FEATURES MAP
BLUEWATER SPM PROJECT
ARANSAS COUNTY, TEXAS
Appendix B: Inshore Geophysical Survey Report
April 18, 2019

Lloyd Engineering
Bathymetric and Remote-Sensing Survey
Bluewater SPM Project
Redfish Bay, Texas

Scope of Work

The following scope of work was in support of design, COE Section 10, & COE Section 404 permitting:

- Side Scan Sonar Survey
- Magnetometer Survey
- Bathymetric Survey
- State Tract plat prep
- Recover and verify survey control
Survey Methodology:

Transect spacing was set at 20m for the Gulf Beach approach and crossing of the Lydia Ann Channel and other tidal inlets near the State Highway 361 causeway in Redfish Bay.

The THC guidelines for cultural resource surveys were followed. In addition, the Corps of Engineers’ standards for Hydrographic Surveying were followed, where appropriate. The survey also followed “Other General Surveys and Studies (Coastal Engineering Surveys)” specifications according to USACOE manual No. 1110-2-1003. Quality control and quality assurance (QA/QC) procedures as presented in the manual were followed, where applicable.

During the survey, the positions of magnetic, fathometer, and side-scan sonar targets of interest were noted and recorded. Upon the completion of the basic survey transects, target locations of interest were returned to and additional survey lines were run over them to collect precise information on their location and configuration.

Control

RTK GPS was used for horizontal and vertical positioning for the survey. Vertical control was verified using GPS-RTK. All checks were completed using published NOAA-NGS control points and/or Corps of Engineers’ local control points. Horizontal Datum for this project was NAD 83 (North American Datum of 1983), projection is Texas South Central Zone (4205).
Utilized Control Monuments:

“CG 71”
N: 13,131,062.64
E: 2,594,180.71
ELEV: 5.9' MLLW (5.7' NAVD 88)

“Pilot”
N: 13,130,490.44
E: 2,598,225.046
ELEV: 6.1' MLLW (5.9' NAVD 88)

Tides and tidal datums:

Tides were monitored using GPS-RTK. The reference datum for this project was NAVD88 and MLLW (Mean Lower Low Water).

Magnetometer Survey

A Geometrics G882 magnetometer was utilized to identify the horizontal location and magnetic signature of contacts in the area. Transect spacing was set to comply with the THC standards. The magnetometer was towed behind the survey vessel at a minimum of 100 feet to eliminate magnetic interference from the vessel. The data was processed for a gamma contour map and anomaly report.

Typical Magnetic Anomalies Located During Magnetometer Survey
Side Scan Sonar Survey

A side scan sonar survey was completed covering the survey area. Transect lines were established to provide 200% bottom coverage and run with a range setting of to provide overlap of the adjacent line’s nadir. Data collected was processed using Chesapeake Software and a geo-referenced tiff format as image produced. A report was produced listing close up images and the sizes of contacts.

Typical Contacts located During Scan Sonar Survey

Single-beam Bathymetry

A single-beam echo sounder was utilized to measure precise depths throughout the area. Transects were set to coincide with side scan sonar and magnetometer surveys. The speed of sound in water was calculated or measured and the echo sounder calibration, including bar check, was verified using manual lead-line measurements on site. The data was reduced to a spacing of 10 feet along transects. When GPS-RTK was utilized for positioning, tide, and/or heave, a local base station is established near the site.

Equipment

GPS-RTK – Trimble R8
Echo Sounder – Odom CV100 at 200kHz
Side Scan Sonar – Edgetech 4200 and 4125 400 kHz minimum
Magnetometer – Geometrics G882

Survey Vessels

26’ Galcier Bay
21’ Dory

Thank you for the opportunity to assist with these surveys.

Seth Gambill
Appendix C: Offshore Crew Roster and Survey Description

NAISMITH MARINE SERVICES, INC.

PERSONNEL LIST

Jim Naismith, RPLS, LSLS and Seth Gambill were in technical charge of the survey. Mr. Naismith and Mr. Gambill specified all survey equipment, setup the survey lines, established shore-based control and setup survey procedures and QA/QC processes specific to this survey project in advance of the start of surveying.

The survey vessel was rigged by Seth Gambill and Jake Pruiett. The field survey personnel included Jake Pruiett, Vincent Magni and Quintin Dobrenski. The boat captains for all surveys were Bo Ryder and Billie Ryder. Bob Gearhart and Ed Baxter provided oversight for cultural resource requirements imposed by the Texas Historical Commission. Jake Pruiett was the head field surveyor for the project and was responsible for deployment, quality checks and ensuring proper functioning of field survey equipment. All multibeam data was checked and processed by Jim Naismith. All side scan sonar, magnetometer and single beam echosounder data was checked by Seth Gambill. Geo-Marine was contracted to process all sub-bottom, magnetometer and side scan sonar data. All single beam echosounder data was processed by Seth Gambill.

SURVEY DESCRIPTION

(a) Navigation System: Trimble Model R8, RTK, GPS receivers were used for all project navigation. For the furthest offshore portions of the survey, SBAS differential GPS corrections were utilized as shore-based RTK GPS corrections were not feasible due to distance of the survey vessel from shore. In areas within eight miles of shore, network based RTK corrections were utilized. The stated accuracy of the Trimble RTK GPS system is +/- 1cm + 1ppm total baseline length for horizontal position and +/- 2cm + 2ppm total baseline length for vertical position. The estimated accuracy for the survey is +/- 0.1m or 10cm. The horizontal accuracy of the SBAS differential GPS corrections is typically sub-meter.

(b) Other instrumentation utilized for the survey were as follows:
- Side Scan Sonar-Edgetech 4200 100/400 kHz
- Magnetometer-Geometrics G882
- Echosounder – Odom CV100 operating at 200 kHz
- Multibeam Echosounder – Odom MB2 operating at 200 kHz
- Heave, Pitch & Roll-Teledyne DMS-05
- Heading – Hemisphere Vector VS131
- Sounder Velocity Profiler-Castaway CTD
- Sub-bottom Profiler-Edgetech 3100 SB-216 (4-24 kHz)
(c) A diagram of the vessel and sensor configurations is shown in Appendix A. The survey vessel “Peggy Ann” is a trawler style 65 ft in length with a 19.5 ft beam. As shown in the vessel diagram, the sub-bottom towfish and side scan towfish were towed from blocks on the vessel outriggers. The magnetometer was towed from a block on the aft deck of the vessel. The position of all towfish were referenced to the primary navigation GPS system, which was mounted on a mast on the starboard side of the vessel. The Motion Reference Unit (MRU) was mounted on the mast, in line with, and directly in front of the primary navigation GPS. The heading GPS units were mounted directly fore and aft of the primary navigation GPS. The echosounder (multibeam in Federal Waters and single beam in State waters) were mounted directly below the primary navigation GPS. Water depths within the offshore portion of the survey area ranged from 20ft to 90+ ft. Cable out measurements were stored in the survey log files. As water depths became shallower, cable out measurements were adjusted.

(d) Due to line length, the project survey area was split into seven discrete survey areas. Each line within each of the seven survey areas was run continuously from start to finish. The survey vessel speed was adjusted, as necessary, to keep the magnetometer within 20ft of the seafloor. Typical speed of the survey vessel was 3.0 to 4.0 knots.

(e) All surveying was conducted during relatively calm wind and wave periods. Swell size during all survey trips was less than 3.0 ft. Wind speed during all survey trips was less than 15 knots.

(f) Survey Log:

First deployment

January 4, 2019-Field survey crew Jake Pruiett and Quintin Dobrenski left the dock at Port Aransas Municipal Harbor at approximately 12:00 with captains Billy Reiter and Bo Reiter. Began surveying at 16:35 on section 2. Ran section 2 through midnight on January 4, 2019 and continued into January 5, 2019. Finished section 2 at roughly 17:00 and arrived back at dock in Port Aransas at 21:00.

Second deployment

January 7, 2019-Field crew Jake Pruiett and Quintin Dobrenski left the dock at Port Aransas Municipal Harbor at approximately 06:00 with captains Billy Reiter and Bo Reiter. Began surveying at 09:57 on section 1. Ran section 1 through midnight on January 7, 2019 and continued into January 8, 2019. Finished section 1 at roughly 17:00 and arrived back at dock in Port Aransas at 02:00 on January 9, 2019.

Third Deployment

January 24, 2019-Field crew Jake Pruiett, Quintin Dobrenski & Vincent Magni left the dock at Port Aransas Municipal Harbor at approximately 06:00 with captains Billy Reiter and Bo Reiter. Began surveying at 10:22 on section 0. Ran section 0 through midnight on January 24, 2019 and
continued into January 25, 2019. Finished section 0 at roughly 07:00 and arrived back at dock in Port Aransas at 10:00 on January 25, 2019.

Fourth Deployment

February 2, 2019-Field crew Jake Pruiett and Quintin Dobrenski left the dock at Port Aransas Municipal Harbor at approximately 06:00 with captains Billy Reiter and Bo Reiter. Ed Baxter was onboard for cultural resource oversight. Began surveying at 10:01 on section 3. Ran section 3 through midnight on February 2, 2019 and continued into February 3, 2019. Finished section 3 at roughly 08:00 and arrived back at dock in Port Aransas at 10:00 on February 3, 2019.

Fifth Deployment

February 4, 2019-Field crew Jake Pruiett, Quintin Dobrenski & Vincent Magni left the dock at Port Aransas Municipal Harbor at approximately 06:00 with captains Billy Reiter and Bo Reiter. Ed Baxter was onboard for cultural resource oversight. Began surveying at 08:44 on section 4. Ran section 4 through midnight on February 4, 2019 and continued into February 5, 2019. Finished section 4 at roughly 01:30 and arrived back at dock in Port Aransas at 02:30 on February 5, 2019.

Sixth Deployment

February 26, 2019-Field crew Jake Pruiett & Vincent Magni left the dock at Port Aransas Municipal Harbor at approximately 06:00 with captains Billy Reiter and Bo Reiter. Bob Gearhart was onboard for cultural resource oversight. Began surveying at 09:20 on section 5. Ran section 5 through 15:00 on February 26, 2019 and survey was called off due to rough sea conditions. Arrived back at dock in Port Aransas at 16:00 on February 26, 2019.

Seventh Deployment

February 27, 2019-Field crew Jake Pruiett and Vincent Magni left the dock at Port Aransas Municipal Harbor at approximately 06:00 with captains Billy Reiter and Bo Reiter. Bob Gearhart was onboard for cultural resource oversight. Began surveying at 07:20 on section 5 but called off section 5 survey due to rough sea conditions. Started close order survey work on anomalies offshore from Section 5. Surveyed close order anomaly until 22:00 on February 27, 2019 then headed inshore and continued on Section 5. Ran section 5 through midnight on February 27, 2019 and continued into February 28, 2019. Finished section 5 at roughly 15:00 and arrived back at dock in Port Aransas at 17:00 on February 28, 2019.

Eighth Deployment

March 1, 2019-Field crew Loren Fielding and Vincent Magni left the dock at Port Aransas Municipal Harbor at approximately 06:00 with captains Billy Reiter and Bo Reiter. Bob Gearhart was onboard for cultural resource oversight. Began surveying at 07:30 on section 6. Surveyed section 6 until 18:00 on March 1, 2019 and arrived back at dock in Port Aransas at 19:00 on
March 1, 2019. Headed back offshore with the same crew on March 2, 2019 at 06:00. Began surveying again on Section 6 at 08:00 and finished section 6 at 17:00. Arrived back in at the dock in Port Aransas at 18:00 on March 2, 2019.

Ninth Deployment

April 2, 2019-Field crew Clay Cottle & Josh Cantu left the dock at Port Aransas Municipal Harbor at approximately 08:00 in the Naismith Marine Services 26-ft Glacier Bay. Ed Baxter was onboard for cultural resource oversight. Began surveying at 09:30 on section 6. Surveyed section 6 until the section was finished at 13:15 on the same day and arrived back at dock in Port Aransas at 14:30.

Inshore Survey work

The inshore survey work was completed on the following dates: February 15 & 22 and March 8, 11, 12, 14, 18, and 25. The 26-ft Glacier Bay was utilized for a majority of the inshore survey work but a 22' Carolina skiff was used in very shallow areas the Glacier Bay couldn’t access. Seth Gambill & Kellen Jennings crewed the survey vessel on February 15 with Bob Gearhart on board for cultural resources oversight. Clay Cottle, Jake Pruett, Vincent Magni, Josh Cantu and Quintin Dobrenski rotated survey responsibilities for the inshore survey work and Ex Baxter was present for cultural resource oversight on all inshore survey days other than February 15.

(g) The survey followed “Other General Surveys and Studies (Coastal Engineering Surveys)” specifications according to USACOE manual No. 1110-2-1003. All equipment was calibrated and bench tested prior to survey activities. Offset measurements were taken during initial vessel rigging then checked a second time after completion of rigging. The altimeter and fathometer on the magnetometer were checked against manual lead line measurements in a protected portion of the Corpus Christi Ship Channel prior to initial survey deployment. The multibeam and single beam echosounders were also checked against manual lead line measurements prior to the initial survey deployment. RTK GPS checks were run on two project control points prior to commencement of survey activities and SBAS differential GPS checks were also made to the project control points.

Crosslines were intermittently run to check the consistency of both the multibeam and single beam echosounders. Sound velocity profiles were collected during survey operations and used for post-processing the multibeam and single beam data. The sub-bottom, magnetometer and side scan sonar to fish cable out measurements were kept as consistent as possible with as little adjustment made to provide the correct towfish altitude as possible.

In post-processing for the inshore portions of the survey, RTK tides were checked against tides at the nearest NOAA tide gauges (Port Aransas and Bob Hall) to ensure accuracy and consistency. For offshore portions of the survey where RTK tides were not available, draft measurement of the echosounder and manual tides from the Port Aransas and Bob Hall tide gauges were used to correct the bathymetric data to the survey datum. Data overlapping
between the seven survey sections were checked against each other (particularly for the single beam and multibeam data) to ensure a good match between survey datasets.

Survey data that didn’t meet the required specification for accuracy and quality were re-run. The only areas that had to be re-surveyed were the survey lines where the magnetometer altimeter showed an altitude of more than 20ft from the sea floor. These areas were re-surveyed after completion of the initial magnetometer survey.

(h) All applicable instrumentation guidelines and survey line spacing requirements were strictly followed for this survey.
Appendix D: Side-Scan Sonar Mosaic (Not for Public Disclosure)
Appendix E: Magnetic Contours (Not for Public Disclosure)
Appendix F: Side-Scan Sonar Contacts (Not for Public Disclosure)
Appendix G: Geophysical Targets Recommended for Avoidance (Not for Public Disclosure)

Table G-1: Geophysical Target Recommended for Avoidance (Not for Public Disclosure)

<table>
<thead>
<tr>
<th>Target ID</th>
<th>Mag (nT)</th>
<th>Sonar Contacts</th>
<th>Depth (ft)</th>
<th>Mineral Lease Tract</th>
<th>Anomaly Width to +/-5-nT contours (ft)</th>
<th>Center Easting (UTM 14N, m, WGS84)</th>
<th>Center Northing (UTM 14N, m, WGS84)</th>
</tr>
</thead>
</table>
Appendix H: Texas Antiquities Permit 8672 and THC Correspondence
Thursday, December 06, 2018

Robert Gearhart
BOB Hydrographics, LLC
1315 Fall Creek Loop
Cedar Park, TX 78613-5820

Re: Project review under the Antiquities Code of Texas
Final Report: South Texas SPM Project
Texas Antiquities Permit # 8672

Dear Colleague:

Thank you for your Antiquities Permit Application for the above referenced project. This letter presents the final copy of the permit from the Executive Director of the Texas Historical Commission (THC), the state agency responsible for administering the Antiquities Code of Texas.

Please keep this copy for your records. The Antiquities Permit investigations requires the production and submittal of one printed copy of the final report, a completed abstract form submitted via our online system, two copies of the tagged PDF final report on CD (one with site location information & one without), and verification that any artifacts recovered and records produced during the investigations are curated at the repository listed in the permit. The abstract form maybe submitted via the THC website (www.thc.state.tx.us) or use url: http://xapps.thc.state.tx.us/Abstract/login.aspx
Additionally, you must send the THC shapefiles showing the boundaries of the project area and the areas actually surveyed via email to archeological_projects@thc.texas.gov.

If you have any questions concerning this permit or if we can be of further assistance, please contact the reviewer, Amy Borgens at (512) 463-9505.

Sincerely,

Nick Barrett:
Antiquities Permit Coordinator
(512) 463-1858

Enclosures

Cc :Texas General Land Office
Bluewater Terminal LLC
This permit is issued by the Texas Historical Commission, hereafter referred to as the Commission, represented herein by and through its duly authorized and empowered representatives. The Commission, under authority of the Texas Natural Resources Code, Title 9, Chapter 191, and subject to the conditions hereinafter set forth, grants this permit for:

Intensive Survey

To be performed on a potential or designated landmark or other public land known as:

Title: South Texas SPM Project
County: Aransas
Location: Redfish Bay from Port Aransas to San Jose Island; Gulf of Mexico from beach, 0.6 miles north of the Port Aransas Jetties, into Federal waters.

Owned or Controlled by: (hereafter known as the Permittee):
Texas General Land Office
1700 N. Congress Ave., STE 935
Austin TX 78701

Sponsored by (hereafter known as the Sponsor)
Bluewater Terminal LLC
2331 City West Blvd.
Houston TX 77042

The Principal Investigator/Investigation Firm representing the Owner or Sponsor is:
Robert Gearhart
BOB Hydrographics, LLC
1315 Fall Creek Loop
Cedar Park, TX 78613-5820

This permit is to be in effect for a period of:
1 Years and 0 Months
and Will Expire on:
12/06/2019

During the preservation, analysis, and preparation of a final report or until further notice by the Commission, artifacts, field notes, and other data gathered during the investigation will be kept temporarily at:
BOB Hydrographics, LLC

Upon completion of the final permit report, the same artifacts, field notes, and other data will be placed in a permanent curatorial repository at:
CAS-Texas State University

Scope of Work under this permit shall consist of:
Underwater Survey, see attached scope and design for more details.
This permit is granted on the following terms and conditions:

1) This project must be carried out in such a manner that the maximum amount of historic, scientific, archeological, and educational information will be recovered and preserved and must include the scientific, techniques for recovery, recording, preservation and analysis commonly used in archeological investigations. All survey level investigations must follow the state survey standards and the THC survey requirements established with the projects sponsor(s).

2) The Principal Investigator/Investigation Firm, serving for the Owner/Permittee and/or the Project Sponsor, is responsible for insuring that specimens, samples, artifacts, materials and records that are collected as a result of this permit are appropriately cleaned, and cataloged for curation. These tasks will be accomplished at no charge to the Commission, and all specimens, artifacts, materials, samples, and original field notes, maps, drawings, and photographs resulting from the investigations remain the property of the State of Texas, or its political subdivision, and must be curated at a certified repository. Verification of curation by the repository is also required, and duplicate copies of any requested records shall be furnished to the Commission before any permit will be considered complete.

3) The Principal Investigator/Investigation Firm serving for the Owner/Permittee and/or the Project Sponsor is responsible for the publication of results of the investigations in a thorough technical report containing relevant descriptions, maps, documents, drawings, and photographs. A draft copy of the report must be submitted to the Commission for review and approval. Any changes to the draft report requested by the Commission must be made or addressed in the report, or under separate written response to the Commission. Once a draft has been approved by the Commission, one (1) printed, unbound copy of the final report containing at least one map with the plotted location of any and all sites recorded and two copies of the report in tagged PDF format on an archival quality CD or DVD shall be furnished to the commission. Onew copy must include the plotted location of any and all sites recorded and the other should not include the site location data. A paper copy and an electronic copy of the completed Abstracts in Texas Contract Archeology Summary Form must also be submitted with the final report to the Commission. (Printed copies of forms are available from the Commission or also online at www.thc.state.tx.us.)

4) If the Owner/Permittee, Project Sponsor or Principal Investigator/Investigation Firm fails to comply with any of the Commission’s Rules of Practice and Procedure or with any of the specific terms of this permit, or fails to properly conduct or complete this project within the allotted time, the permit will fall into default status. A notification of Default status shall be sent to the Principal Investigator/Investigation Firm, and the Principal Investigator will not be eligible to be issued any new permits until such time that the conditions of this permit are complete or, if applicable, extended.

5) The Owner/Permittee, Project Sponsor, and Principal Investigator/Investigation Firm, in the conduct of the activities hereby authorizes, must comply with all laws, ordinances and regulations of the State of Texas and of its political subdivisions including, but not limited to, the Antiquities Code of Texas; they must conduct the investigation in such a manner as to afford protection to the rights of any and all lessees or easement holders or other persons having an interest in the property and they must return the property to its original condition insofar as possible, to leave it in a state which will not create hazard to life nor contribute to the deterioration of the site or adjacent lands by natural forces.

6) Any duly authorized and empowered representative of the Commission may, at any time, visit the site to inspect the fieldwork as well as the field records, materials, and specimens being recovered.

7) For reasons of site security associated with historical resources, the Project Sponsor (if not the Owner/Permittee), Principal Investigator, Owner, and Investigation Firm shall not issue any press releases, or divulse to the news media, either directly or indirectly, information regarding the specific location of, or other information that might endanger those resources, or their associated artifacts without first consulting with the Commission, and the State agency or political subdivision of the State that owns or controls the land where the resource has been discovered.

8) This permit may not be assigned by the Principal Investigator/Investigation Firm, Owner/Permittee, or Project Sponsor in whole, or in part to any other individual, organization, or corporation not specifically mentioned in this permit without the written consent of the Commission.

9) Hold Harmless: The Owner/Permittee hereby expressly releases the State and agrees that Owner/Permittee will hold harmless, indemnify, and defend (including reasonable attorney’s fees and cost of litigation) the State, its officers, agents, and employees in their official and/or individual capacities from every liability, loss, or claim for damages to persons or property, direct or indirect of whatsoever nature arising out of, or in any way connected with, any of the activities covered under this permit. The provisions of this paragraph are solely for the benefit of the State and the Texas Historical Commission and are not intended to create or grant any rights, contractual or otherwise, to any other person or entity.

10) Addendum: The Owner/Permittee, Project Sponsor and Principal Investigator/Investigation Firm must abide by any addenda hereto attached.

Upon a finding that it is in the best interest of the State, this permit is issued on 12/06/2018.

Pat Mercado-Allinger,  
Archeology Division Director  

Mark Wolfe,  
Executive Director
Robert Gearhart

From: Amy Borgens <Amy.Borgens@thc.texas.gov>  
Sent: Friday, December 7, 2018 11:02 AM  
To: Robert Gearhart  
Cc: 'Denise O’Brian'; 'Marisa Weber'; 'Justin Wiedeman'; Jim Naismith  
Subject: Re: antiquities permit 8672 amendment requested

Thank you Bob,

The amendment is approved. This correspondence will be added to the file for permit no. 8672.

Amy

Amy A. Borgens, MA  
State Marine Archeologist  
Archeology Division  
Texas Historical Commission  
P.O. Box 12276  
Austin, Texas 78711  
(office) 512.463.9505  
(fax) 512.463.8927  
www.thc.state.tx

From: Robert Gearhart <bob.hydrographics@gmail.com>  
Sent: Friday, December 7, 2018 10:50:58 AM  
To: Amy Borgens  
Cc: 'Denise O’Brian'; 'Marisa Weber'; 'Justin Wiedeman'; Jim Naismith  
Subject: antiquities permit 8672 amendment requested

Amy,

I’m attaching a revised survey area for Permit 8672. The alignment angle seaward of the 3-nautical-mile line has been shifted slightly toward the south. A dog leg toward the north also has been added in federal waters. The only change in state waters is shifting the survey corridor southward, as described above. The total shift is about 1000 feet at the outer limit of state waters. I would appreciate if you would amend the permit to reflect this change.
Bob
Robert Gearhart  
BOB Hydrographics, LLC  
1315 Fall Creek Loop  
Cedar Park, Texas 78613

Re: Project review under Section 106 of the National Historic Preservation Act of 1966 and the Antiquities Code of Texas  
Draft Report Review Marine Archeology Assessment in Support of the Bluewater SPM Project, Nueces and Aransas Counties, Texas and adjoining Federal Waters  
Texas Antiquities Permit No. 8672, Tracking No. 201909253

Dear Mr. Gearhart:

This letter serves as comment on the proposed federal undertaking from the State Historic Preservation Officer, the Executive Director of the Texas Historical Commission (THC). As the state agency responsible for administering the Antiquities Code of Texas, these comments also provide recommendations on compliance with state antiquities laws and regulations.

The review staff, led by State Marine Archeologist Amy A. Borgens, has completed its review. Bob Hydrographic, LLC, with Naismith Marine, completed an underwater archeological remote-sensing survey for the Bluewater SPM Project in April 2019. Three magnetic targets (Anomalies 1-3) were recommended for avoidance in the draft report for Antiquities Permit No. 8672: two of these targets occur in state waters and one is in federal waters. The THC concurs with these recommendations. Anomalies 2 and 3 are in an area wherein pipeline installation will occur via horizontal directional drilling, so no impacts will be introduced to these two targets by the Bluewater SPM project. The avoidance margins from Anomalies 1-3 are defined as 150 m beyond the magnetic contours for Anomaly 1; 50 m from the sonar contours of the archeological site of Anomaly 2; and 50 m beyond the contours of Anomaly 3.

The sonar image suggests Anomaly 2 is a historic watercraft and this is strengthened by its proximity to a shipwreck plotted on historic 1900 USC&G Chart 209. Please submit an archeological site form and acquire a trinomial for Anomaly 2. For the final report, please revise the information on page 33 to include the trinomial. In the abstract also please include the specific identities of the recommended targets (Anomalies 1, 2, and 3) and the trinomial for Anomaly 2. It is recommended the site form be included as an appendix to the report.

Thank you for your cooperation in this federal and state review process, and for your efforts to preserve the irreplaceable heritage of Texas. If you have any questions concerning our review or if we can be of further assistance, please contact Amy Borgens at amy.borgens@thc.texas.gov or 512-463-9505.

Sincerely,

Mark Wolfe  
State Historic Preservation Officer  
MW/ab
Appendix I: 41AS119 Archaeological Site Form
(Not for Public Disclosure)