APPENDIX D
CULTURAL RESOURCES

BAY AQUATIC BENEFICIAL USE SITES
GALVESTON BAY, TEXAS

U.S. ARMY CORPS OF ENGINEERS, GALVESTON DISTRICT
2000 Fort Point Road
Galveston, Texas 77550

BOB Project 2024-01

DRAFT
SUBMERGED ARCHAEOLOGICAL ASSESSMENT OF BAY AQUATIC BENEFICIAL USE SITES, CHAMBERS COUNTY, TEXAS

Prepared for:

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Prepared by:

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Principal Investigator:
Robert Gearhart

May 8, 2025

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Texas Antiquities Permit No. 31570

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Table of Contents

Table of Contents (continued)

List of Figures

List of Tables

Abstract

BOB Hydrographics, LLC (BOB) conducted a submerged archaeological survey and assessment of proposed Bay Aquatic Beneficial Use Sites, located between Atkinson Island and the Mid-Bay Placement Area, on the east side of the Houston Ship Channel, in Galveston Bay. ANAMAR Environmental Consulting, Inc. contracted with BOB, on behalf of the project sponsor, the United States Army Corps of Engineers, Galveston District.

The project encompasses portions of Galveston Bay State Mineral Lease Tracts 95-96, 116-118 127-131, 205-209, and 217-221. The planned survey totals 5,178 acres, including a 50-meter-wide survey buffer, mandated by the Texas Historical Commission. Magnetometer data was acquired over 5,362 acres. Shallow areas, totaling 4 acres, were necessarily excluded from the survey.

The purpose of this study was to assess the potential for submerged archaeological sites; however, no artifacts were collected during the survey. Submerged archaeological sites, in this context, might include sunken or abandoned watercraft. A review of the cultural background determined that 13 submerged archaeological surveys have been conducted within 1 kilometer of this project. At least 11 wrecks have been reported within 1 kilometer of the project area. No prehistoric archaeological sites have been reported within 1 kilometer of the project area.

Geophysical survey was completed by BOB from March 11-26, 2024 and from October 8-26, 2024. Work was completed under Texas Antiquities Permit 31570. The survey was conducted from BOB's 20-foot aluminum work boat, equipped with a side-scan sonar, magnetometer, single-beam echo sounder, and a satellite-based positioning system. BOB's survey crew included Robert Gearhart and Michael Baxter. Water depths ranged from 4 to 11 feet below Mean Lower Low Water.

BOB initially recommended avoidance of 28 magnetic anomalies, interpreted as potential historic sites that might meet eligibility criteria for the State Antiquities Landmark and for the National Register of Historic Places. All 28 anomalies were subsequently cleared from further concern by probing the seafloor under an amendment to permit 31570. Dredging an Excavated PA has potential to disturb intact prehistoric archaeological sites in areas overlapping the San Jacinto and Trinity paleo-valleys. Intact sites may be preserved in fluvial terrace and floodplain sediments of both paleo-valleys. BOB recommends archaeological monitoring of levee construction that uses material sourced from either paleo-valley. No monitoring is recommended for levee construction using materials dredged from former upland areas, outside of the paleo-valleys, due to a low likelihood of finding intact sites through further survey, coring or monitoring. The margins of both paleo-valleys should be delineated inside the BABUS project area, prior to construction, based on a combination of acoustic sub-bottom profiles and geotechnical cores. Existing data from earlier studies may be available for that purpose.

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. Archaeological project records will be curated by the Texas Archeological Research Laboratory at the University of Texas in Austin.

I. Introduction

BOB Hydrographics, LLC (BOB) conducted a submerged archaeological survey and assessment in support of environmental permitting for proposed construction of Bay Aquatic Beneficial Use Sites (BABUS) in Upper Galveston Bay (Figure 1). Cultural resources investigations were required so proposed construction-related activities can avoid potential historic sites resting on or embedded in the seafloor. ANAMAR Environmental Consulting, Inc. (ANAMAR) contracted with BOB, on behalf of the project sponsor, the United States (US) Army Corps of Engineers, Galveston District. Work was completed under Texas Antiquities Permit (TAP) 31570.

The project area is in upper Galveston Bay, southeast of Atkinson Island, north of the Mid-Bay Placement Area (Blue Water Atoll), and east of the Houston Ship Channel. The BABUS project is in a conceptual stage, so its configuration and position within the archaeological survey area is preliminary. The current design of the BABUS project has a footprint of 4,353 acres, including 3,264 acres of Placement Areas (PA) and 1,089 acres of containment levees (Figure 2). The interiors of the BABUS PAs will be filled gradually with material dredged from areas of the Houston Ship Channel north of Morgans Point. Placement of the material will occur over a projected 50-year period or until the estimated capacity of 100 million cubic yards is reached.

The project will consist of two types of PA: Excavated and Marsh Fill. The Excavated PA will be created by excavating the bay bottom to a depth of -70 ft below Mean Lower Low Water (MLLW), dependent on further engineering and design work. Current plans call for excavating 1,187 acres. Excavated material would be used to construct containment levees around all of the PAs. The balance of PA areas will be of the Marsh Fill variety. Marsh Fill PAs are anticipated to be filled with dredged material, raising the existing bay bottom (averaging -8 ft MLLW) to elevations of 0 to +3.5 ft MLLW, creating intertidal marsh and bird island habitats. Current plans call for an ultimate Marsh Fill area of 3,264 acres. Two Marsh Fill PAs, totaling 1,659 acres, will be constructed initially, one each on the north and south ends of the project. Another 1,605 acres of Marsh Fill PA will be centrally located, once the Excavated PA has been refilled with dredged material to an elevation suitable for sustaining the desired marsh habitat.

Project effects to the seafloor would include: dredging 1,187 acres to a depth of -70 ft MLLW, averaging 62 ft below the bay bottom; construction of earthen levees around each PA; and covering 1,659 acres of existing bay bottom, inside of Marsh Fill PAs, with dredged material, delivered by temporary slurry pipelines.

The project encompasses portions of Galveston Bay State Mineral Lease Tracts 95-96, 116-118 127-131, 205-209, and 217-221. The planned survey totals 5,178 acres, including a 50-meter (m)-wide survey buffer, mandated by the Texas Historical Commission (THC). Magnetometer data was acquired over 5,362 acres. Shallow areas, totaling 4 acres, were necessarily excluded from the survey.

The purpose of this study was to assess the potential for submerged archaeological sites in the survey area. No artifacts were collected. Submerged archaeological sites, in this context, might include sunken or abandoned watercraft. A review of the cultural background determined that 13 submerged archaeological surveys have been conducted within 1 kilometer (km) of this project. At least 11 wrecks

have been reported within 1 km of the project area. No prehistoric archaeological sites have been reported within 1 km of the project area.

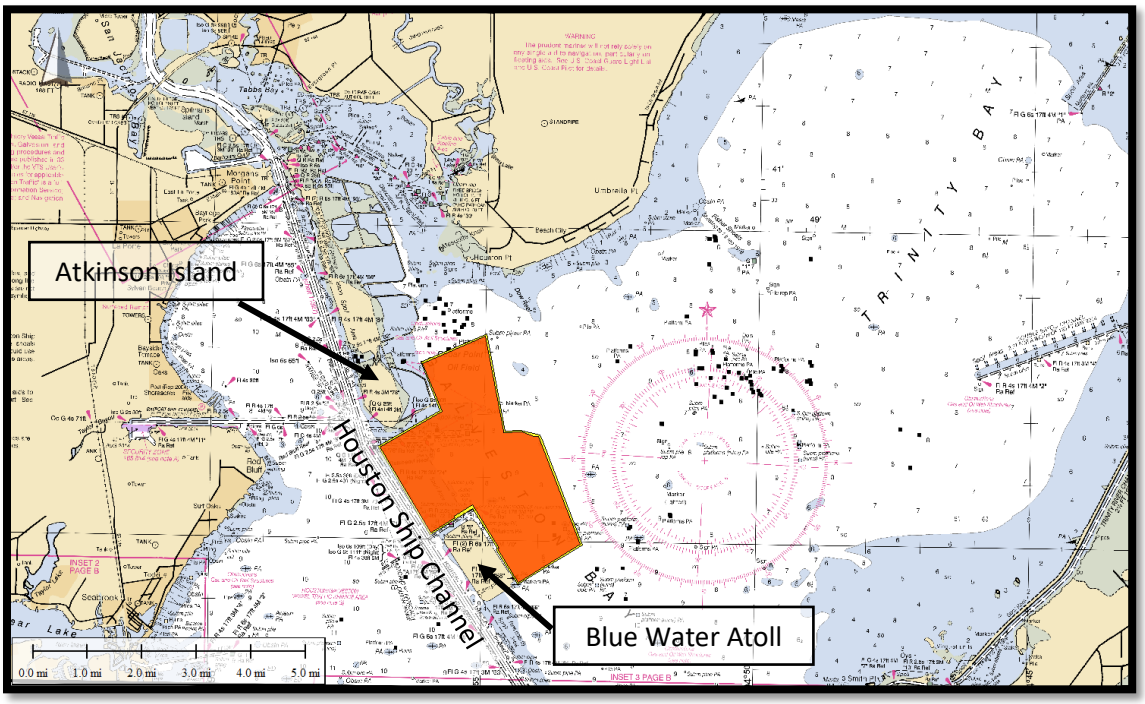

Figure 1: Project Location (shaded orange); Base Map: National Oceanic and Atmospheric Administration (NOAA) Chart 11326, Galveston Bay, Side A

Geophysical survey was completed by BOB from March 11-26, 2024 and from October 8-26, 2024. The survey was conducted from BOB's 20-foot (ft) aluminum work boat, equipped with a side-scan sonar, magnetometer, single-beam echo sounder, and a satellite-based positioning system. BOB's survey crew included Robert Gearhart and Michael Baxter. Water depths ranged from 4 to 11 feet below MLLW.

Analysis of geophysical survey results from this investigation discovered 28 potentially-significant magnetic anomalies, interpreted as potential historic sites that might meet eligibility criteria for the State Antiquities Landmark and for the National Register of Historic Places. All 28 anomalies were subsequently cleared from further concern by probing the seafloor under an amendment to permit 31570.

Dredging an Excavated PA (Figure 2) has potential to disturb intact prehistoric archaeological sites in areas overlapping the San Jacinto and Trinity paleo-valleys. Intact sites may be preserved in fluvial terrace and floodplain sediments of both paleo-valleys. BOB recommends archaeological monitoring of levee construction that uses material sourced from either paleo-valley. No monitoring is recommended for levee construction using materials dredged from former upland areas, outside of the paleo-valleys, due to a low likelihood of finding intact sites through further survey, coring or monitoring. The margins of both paleo-valleys should be delineated inside the BABUS project area, prior to construction, based on a combination of acoustic sub-bottom profiles and geotechnical cores. Existing data from earlier studies may be available for that purpose.

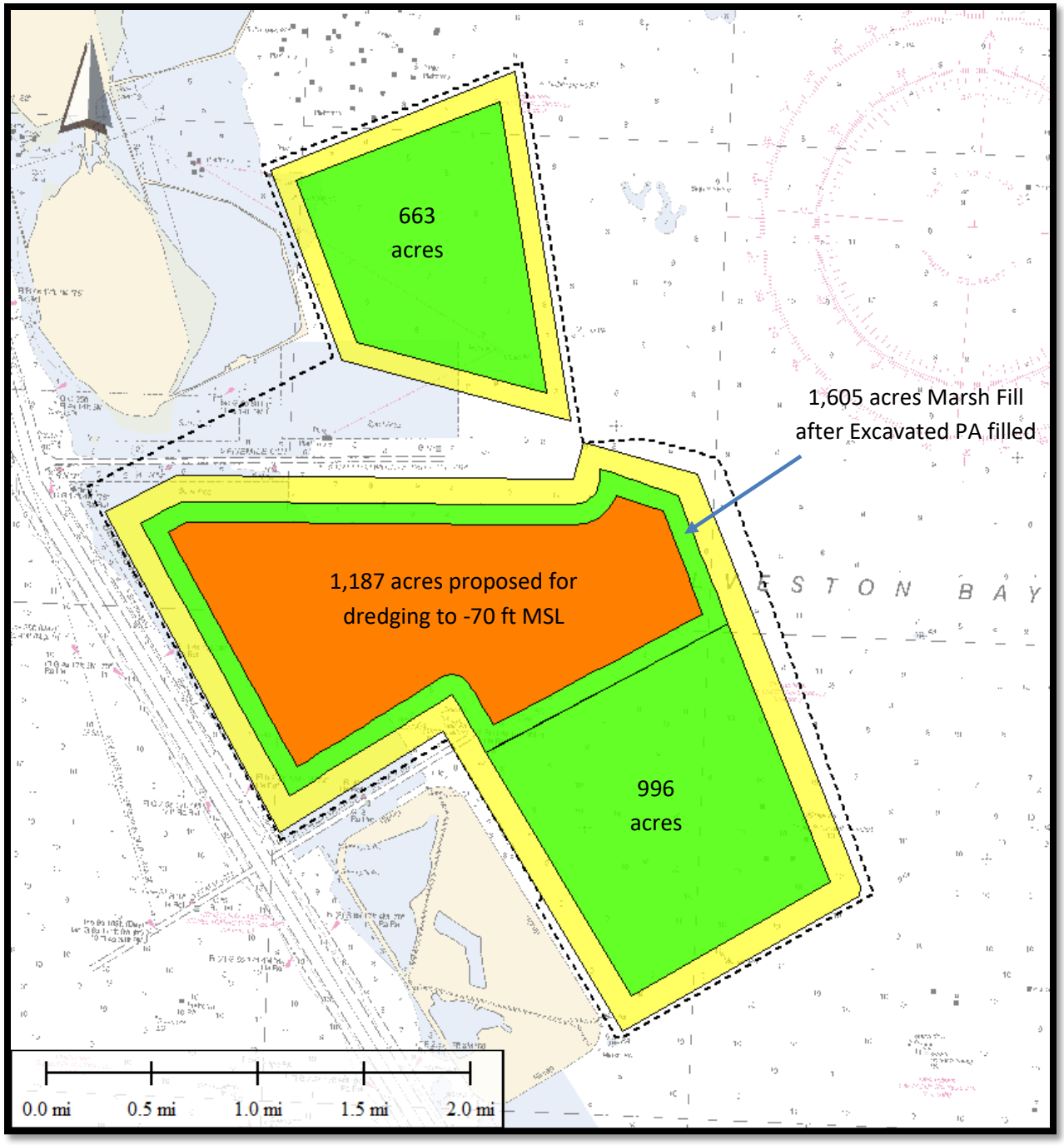

Figure 2: Preliminary Design of BABUS Placement Areas
(yellow=levee; green=Marsh Fill PAs; orange=Excavated PA and future Marsh Fill PA)

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. The results reported in this document may support application by the sponsor for a US Army Corps of Engineers Permit. 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 Galveston Bay are publicly owned by the state of Texas and administered by the General Land Office; therefore, TAP 31570 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 TAPs. Archaeological project records will be curated by the Texas Archeological Research Laboratory at the University of Texas in Austin.

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 survey area and environmental factors affecting the potential occurrence and preservation of submerged archaeological sites. Section III summarizes the relevant cultural background, including its prehistory and maritime history, evidence for intact archaeological sites, and a summary of previous submerged archaeological investigations within a 1-km radius of the survey. 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 survey areas. Bibliographic references cited in the text are included as Section VI. Geophysical survey results are provided as appendices, including side-scan sonar mosaics (Appendix A) and magnetic contours (Appendix B). A table of significant findings is included as Appendix C. Close-order contours of magnetic anomalies, initially interpreted as significant, are included in Appendix D. Tabulated and plan view results of probing are included in Appendix E. A copy of TAP 31570 and THC correspondence is included as Appendix F.

II. Environmental Background

The potential occurrence and preservation of submerged archaeological sites in the survey area are largely determined by the physical environment. Locations of prehistoric sites along the former San Jacinto River and Trinity River valleys were determined by the distribution of ecological zones and natural resources valued by early human inhabitants of the area. Preservation of prehistoric sites depended on environmental factors contributing to burial and to reduced wave energy that, combined, would minimize site erosion during sea level rise. Historic watercraft sank due to a variety of environmental hazards, including shoals and dangerous weather conditions. Long-term preservation of submerged historic sites depended on environmental factors promoting their burial in low-oxygen conditions.

Sea Level Rise

Continental glaciers held back significant amounts of water from the sea during the peak of the last ice age, resulting in a much lower sea level than exists today. Seas fell during the most recent glacial maximum to about 120 m below their present level (Heinrich, et al. 2020: 6). Sea level remained at a lowstand from about 22,000 to 16,000 years ago. During that period, the shoreline was located near the margin of the Outer Continental Shelf. As continental glaciers melted around the world, seas rose to cover the shelf and flooded river valleys. Evans (2016:18, Figure 2.5) constructed a composite sea level curve, illustrating the timing of transgression in the northwestern Gulf of Mexico (Figure 3), based on reanalysis of earlier efforts, including Curray (1960); Shepard (1960); Nelson and Bray (1970); Frazier (1974); Morton et al. (2000); Blum et al. (2001); Tornqvist et al. (2006); and Blum et al. (2008).

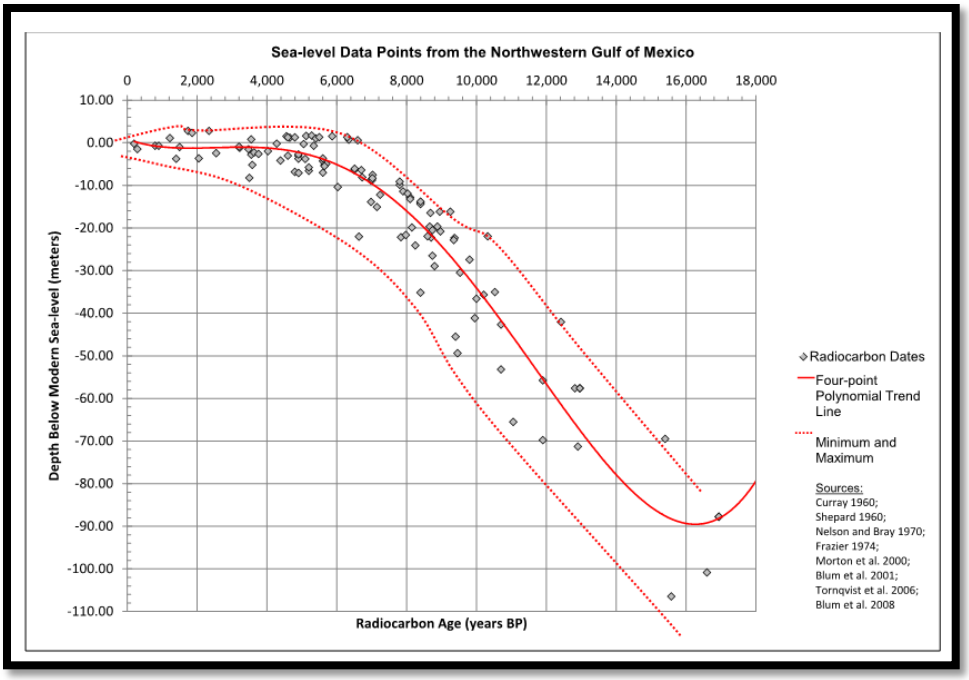

Figure 3: Sea level curve for the northwestern Gulf of Mexico (from Evans 2016:18, Figure 2.5)

Prior to the formation of Galveston Bay, the confluence of the Pleistocene-age San Jacinto and Trinity rivers was located about 2 miles south of the survey area (Figure 4; Anderson, et al. 2008). Valley portions of the survey area were covered by deltaic sediments beginning about 8500 years before present (BP). By about 7700 BP, both valleys were flooded by rising seas. Much of the survey area lies over a former upland surface, part of the Beaumont Clay formation, which is about 5 meters (16 ft) below Mean Sea Level (MSL) (Figure 5). The Beaumont Formation was deposited during the Late Pleistocene, beginning about 129,000 years ago and ending with the Holocene. The Beaumont Clay upland did not flood until after 2500 BP. Today the Beaumont surface is covered by 6-9 ft of bay mud. The southeastern and western margins of the survey area (Figure 5) overlie the paleo-valleys, presumably including fluvial stream terraces, which are intermediate in elevation between the submerged valley floodplains and the valley margins. Anderson, et al. (2008: 92) identified prominent terraces at elevations of -14 meters (-46 ft) and -10 meters (-33 ft) MSL throughout much of Galveston Bay.

Flooding due to sea level rise, also known as marine transgression, is marked by a geological disconformity between terrestrial and marine sediments, referred to by geologists as a transgressive surface. Heinrich, et al. (2020: 30-33) describe a type of transgressive surface, called a coastal flooding surface, which is relevant to the BABUS Survey. A coastal flooding surface is an abrupt transition from terrestrial sediments of a coastal plain to marine sediments deposited in a bay, lagoon or sound environment due to sea level rise. The resulting "discontinuity can be either the relatively intact surface of a coastwise terrace, fluvial terrace, floodplain, or delta plain or, more commonly, eroded to form a minor ravinement [erosion] surface" (Heinrich, et al. 2020: 30). Former valley portions of the survey area are more likely to contain intact fluvial terrace and floodplain sediments, overlain by somewhat eroded deltaic sediments. The top of the Beaumont Formation in former upland portions of the survey area is presumed to have eroded during marine transgression.

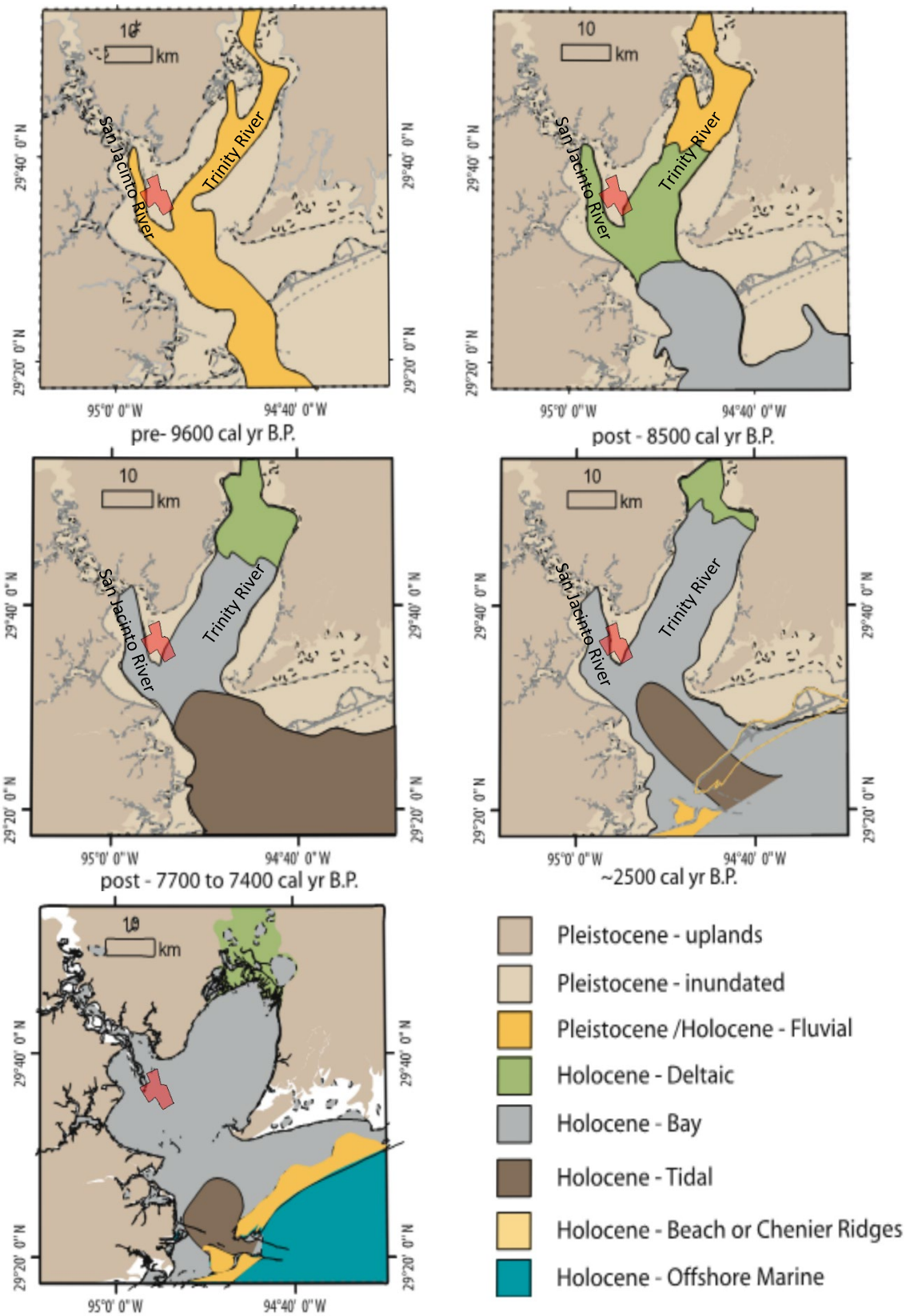

Figure 4: Evolution of Galveston estuary complex (after Anderson, et al. 2008: 101-102)

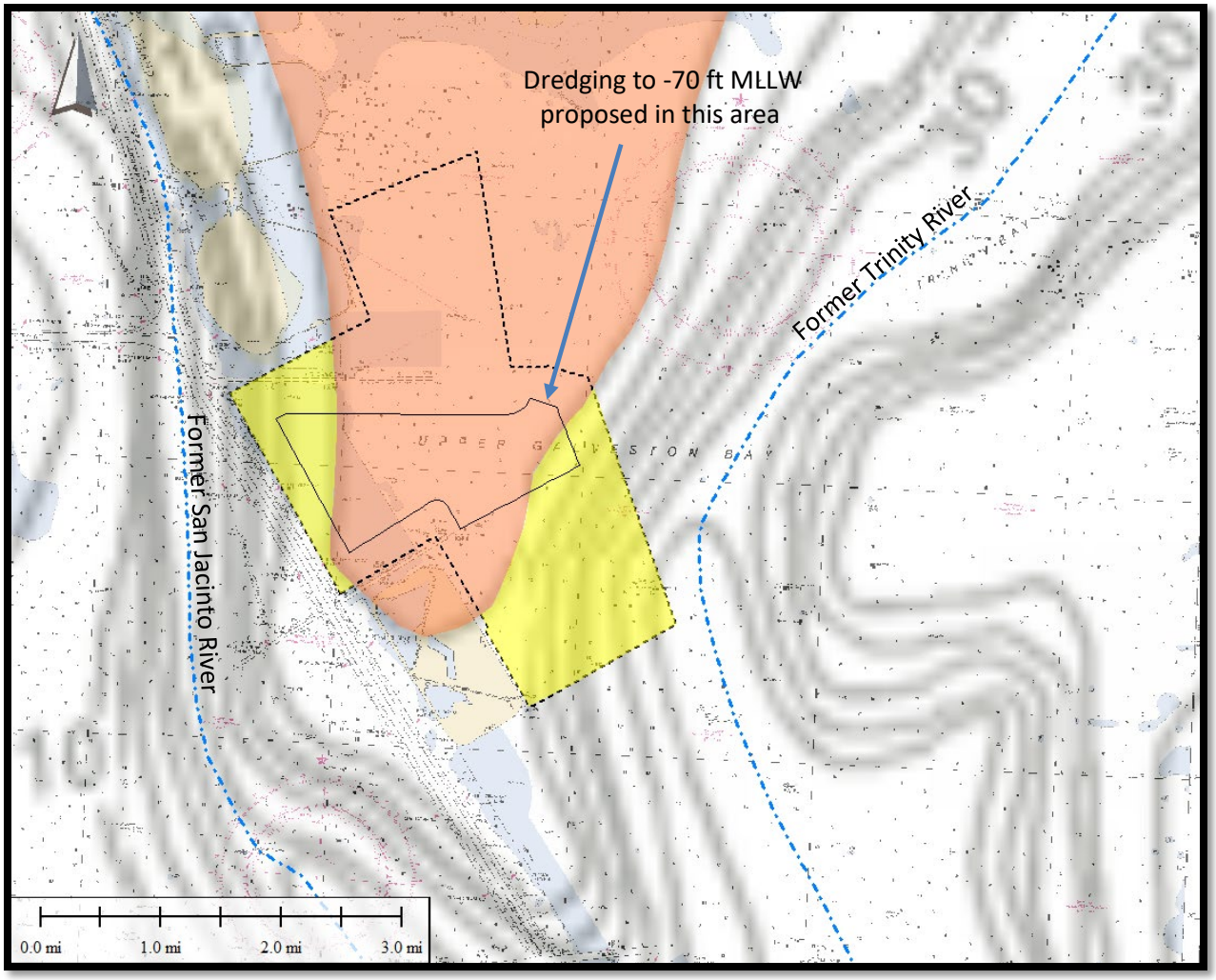

Figure 5: Approximate former upland (shaded orange) and paleo-valley (shaded yellow) Contours represent depth of burial (5-meter MSL interval) of the Late Pleistocene land surface, after Anderson et al. (2008: 94).

Bathymetry

Depths from single-beam data, acquired for the project sponsor by Echo Ocean Science, LLC are illustrated as color-shaded relief in Figure 6. Water depths, corrected for tides, range from about 4 ft below MLLW, in a spoil area at the western corner of the survey, to 11 ft below MLLW in the southeastern corner of the survey area. Shoaling has occurred due to the placement of dredged material, near the Houston Ship Channel and along the margins of Atkinson Island and Blue Water Atoll. Areas further from placement areas range in depth from 8-11 ft below MLLW.

Depths of 7-10 ft below MLLW are indicated in the survey area on NOAA Chart 11327 (Figure 7). Soundings on NOAA Chart 11337 were acquired from 1962 to 1965, in the southeastern third of the survey area (Hollis, et al. 1962-1965), and from 1995 to 1996, in the western two-thirds of the survey (Harbison 1995

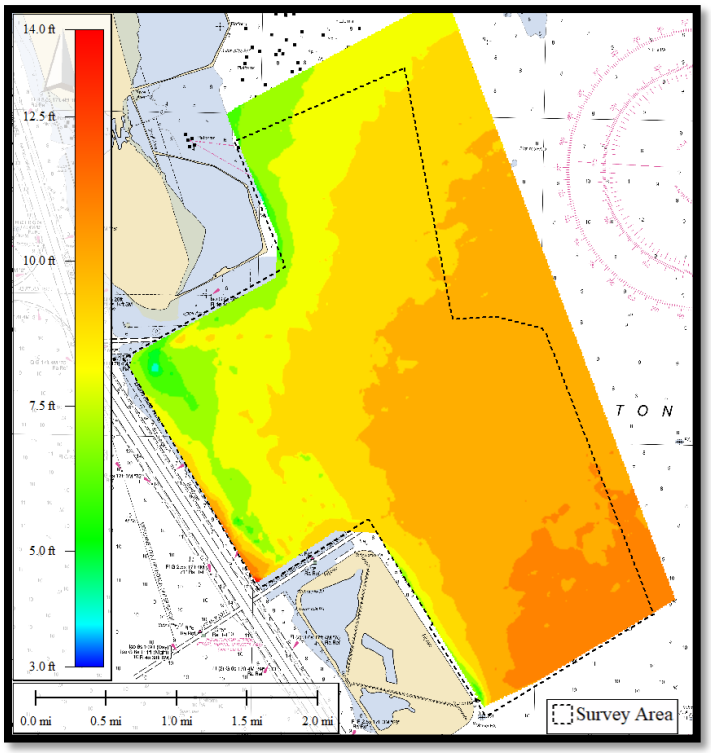

Figure 6: Bathymetry (ft below MLLW). Base Map: NOAA Chart 11327. Data acquired for Sponsor by Echo Ocean Science, LLC, October 30 to November 6, 2022.

and Illg 1996). The spoil area north of "Five Mile Cut" was added by 1964. The spoil area bordering the Houston Ship Channel in the western part of the survey area was added by 1973.

Historical soundings, predating 1962, were examined in an effort to better understand how the seafloor has changed in recent times. Figure 8 shows the survey area landscape of *circa* 1854 to 1884. Depth soundings from that period ranged from 9-11 ft, Mean Low Water (MLW) [8.87-10.87 ft MLLW], across the survey area, gradually increasing in depth from north to south (US Coast and Geodetic Survey [USCGS] 1885). Depth soundings from *circa* 1903 to 1904 (Figure 9) ranged from 7.25-9 ft, MLW [7.12-8.87 ft MLLW] (USCGS 1905). The Houston Ship Channel was maintained to a depth of 18.5 ft at the time. Shoals from dredge spoil were indicated along its northeastern margin. There were no reefs or severe shoals charted in the area during that period.

The depth decreases that occurred between 1854-1884 and 1903-1904 cannot be explained, except to conjecture that severe weather events, combined with changing land use practices upstream, might have caused short-term fluctuations, on the order of a foot or more, this close to the San Jacinto River Delta. The increase in depths since 1903-1904 might be partially due to subsidence, which has been a factor since the early 20th century. Gabyrsch and Bonnet (1977: 12-14) mapped subsidence of Houston and surrounding areas, due to withdrawal of groundwater for urban and industrial use during the 20th century. Their study estimated that 2.2-2.7 ft of subsidence occurred in the project vicinity from 1906-1973. Mitigation measures, such as regulation of ground water withdrawal, beginning in 1975, have been

successful in slowing the rate of subsidence, although additional land settlement might have occurred since then. Gabyrsch and Bonnet's estimate is fairly consistent with the change observed between 1903-1904 (Figure 9) and 2022 (Figure 6).

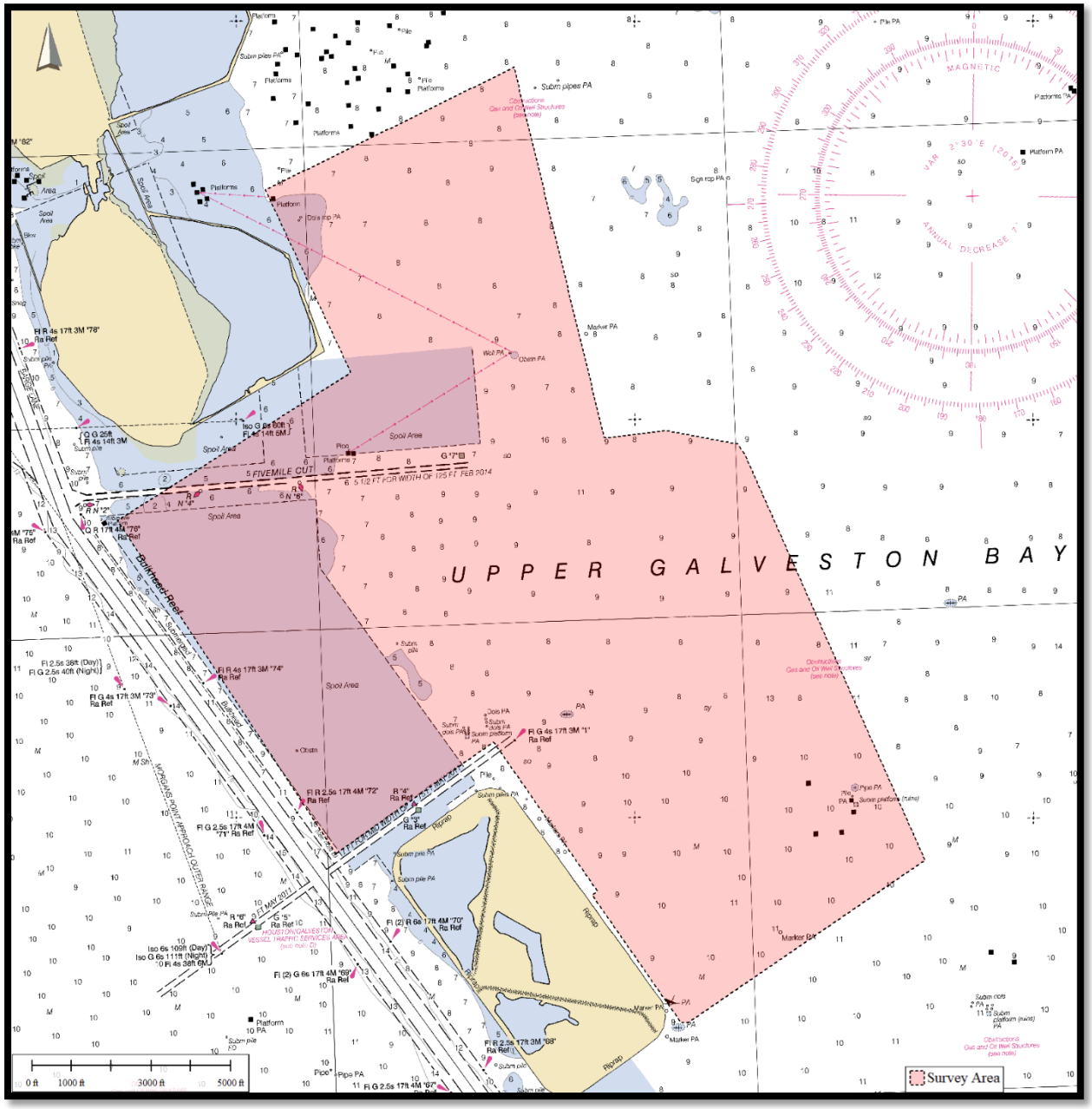

Figure 7: Soundings from 1962 to 1996 (NOAA Chart 11327)

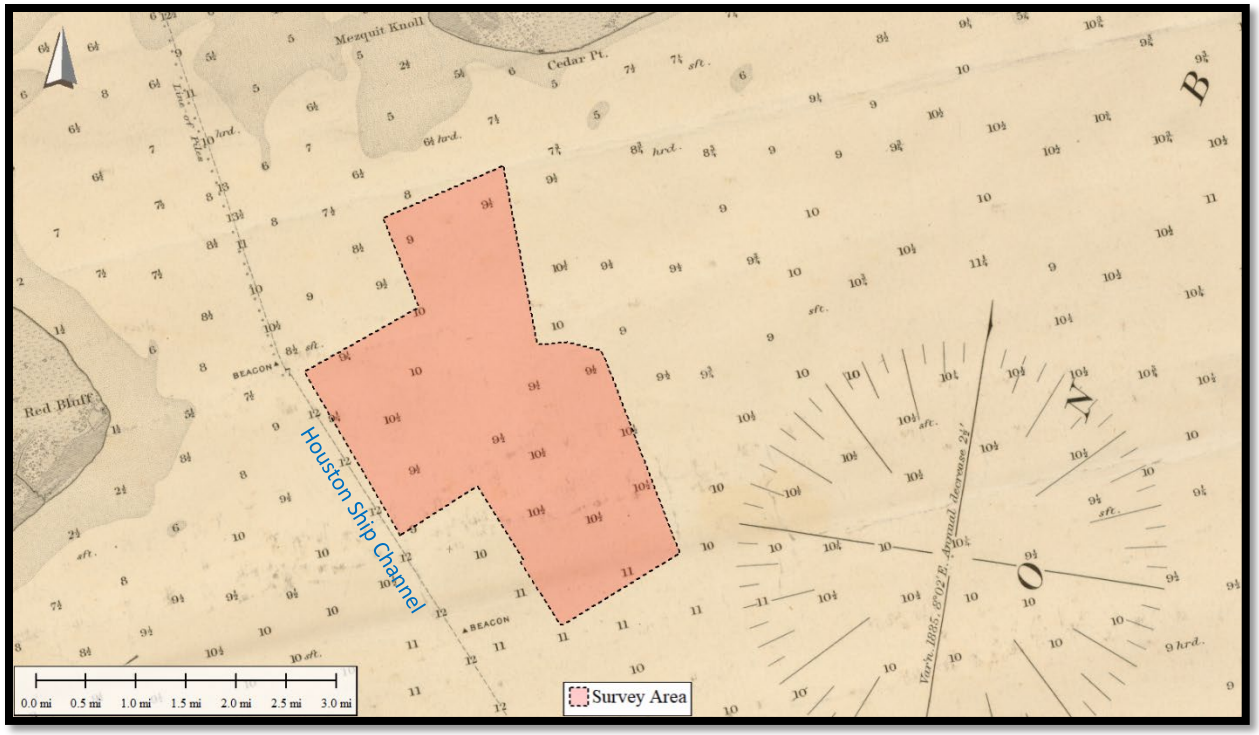

Figure 8: Survey area circa 1854 to 1884 (shaded red; base map: USCGS 1885)

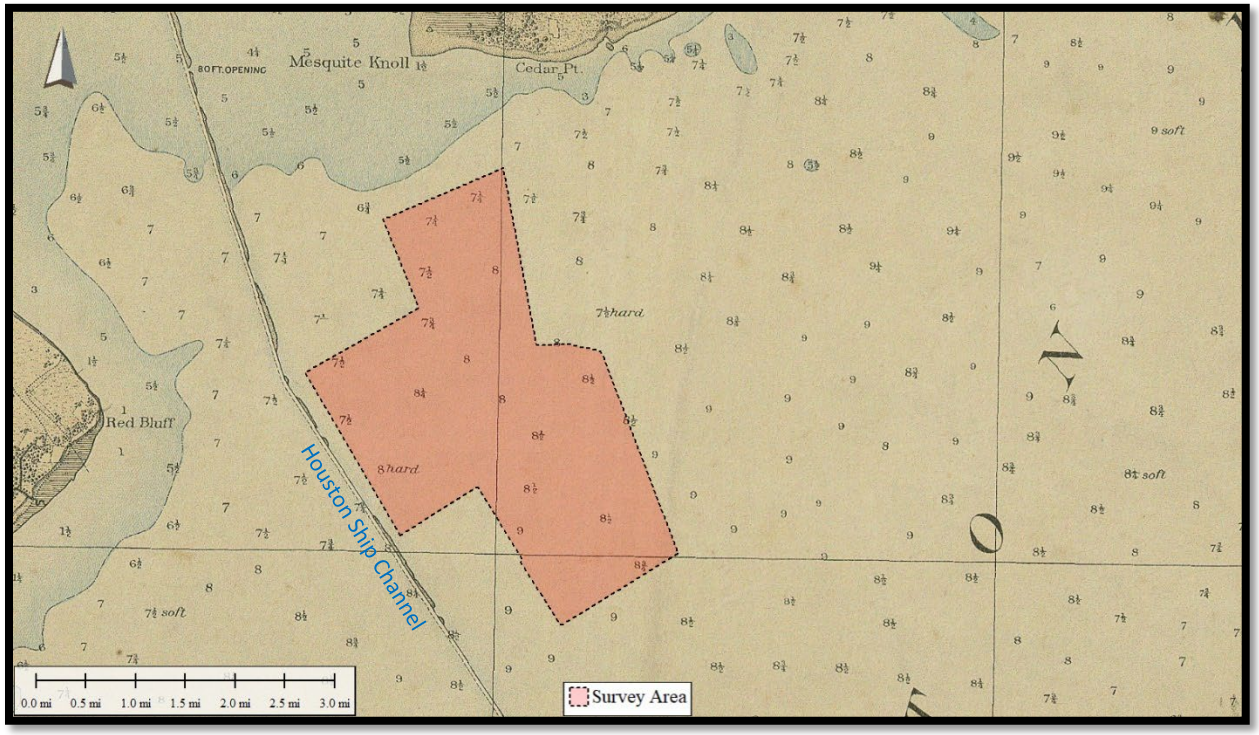

Figure 9: Survey area *circa* 1903 to 1904 (shaded red; base map: USCGS 1905)

Prehistoric Site Potential

The survey area was exposed to subaerial conditions for much of the past 30,000 years. Human settlement of the area may have begun as early as 24,000 years ago, depending on when humans first entered the region. There is potential for preservation of prehistoric sites in buried terrace and floodplain deposits beneath portions of the survey area (highlighted yellow in Figure 5).

Prehistoric site locations in submerged areas, as with terrestrial sites that are above sea level today, would have correlated with high-use landforms that offered humans concentrated food resources in proximity to fresh water. Geomorphic features with elevated potential for human habitation would have included topographic high spots located near fresh water. Alluvial terraces would have offered protection from flooding near abundant food sources and potable water. Lower-lying areas near fresh water, such as floodplains, river banks, natural levees, marsh shorelines and sand bars, might have been attractive locations for seasonal encampments, provided they were occasionally dry. Early inhabitants likely also built mounds from discarded mollusk shells near estuaries and streams, as observed at many archaeological sites along the Gulf Coast. Such shell mounds, or middens, also may have afforded some protection from seasonal flooding.

The potential for preservation of submerged prehistoric sites until the present day is dependent upon the survival of high-use landforms, described above, through the process of sea level rise, or transgression, during the Holocene. Coastal flooding during the rise of sea levels substantially altered landscapes. Former coastal plains were unprotected from the full energy of ocean waves. Sites in such areas were destroyed by erosion as the shoreface slowly migrated inland. On the other hand, sites capped by alluvium or marsh deposits may have survived the transgressive process. Heinrich, et al. (2020) summarized the preservation potential of paleo-landscapes on the continental shelf in the northwestern Gulf of Mexico. They conclude that “there may be situations associated with fluvial aggradation and subsequent estuarine deposition within paleovalleys that could potentially provide an opportunity for preservation of buried geomorphic surfaces and intact prehistoric landscapes (ibid. 2020: 6).”

The southeastern and western margins of the survey area are believed to overlie fluvial terrace and floodplain deposits (areas shaded yellow in Figure 5). Fluvial terraces and floodplains in the paleo-valleys would have been likely locations for both the occurrence and preservation of prehistoric archaeological sites predating 7,700 BP, when the valleys flooded. Depending on the ages of such sites, they may be buried at variable depths within terrace and floodplain sediments. As seas inundated the paleo-valleys, terrace sediments were capped by deltaic and marsh deposits, providing further protection of archaeological sites from erosion. Once the valleys became completely flooded, deltaic and marsh deposits were capped by estuarine (bay mud) sediments.

Much of the survey area lies above a former upland surface of Beaumont Clay, buried about 5 meters (16.4 ft) below MSL (Anderson, et al. 2008: 94). Archaeological sites formed in this upland area, between the San Jacinto and Trinity valley margins, would have been more exposed to wave energy of the open bay when flooded and likely would not have survived shoreface erosion caused by rising seas. Archaeological sites on the upland Beaumont surface would have lacked the protective cover of fluvial

terrace and deltaic sediments. Survival of upland archaeological sites, submerged by rising seas, is not anticipated in the survey area due to erosion of the upper sediment profile by waves.

Historic Site Potential

Navigation Hazards

Factors contributing to the loss of watercraft vary depending on environment 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 (fires, boiler explosions, injuries, mechanical failures, etc.).

Severe weather accounted for 55 percent of total losses reported by the US Lifesaving Service from 1876 through 1914. Mariners had short warning of approaching storms prior to modern weather forecasting. The Gulf 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 affect the Texas Coast. These “Northers” may have winds exceeding 50 miles per hour, generating dangerous waves, and can last 24–36 hours (McGowen, et al. 1976:19–23, 94). Dense fog also is common during the winter months.

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. Almost half of all losses from foundering were caused by weather. 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. Weather caused two thirds of losses from stranding. Stranding during severe weather could have occurred across a range of water depths, depending on a vessel’s draft and the height of a storm’s surge. Recovery of a stranded vessel would depend on the severity of weather that caused the event. Forty-six percent of stranding events resulted in a total loss. The survey area lacked any natural shorelines or shoals during the historic period.

Harbor improvements coincided with steady advancements in the safety of ships to offset rates of marine losses as the number of commercial watercraft steadily increased during the second half of the nineteenth 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. While 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).

Intentional abandonment was a common method to dispose of watercraft at the end of their useful lives, prior to modern environmental regulations. Many wooden hulls, including aging sailing vessels, were abandoned in backwater environments. Any area with sufficient water depth to accommodate a vessel without creating a hazard to navigation might have been used for this purpose. Intentional abandonment was not considered accidental loss, so statistics are unavailable. Vessel abandonment is unlikely in the survey area.

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 the ship's 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 sufficient, 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 2010). Iron and steel hulls, nevertheless, can survive seawater exposure for well over a century.

III. Cultural Background

Prehistory

The earliest migration of humans into the Western Hemisphere occurred during a prolonged period of lower sea level coinciding with the last glacial maximum. The survey area remained exposed from the time of earliest human presence in the New World until rising sea level flooded the area by about 2500 years ago. Two well-documented cultural periods, often referred to as Paleo-Indian and Archaic, coincided with the period of lower sea levels in Southeast Texas.

The bulk of evidence for the earliest humans in the New World dates from around 13,000 to 14,000 years ago, coinciding roughly with the end of the late-Wisconsin Glaciation and the beginning of the Paleo-Indian Stage. The Paleo-Indian Stage has been traditionally defined by the presence of finely crafted,

lanceolate projectile points and by a substantial reliance on megafauna for subsistence. The Clovis complex of fluted-blade projectile points are the earliest diagnostic stone tools from the Paleo-Indian Stage. Waters, et al. (2020) conclude that the earliest reliable, calibrated Carbon-14 dates for Clovis projectile points are 13,050 years BP.

The Clovis culture was, for many decades, believed synonymous with the earliest peopling of the New World; however, new archaeological discoveries and genetic analyses, increasingly, suggest a much earlier arrival. Waters and Stafford (2014) suggest that the Clovis complex 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 by the peak of the last glacial maximum, 24,000 years ago, is supported by a growing body of evidence, including radiocarbon dates from cut-marked bone samples, discovered at Bluefish Caves in Canada (Bourgeon, et al. 2017), by radiocarbon and optically stimulated luminescence dates associated with human footprints at White Sands, New Mexico (Pigati, et al. 2023), and by studies of mitochondrial DNA (e.g., Bonatto and Salzano 1997). Such an early date would expand the potential distribution of prehistoric sites in the Gulf of Mexico to near the continental shelf margin, including all portions of the shelf exposed during the last glacial maximum.

The Archaic Period lasted from about 8,000-1,000 years BP. It is unclear whether the cultural traditions or adaptations of the Archaic were substantially different from the preceding Paleo-Indian Period. Both relied on nomadic, hunting and gathering for subsistence. The most noticeable, and often cited, differences are the absence of Pleistocene mega-fauna, due to extinctions, 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), presumably because many larger species were no longer available.

Evidence for Submerged Prehistoric Sites

The duration of subaerial conditions across the project area includes the postulated pre-Clovis culture, the Paleo-Indian Period, and the early Archaic Period. Stright (1990) summarized inundated sites discovered along the Gulf of Mexico coast at depths up to 59 ft below MSL. 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). Analysis of 880 artifacts from the McFaddin Beach collection (Stright, et al. 1999: 112) included nearly 400 dating from the Paleo-Indian period, as well as a large number attributed to the Middle Archaic Period (4,500 to 1,300 years BP). 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.

McFaddin Beach is not an *in situ* archaeological site. Paleo-Indian artifacts found at McFaddin Beach are believed to have washed ashore from submerged offshore sites located along former streams, incised into the Beaumont Clay, before the coastal plain was eroded by rising seas during the Holocene. While these artifacts might have come from anywhere between the beach and the Sabine-Neches Paleo-Valley, Evans (2016: 28, citing Stright 1986 and Ricklis 2004:184) makes the point that most Paleo-Indian sites in southeast Texas and Louisiana have been found in association with streams.

Inundated sites have been discovered occasionally as a result of dredging. For example, human remains and artifacts were recovered from the Texas City Channel in Galveston Bay (Aten and Good 1984). This site, 41GV81, situated near the ancestral Trinity River Valley, contained 4,000 bone specimens from Pleistocene species, such as horse and tapir, including half of a human femur and 42 bones that appeared to have been modified, plus a variety of lithics interpreted as stone tools.

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. Archaeologists have made only two concerted attempts to recover buried archaeological deposits from the western Gulf of Mexico continental shelf. The first such effort, by Coastal Environments, Inc. (Pearson, et al. 1986), reconstructed the paleogeography of the relict Sabine-Neches River Valley offshore of Sabine Pass, Texas. A more recent study (Evans 2016) tested potential archaeological features buried on the continental shelf, offshore of Galveston and Freeport, in water depths ranging from 49-115 ft. Evans' study included portions of the relict Sabine-Neches, Trinity/San Jacinto and Brazos River valleys.

Coastal Environments' study demonstrated that pre-transgressive subaerial deposits of an archaeological age are preserved in submerged and buried Sabine-Neches Paleo-Valley sediments. Furthermore, they concluded that archaeological deposits likely were encountered in the Sabine Pass 6 lease block (Pearson, et al. 1986: 127-162). They cite evidence from two features discovered at and below the transgressive zone, at water depths of 54 and 59 ft MSL, including a deposit of *Rangia cuneata* clam shells and a concentration of bone fragments from several species. The shell was radiocarbon dated to 8,055 +/- 90 BP. Two factors pointed to the possibility of human association with features deposited in a subaerial environment. First of all, many of the fish bone fragments had been burned and were associated with carbonized seeds and vegetal matter (Pearson, et al. 1986: 153; Stright 1990). Secondly, pollen associated with the *Rangia* deposit supported the hypothesis that the shells may have been exposed above sea level. Unfortunately, the core sample sizes were too small to allow a definitive determination of cultural origin for the shell deposits.

Suspected terraces and natural levees, associated with paleo-channel systems were interpreted in each of Evans' (2016) study areas at depths ranging from 1.5 to 6 meters (5–20 ft) below the seafloor. Depths of those features suggested dry land exposure of the High Island study areas from 10,200 to 5,000 years BP and exposure of the Galveston study areas from 11,800 to 7,800 years BP. Pollen data from HI178 suggested a wetland environment with nearby terrestrial flora contributing to the mix. Pollen from GA426 indicated a meadow environment. Cores from both locations contained a layer of charcoal. Potential shell middens were interpreted at both GA356 and HI160. Unfortunately, conclusive evidence of archaeological sites is lacking from all four of Evans' study areas.

There is no record of prehistoric sites within 1 km of the survey area. All of the emergent land within that distance has been recently created by placement of dredged materials. There is potential for submerged prehistoric sites in the survey area; however, there is no reported evidence of their discovery. There is no expectation of intact prehistoric sites buried on the former upland surface (Beaumont Clay), located about 16 ft below sea level, or in the overlying bay mud, within 6-9 ft of the seafloor. However, intact archaeological sites may exist in the survey area, associated with fluvial terraces and floodplains buried in

the Trinity River and San Jacinto River paleo-valleys. Areas of potential site preservation include paleo-valley sediments (highlighted yellow in Figure 5) buried about 33-115 ft below sea level beneath the southeastern and western portions of the survey area.

Maritime History

Spanish claims to the Galveston area began in 1519, when a Spaniard named Alonso Alvarez de Piñeda led an expedition, on behalf of the governor of Jamaica, to map lands bordering the Gulf of Mexico. Piñeda produced the earliest known map of the Gulf of Mexico showing major inlets along its coast. There is no reliable evidence that he explored inland of the Texas Coast, but at the least, he demonstrated there was no shortcut to Asia through the Gulf of Mexico (Chipman and Joseph 2010: 24-25).

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 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).

In 1539, Hernando de Soto led the first extensive European expedition through what is now the southeastern US. De Soto had hopes of finding gold and silver to match that of his conquests in Central and South America. Instead, he died of a fever after three years of fruitless search, handing over leadership of the expedition to Luis de Moscoso Alvarado shortly before his death. Moscoso led the remnants of de Soto's expedition, over 300 men, down the Mississippi River in 1543 and sailed along the Gulf Coast, passing Galveston Island, in seven makeshift boats to Pánuco. The Hernando de Soto expedition lost half of its men, failed to find any precious metals, and blazed a path of violence and disease through native populations. Its main accomplishment was expanding Spain's territorial claims in North America (Chipman and Joseph 2010:36-43; Weddle 1991:100).

The Spanish silver fleet, sailing out of Veracruz, conducted steady trade with Havana from the mid-sixteenth century 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 about 70 miles south of Mustang Island. Another Spanish ship from Veracruz, *El Nuevo Constante*, wrecked near the Louisiana Coast, about 75 miles east of Sabine Pass, in 1766 (Pearson and Hoffman 1995).

Loss of the 1554-fleet, including *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, including women and children (only 32 people returned to Veracruz), 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 and Joseph 2010:48 and Weddle 1991:100-103). Lavazares continued clockwise along the coast until contrary winds, east of Mobile Bay, forced his return to Veracruz. 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.

The voyages of Lavazares and Gayon retraced Piñeda's path from four decades earlier and reinforced Spain's claim to the Gulf Coast. Nevertheless, while Spain claimed a vast territory, their population and trade centers were located far to the south and west. The Spanish crown did little to promote exploration or settlement along the northern Gulf Coast, instead focusing on inland expeditions and establishment of missions to Christianize the natives. Ultimately Spain's territory in Texas and the Southeast proved too large and isolated to sustain. It was not until France began to encroach in the region that Spain attempted to reassert control.

In 1682, a French expedition, led by René Robert Cavelier, Sieur de La Salle, traveled down the length of the Mississippi River to its mouth, claiming the Louisiana Territory on behalf of King Louis XIV and France. La Salle was partially following in the footsteps of the Spaniard Moscoso down the lower Mississippi, albeit in a much more deliberative manner. The French territorial claim established by La Salle extended to much of what later became the Louisiana Purchase. La Salle returned to the Gulf Coast by ship in 1685 intent on establishing a permanent colony near the mouth of the Mississippi River. Unfortunately for La Salle and his 300 colonists, they missed the Mississippi River and arrived, instead, at Matagorda Bay on the Texas Coast.

By 1686 when Spain heard rumors of a French colony in the heart of their territory, La Salle's Fort St. Louis was already doomed to failure. The expedition lost one of three ships upon their arrival. A second ship soon returned to France with a group of colonists, including La Salle's engineer, Minet, who took with him the first map of Matagorda Bay. Their last ship, *La Belle*, grounded during a storm in early 1686 and was lost in Matagorda Bay while La Salle was away on an overland expedition, attempting to relocate the Mississippi River. La Salle was murdered by his own men, in a subsequent overland voyage about a year later, on March 19, 1687. The location of La Salle's murder likely was between the Navasota and Trinity Rivers in modern Madison or Walker County (Weddle 2001: 214-234). Those colonists remaining at Fort St. Louis, having no way to return to Europe, eventually perished.

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."

An expedition led by Martín de Rivas and Pedro de Iriarte departed Veracruz on December 25, 1686 in search of La Salle. They sailed clockwise along the Gulf Coast with instructions to sail only by day, keep within sight of land, and enter all bays and rivers until they reached the supposed latitude of the reputed

Espíritu Santo Bay or the Mississippi River. Along the way, on April 3, 1687, they discovered wreckage of a French ship (*La Belle*) in Matagorda Bay, which they correctly presumed to have belonged to La Salle. Unknown to Rivas and Iriarte, La Salle had died two weeks before their discovery, and the remnants of his colony were clinging to life only a few miles upstream from them. Alonso de León finally discovered the abandoned remains of Fort St. Louis in 1689 upstream from Lavaca Bay on Garcitas Creek (Weddle 1991: 52-70).

Rivas and Iriarte continued their expedition, after discovering *La Belle*, to rule out other locations along the northern Gulf Coast and to find the river "Micipipi" on which the French reportedly were intent upon establishing a settlement. They entered West Galveston Bay through San Luis Pass, which they called Santa Suzana, in mid-April. Continuing along the coast, they encountered the main mouth of Galveston Bay. Discouraged by shoals, they spent little time exploring but returned on April 25 for a closer inspection. They sailed inland to a point of land believed to be Eagle Point, but found no evidence of prior European visitors (Weddle 1991: 52-70).

La Salle's expedition ended in failure, but his influence reached far into the future. The boundary between Louisiana and Texas remained contentious and shifting for the next century and a half. Spain responded to the French incursion by establishing a network of missions, presidios and settlements in East Texas and Louisiana, 100 to 200 miles upstream from the coast, on the Neches, Sabine, and Red rivers, through the first quarter of the eighteenth century (Chipman and Joseph 2010: 106-107).

Jean Baptiste Bénard de La Harpe produced the earliest detailed map of Galveston Bay in 1721. La Harpe intended to reestablish La Salle's abandoned fort, but he unknowingly arrived at the wrong bay. While in Galveston Bay, La Harpe met a French sailor named Francois Simars de Bellisle, an officer from a French ship, *Maréchal d'Estrée*, that stranded near the entrance to Galveston Bay in 1719 (Folmer 1940). The ship was later floated, but Bellisle and a small group of officers elected to stay behind. He was the sole survivor of the group. Bellisle was a slave to Native Americans for over a year during which time he wandered Coastal Texas from Galveston Bay to Fort Saint-Jean-Baptiste at present-day Natchitoches, Louisiana (Folmer 1940).

Galveston was settled soon after the Louisiana Purchase of 1803. Privateers based their operations on Galveston Island and Point Bolivar, supported by French, Mexican and Anglo-American interests seeking to overturn Spanish control of the region. Louis-Michel Aury operated from Galveston Island, beginning in 1816, during the Mexican War for Independence. Aury, with the support of Mexicans in New Orleans, organized Galveston's first government, declared the town an official port of the Mexican Republic, and began raiding Spanish shipping. Within a year, Aury led an attack in Mexico with over 700 troops. While he was in Mexico, Jean Lafitte took over Aury's Galveston fort. James Long declared a Texas Republic in 1819 and installed Lafitte as governor of the island. Lafitte was forced from the island in 1821 when the US government enforced a policy against piracy in the Gulf of Mexico (Davis 2005:419–420).

In 1824, Stephen F. Austin encouraged the newly independent Mexican government to settle Galveston to facilitate the shipment of cotton to England. The Congress of Mexico established a port of customs at Galveston in 1825 (Cotham 1998:1; Francaviglia 1998:91, 95). Galveston was incorporated as a city late in

1836 after Texas won independence from Mexico, and within two years, Galveston became the largest source of cotton shipped to the East Coast and Europe. Houston was founded that same year on the banks of Buffalo Bayou, several miles upstream from Galveston Bay. When the Civil War began, Galveston was the second largest city in Texas, and by 1870 it was the largest (Cotham 1998:184).

Houston was founded by the Allen brothers in 1836 on the banks of Buffalo Bayou several miles upstream from Galveston Bay. Houston leaders soon recognized the need for navigational improvements along Buffalo Bayou to attract commerce inland from Galveston. They began to clear snags and obstructions from Buffalo Bayou as early as the 1840s. Downstream from Buffalo Bayou, the San Jacinto River flowed into Galveston Bay over a small deltaic feature known as Clopper's Bar (United States Coast Survey 1852). The bar was an obstacle and a hazard to navigation between the river and the bay. All vessel traffic between Galveston Bay and points upstream, including Buffalo Bayou, had to cross Clopper's Bar.

The Buffalo Bayou Ship Channel Company made the first attempt to improve a channel across Galveston Bay in 1869 by cutting a channel through Morgan's Point to bypass Clopper's Bar. The project encountered financial difficulties and was forced to sell to Charles Morgan. Morgan Line steamboats had begun making regular runs between New Orleans and the Texas Coast following the Civil War, subsidized by contracts with the federal government to deliver mail. The Morgan Line offered the only regular steamship service along the Texas Coast at that time.

Charles Morgan's company completed the canal through his namesake point and went on to dredge the first channel across Galveston Bay. Meanwhile, the Rivers and Harbors Act of 1870 funded a survey for a federal ship channel extending across Galveston Bay to Buffalo Bayou, recognizing that Houston was becoming a major railway hub. Houston was granted status as an official federal port of entry that same year (Alperin, 1977). The first deep-draft ship to pass through what is now the Houston Ship Channel was the Morgan Line steamer *Clinton* in 1876. Morgan charged a toll for passage on his ship channel until it was sold to the federal government when he died in 1878 (Foster et al. 1993: 48-50). Since then, the ship channel has been repeatedly widened and deepened to accommodate ever larger vessels.

Completion of the Houston Ship Channel revived industrial growth that had been hampered by major hurricanes in 1875 and 1900. In 1915, one of the largest oil mixing plants in the country was nearing completion at Lynchburg by the Gulf Refining Company. "In connection with the industrial works the company is making extensive improvements to deep-water and pipeline terminal facilities here. It is reported that it will obtain much of its crude oil supply from the Tampico (Mexico) fields. Its first tank steamers due to arrive here the latter part of the month" (Journal of Automobile Progress 1915: 1099).

Oil was discovered in 1903 at the mouth of Goose Creek in Tabbs Bay. Production of the Goose Creek Oilfield took off in 1916 when Charles Mitchell brought in a 10,000-barrel gusher. Humble Oil (now ExxonMobil) built its first major refinery adjacent to the Goose Creek Oilfield and named the plant and townsite Bayfield. The first offshore drilling occurred at the Goose Creek Field in 1918 (Benham 1952). The Cedar Point Oil Field, centered just north of the survey area, was first identified in 1938 when the Standard Oil Company of Texas and the Salt Dome Oil Corporation completed a successful first test well, State No. 1-118 (Wilson 1938).

The "Five Mile Cut" channel, and associated spoil areas, through the survey area were created by 1964 (USCGS 1965). Atkinson Island was still a narrow spoil area alongside the Houston Ship Channel at that time. Construction began by 1973 on a levee to expand the Atkinson Island spoil area, adjacent the northwest corner of the survey area (USCGS 1973). A spoil area covering the western part of the survey also was begun by this same time. Charts of Upper Galveston Bay indicate a levee around the latter spoil area was under construction in 1973, was complete around three sides in 1981, and was no longer charted in 2009 (USCGS 1973, 1981 and 2009). Mid-Bay Marsh was under construction by 2011 (USCGS 2011).

Evidence for Historic Shipwrecks

Shipwrecks reported within 1 km of the survey areas are included in Table 1. Sources consulted for Table 1 include the THC's Texas Archaeological Sites Atlas (Atlas); NOAA's Automated Wreck and Obstruction Information System (AWOIS) database; a shipwreck database compiled by PBS&J; the NOAA Office of Coast Survey's Historical Map and Chart Collection, https://historicalcharts.noaa.gov; 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 AWOIS positions pre-dating the era of satellite position systems can vary considerably from actual locations. The NOAA, Office of Coast Survey's Historical Map and Chart Collection includes digital copies of paper charts that were scanned prior to being transferred to the National Archives.

At least 11 shipwrecks have been reported within 1 km of the survey areas by one or more of the sources listed in Table 1. Three of those wrecks overlap the study area (indicated by * in Table 1). There also is potential for unreported wrecks dating back to the time of early European navigation throughout the area. Positions reported in historical accounts are often imprecise, and archaeologists have yet to record any of the wrecks listed in Table 1.

Table 1: Shipwrecks Reported Within One Kilometer of a Survey Area

Name of Vessel	THC No.	AWOIS No.	PBS&J No.	Description	Date Lost
Ellen Frankland	2175			steamship	1844
Unknown	1167			NOAA wreck symbol	1968
Unknown		Near 9321		NOAA wreck symbol	1971
Unknown				NOAA wreck symbol	1973
Unknown*	1327		206	NOAA wreck symbol	1974
Unknown*				NOAA wreck symbol	1981
Unknown		9365	531	NOAA wreck symbol	1984
Unknown		9316	537	fishing vessel	1992
Unknown		9315	538	fishing vessel	1992
Unknown				NOAA wreck symbol	Pre-2009
Unknown*				NOAA wreck symbol	Pre-2015

* Overlaps Survey Area

Previous Investigations

Thirteen submerged archaeological surveys have been completed within 1 km of the present survey area (Figure 10 and Table 2), including six that overlap the study area (indicated by * in Table 2). Four of the overlapping investigations were conducted prior to August, 2008, when the THC adopted more stringent survey requirements, reducing the transect interval from 30 m to 20 m. The THC required updated surveys, using the current standards, in portions of those earlier investigations that overlap the present study.

The earliest nearby investigation was in 1991. Espey, Huston & Associates, Inc. (EH&A) conducted an archaeological remote-sensing survey along 40 miles of the Houston Ship Channel, from Bolivar Roads to the Beltway 8 Bridge, plus 3.6 miles of the Galveston Ship Channel (Hoyt 1992). The project was conducted on behalf of the US Army Corps of Engineers, Galveston District, under TAP 1128. EH&A mapped over 3,400 magnetic anomalies and 570 sonar targets with the goal of finding shipwrecks and other historic sites that might be affected by future channel improvements. Their survey included 13 transects, spaced 43 m apart and centered on the Houston Ship Channel. Their survey overlaps 3 acres of the present study, in a narrow area adjacent the ship channel. Two magnetic anomaly clusters, localities 7 and 8, were recommended as potentially significant within 1 km of the present survey area.

Localities 7 and 8 were investigated by EH&A divers under TAP 1194 (Hoyt and Schmidt 1993: 38-42, 69). Locality 8 was cleared from further concern. Locality 7 included 10 magnetic anomalies, grouped into 3 clusters. Divers located a broad scatter of hand-formed bricks, believed to date from the late 1800s, and one unidentified metallic concretion. The seafloor was probed extensively in the vicinity of the brick scatter; however, no hull remains were discovered. EH&A recommended further investigation of Locality 7 to rule out the presence of a buried shipwreck. No targets were recommended for avoidance or further investigation in the overlapping area.

Locality 7 was investigated again by EH&A archaeologists under TAP 1424 (Hoyt, et al. 1998). Close-order magnetometer survey provided a higher-resolution view of the magnetic anomalies surrounding the location where divers had previously discovered artifacts. Results of their new survey indicated that earlier probing had missed a large anomaly, BC-1, which might indicate the location of a buried shipwreck. Additional historic research suggested a possibility that the scattered bricks may be associated with the loss of the steamer *C.K. Hall* during a storm on October 2, 1871. The *C.K. Hall* jettisoned a cargo of bricks before cutting their anchor lines during a hurricane. Anomaly BC-1 was recommended for future diver assessment.

In 1994, EH&A completed remote-sensing surveys, under TAP 1529, that included five beneficial use areas along the Houston Ship Channel (Hoyt, et al. 1995). EH&A's survey transects were spaced 100 ft apart, which was the standard for Texas at that time. Two of their survey areas, Atkinson Island and Mid-Bay Marsh, are within 1 km of the present study. Five magnetic anomalies were recommended for testing in their Atkinson Island survey, including one, AI-3, within 1 km of the present study area. Four magnetic

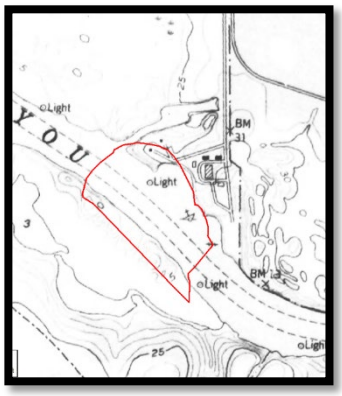

Figure 10: Previous Investigations Within 1 Kilometer of the Survey Area

Table 2: Previous Investigations Within One Kilometer of Survey Area

Antiquities Permit	Principal Investigator/ Citation	Project Description	Contractor
1128*	Steven Hoyt/ Hoyt (1992)	Underwater Investigations, Houston-Galveston Navigation Channels, Texas Project, Galveston, Harris, Liberty and Chambers Counties, Texas.	Espey, Huston & Associates / US Army Corps of Engineers
1194	Steven Hoyt/ Hoyt and Schmidt (1993)	Bay Ground Truthing: Phase I and Phase II Houston-Galveston Navigation Channels Texas Project, Galveston, Harris, Liberty Counties, Texas	Espey, Huston & Associates / US Army Corps of Engineers
1424	Steven Hoyt/ Hoyt, et al. (1998)	Intensive Archival Research, Close-Order Magnetometer Survey, Dating, and Offshore Diving, Houston-Galveston Navigation Channels, Texas Project. Galveston, Harris, Liberty, and Chambers Counties, Texas, Offshore, Galveston Bay and Houston ship Channel.	Espey, Huston & Associates / US Army Corps of Engineers
1529*	Steven Hoyt/ Hoyt, et al. (1995)	Beneficial Use Areas Survey, Houston-Galveston Navigation Channels, Texas Project, Galveston, Harris, Liberty, and Chambers Counties, Texas, Galveston Bay	Espey, Huston & Associates / US Army Corps of Engineers
2204*	Clell Bond/ Enright, et al. (2002)	Historical Research and Marine Remote-sensing Survey of Proposed Oyster Reef Pads and Boater's Cuts, Galveston Bay, Chambers and Galveston Counties, Texas.	PBS&J / US Army Corps of Engineers
2676	Robert Gearhart/ Watts, et al. (2003)	Remote-Sensing Survey and Diver Assessment of Five Localities, Houston-Galveston Navigation Barge Lanes Project, Galveston, Chambers, and Harris counties, Texas.	PBS&J / US Army Corps of Engineers
2699	Stephen James/ James and Madrigal (2001)	Analysis of Remote Sensing Data Relative to the Presence of Submerged Cultural Resources for the Galveston Bay Pipeline Project.	Panamerican Consultants, Inc. / URS Corporation
4645*	Stephen James/ James, et al. (2007)	Submerged Cultural Resources Remote Sensing Survey of a Proposed Pipeline and Wellhead in State lease Tracts 115 and 130, Upper Galveston Bay, Chambers County, Texas	Panamerican Consultants, Inc. / Davis Petroleum

Antiquities Permit	Principal Investigator/ Citation	Project Description	Contractor
5435*	Douglas Jones/ Jones, et al. (2010)	Atkinson Island Remote-Sensing Survey and Assessment of Four Anomalies, Houston Ship Channel Project	PBS&J / US Army Corps of Engineers
6041	Lee Cox/ Cox and Scott (2012)	Marine Archaeological Survey for the Proposed Bayport Ship Channel Improvement Project and Flare Project, Harris and Chambers Counties	HRA Gray & Pape / AECOM and Port of Houston Authority
6252	Jeff Enright/ Enright, et al. (2012)	Remote-Sensing Along the Bayport and Houston Ship Channels and Assessment of Two Anomalies for Improvements to the Bayport Ship Channel Project	SEARCH, Inc. / US Army Corps of Engineers
6629	Jeff Enright/ Tubby (2013)	Marine Archeological Survey, LINC Energy Proposed Gathering Line System, Trinity Bay, Chambers County, Texas	SEARCH, Inc. / LINC Energy
9613*	Jason Burns/ Burns, et al. (2021)	Underwater Cultural Resources Survey of the Houston Ship Channel Expansion Channel Improvement Project Harris, Galveston, and Chambers Counties Texas	RECON Offshore and HDR / Port of Houston Authority

* Overlaps Survey Area

anomalies were recommended for testing in their Mid-Bay Marsh survey, including two within 1 km of the present study area. Their Mid-Bay Marsh survey overlaps 238 acres of the present study. EH&A did not recommend any geophysical targets for avoidance in the overlapping area.

In 1999, PBS&J conducted a submerged archaeological survey of 16 proposed oyster mitigation reef pads and 4 boaters' cut channels in Galveston Bay. The work was conducted under TAP 2204 (Enright, et al. 2002). Three of the boaters' cut channels, 1, 3 and 4, are located within 1 km of the present study area. Boaters' Cut 3 overlaps about 28 acres of the present survey. No geophysical targets were recommended for avoidance in the overlapping area.

In 2001 and 2002, PBS&J completed remote-sensing surveys, diver investigations, hard-bottom oyster habitat mapping, and geo-technical studies in support of proposed construction of barge lanes on each side of the Houston to Galveston Navigation Channel between Morgans Point and Redfish Island. The work was conducted under TAP 2676 (Watts, et al. 2003). A portion of the barge lanes and two proposed reef pads, "South of Boater's Cut" and "East of Pad 4a," are located within 1 km of the present survey but do not overlap the study area. Two magnetic anomalies, CH0047 and CH0048, initially were recommended for avoidance along the barge lanes, within 1 km of the study area. Both anomalies were subsequently

recommended for archaeological clearance. Four magnetic anomalies, CH0053, CH0054, CH0055, and CH0056, were recommended for avoidance in reef pads within 1 km of the present study area.

In 2000, Panamerican Consultants, Inc. completed a submerged archaeological survey of a pipeline route, proposed across portions of Galveston Bay. Their project is located within 1 km of the present survey but is situated entirely west of the Houston Ship Channel and does not overlap the study area. Work was completed on behalf of Cowboy Pipeline Service Company under TAP 2699 (James and Madrigal 2001). Seven magnetic anomalies were recommended for avoidance.

In September 2007, Panamerican Consultants, Inc. conducted a remote-sensing survey of a proposed pipeline and wellhead in Upper Galveston Bay. Their survey was completed under TAP 4645 on behalf of Davis Petroleum Corporation. Three acres of their survey overlaps the present study area. Two magnetic anomalies were recommended for avoidance; however, neither overlaps the present survey.

In 2009, PBS&J conducted a submerged archaeological survey, under TAP 5435 (Jones, et al. 2010), for the US Army Corps of Engineers, Galveston District. The purpose of their survey was to assess placement areas proposed in support of the Houston Ship Channel Project in Chambers County. Their survey encompassed 1300 acres east of Atkinson Island, including 175 acres that overlaps the present study area. Four magnetic anomalies were recommended as possible submerged cultural resources. All four anomalies were investigated by hydraulic probing. Three anomalies were cleared from further concern by probing. One anomaly, AI-12, was recommended for continued avoidance. Anomaly AI-12 was subsequently investigated by divers and was recommended for clearance from further consideration as a potential historic site. None of PBS&J's recommended anomalies is located inside the present survey area.

In 2011, HRA Gray & Pape, LLC oversaw a submerged cultural resources survey of the Bayport Ship Channel Improvement Project and the Bayport Flare Easing Project, totaling 266 acres. Work was completed on behalf of the Port of Houston Authority under TAP 6041 (Cox and Scott 2012). Two geophysical targets were recommended for avoidance; however, their project does not overlap the present study area.

In 2012, Southeastern Archaeological Research, Inc. conducted a submerged archaeological survey and diver investigation of proposed improvements to the Bayport Ship Channel. Work was completed on behalf of the US Army Corps of Engineers, Galveston District under TAP 6252 (Enright, et al. 2012). Their investigations do not overlap the present study area. Previous investigations (Hoyt and Schmidt 1993) identified a scatter of bricks, dating from the late nineteenth century, and a small iron concretion. Divers investigated two previously recorded magnetic anomalies (Hoyt, et al. 1998) plus two new targets, discovered by their own updated survey. No cultural resources were discovered by diving, and the survey areas were recommended for cultural resources clearance.

In 2013, Southeastern Archaeological Research, Inc. conducted a submerged archaeological survey of a gathering line system in the vicinity of Cedar Point. Work was completed on behalf of LINC Energy under TAP 6629 (Tubby 2013). Their survey does not overlap the present study area. No geophysical targets were recommended for avoidance.

In 2020, the Port of Houston Authority contracted HDR Engineering, Inc. for a cultural resources assessment of the Houston Ship Channel Expansion Channel Improvement Project in Harris, Galveston, and Chambers Counties. HDR subcontracted RECON Offshore to conduct a submerged archaeological survey of the project. Their archaeological assessment was performed under TAP 9613 (Burns, et al. 2021). The project totaled 4,667 acres, including a proposed dredge placement area, their M11 survey area, which overlaps 103 acres of the present study. Area M11 was not resurveyed by Burns, et al., because it was surveyed in 2009 by PBS&J (Jones, et al. 2010). No areas were recommended for archaeological avoidance in the overlapping area.

IV. Research Design

The purpose of this archaeological assessment is to map geophysical anomalies that have potential cultural significance. Cultural significance for the period of written history, in this context, typically refers to association with sunken or abandoned watercraft. Potential historic significance must be extended to geophysical anomalies having characteristics similar to verified shipwreck sites, because the actual identity of anomaly sources, especially buried sources, often cannot be determined based solely on geophysical data.

Historic wrecks in Texas bays and shallow areas in the Gulf of Mexico are 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 portions of wooden hulls can retain a high level of artifact preservation and historic integrity. Wrecks that survive above the mudline for more than a few years tend to be constructed of materials other than wood. The primary instrument for locating submerged historic watercraft in buried contexts is the magnetometer. Magnetometers are capable of detecting ferromagnetic components of a wreck, whether buried or exposed, whereas side-scan sonar is limited to imaging exposed wrecks.

Prehistoric cultural significance refers to submerged landforms potentially associated with intact human habitation sites. The focus for the prehistoric period is necessarily on finding landforms with site potential rather than on finding archaeological sites, themselves, because the presence of submerged prehistoric sites cannot be verified from geophysical data alone. Buried landforms of particular interest include river valleys (paleo-valleys), stream channels (paleo-channels), stream terraces, natural levees, and shell deposits. Any such buried landforms, if exposed above sea level during the period of human presence in the area, perhaps as early as 24,000 years BP, might have attracted human habitation.

Survey Methods

Geophysical investigations were 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 TAP issued by the THC; 2) the survey line interval cannot exceed 20 m (30 m when greater than 3 nautical miles offshore); 3) bottom-disturbing activities must be avoided within 50 m of potentially significant targets (150 m 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 global positioning system (GPS) receiver; 6) the magnetometer must be towed within 6 m 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 kiloHertz; 8) the positioning system should sample at least once per second; and 9) no artifact collection is permitted. Variance from the above requirements must be approved in advance by the THC.

The geophysical survey was completed from March 11-26, 2024 and from October 8-26, 2024, under TAP 31570. The survey was conducted from BOB's 20-ft Lobell survey boat equipped with a differential GPS / Heading Receiver, a single-beam echosounder with a 200-kiloHertz transducer, a Geometrics G-882 Magnetometer, and an Edgetech 4125P Side-Scan Sonar (400/900 kiloHertz). The magnetometer was towed on the surface behind the survey vessel sufficiently far (about 50 ft) to prevent interference by the boat. Side-scan sonar data was recorded to a range of 25 m. The sonar was towed near the surface, from the bow of the boat. Tidal corrections were based on water levels from the NOAA tide station at Morgan's Point (Station 8770613).

Vector data, including sensor positions, water depth and magnetometer, were logged by Hypack navigation software. Side-scan sonar data was logged in Edgetech's Discover software. Geographic positions were embedded in the digital side-scan data as it was recorded. Hypack MAX software was used to combine sonar data from each transect into a composite sonar mosaic.

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 average 1.25 m between data points. Diurnally-corrected magnetometer data was contoured using Blue Marble's Global Mapper® software (Version 20.1) at a 5-nT contour interval. Magnetic amplitudes between +5 nT and −5 nT are considered insignificant for this purpose. 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. Ferromagnetic debris far outnumbers shipwrecks, necessitating some means of distinguishing between the two when conducting archaeological assessments.

Archaeologists have interpreted magnetic anomalies using a variety of criteria over the decades since marine geophysical surveys have been used for cultural resource investigations. Various factors, including

amplitude, complexity, and horizontal dimensions, have been considered important when trying to distinguish shipwreck anomalies from debris (non-shipwreck) anomalies. The interpretation method used by this author considers an additional factor, orientation, as an aid to segregating potential shipwreck anomalies from debris anomalies. Each of these factors is described in more detail below. The role of side-scan sonar in aiding interpretation is also considered.

The interpretative method described below is based primarily upon a study by Gearhart (2011b) comparing magnetic data from a large and diverse collection of anomaly sources, including 29 verified shipwrecks and many debris sources, with the goal of characterizing significant differences between shipwreck and debris anomalies. To date, this collection of magnetic anomalies has been expanded to include 42 verified shipwrecks (Gearhart 2011b, 2016, 2018, and 2019). A subset of 22 shipwreck anomalies is summarized in Table 3 and illustrated in Figure 11, for comparison with the results of this survey.

Shipwrecks included in this sample 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, 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.

Role of Side-Scan Sonar

Anomaly sources exposed at the seafloor can be detected by side-scan sonar, which may, on occasion, be useful for determining their identity. Sonar targets often are unreliable indicators of magnetic source identity, but sonar occasionally provides unambiguous verification. Shipwrecks with metal hulls are usually exposed on the seafloor, thus tend to be fairly obvious on a sonar image.

Gearhart (2011a) reported that 100 percent of shipwrecks (n=74) discovered by geophysical surveys regulated by the Bureau of Ocean Energy Management (BOEM) in shallow, Gulf of Mexico waters (less than 600 ft deep) appear on side-scan sonar imagery. About one third of that number are confirmed to have metal hulls. The rest are presumed to be metallic, simply because their ship-shaped structures are preserved in the water column. By comparison, only 7 wood-hulled wrecks were known to BOEM from the same area up to that time. But none of the wooden hulls were discovered by geophysical surveys, even though wood-hulled wrecks in the US, pre-dating World War II, are 13 times more abundant than metal-hulled wrecks (Gearhart 2011a).

Exposed wreckage of wood-hulled sailing ships quickly disintegrates in Gulf Coast bays and adjacent coastal waters, leaving only buried components, which typically have no sonar target, intact. Shipwrecks

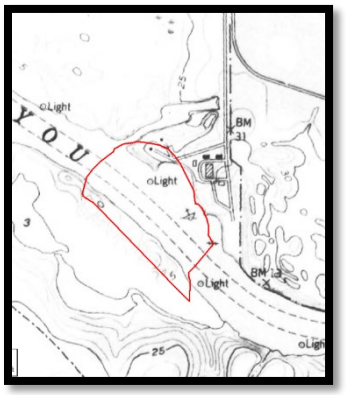

Figure 11: Magnetic Anomalies of 22 Verified Shipwrecks (not discovered in this survey area)

Table 3: Magnetic Anomalies of 22 Verified Shipwrecks (not discovered in this survey area)

Shipwreck (Figure 11)	Min. Ampl. (nT)	Max. Ampl. (nT)	Date Lost; Hull Material; Propulsion; Hull Dimensions (ft); Notes
41AS119	-3,867	6,155	unknown age; iron?; steam?; 138x33
41CL100	-1,904	4,259	1856?; wood; steam; unknown size; divers confirmed presence of boilers; suspect Morgan steamer *Perseverance*; Hoyt (2005)
41GV143	-6,197	9,050	1865; wood; steam; 182x23
Mag 13	-312	1,216	unknown age; wood; sail?; est. 35x13; found by probing; buried 2-10 ft
Mag 24	-28	31	unknown age; wood; sail?; est. 65x15; found by probing; buried 14 ft; low amplitude due in part to 35-ft sensor-source distance
41NU291	-1,333	3,358	1845; wood; steam; 125x18
41CH372	-3,258	4,838	c. 1970; steel; diesel; 83x18
*41CL103	-113	78	possibly 19th-century; wood?; sail?; unknown size; same site as NUMA Target 3 (Wilbanks, et al. 2000); divers found flat metal bar stock and a possible capstan, buried >6 ft
41CL102	-158	108	late 18th- or early 19th-century; wood; sail?; unknown size; same site as NUMA Target 2, "Carronade Wreck," (Wilbanks, et al. 2000); buried 12 ft
Sonar 1	-1,817	55,394	unknown age; steel?; diesel?; 70x24
Sonar 8	-817	1,006	unknown age; steel?; barge; 77x28
Sonar 2	-1,670	13,902	unknown age; steel?; diesel?; 86x18
Sonar 7	-1,646	10,223	unknown age; steel?; diesel?; 114x32
Sonar 4	-1,974	4,025	unknown age; steel?; diesel?; 81x14
Sonar 6	-1,768	8,782	unknown age; steel?; diesel?; 47x20
41GV68	-2,425	3,170	1863; iron; steam; 210x34
41NU252	-403	653	1876; iron; steam; 234x33
BOEM 1614	-2,698	2,562	unknown age; steel; barge; 89x30
41NU292	-3,148	3,253	1920; wood; freighter-barge conversion; 282x46
BOEM 773	-4,691	10,264	1954; steel; barge; 240x50
41GV177	-7,947	9,031	1875; iron; steam; 242
BOEM 323	-4,328	5,888	unknown age; steel; diesel; 220x30

**This anomaly was incorrectly attributed to 41CL92 in Gearhart publications pre-dating October 1, 2020*

with wooden hulls and machine-powered propulsion systems might appear on sonar or might not. Lower portions of the wooden hull itself would tend to bury, but steam machinery is large and may remain exposed above the seafloor. Gas- and diesel-powered machinery tends to be smaller thus might be more easily buried than steam machinery.

Amplitude

Anomaly amplitude depends greatly upon the mass of the source and its distance from the magnetometer sensor. 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 (range: 191-376 nT) for wood-hulled sailing vessels (n=7); 5,020 nT (range: 663-15,247 nT) for wood-hulled, machine-powered vessels

(n=7); and 10,386 nT (range: 688-36,050 nT) for iron/steel-hulled vessels (n=12). Anomalies from verified, wood-hulled sailing vessels in Gearhart (2011b) have lower peak-to-peak amplitude than anomalies associated with either machine-powered or iron/steel-hulled vessels; however, amplitudes from machine-powered and iron/steel-hulled vessels overlap one another.

Magnetic debris can produce amplitudes virtually anywhere within the range of shipwreck anomalies, thus amplitude, alone, is of little use for differentiating shipwrecks from debris. Nevertheless, amplitude may aid in anomaly interpretation when considered in combination with other factors. For example, a buried anomaly source with amplitude greatly exceeding the range of verified, wood-hulled shipwrecks might be more likely caused by debris, since high-amplitude shipwreck anomalies, those with iron/steel hulls or machinery, are more likely exposed on the seafloor.

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 m (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 m, 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 visually obvious. This problem was compounded by the lower accuracy of positioning systems prior to GPS. Thus, even a simple dipole might have appeared 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 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. It is important to distinguish simple and complex anomaly sources from simple and complex anomaly shapes. The collection of anomalies from verified shipwrecks, reported by Gearhart (2011b, 2016, 2018, and 2019) indicates, contrary to earlier models, that anomalies caused by shipwrecks (complex sources), in mid latitudes, tend to be dominated by a simple, primary dipole (the dipole having the largest peak to peak amplitude), oriented approximately in line with magnetic north (Figure 11, for example; also see "Orientation" below). In fact, complex debris sources, containing multiple interacting ferromagnetic sources, and most simple-source debris anomalies, also tend toward simple, dipolar shapes.

The key difference between anomalies having simple versus complex sources is that simple-source anomalies are not necessarily aligned with magnetic north; whereas, a north-south alignment of the

primary dipole should apply to all mid-latitude, complex-source anomalies, including those of shipwrecks. Complex-source anomalies occurring nearer to either of earth's poles, should have the negative side of their primary dipole wrapping further around a more prominent, positive peak, eventually surrounding it at earth's magnetic poles (Gearhart 2011b: Figure 4.1c). The primary dipole of each wreck in the author's sample (all from mid-latitudes), has a negative peak with an area comparable in size to its positive peak.

Many wreck anomalies, in mid latitudes, also have secondary amplitude peaks, in addition to their primary, north-south-aligned dipole. Secondary peaks, as defined here, have lower amplitude than a wreck's primary dipole. Secondary peaks can be induced immediately north or south of, and in line with, the primary dipole, depending on the inclination of earth's magnetic field (e.g., peaks labelled "A" in Figures 12, 13, and 14; see also Gearhart 2011b: Figure 4.1c). The amplitude of induced secondary peaks should be greater, relative to that of the primary dipole, in complex-source anomalies located closer to earth's magnetic equator.

Amplitude peaks of this nature are not necessarily located over an anomaly source and may not indicate the presence of widely-scattered wreckage. In Gearhart's sample of mid-latitude wreck anomalies, this type of secondary peak seems to be associated most closely with wrecks of relatively high mass, such as ferrous hulls. In such cases, magnetic lines-of-force can loop so far to the north and/or south of a source that they, respectively, 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 (see Figure 12, for example). They will always have polarity opposite the adjoining peak of the main dipole. Such peaks are symmetrical about an anomaly's north-south axis and cannot 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 (Figure 13).

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. Such an effect may be emphasized 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 (e.g., Gearhart 2011b: Figure 4.3). Such object-dependent, secondary peaks should have random orientations and positions, with respect to the main dipole, since they are directly caused by objects, which are both randomly-oriented and randomly-positioned within a larger debris field. They may overlie and disrupt the symmetry of the primary north-south dipole (e.g., peaks labelled "B" in Figures 11 and 14).

Horizontal Dimensions

Horizontal size is a common and valid measure used by archaeologists for discriminating potential shipwreck anomalies from those believed more likely caused by debris; however, shipwreck anomalies cannot be distinguished from debris anomalies based on size alone. Small wooden watercraft, even many steamboats, tend to have anomalies no wider than many debris anomalies. Nevertheless, width is believed to be useful for discriminating the smallest significant anomalies (potential shipwrecks) from smaller debris anomalies that do not overlap the size range of verified wreck anomalies. Garrison, et al (1989: II, 223) suggested that the area of typical shipwreck anomalies was 10,000 square m (2.47 acres);

whereas, Pearson (2010), for example, considered an anomaly significant if it had a width of 65 ft or more, provided the anomaly also had an amplitude of at least 50 nT.

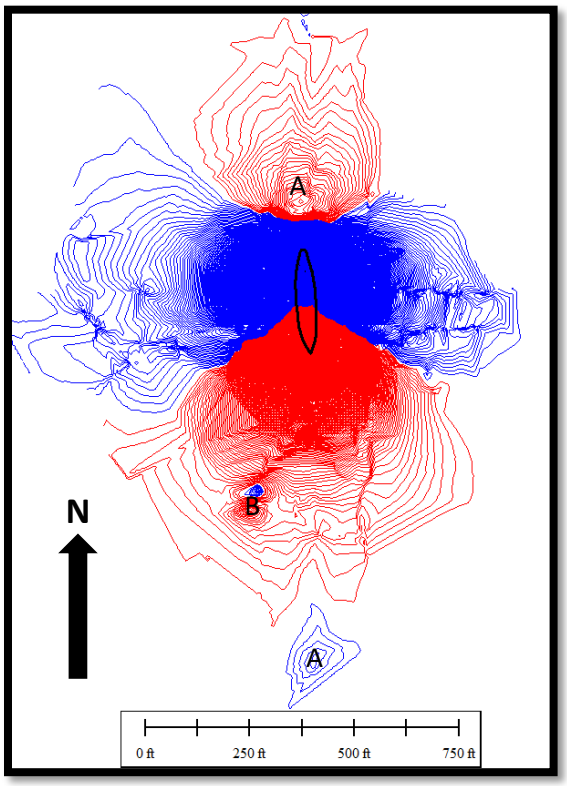

Figure 12: City of Waco Anomaly (iron hull); not discovered in this survey area

The smallest verified wreck anomaly known to this author, from a current sample of 42 wreck anomalies (Gearhart 2011b, 2016, 2018, and 2019), is Site 41CL103 (Figures 11 and 15), which covers an area of only 1,580 square m (0.39 acres), out to the +/- 5-nT contours, and measures 176 ft (north-south) x 155 ft (east-west) (53.6 x 47.2 m, respectively), averaging 165.5 ft (50.4 m) across. The 41CL103 anomaly is significantly smaller than (less than 1/6th the size of) Garrison, et al.'s (1989) characterization of shipwreck anomalies and is about 2.5 times larger than Pearson's (2010) threshold width for anomaly significance. In fact, all wooden-sailing-ship anomalies and all but one wooden-steamboat anomaly, known to this author, are smaller than 10,000 square m. Furthermore, all 42 wreck anomalies, known to this author, are more than twice as wide as Pearson's significance threshold. Smaller shipwreck anomalies are presumed to exist; however, a lower limit for the size of a significant anomaly remains open for interpretation. A working estimate for the minimum size of a significant anomaly is suggested below.

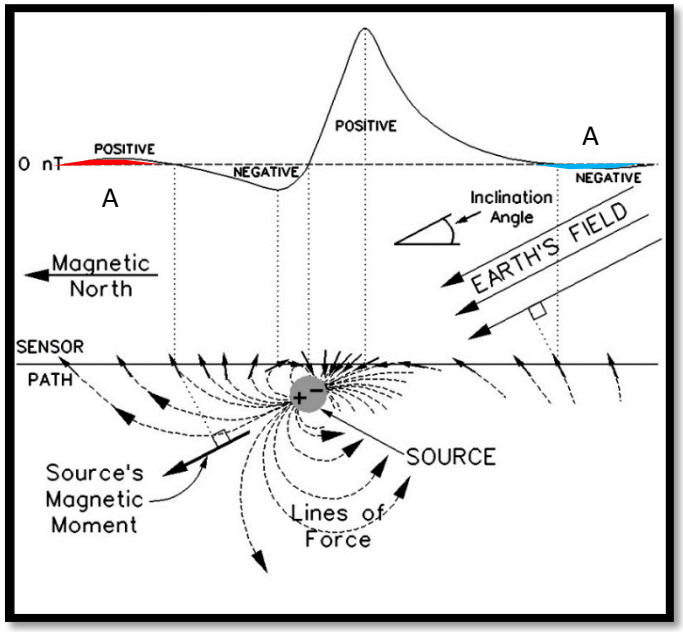

Figure 13: Induced Magnetic Anomaly

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 to 1820, was 69.0 x 20.4 x 9.0 ft (21.0 x 6.2 x 2.7 m), with a cargo capacity of 138.8 tons (based on Work Projects Administration [1941] as summarized in Ford, et al. 2008: Tables 4.2 and 4.3). The largest vessels registered in New Orleans during that period were ships (23.2 percent of 604 total registered vessels) and brigs (24.2 percent). "The predominant watercraft was the schooner [43 percent],

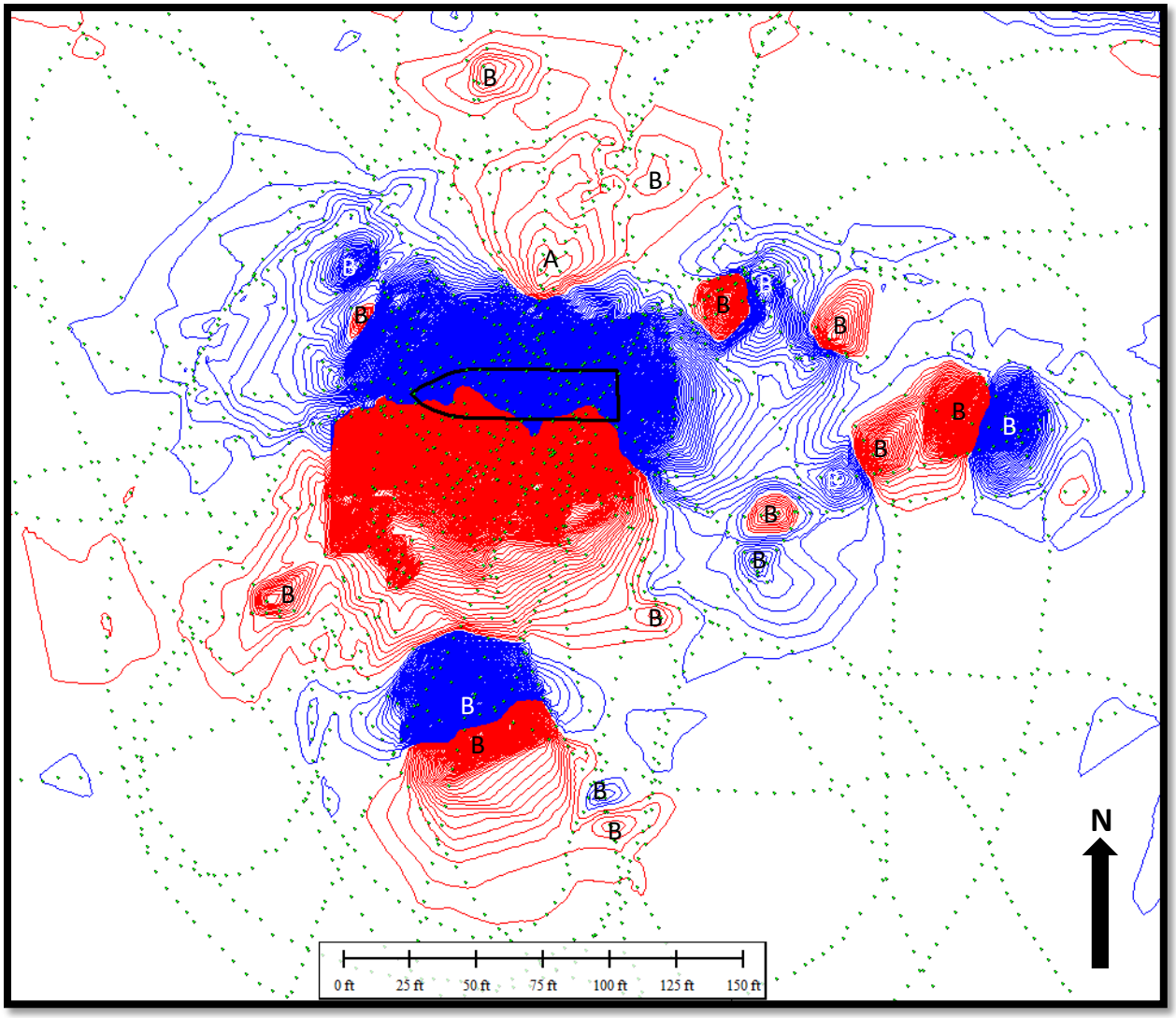

Figure 14: 41CH372 Anomaly (steel hull), 5-nT contour interval; not discovered in this survey area

though smaller vessels such as the pilotboat [a small schooner, built for speed], felucca [1.2 percent], pirogue, and sloop [6.1 percent] were easily adapted for use along the Gulf coast" (Ford, et al. 2008:71). Registered schooners averaged 59.6 X 17.7 X 6.7 ft and 69 tons (ranging from 8-200 tons).

Among the smallest vessels registered in New Orleans during that period were Feluccas, averaging 44.0 x 12.1 x 4.1 ft and 23.0 tons. "Feluccas were smaller than the pilotboats, were of a more shallow draft, and could have one or two masts… The vessel did not have a deck except for a small extent at the bow and stern. The term pirogue was sometimes used interchangeably to refer to this type of vessel" (Ford, et al. 2008:67).

The smallest vessel registered in New Orleans during the same period was the schooner *Tickler*, built in 1806 in New York. *Tickler* measured only 29 x 10 x 3.6 ft and had a cargo capacity of 8.7 tons (Work Projects Administration 1941: 127). The schooner *Tickler* will serve as a proxy for the smallest watercraft likely to

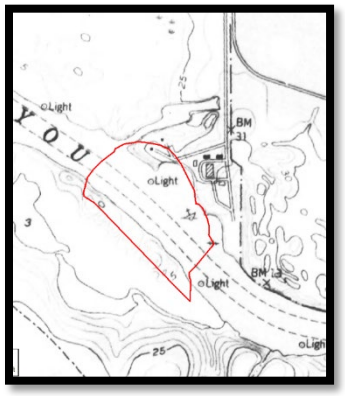

Figure 15: Smallest Example of a Verified Shipwreck Anomaly, Site 41CL103 (not discovered in this survey area)

be engaged in waterborne commerce or commercial fishing in the study area. The minimum anomaly size expected from a wooden hull, matching the schooner *Tickler's* dimensions, is estimated below, based on a comparison with the Mag-13 Wreck anomaly (Table 3 and Figure 16).

The smallest hull, of known dimensions, in Gearhart's anomaly dataset is the Mag-13 Wreck (figures 10 and 15), which measures about 35 x 13 ft, based on diver probes (Gearhart 2016). The Mag-13 anomaly measures 197 x 164 ft, an average of 180.5 ft across[3]. The dimensions of the schooner *Tickler* are 81 percent smaller than the Mag-13 hull. It seems reasonable that an intact wooden vessel of *Tickler's* dimensions might have a proportionally smaller anomaly, measuring perhaps only 81 percent as wide as the Mag-13 anomaly. Based on that assumption, the *Tickler* anomaly, hypothetically, might measure as small as 160 x 133 ft across, or an average diameter of 147 ft. Unknown factors might affect the validity of this estimate, including, total ferrous mass of a site (including the Mag-13 Wreck) and dispersion of ferrous sources on a site; therefore, a more conservative width of 135 ft will be assumed as the hypothetical width for the smallest significant anomaly.

This smaller width limit, or threshold, is a working number, subject to future revision based on new data. To summarize, this width threshold for the hypothetical, smallest significant anomaly is about 75 percent smaller than the anomaly of the Mag-13 Wreck, which is the smallest hull, of known dimensions, in Gearhart's anomaly dataset. It is about 82 percent smaller than the 41CL103 anomaly, which is the smallest verified wreck anomaly known to this author. And it is 92 percent smaller than a hypothetical anomaly for the schooner *Tickler*, which is the smallest vessel registered in New Orleans during the period 1804-1820.

The area of this hypothetical, smallest significant anomaly, encompassed by its +/- 5-nT contours, is estimated as 0.26 acres[4], corresponding to the area of an 82-percent-scale (width) version of the 41CL103 anomaly, measuring 135 ft across. More accurate estimates of area require contoured data from close-order surveys (<= 10-m transect spacing); whereas measurements of anomaly width can be made along data transects when close-order data is unavailable.

Orientation

Shipwreck anomalies (e.g., Figure 11) consistently share a common orientation, in the horizontal plane, with respect to earth's magnetic field, despite the great diversity of wrecks described above. All 42 wreck anomalies observed by this author, to date, are oriented with their primary negative pole situated north of their positive pole. The horizontal orientation (magnetic declination) of 29 dipoles over verified shipwrecks, reported in Gearhart (2011b), agrees on average within +/- 10 degrees (east or west) of the local direction of magnetic north. Declination is 0 degrees when a dipole's negative pole is due north (magnetic) of its positive pole (in mid-northern latitudes). Similar northerly orientation is expected of all wrecks, and all other complex anomaly sources, in mid-latitudes of the northern hemisphere. The primary

[3] An accurate area for the Mag-13 Wreck anomaly is unknown, because its shape is influenced by an adjacent magnetic anomaly.

[4] This acreage estimate is equivalent to 66.5 percent, not 82 percent, of the 41CL103 anomaly area, because area is a two-dimensional value, whereas width has only one dimension. The ratio of the square of widths for the smallest significant anomaly and the 41CL103 anomaly is 135^2/165.5^2=.665 or 66.5 percent.

negative pole should be south of the primary positive pole in mid-latitudes of earth's southern magnetic hemisphere. The maximum reported difference between a wreck anomaly's declination and the direction of magnetic north is 26 degrees for Site 41GV143, the *Denbigh* blockade runner (Figure 11). The larger-than-normal declination of 41GV143 might be attributable to a singular, large ferrous source, very near the magnetometer path, as this wreck is very shallow.

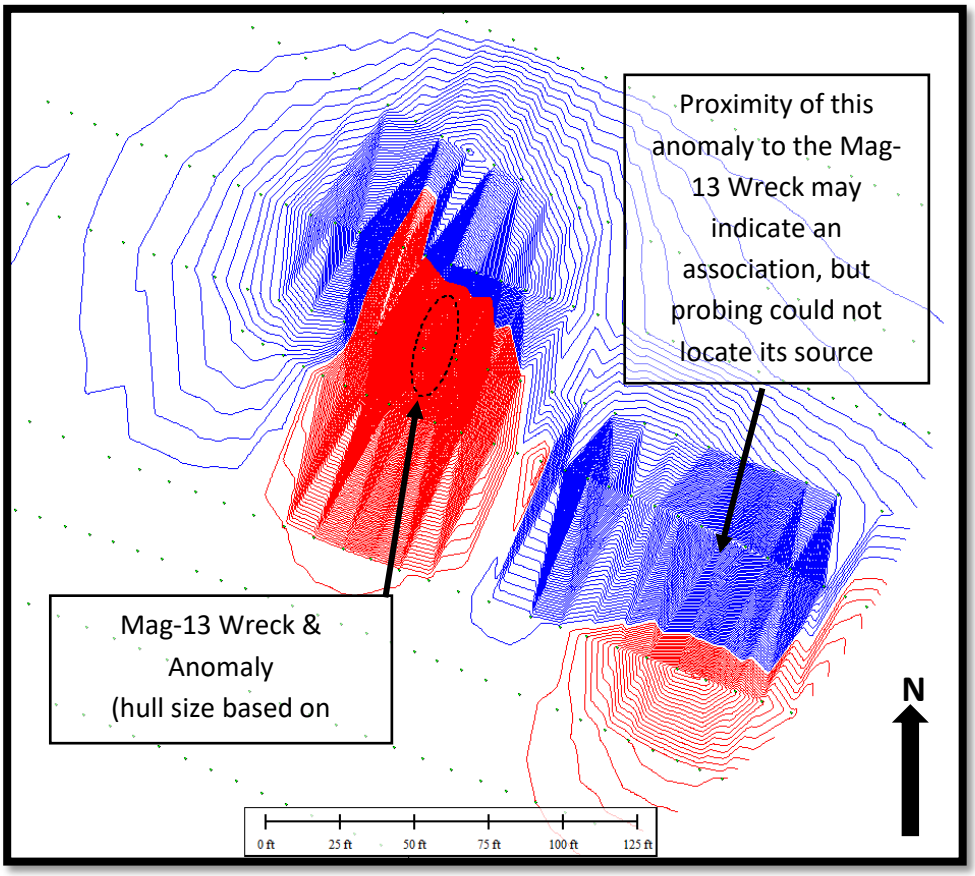

Figure 16: Mag-13 Wreck Anomaly (wooden hull)
5-nT contour interval (Gearhart 2016: 46); not discovered in this survey area

Orientation can be used to 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, by chance alone, should 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 subset of debris anomalies, having northerly orientations, from anomalies of complex sources, including buried shipwrecks.

Anomalies can be eliminated from consideration as potential shipwrecks by demonstrating that their orientations differ substantially from the direction of magnetic north. 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. 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 share some non-northerly magnetic moment, thus enhancing reinforcement, rather than cancellation, of their remanent magnetic fields.

Exceptions, such as 41GV143 (Figure 11), may occur due to the presence of a relatively high-mass iron component (in comparison to neighboring magnetic sources) whose remanent field is not sufficiently cancelled by similarly-massive, nearby objects. This has not been an issue with the other 41 wreck anomalies observed by this author and resulted in a relatively minor effect at 41GV143. Nevertheless, the possibility should be considered by interpreters. The sensor-source distance, below which orientation might be affected by such circumstances, would vary with the mass of the object in question, relative to the mass of surrounding ferrous components. For example, a propellor or paddle wheel shaft on a wooden wreck might produce a noticeable deviation from a northerly orientation, particularly if other machinery, that might have provided a comparable level of remanent-field cancellation, had been salvaged from the site.

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 41CL103, shown in Figure 15. 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 of sufficient size, having a polar orientation like that of 41CL103, 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.

Significance Criteria

BOB's minimum criteria for archaeological assessment of magnetic anomalies (applicable in mid-latitudes of the northern hemisphere) require that a significant anomaly, surveyed at 20-m 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 average at least 135 ft (41.1 m) across (to the +/- 5-nT contours); and c) it should appear on a minimum of 2 transects. If survey lines are spaced at 10-m intervals or less, a significant anomaly should meet the following conditions: d) it must have at least one dipole, oriented with its negative pole north of its positive pole; e) it should average at least 135 ft (41.1 m) across or encompass at least 0.26 acres (to the +/- 5-nT contours); and f) it should appear on a minimum of 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 under such circumstances. If survey lines are spaced more than 20 m apart, a significant anomaly g) may be limited to a single transect; and h) may appear as a monopole, provided the transect follows a predominantly east-west heading. Exceptions may be made, at the Principal Investigator's discretion, based on mitigating circumstances or professional judgment. Resemblance to verified shipwreck anomalies, such as those reported by Gearhart (2011b, 2016, 2018, and 2019) or illustrated in Figure 11, should be an important factor in such judgments when close-order survey has been conducted.

Probing Methods

Anomalies that could not be easily avoided were probed, at the request of ANAMAR, to rule out the presence of buried shipwrecks. TAP 31570 was amended on October 9, 2024, in consultation with the State Marine Archaeologist, to include probing investigations. Probing was conducted, November 4-20, 2024. Work was performed from a 20-ft boat by a crew of three persons, including David Baxter, Michael Baxter, and the Principal Investigator.

The probe was made of ½-inch iron pipe connected to a water pump. The boat was navigated to desired locations using Hypack software and a dual-GPS Heading system (differentially corrected for sub-meter accuracy). Navigation guidance at the helm ensured that the probe, deployed from the bow of the boat, was positioned correctly prior to penetrating the seafloor.

The proposed horizontal limits of probing were determined in advance based on analysis of magnetic data. Probes were spaced on a grid an average of 10 ft apart. A sufficient number of probes were placed across the central portion of an anomaly, based on the judgment of the Principal Investigator, to verify the presence/absence of a buried shipwreck. Probes were planned, in consultation with the THC, to penetrate at least 6 ft below the bay bottom, unless an anomaly source or refusal layer was discovered at a lesser depth.

V. Results

Geophysical Survey

BOB conducted an archaeological assessment of all geophysical data acquired during the survey. A total of 5,362 acres was surveyed. Shallow areas, totaling 4 acres, were necessarily excluded from the survey. Data maps for side-scan sonar and magnetometer are included in appendices A and B, respectively. Appendix C contains a tabular summary of significant geophysical survey findings and recommendations. Large-scale views of magnetic anomalies, initially interpreted as potential wrecks, are included in Appendix D. All potentially significant anomalies have been cleared from further consideration by probing. Results of probing are tabulated and overlaid on magnetic anomalies in Appendix E.

Side-Scan Sonar

A side-scan sonar mosaic is illustrated in Appendix A. The image uses a normal, gray-scale color scheme, so harder substrates are represented by darker shades, and acoustic shadows are white. Large-scale features visible in sonar data include dredge pipes, petroleum platforms, and numerous shell reefs. No sonar targets are associated with the 28 magnetic anomalies initially recommended as significant (Appendix C), and no culturally significant sonar targets were discovered by the survey.

One unidentified cluster of at least 16 linear objects, all associated with non-significant magnetic anomalies, is designated as Sonar Target ST1 (Figure 17 and Appendix A: Sheet 12). The objects resemble pipe segments of various lengths, ranging from 5 to 95 ft long. NOAA Chart 11327 shows a “Subm pile” near ST1 in 2009 (USCGS 2009). ST1 measures about 400 ft in diameter and is located just outside of a former placement area levee, now submerged, constructed in the early 1970s (USCGS 1973). A shoal

developed around ST1, adjacent but outside of the now submerged levee (USCGS 2009), suggesting a possible association with that disposal area. ST1 is not considered culturally significant.

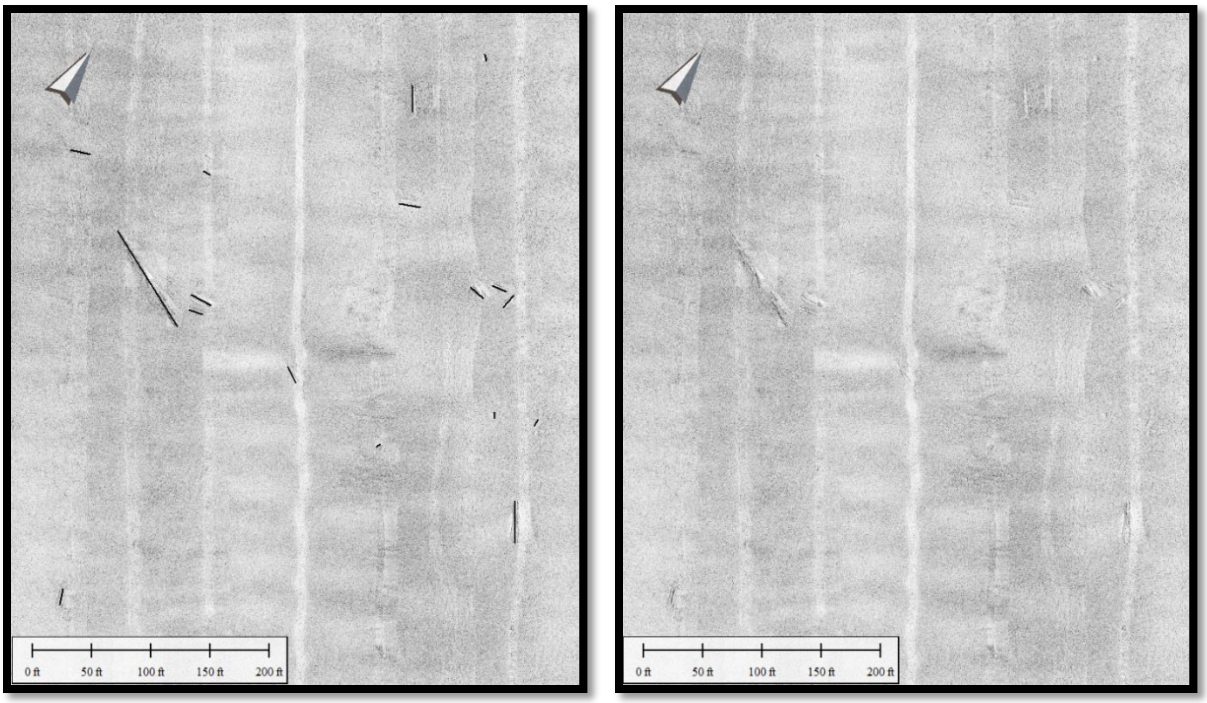

Figure 17: Sonar Target ST1 (left image delineates objects; right image shows only sonar data)

Shell reefs are the largest features visible in the sonar mosaic. Shell appears as darker areas and, viewed at a large scale, has a rough texture. Examples are indicated in Appendix A. Broader areas of shell are mostly associated with old spoil areas on the west side of the survey and along Five-Mile Cut (Appendix A: Index).

Many small, oval reefs mark the vicinity of former petroleum wells. These are not always centered on well locations, as indicated by magnetic anomalies, so are interpreted as locations where drill cuttings were dumped. The drill cuttings were subsequently populated by oysters. Such reefs are associated with older abandoned and/or plugged wells. Prior to 1969, unrestricted disposal of cuttings and drilling mud was allowed in Texas offshore and estuarine zones. A 1969 revision to the rule clarified that only oil-free cuttings and fluids could be disposed in Texas waters (Texas Administrative Code, Title 16, Part 1, Chapter 3, Rule 3.8, paragraph e, 2, E; Order Number 20-59,200, effective May 1, 1969; https://www.law.cornell.edu/regulations/texas/16-Tex-Admin-Code-SS-3-8), so drilling waste is now routinely transported to shore. Reefs associated with older wells can be seen in Appendix A, sheets 4, 6, 10, 12, 17, 18, 20, 21, 23, 25 and 26.

Several sonar features are related to dredging. A large pump barge was anchored near the southwestern corner of the survey during the October field session (Appendix A: Sheet 25). The barge was pumping material through two slurry pipelines, laid on the seafloor, from the Houston Ship Channel to a new placement area, east of the survey area. Dredge pipelines are visible in the sonar data (Appendix A) crossing map sheets 21, 23 and 25. An apparent gap in the dredge pipelines between sheets 21 and 23

was surveyed in March of 2024, before the pipes were present. Several disconnected segments of dredge pipe appear in the sonar data (Appendix A: sheets 10 and 13). These are believed to have been stored recently on the seafloor until needed. Two other areas, associated with the inactive spoil area along the western side of the survey, contain submerged pipe segments that are interpreted as abandoned (Appendix A: sheets 5 and 15).

Smaller features visible in the sonar data include a Coast Guard Range Tower (Appendix A: Sheet 10), three petroleum wellheads (Appendix A: Sheet 26), and two petroleum platforms (Appendix A: sheets 6 and 26). The status of these visible wellheads and platforms is unknown.

Magnetometer

Magnetic anomalies greater than +/- 5 nT are illustrated as contours in Appendix B. Survey transects and pre-planned lines have been overlaid on magnetic contour maps to document coverage. Additional close-order data were gathered over selected targets at a 10-m interval to assist in evaluating their historic potential. BOB initially interpreted 28 magnetic anomalies as meeting some or all criteria for archaeological significance, described above in Section IV. All of those anomalies were later cleared from archaeological concern by probing the seafloor.

Magnetic anomalies initially interpreted as significant are tabulated in Appendix C. Anomaly widths and areas in Appendix C extend to their +/- 5-nT contours. Close-order data over those 28 anomalies are contoured using a 5-nT interval, at a scale of 1:800, in Appendix D. Each anomaly in Appendix D is illustrated alongside a reference anomaly, which was recorded over a verified shipwreck. The reference anomaly used for comparison in Appendix D is an 82-percent reduction of the smallest wreck anomaly known to this author, recorded over archaeological Site 41CL103.

Thirty-nine magnetic anomalies correlate with petroleum wells, charted by the TRC within the area surveyed for this project (Appendix B, sheets 1, 2, 3, 4, 6, 7, 9, 10, 12, 16, 17, 18, 20, 21, 22, 23, 25 and 26). The TRC reports 7 pipelines crossing the survey area. Four of those pipelines correlate with linear anomalies detected by this survey (Appendix B: sheets 2, 3, 4, 6, 7, 14, 18, 21, 24 and 26). Magnetic anomalies are also associated with a Coast Guard Range Tower (Appendix A: Sheet 10) and two petroleum platforms (Appendix A: sheets 6 and 26). The status of pipelines observed in the data is unknown.

Probing

Twenty-eight magnetic anomalies (appendices C and D), initially were recommended for avoidance, based on significance criteria described in Section IV above. Those 28 anomalies were investigated further, at the request of ANAMAR, by probing the seafloor along a grid, centered over each target. Probing was completed in November, 2024 under an amendment to Permit 31570.

Results and positions of anomaly probes are tabulated and overlaid on magnetic contours in Appendix E. A total of 819 probes were completed. Probes penetrated at least 6 ft into the seafloor, as planned, except where refusal was encountered at a lesser depth. The average probe penetration was 7.3 ft below the mudline (17.5 ft below water level).

All of the probes encountered soft mud, beginning at the seafloor and extending their full depth or to refusal. An occasional thin layer of shell, shell hash, or firm sediment was encountered at lesser depths (Appendix E). A firm clay refusal or a combination of shell and shell hash was encountered, 5.9-10.1 ft below the seafloor, at 20 anomalies (Appendix E: anomalies 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, 20, 23, 24, 25, 26 and 27). This layer is interpreted as the bottom of Holocene estuarine sediments at or near the top of the former Pleistocene land surface. Those depths are consistent with Figure 5, after Anderson, et al. (2008: 94), who place the top of the Pleistocene surface at about 5 m (16.4 ft) below sea level in this area.

Solid, metallic objects were encountered at Anomaly 11 (Appendix E: Figure E-11) and Anomaly 23 (Appendix E: Figure E-23). Neither object appears on side-scan sonar imagery. The object at Anomaly 11 is less than 1 ft across and is buried 0.4 ft. The object at Anomaly 23 measures at least 5 by 11 ft across and is buried 0.3 to 1.3 ft. Results of probing at all 28 anomalies have conclusively demonstrated that none are associated with a buried shipwreck.

Recommendations

BOB initially recommended archaeological avoidance of 28 magnetic anomalies (1-28 in appendices C and D) that meet some or all criteria for archaeological significance, as described above in Section IV. All of those anomalies have been cleared from further concern based on the results of probing the seafloor (Appendix E).

Dredging an Excavated PA (Figure 2) has potential to disturb intact prehistoric archaeological sites in areas overlapping the San Jacinto and Trinity paleo-valleys (Figure 5). Intact sites may be preserved in fluvial terrace and floodplain sediments of both paleo-valleys. BOB recommends archaeological monitoring of levee construction that uses material sourced from either paleo-valley. No monitoring is recommended for levee construction using materials dredged from former upland areas, outside of the paleo-valleys, due to a low likelihood of finding intact sites through further survey, coring or monitoring. The margins of both paleo-valleys should be delineated inside the BABUS project area, prior to construction, based on a combination of acoustic sub-bottom profiles and geotechnical cores. Existing data from earlier studies may be available for that purpose.

If shipwreck remains, or other potentially historic or archaeological materials, are discovered anywhere during construction, work must be halted immediately, within 50 m (164 ft) of the find, and steps taken to ensure that the find is not disturbed. Notify the State Marine Archaeologist at the THC promptly for further direction concerning the discovery.

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Appendix A: Side-Scan Sonar Mosaic

Appendix B: Magnetic Contours

Appendix C: Magnetic Anomaly and Side-Scan Sonar Findings

Anomaly	Avoidance Required	Magnetic Amplitude (nT)	Sonar	East UTM WGS84 15N (m)	North UTM WGS84 15N (m)	Depth (ft) MLLW	Dimensions (ft NS x EW) & Area	Appendix Illustrations
1	no	+211/-35	no	314,785	3,275,086	9.7	272x301, 1.64 acres	A&B-19, D-1
2	no	+320/-21	no	313,872	3,275,647	9.1	296x302, 1.29 acres	A&B-16, D-2
3	no	+195/-31	no	315,377	3,275,186	9.9	213x233, 0.88 acres	A&B-20, D-3
4	no	+333/-26	no	315,533	3,275,270	10.1	218x268, 0.94 acres	A&B-20, D-4
5	no	+1160/-279	no	316,448	3,275,144	10.1	210x297, 0.84 acres	A&B-24, D-5
6	no	+712/-40	no	314,722	3,276,152	10.3	219x236, 0.83 acres	A&B-17, D-6
7	no	+1240/-105	no	314,215	3,277,027	9.7	250x267, 1.13 acres	A&B-9, A&B-13, D-7
8	no	+392/-43	no	314,055	3,277,127	9.0	199x178, 0.69 acres	A&B-9, D-8
9	no	+208/-23	no	315,178	3,276,728	9.1	293x315, 1.58 acres	A&B-13, D-9
10	no	+320/-25	no	315,355	3,276,003	9.5	174x196, 0.51 acres	A&B-17, D-10
11	no	+480/-386	no	314,826	3,274,162	9.8	126x165, 0.38 acres	A&B-22, D-11
12	no	+1063/-1510	no	314,927	3,273,984	9.8	152x179, 0.39 acres	A&B-22, D-12
13	no	+208/-17	no	313,454	3,275,159	8.8	227x259, 0.93 acres	A&B-16, D-13
14	no	+332/-23	no	313,762	3,277,317	8.9	171x162, 0.45 acres	A&B-9, D-14
15	no	+729/-63	no	312,417	3,277,077	8.3	189x202, 0.58 acres	A&B-5, D-15
16	no	+671/-34	no	312,186	3,277,047	8.6	173x174, 0.47 acres	A&B-5, D-16
17	no	+869/-43	no	312,235	3,277,434	7.7	186x194, 0.57 acres	A&B-5, D-17
18	no	+840/-867	no	312,584	3,277,485	9.2	132x162, 0.33 acres	A&B-6, D-18
19	no	+822/-25	no	312,718	3,277,640	7.1	530x380, 3.59 acres	A&B-6, D-19
20	no	+621/-38	no	313,339	3,278,402	7.1	179x182, 0.49 acres	A&B-3, D-20
21	no	+339/-99	no	315,413	3,273,808	9.3	186x169, 0.49 acres	A&B-22, D-21
22	no	+1665/-4395	no	316,415	3,274,792	9.3	159x284, 0.77 acres	A&B-23, D-22
23	no	+760/-507	no	316,706	3,275,469	6.5	128x158, 0.33 acres	A&B-24, D-23

Anomaly	Avoidance Required	Magnetic Amplitude (nT)	Sonar	East UTM WGS84 15N (m)	North UTM WGS84 15N (m)	Depth (ft) MLLW	Dimensions (ft NS x EW) & Area	Appendix Illustrations
24	no	+1187/-112	no	314,416	3,278,638	8.8	283x265, 1.22 acres	A&B-7, D-24
25	no	+319/-25	no	314,160	3,279,678	9.6	147x167, 0.31 acres	A&B-4, D-25
26	no	+636/-23	no	313,109	3,279,551	10.2	148x119, 0.33 acres	A&B-1, D-26
27	no	+589/-27	no	313,095	3,279,461	11.2	164x150, 0.37 acres	A&B-1, D-27
28	no	+1123/-60	no	312,918	3,279,477	8.7	170x160, 0.45 acres	A&B-1, D-28
Not picked	No	+974/-951	ST1	313,380	3,275,763	8.2	400x400, 3.5 acres	A&B-12

Appendix D: Close-Order Magnetic Contours of Appendix C Anomalies

Appendix E: Probing Results

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
1	372	6.5	soft mud; shell and clay at bottom of hole	314786.9	3275098.7
1	373	6.5	soft mud; shell and clay at bottom of hole	314787.8	3275095.8
1	374	6.5	soft mud; shell and clay at bottom of hole	314784	3275097.7
1	375	6.5	soft mud; shell and clay at bottom of hole	314792.7	3275090.8
1	376	6.5	soft mud; shell and clay at bottom of hole	314788.9	3275092.8
1	377	6.5	soft mud; shell and clay at bottom of hole	314791.7	3275093.8
1	378	6.5	soft mud; clay at bottom of hole	314785	3275094.8
1	379	6.4	soft mud; clay at bottom of hole	314786	3275092.2
1	380	6.4	soft mud; clay at bottom of hole	314789.5	3275089.6
1	381	6.4	soft mud; clay at bottom of hole	314793.7	3275087.8
1	382	6.4	soft mud; clay at bottom of hole	314790.7	3275087.1
1	383	6.4	soft mud; clay at bottom of hole	314786.9	3275089
1	384	6.4	soft mud; clay at bottom of hole	314783	3275091
1	385	6.4	soft mud; clay at bottom of hole	314778.3	3275095.8
1	386	6.4	soft mud; clay at bottom of hole	314781.9	3275094
1	387	6.3	soft mud; clay at bottom of hole	314781.2	3275096.9
1	388	7.3	soft mud	314779.2	3275093
1	389	6.3	soft mud	314784.1	3275088.2
1	390	6.3	soft mud	314787.8	3275086.1
1	391	6.8	soft mud	314781.1	3275087.3
1	392	6.8	soft mud	314780.3	3275090.2
1	393	6.3	soft mud	314775.1	3275094.8
1	394	6.3	soft mud	314776.3	3275092
1	395	6.8	soft mud	314777.2	3275089.2
1	396	6.3	soft mud	314778	3275086.3
1	397	6.2	soft mud	314782	3275084.2
1	398	6.7	soft mud	314779	3275083.2
1	399	7.2	soft mud	314774.8	3275085.5
1	400	6.7	soft mud	314774.2	3275088
1	401	6.7	soft mud	314773.2	3275090.9
1	402	6.2	soft mud; shell hash at bottom of hole	314780.1	3275080.5
1	403	6.2	soft mud; shell hash at bottom of hole	314780.9	3275077.5
1	404	6.2	soft mud; shell hash at bottom of hole	314783	3275081.5
1	405	6.2	soft mud; shell hash at bottom of hole	314784.8	3275085.2
1	406	6.2	soft mud; shell hash at bottom of hole	314785.9	3275082.4
1	407	6.2	soft mud; shell hash at bottom of hole	314788.6	3275083

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
1	408	6.2	soft mud; shell hash at bottom of hole	314791.7	3275084.5
1	409	6.6	soft mud; shell hash at bottom of hole	314794.5	3275085.1
1	410	6.1	soft mud; shell hash at bottom of hole	314795.5	3275082.3
1	411	6.1	soft mud; shell hash at bottom of hole	314796.5	3275079.5
1	412	6.1	soft mud; shell hash at bottom of hole	314792.6	3275081.3
1	413	6.1	soft mud; shell hash at bottom of hole	314789.6	3275080.3
1	414	6.1	soft mud; shell hash at bottom of hole	314786.8	3275079.3
1	415	6.1	soft mud; shell hash at bottom of hole	314783.8	3275078.5
1	416	6.1	soft mud; shell hash at bottom of hole	314784.7	3275075.6
1	417	6.1	soft mud; shell hash at bottom of hole	314787.7	3275076.5
1	418	6.6	soft mud; shell hash at bottom of hole	314790.6	3275077.6
1	419	6.6	soft mud; clay at bottom of hole	314793.4	3275078.7
1	420	6.6	soft mud; clay at bottom of hole	314791.7	3275074.5
1	421	6.1	soft mud; clay at bottom of hole	314788.6	3275073.6

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
2	422	7.5	soft mud; shell at bottom of hole	313869.7	3275662.4
2	423	7.0	soft mud; shell at bottom of hole	313872.5	3275661.2
2	424	7.5	soft mud; shell at bottom of hole	313865.8	3275660.5
2	425	7.5	soft mud; shell at bottom of hole	313868.7	3275659.3
2	426	7.5	soft mud; shell at bottom of hole	313871.6	3275658.4
2	427	7.5	soft mud; shell at bottom of hole	313874.3	3275657.6
2	428	7.0	soft mud; shell at bottom of hole	313877.3	3275656.7
2	429	7.5	soft mud; shell at bottom of hole	313864.9	3275657.3
2	430	7.5	soft mud; shell at bottom of hole	313867.8	3275656.4
2	431	7.5	soft mud; shell at bottom of hole	313870.5	3275655.6
2	432	7.6	soft mud; shell at bottom of hole	313873.4	3275654.7
2	433	7.6	soft mud; shell at bottom of hole	313876.4	3275653.9
2	434	7.6	soft mud; shell at bottom of hole	313863.9	3275654.3
2	435	7.6	soft mud; shell at bottom of hole	313866.7	3275653.6
2	436	7.6	soft mud; shell at bottom of hole	313869.8	3275652.7
2	437	7.6	soft mud; shell at bottom of hole	313872.6	3275651.8
2	438	7.1	soft mud; shell at bottom of hole	313875.5	3275650.8
2	439	7.1	soft mud; shell at bottom of hole	313878.4	3275649.9
2	440	7.1	soft mud; shell at bottom of hole	313874.6	3275647.6
2	441	7.1	soft mud; shell at bottom of hole	313871.7	3275648.9
2	442	7.6	soft mud; shell at bottom of hole	313868.8	3275649.6
2	443	7.6	soft mud; shell at bottom of hole	313865.8	3275650.5
2	444	7.6	soft mud; shell at bottom of hole	313862.8	3275651.4
2	445	7.6	soft mud; shell at bottom of hole	313864.7	3275647.6
2	446	7.6	soft mud; shell at bottom of hole	313867.7	3275646.7

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
3	348	5.9	soft mud; shell at bottom of hole	315382	3275189.9
3	349	5.9	soft mud; shell at bottom of hole	315378.6	3275189.8
3	350	6.4	soft mud; shell at bottom of hole	315382.2	3275186.9
3	351	5.9	soft mud; shell at bottom of hole	315379.2	3275186.8
3	352	5.9	soft mud; shell at bottom of hole	315375.8	3275189.3
3	353	6.0	soft mud; shell at bottom of hole	315372.9	3275189
3	354	6.4	soft mud; shell at bottom of hole	315376.2	3275186.1
3	355	6.4	soft mud; shell at bottom of hole	315379.8	3275183.5
3	356	6.4	soft mud; shell at bottom of hole	315380	3275180.7
3	357	6.4	soft mud; shell at bottom of hole	315376.7	3275183.3
3	358	6.4	soft mud; shell at bottom of hole	315373.1	3275185.7
3	359	6.4	soft mud; shell at bottom of hole	315369.8	3275188.5
3	360	6.4	soft mud; shell from 5.9 to bottom of hole	315370	3275185.6
3	361	6.4	soft mud; shell from 5.9 to bottom of hole	315373.7	3275182.8
3	362	6.4	soft mud; shell from 5.9 to bottom of hole	315377	3275180.2
3	363	6.4	soft mud; shell at bottom of hole	315377.3	3275177.3
3	364	6.4	soft mud; shell at bottom of hole	315374	3275180
3	365	6.9	soft mud; shell at bottom of hole	315370.6	3275182.7
3	366	6.4	soft mud; shell at bottom of hole	315367.6	3275182.3
3	367	6.3	soft mud; shell at bottom of hole	315370.9	3275179.4
3	368	6.3	soft mud; shell at bottom of hole	315374.4	3275176.8
3	369	6.3	soft mud; shell at bottom of hole	315371.2	3275176.2
3	370	6.3	soft mud; shell at bottom of hole	315367.9	3275178.9
3	371	6.3	soft mud; shell at bottom of hole	315368.1	3275176

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
4	319	6.4	soft mud; shell at bottom of hole	315538.4	3275277.5
4	320	6.4	soft mud; shell at bottom of hole	315539.8	3275274.3
4	321	6.4	soft mud; shell at bottom of hole	315535.5	3275276.2
4	322	6.4	soft mud; shell at bottom of hole	315536.8	3275273.7
4	323	6.4	soft mud; shell at bottom of hole	315540.4	3275271.5
4	324	6.4	soft mud; shell at bottom of hole	315537.9	3275270.7
4	325	6.4	soft mud; shell at bottom of hole	315532.9	3275275.2
4	326	6.4	soft mud; shell at bottom of hole	315533.9	3275272.6
4	327	6.4	soft mud; shell at bottom of hole	315538.7	3275267.7
4	328	6.4	soft mud; shell lens at 2.4; shell at bottom of hole	315534.9	3275269.6
4	329	6.4	soft mud; shell lens at 2.4; shell at bottom of hole	315529.8	3275274.2
4	330	6.8	soft mud; shell lens at 2.4; shell at bottom of hole	315531.2	3275271.5
4	331	6.3	soft mud; shell lens at 2.3; shell at bottom of hole	315532.1	3275268.8
4	332	6.3	soft mud; shell at bottom of hole	315535.6	3275266.6
4	333	6.3	soft mud; shell at bottom of hole	315539.7	3275264.7
4	334	6.3	soft mud; shell at bottom of hole	315536.9	3275263.9
4	335	6.3	soft mud; shell at bottom of hole	315540.8	3275262.1
4	336	6.3	soft mud; shell at bottom of hole	315537.9	3275261.3
4	337	6.3	soft mud; shell at bottom of hole	315534.1	3275262.8
4	338	6.3	soft mud; shell at bottom of hole	315533	3275265.6
4	339	6.3	soft mud; shell at bottom of hole	315529.2	3275267.7
4	340	6.3	soft mud; shell at bottom of hole	315530.1	3275264.8
4	341	6.3	soft mud; shell at bottom of hole	315531.1	3275261.8
4	342	6.3	soft mud; shell at bottom of hole	315532.1	3275259.2
4	343	6.3	soft mud; shell at bottom of hole	315534.9	3275259.9
4	344	7.3	soft mud; shell from 6.3 to bottom of hole	315538.7	3275257.8
4	345	6.3	soft mud; shell at bottom of hole	315541.7	3275258.9
4	346	6.3	soft mud; shell at bottom of hole	315535.9	3275257.2
4	347	6.3	soft mud; shell at bottom of hole	315532.9	3275255.8

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
5	636	7.2	soft mud; firm lens at 5.2	316448.4	3275132.7
5	637	5.2	soft mud; firm at bottom of hole	316451.3	3275134
5	638	5.2	soft mud; firm at bottom of hole	316444.4	3275134
5	639	7.2	soft mud; firm lens at 5.2	316443.1	3275136.5
5	640	7.2	soft mud; firm lens at 5.2	316441.3	3275139.6
5	641	7.2	soft mud; firm lens at 5.2	316447.2	3275135.3
5	642	7.2	soft mud; firm lens at 5.2	316445.8	3275138.2
5	643	7.2	soft mud; firm lens at 5.2	316444.2	3275140.7
5	644	7.2	soft mud; firm lens at 5.2	316442	3275145.9
5	645	7.2	soft mud; firm lens at 5.2	316443	3275143.3
5	646	7.2	soft mud; firm lens at 5.2	316449.9	3275136.5
5	647	6.2	soft mud; firm at bottom of hole	316448.3	3275139.3
5	648	7.2	soft mud; firm lens at 5.2	316447	3275142.3
5	649	7.2	soft mud; firm lens at 5.2	316445.8	3275144.9
5	650	7.2	soft mud; firm lens at 5.2	316444.4	3275147.7
5	651	7.1	soft mud; firm lens at 5.1	316454	3275135.4
5	652	7.1	soft mud; firm lens at 5.1	316452.7	3275138.2
5	653	7.1	soft mud; firm lens at 5.1	316449.7	3275143.5
5	654	7.0	soft mud; firm lens at 5.0	316454	3275142.2
5	655	6.0	soft mud; firm lens at 5.0	316446.8	3275149
5	656	6.3	soft mud; firm lens at 5.3	316451.3	3275147.8
5	657	6.3	soft mud; firm lens at 5.3	316452.3	3275145
5	658	6.3	soft mud; firm lens at 5.3	316448.2	3275146.5
5	659	6.3	soft mud; firm lens at 5.3	316451.2	3275140.8

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
6	244	6.5	soft mud	314723.5	3276158.8
6	245	6.5	soft mud	314721.4	3276156.9
6	246	6.5	soft mud	314725.4	3276156.4
6	247	6.5	soft mud	314723.3	3276154.5
6	248	6.5	soft mud	314719.2	3276154.8
6	249	7.5	soft mud	314727.6	3276154.5
6	250	6.5	soft mud	314725.2	3276152.3
6	251	6.5	soft mud	314720.9	3276152.5
6	252	6.5	soft mud	314716.8	3276152.9
6	253	6.5	soft mud	314729.8	3276152.2
6	254	6.5	soft mud	314727.5	3276150.1
6	255	6.5	soft mud	314723.2	3276150.2
6	256	6.5	soft mud	314731.7	3276149.9
6	257	6.5	soft mud	314725	3276148.5
6	258	6.5	soft mud	314720.9	3276148.3
6	259	6.5	soft mud	314716.7	3276148.8
6	260	6.5	soft mud	314714.7	3276150.9
6	261	6.5	soft mud	314719	3276150.8
6	262	6.5	soft mud	314729.5	3276148.1
6	263	6.5	soft mud	314727.3	3276146.1
6	264	6.5	soft mud	314722.9	3276146.3
6	265	6.5	soft mud	314718.7	3276146.2
6	266	6.5	soft mud	314720.6	3276144.2
6	267	6.5	soft mud	314724.8	3276143.6
6	268	6.5	soft mud	314722.7	3276142.1

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
7	175	8.0	soft mud; shell hash at 6.0	314220.2	3277029.4
7	176	7.0	soft mud; shell hash at 6.0	314213.7	3277031.4
7	177	7.0	soft mud; shell hash at 6.0	314215.9	3277029.5
7	178	6.0	soft mud; shell hash at bottom of hole	314222.5	3277027.3
7	179	7.0	soft mud; shell hash at 6.5	314218	3277027.2
7	180	6.5	soft mud; shell hash at bottom of hole	314224.1	3277025
7	181	6.1	soft mud; shell hash at bottom of hole	314220	3277025.1
7	182	6.6	soft mud; shell hash at bottom of hole	314213.5	3277027.5
7	183	6.1	soft mud; shell hash at bottom of hole	314211.5	3277029.6
7	184	6.1	soft mud; shell hash at bottom of hole	314222	3277022.4
7	185	6.1	soft mud; shell hash at bottom of hole	314217.8	3277022.9
7	186	6.1	soft mud; shell hash at bottom of hole	314224.1	3277020.2
7	187	6.6	soft mud; shell hash at bottom of hole	314215.8	3277025.1
7	188	6.1	soft mud; shell hash at bottom of hole	314209.1	3277027.9
7	189	6.6	soft mud; shell hash at bottom of hole	314211.5	3277025.4
7	190	6.6	soft mud; shell hash at bottom of hole	314219.8	3277020.5
7	191	6.6	soft mud; shell hash at bottom of hole	314213.2	3277022.7
7	192	6.6	soft mud; shell hash at bottom of hole	314226	3277018
7	193	6.1	soft mud; shell hash at bottom of hole	314221.7	3277018.1
7	194	6.1	soft mud; shell hash at bottom of hole	314223.7	3277015.8
7	195	6.1	soft mud; shell hash at bottom of hole	314217.6	3277018.7
7	196	6.6	soft mud; shell hash at bottom of hole	314215.4	3277021
7	197	6.6	soft mud; shell hash at bottom of hole	314208.9	3277023.1
7	198	6.1	soft mud; shell hash at bottom of hole	314211.2	3277021.2
7	199	6.6	soft mud; shell hash at bottom of hole	314213.2	3277018.5

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
8	154	7.8	soft mud; shell hash lens at 6.3	314057.9	3277131.2
8	155	6.8	soft mud; shell hash at bottom of hole	314059.7	3277128.5
8	156	6.8	soft mud; shell hash at bottom of hole	314053.2	3277131
8	157	6.3	soft mud; shell hash at bottom of hole	314055.4	3277128.7
8	158	6.3	soft mud; shell hash at bottom of hole	314061.9	3277126.4
8	159	6.3	soft mud; shell hash at bottom of hole	314057.4	3277126.3
8	160	6.3	soft mud; shell hash at bottom of hole	314051.1	3277129.2
8	161	6.1	soft mud; shell hash at bottom of hole	314059.6	3277124.5
8	162	6.8	soft mud; shell hash lens at 6.1	314053.1	3277126.6
8	163	6.3	soft mud; shell hash at bottom of hole	314061.2	3277122.1
8	164	6.3	soft mud; shell hash at bottom of hole	314055.2	3277124.3
8	165	6.3	soft mud; shell hash at bottom of hole	314048.9	3277127.2
8	166	6.8	soft mud; shell hash lens at 6.3	314057.4	3277122.4
8	167	6.3	soft mud; shell hash lens at 5.8	314050.7	3277124.7
8	168	6.4	soft mud; shell hash lens at 5.8	314052.9	3277122.5
8	169	6.4	soft mud; shell hash at bottom of hole	314059.4	3277119.9
8	170	6.9	soft mud; shell hash at bottom of hole	314055.1	3277120.1
8	171	5.9	soft mud; shell hash at bottom of hole	314048.9	3277122.9
8	172	6.9	soft mud; shell hash at bottom of hole	314057.2	3277118.2
8	173	6.4	soft mud; shell hash at bottom of hole	314050.7	3277120.6
8	174	6.9	soft mud; shell hash lens at 5.9	314052.8	3277118.5

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
9	200	7.7	soft mud	315175.7	3276742.5
9	201	7.7	soft mud	315173	3276744.1
9	202	7.7	soft mud	315171.8	3276740.8
9	203	7.7	soft mud	315174.8	3276739.9
9	204	7.7	soft mud	315169	3276742
9	205	7.7	soft mud	315166.1	3276742.8
9	206	6.7	soft mud	315177.6	3276739
9	207	6.6	soft mud	315180.5	3276737.8
9	208	6.6	soft mud	315183.4	3276737.1
9	209	6.6	soft mud; shell at bottom of hole	315176.7	3276735.8
9	210	6.6	soft mud; shell at bottom of hole	315165.1	3276740.2
9	211	6.6	soft mud	315168.2	3276739.5
9	212	6.6	soft mud	315170.9	3276738
9	213	6.6	soft mud	315173.8	3276737.1
9	214	6.6	soft mud	315179.5	3276735.1
9	215	6.6	soft mud	315182.3	3276734.1
9	216	6.6	soft mud	315172.6	3276733.9
9	217	6.6	soft mud; shell at 5.6	315170	3276735.6
9	218	6.6	soft mud	315166.9	3276736
9	219	6.6	soft mud	315164.1	3276737.7
9	220	6.7	soft mud; shell at bottom of hole	315175.5	3276733.3
9	221	6.7	soft mud	315178.6	3276732.4
9	222	6.7	soft mud; shell at bottom of hole	315181.3	3276731.1
9	223	6.7	soft mud; shell at bottom of hole	315180.2	3276727.9
9	224	6.7	soft mud	315177.5	3276729.3
9	225	6.7	soft mud; shell at bottom of hole	315174.5	3276730.2
9	226	6.7	soft mud; shell at bottom of hole	315168.7	3276732.5
9	227	6.7	soft mud	315171.6	3276731.5
9	228	6.7	soft mud; shell at bottom of hole	315166.1	3276733.3
9	229	6.7	soft mud	315162.9	3276734.2
9	230	7.7	soft mud	315194.9	3276732.7
9	231	7.7	soft mud; shell at bottom of hole	315191.8	3276733.8
9	232	6.7	soft mud	315193.9	3276729.9
9	233	6.7	soft mud; shell at bottom of hole	315190.9	3276730.9
9	234	6.7	soft mud	315185.1	3276732.9
9	235	7.7	soft mud	315188.1	3276731.9
9	236	7.7	soft mud	315187	3276728.8
9	237	7.7	soft mud	315184.4	3276730.3
9	238	7.7	soft mud	315189.8	3276728
9	239	7.7	soft mud	315192.7	3276726.9
9	240	7.7	soft mud	315191.7	3276724.1

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
9	241	7.7	soft mud	315189	3276725.3
9	242	7.7	soft mud	315185.9	3276726.1
9	243	7.7	soft mud	315183	3276727.1

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
10	269	7.4	soft mud	315355.2	3276010.6
10	270	6.9	soft mud	315353	3276008.5
10	271	6.4	soft mud	315357.1	3276007.9
10	272	7.4	soft mud	315354.9	3276006.3
10	273	6.4	soft mud	315350.6	3276006.2
10	274	6.9	soft mud	315359.4	3276006
10	275	7.4	soft mud	315357.1	3276003.9
10	276	6.4	soft mud	315352.7	3276004.2
10	277	6.4	soft mud	315348.3	3276004.3
10	278	6.4	soft mud	315361.4	3276003.5
10	279	7.4	soft mud; shell at bottom of hole	315354.7	3276001.9
10	280	7.4	soft mud; shell at bottom of hole	315356.8	3275999.8
10	281	7.5	soft mud; shell at bottom of hole	315361	3275999.4
10	282	7.5	soft mud; shell at bottom of hole	315358.9	3276001.6
10	283	7.5	soft mud; shell at bottom of hole	315363	3276001.3
10	284	7.0	soft mud; shell at bottom of hole	315358.8	3275997.5
10	285	7.0	soft mud; shell at bottom of hole	315352.6	3275999.6
10	286	7.0	soft mud; shell at bottom of hole	315350.6	3276002.2
10	287	7.0	soft mud; shell at bottom of hole	315354.2	3275997.4
10	288	7.1	soft mud; shell at bottom of hole	315356.7	3275995.3
10	289	7.1	soft mud; shell at bottom of hole	315346.2	3276002.4
10	290	7.6	soft mud; shell at bottom of hole	315348	3276000.1
10	291	7.6	soft mud; shell at bottom of hole	315350.3	3275998
10	292	7.1	soft mud; shell at bottom of hole	315352.4	3275995.7
10	293	7.1	soft mud; shell at bottom of hole	315354.3	3275993.3
10	294	7.6	soft mud; shell at bottom of hole	315372.3	3275975.9
10	295	7.6	soft mud; shell at bottom of hole	315370	3275978.1
10	296	7.6	soft mud; shell at bottom of hole	315367.9	3275980.5
10	297	7.7	soft mud; shell at bottom of hole	315365.9	3275982.7
10	298	7.2	soft mud; shell at bottom of hole	315364.1	3275985.1
10	299	6.7	soft mud; shell at bottom of hole	315361.6	3275983
10	300	7.2	soft mud; shell at bottom of hole	315363.5	3275980.5
10	301	6.7	soft mud; shell at 6.2	315367.7	3275976.3
10	302	7.7	soft mud; shell at bottom of hole	315365.8	3275978.5
10	303	7.7	soft mud; shell at bottom of hole	315370	3275973.8
10	304	7.2	soft mud; shell at bottom of hole	315367.8	3275972.1
10	305	7.7	soft mud; shell at bottom of hole	315365.5	3275974.3
10	306	7.7	soft mud; shell at bottom of hole	315363.6	3275976.6
10	307	7.7	soft mud; shell at bottom of hole	315361.6	3275978.8
10	308	7.7	soft mud; shell at bottom of hole	315359.4	3275980.8
10	309	7.2	soft mud; shell at bottom of hole	315357	3275978.9

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
10	310	7.7	soft mud; shell at bottom of hole	315359.4	3275976.7
10	311	7.7	soft mud; shell at bottom of hole	315361.3	3275974.3
10	312	7.7	soft mud	315363.1	3275972
10	313	7.7	soft mud; shell at bottom of hole	315365.3	3275969.9
10	314	6.7	soft mud; shell at bottom of hole	315363	3275967.7
10	315	6.7	soft mud; shell at bottom of hole	315360.8	3275969.9
10	316	7.7	soft mud	315358.9	3275972.2
10	317	7.7	soft mud	315356.9	3275974.4
10	318	7.2	soft mud	315355	3275976.8

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
11	475	7.5	soft mud; shell hash at bottom of hole	314842.3	3274161.4
11	476	7.5	soft mud; shell hash at bottom of hole	314842.1	3274158.3
11	477	8.0	soft mud; shell hash at bottom of hole	314842.3	3274155.3
11	478	7.9	soft mud	314839.3	3274152.2
11	479	7.9	soft mud; shell at bottom of hole	314839.4	3274155.4
11	480	8.4	soft mud; shell at bottom of hole	314839.1	3274158.4
11	481	7.9	soft mud; shell at bottom of hole	314839.2	3274161.5
11	482	7.9	soft mud; shell lens at 5.9; shell at bottom of hole	314836.2	3274161.3
11	483	7.9	soft mud; shell lens at 5.9; shell at bottom of hole	314835.9	3274158.4
11	484	7.9	metallic object at 0.4; less than 1-ft wide	314836	3274155.3
11	485	7.9	soft mud; shell at bottom of hole	314832.8	3274158.4
11	486	7.9	soft mud; shell at bottom of hole	314832.9	3274161.4
11	487	7.9	soft mud; shell at bottom of hole	314833.1	3274164.4
11	488	7.9	soft mud; shell at bottom of hole	314830	3274164.4
11	489	8.4	soft mud; shell lens at 5.9; shell at bottom of hole	314830	3274161.4
11	490	8.4	soft mud; shell at bottom of hole	314829.9	3274158.3
11	491	8.4	soft mud	314826.9	3274158.3
11	492	8.4	soft mud	314827.1	3274161.5
11	493	7.4	soft mud; shell lens at 5.9; shell at bottom of hole	314826.9	3274164.4
11	494	6.9	soft mud; shell at bottom of hole	314823.9	3274158.4
11	495	7.9	soft mud; shell lens at 6.9; shell at bottom of hole	314824	3274161.4
11	496	7.8	soft mud; shell at bottom of hole	314823.8	3274164.4
11	497	7.8	soft mud; shell at bottom of hole	314820.6	3274161.5
11	498	8.3	soft mud	314820.7	3274158.3

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
12	499	7.6	soft mud	314923.1	3273987.9
12	500	7.6	soft mud	314926.2	3273987.7
12	501	7.6	soft mud	314929.2	3273988
12	502	7.6	soft mud; clay at bottom of hole	314932.1	3273984.9
12	503	7.6	soft mud; clay at bottom of hole	314929.2	3273984.7
12	504	7.6	soft mud; clay at bottom of hole	314926.1	3273984.6
12	505	7.6	soft mud; clay at bottom of hole	314923.1	3273984.7
12	506	8.1	soft mud; clay at bottom of hole	314920.1	3273984.6
12	507	7.5	soft mud	314919.9	3273981.6
12	508	7.5	soft mud	314923	3273981.8
12	509	8.5	soft mud	314926.1	3273981.9
12	510	7.5	soft mud	314929.2	3273981.6
12	511	7.5	soft mud	314932.1	3273981.5
12	512	7.5	soft mud; clay at bottom of hole	314932.2	3273978.6
12	513	7.5	soft mud; clay at bottom of hole	314929.2	3273978.8
12	514	7.5	soft mud; clay at bottom of hole	314926.2	3273979
12	515	7.5	soft mud; clay at bottom of hole	314923	3273978.6
12	516	7.5	soft mud; clay at bottom of hole	314926.2	3273975.8
12	517	7.5	soft mud; clay at bottom of hole	314929.2	3273975.8
12	518	7.5	soft mud; clay at bottom of hole	314932.2	3273975.7

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
13	447	8.5	soft mud; shell hash lens at 7.5	313460.9	3275159.2
13	448	7.5	soft mud; shell hash at bottom of hole	313461.1	3275156.1
13	449	7.5	soft mud; shell hash at bottom of hole	313461.5	3275153
13	450	7.5	soft mud; shell hash at bottom of hole	313458.8	3275152.7
13	451	7.5	soft mud; shell hash at bottom of hole	313458.3	3275155.8
13	452	7.0	soft mud; shell hash at bottom of hole	313457.8	3275158.8
13	453	7.6	soft mud; shell hash at bottom of hole	313457.4	3275161.9
13	454	7.6	soft mud; shell hash at bottom of hole	313457.1	3275164.8
13	455	7.6	soft mud; shell hash at bottom of hole	313453.8	3275164.5
13	456	7.6	soft mud; clay at bottom of hole	313454.6	3275161.5
13	457	7.6	soft mud; clay at bottom of hole	313454.7	3275158.2
13	458	7.6	soft mud; clay at bottom of hole	313455.3	3275155.5
13	459	7.6	soft mud; clay at bottom of hole	313455.5	3275152.4
13	460	7.6	soft mud; clay at bottom of hole	313452.7	3275152
13	461	7.5	soft mud; clay at bottom of hole	313452.1	3275155
13	462	7.0	soft mud; shell at bottom of hole	313451.9	3275158
13	463	7.0	soft mud; shell at bottom of hole	313451.7	3275161.1
13	464	7.5	soft mud; clay at bottom of hole	313450.9	3275164
13	465	7.5	soft mud; shell at bottom of hole	313448.2	3275163.7
13	466	7.5	soft mud; shell at bottom of hole	313448.5	3275160.7
13	467	7.5	soft mud; shell at bottom of hole	313448.9	3275157.7
13	468	7.5	soft mud; shell at bottom of hole	313449.3	3275154.7
13	469	8.5	soft mud; clay from 7.5 to bottom of hole	313449.3	3275151.6
13	470	7.5	soft mud; shell at bottom of hole	313446.6	3275151
13	471	7.5	soft mud; clay at bottom of hole	313446.1	3275154.3
13	472	7.5	soft mud; shell hash at bottom of hole	313445.7	3275157.3
13	473	7.5	soft mud; clay at bottom of hole	313445.3	3275160.3
13	474	7.5	soft mud; clay at bottom of hole	313445	3275163.3

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
14	103	7.5	soft mud	313761.3	3277324.1
14	104	7.5	soft mud	313759.1	3277322.1
14	105	7.5	soft mud	313763.1	3277322.1
14	106	7.5	soft mud	313761	3277319.9
14	107	7.5	soft mud	313756.8	3277320.2
14	108	7.5	soft mud	313765.4	3277319.7
14	109	7.0	soft mud	313763	3277317.1
14	110	7.5	soft mud; probe broke at hose joint	313767.4	3277317.5
14	111	6.6	soft mud; shell hash at bottom of hole	313760.8	3277315.8
14	112	6.6	soft mud	313765.5	3277315.7
14	113	6.6	soft mud	313756	3277315.6
14	114	6.6	soft mud; shell hash at bottom of hole	313758.6	3277317.3
14	115	6.6	soft mud; shell hash at bottom of hole	313754.5	3277317.9
14	116	6.6	soft mud	313756.6	3277315.6
14	117	6.6	soft mud	313752.6	3277316.3
14	118	6.7	soft mud	313769.1	3277315.2
14	119	6.7	soft mud	313767.3	3277313.2
14	120	6.7	soft mud	313763.2	3277313.4
14	121	6.7	soft mud	313758.7	3277313.4
14	122	6.7	soft mud	313754.3	3277313.8
14	123	6.7	soft mud	313756.4	3277311.5
14	124	6.7	soft mud	313760.6	3277311.3
14	125	6.7	soft mud	313764.9	3277311.5
14	126	6.7	soft mud	313762.6	3277308.9
14	127	6.7	soft mud	313758.3	3277308.9
14	128	6.7	soft mud	313760.4	3277307

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
15	52	7.0	soft mud	312424.8	3277071
15	53	7.0	soft mud	312421.8	3277070.2
15	54	7.0	soft mud	312419.2	3277068.9
15	55	7.0	soft mud	312416.3	3277067.4
15	56	7.0	soft mud	312414	3277066.1
15	57	7.0	soft mud	312423.9	3277074.5
15	58	6.9	soft mud	312420.6	3277072.5
15	59	6.9	soft mud	312418.1	3277071.1
15	60	6.9	soft mud	312415.7	3277070.4
15	61	7.0	soft mud	312412.4	3277069.4
15	62	7.0	soft mud	312416.6	3277074.3
15	63	7.0	soft mud	312419.4	3277075.9
15	64	7.0	soft mud	312422.6	3277077.1
15	65	7.2	soft mud	312409	3277077.7
15	66	7.3	soft mud	312420.1	3277082.8
15	67	7.3	soft mud	312417.5	3277081.4
15	68	7.3	soft mud	312414.5	3277080.1
15	69	7.3	soft mud	312411.6	3277079.4
15	70	7.4	soft mud	312410	3277075.3
15	71	7.4	soft mud	312421.4	3277079.8
15	72	7.3	soft mud	312419	3277078.6
15	73	7.3	soft mud	312412.8	3277076.3
15	74	7.3	soft mud	312415.7	3277077.4
15	75	7.3	soft mud	312411.1	3277072.6
15	76	7.3	soft mud	312413.7	3277073.4

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
16	77	7.8	soft mud; shell at 1.8	312187.2	3277051.5
16	78	7.8	soft mud	312184.1	3277052.1
16	79	7.8	soft mud	312189.8	3277050.8
16	80	7.8	soft mud	312192.6	3277050
16	81	7.8	soft mud	312180.9	3277052.4
16	82	7.8	soft mud	312180	3277049.7
16	83	7.9	soft mud	312192.1	3277047.2
16	84	7.9	soft mud	312189.2	3277047.6
16	85	7.9	soft mud	312186.3	3277048.3
16	86	7.9	soft mud	312183	3277049.2
16	87	7.9	soft mud	312185.2	3277045.4
16	88	7.9	soft mud	312182.6	3277046
16	89	8.0	soft mud	312188.7	3277044.9
16	90	8.0	soft mud; shell hash at 7	312191.5	3277044.3
16	91	9.0	soft mud	312191.5	3277044.3
16	92	8.0	soft mud	312179.6	3277047
16	93	8.0	soft mud	312178.8	3277044
16	94	8.0	soft mud	312181.8	3277043.1
16	95	8.0	soft mud	312184.9	3277042.2
16	96	8.0	soft mud	312187.7	3277041.8
16	97	8.0	soft mud	312191.1	3277041.2
16	98	8.0	soft mud	312190	3277038
16	99	8.0	soft mud	312177.9	3277040.6
16	100	8.0	soft mud; denser sediment layer at 6	312181.1	3277039.9
16	101	8.0	soft mud	312184	3277039.2
16	102	8.0	soft mud	312187.1	3277038.9

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
17	27	9.5	soft mud	312242	3277437.7
17	28	8.5	soft mud	312241.6	3277434.7
17	29	8.5	soft mud	312238.2	3277437.3
17	30	8.5	soft mud	312241.1	3277431.5
17	31	8.5	soft mud	312235.4	3277438
17	32	8.5	soft mud; shell hash lens at 4.5	312238	3277434.8
17	33	8.5	soft mud; shell hash lens at 2.5	312238.1	3277431.5
17	34	8.6	soft mud	312231.6	3277437.9
17	35	8.6	soft mud; shell hash lens at 2.6	312235.6	3277435
17	36	8.6	soft mud; shell hash lens at 2.6	312241.2	3277428.5
17	37	9.6	soft mud; shell hash lens at 2.6; shell hash at bottom of hole	312238.1	3277428.4
17	38	9.6	soft mud	312229.1	3277438.1
17	39	9.6	soft mud	312232.2	3277435
17	40	9.6	soft mud; shell hash lenses at 2.6 and 6.6	312235.8	3277432
17	41	9.6	soft mud; shell hash lens at 2.6; clay at bottom of hole	312240.7	3277425.3
17	42	9.6	soft mud; shell hash lenses at 2.6 and 6.6; clay at bottom of hole	312234.9	3277428.3
17	43	9.6	soft mud; shell hash lens at 2.6	312232.3	3277431.6
17	44	9.6	soft mud; shell hash lens at 0.6; clay at bottom of hole	312237.7	3277425
17	45	10.1	soft mud; clay at bottom of hole	312229	3277434.9
17	46	10.1	soft mud; clay at bottom of hole	312228.4	3277431.5
17	47	9.7	soft mud; shell hash lenses at 2.7 and 6.7; clay at bottom of hole	312231.8	3277428.2
17	48	9.7	soft mud; clay at bottom of hole	312235.1	3277426
17	49	9.7	soft mud; shell hash lens at 4.7; clay at bottom of hole	312229.2	3277426.4
17	50	9.7	soft mud; shell hash lens at 7.2; clay at bottom of hole	312228.9	3277429.1
17	51	9.7	soft mud; shell hash lens at 6.7; clay at bottom of hole	312232.2	3277425.8

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
18	1	7.8	soft mud	312589.5	3277493.8
18	2	7.8	soft mud	312589.9	3277486.3
18	3	7.8	soft mud; shell at bottom of hole	312592.3	3277480.8
18	4	7.8	soft mud	312590.8	3277483.3
18	5	7.8	soft mud; shell at bottom of hole	312589.2	3277489.7
18	6	7.8	soft mud	312586.2	3277487.4
18	7	7.8	soft mud	312587.4	3277483.2
18	8	7.8	soft mud	312587.7	3277485
18	9	6.8	soft mud	312586.2	3277491.5
18	10	6.8	soft mud	312589.6	3277480.2
18	11	7.9	soft mud	312582.4	3277490.1
18	12	6.9	soft mud	312586.4	3277479.1
18	13	6.9	soft mud	312585.1	3277481.7
18	14	6.9	soft mud	312584	3277484.7
18	15	6.9	soft mud	312583.5	3277488
18	16	7.0	soft mud	312583.3	3277490.7
18	17	5.9	soft mud	312578.7	3277490.2
18	18	6.9	soft mud	312580.6	3277486.6
18	19	5.9	soft mud	312581.6	3277484.5
18	20	5.9	soft mud	312576.6	3277489.3
18	21	6.0	soft mud	312577.7	3277486
18	22	6.0	soft mud	312582.3	3277481.1
18	23	7.0	soft mud	312578.6	3277483.5
18	24	6.2	soft mud	312579.7	3277480.4
18	25	6.2	soft mud	312583.2	3277477.6
18	26	6.2	soft mud	312580	3277477.1

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
19	771	8.3	soft mud	312707.9	3277651.8
19	772	4.8	soft mud; shell at bottom of hole	312710.8	3277651.9
19	773	3.8	soft mud; shell at bottom of hole	312714	3277651.8
19	774	9.4	soft mud	312717	3277651.6
19	775	9.4	soft mud; shell lens at 4.4	312720.2	3277651.9
19	776	4.9	soft mud; shell from 3.9 to bottom of hole	312723.2	3277651.8
19	777	8.4	soft mud	312708	3277649.1
19	778	9.4	soft mud; shell from 3.9 to 4.9	312711.1	3277648.8
19	779	5.5	soft mud; shell from 3.5 to 5.5	312714	3277648.7
19	780	9.5	soft mud; shell lens at 3.5	312717	3277648.7
19	781	8.5	soft mud; shell from 3.5 to 4.5	312720.2	3277648.8
19	782	8.5	soft mud; shell from 3.5 to 4.5	312723	3277648.9
19	783	9.5	soft mud; shell from 3.5 to 4.5	312723.2	3277646
19	784	8.5	soft mud; shell from 3.5 to 4.5	312720	3277645.8
19	785	9.5	soft mud	312714.1	3277645.7
19	786	8.5	soft mud; shell lens at 3.5	312717.2	3277645.8
19	787	8.5	soft mud	312711.1	3277645.8
19	788	5.5	soft mud; shell from 4.5 to bottom of hole	312708	3277645.8
19	789	8.5	soft mud; shell from 3.5 to 4.0	312708.1	3277642.7
19	790	9.5	soft mud	312711.1	3277642.6
19	791	9.5	soft mud	312714	3277642.6
19	792	9.5	soft mud	312716.9	3277642.6
19	793	8.5	soft mud; shell from 3.5 to 4.5	312720.1	3277642.6
19	794	9.5	soft mud; shell from 3.5 to 4.0	312722.8	3277642.9
19	795	4.1	soft mud; shell from 3.5 to 4.0	312707.9	3277639.7
19	796	9.6	soft mud; shell from 3.5 to 4.0	312711.1	3277639.5
19	797	10.6	soft mud	312713.9	3277639.7
19	798	9.6	soft mud; shell from 4.1 to 4.6	312717.1	3277639.7
19	799	9.6	soft mud; shell from 4.1 to 4.6	312720.1	3277639.6
19	800	9.6	soft mud	312723	3277639.7
19	801	9.6	soft mud; shell from 4.1 to 4.6	312708.1	3277636.5
19	802	9.6	soft mud; thin shell lens at 4.1	312711	3277636.6
19	803	4.6	soft mud; shell from 3.6 to 4.6	312713.8	3277637
19	804	9.6	soft mud	312717.2	3277636.5
19	805	9.6	soft mud; shell lens at 4.1	312720.3	3277636.5
19	806	9.6	soft mud	312723.4	3277636.7
19	807	3.6	soft mud; shell at bottom of hole	312708.2	3277633.7
19	808	9.6	soft mud	312711	3277633.7
19	809	9.6	soft mud; shell lens at 4.1	312714.3	3277633.6
19	810	9.6	soft mud; shell lens at 4.1	312717.2	3277633.8
19	811	9.6	soft mud; shell lens at 4.1	312713.8	3277648.6

19	812	9.6	soft mud; shell lens at 4.1	312710.8	3277649
19	813	9.7	soft mud; shell lens at 4.2	312708.2	3277648.8
19	814	9.7	soft mud; shell lens at 4.2	312722.9	3277651.8
19	815	9.7	soft mud; thin shell lens at 4.2	312720.5	3277651.9
19	816	9.7	soft mud	312716.8	3277651.8
19	817	4.2	softr mud; shell from 3.7 to bottom of hole	312714.1	3277652.3
19	818	9.7	soft mud; shell lens at 4.2	312710.9	3277652.2
19	819	9.7	soft mud; shell lens at 4.2	312708.4	3277652

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
20	129	7.1	soft mud	313338.9	3278409.8
20	130	7.6	soft mud	313336.6	3278407.4
20	131	7.6	soft mud	313340.8	3278407.7
20	132	7.6	soft mud	313338.6	3278405.2
20	133	7.6	soft mud	313334.3	3278405.3
20	134	7.6	soft mud	313343.1	3278405.2
20	135	7.6	soft mud	313340.8	3278403
20	136	7.7	soft mud	313344.8	3278403.2
20	137	7.2	soft mud	313331.8	3278403.3
20	138	6.7	soft mud; firmer sediment layer at 2.7	313336.2	3278403.3
20	139	7.7	soft mud; shell hash at bottom of hole	313338.3	3278401.3
20	140	7.7	soft mud; shell hash at bottom of hole	313334	3278401.5
20	141	7.7	soft mud	313342.7	3278400.7
20	142	6.7	soft mud; shell hash at bottom of hole	313347.4	3278400.5
20	143	6.7	soft mud; shell hash at bottom of hole	313340.4	3278398.7
20	144	7.7	soft mud	313331.8	3278399.3
20	145	7.7	soft mud; shell hash at bottom of hole	313335.9	3278398.9
20	146	6.8	soft mud	313329.9	3278401.4
20	147	6.8	soft mud	313333.8	3278397.3
20	148	6.8	soft mud	313338.2	3278397.1
20	149	7.8	soft mud; shell hash at bottom of hole	313344.7	3278398.5
20	150	7.8	soft mud; shell hash at bottom of hole	313342.7	3278396.5
20	151	7.8	soft mud; shell hash at bottom of hole	313340.2	3278394.3
20	152	7.8	soft mud; shell hash at bottom of hole	313336.2	3278394.6
20	153	7.7	soft mud; shell hash at bottom of hole	313338.2	3278392.3

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
21	690	6.5	soft mud; shell lens at 4.5	315419.7	3273798.5
21	691	6.5	soft mud; shell lens at 5.0	315413.7	3273797
21	692	6.5	soft mud; shell lens at 4.5	315416.6	3273797.7
21	693	6.5	soft mud; shell lens at 4.5	315412.9	3273800
21	694	6.5	soft mud; shell lens at 4.5	315409.9	3273798.9
21	695	6.5	soft mud; shell lens at 4.5	315415.9	3273800.8
21	696	6.6	soft mud; shell lens at 4.6	315418.7	3273801.5
21	697	6.6	soft mud; shell lens at 4.6	315417.8	3273804.4
21	698	6.6	soft mud; shell lens at 4.6	315415.1	3273803.7
21	699	6.6	soft mud; shell lens at 4.6	315412.1	3273803
21	700	6.6	soft mud; shell lens at 4.6	315409.2	3273802
21	701	6.6	soft mud; shell lens at 4.6	315408.5	3273805.2
21	702	6.6	soft mud; shell lens at 4.6	315411.3	3273805.7
21	703	6.6	soft mud; shell lens at 4.6	315414.3	3273806.7
21	704	6.6	soft mud; shell lens at 4.6	315417.2	3273807.5
21	705	6.6	soft mud; shell lens at 4.6	315416.4	3273810.2
21	706	6.6	soft mud; shell lens at 4.6	315413.5	3273809.7
21	707	6.6	soft mud; shell lens at 4.6	315410.3	3273808.7
21	708	6.7	soft mud; shell lens at 4.7	315407.5	3273808.2
21	709	6.7	soft mud; shell lens at 4.7	315409.8	3273811.8
21	710	6.7	soft mud; shell lens at 4.7	315406.9	3273810.9

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
22	660	6.2	soft mud; shell lens at 5.2	316420.8	3274783.2
22	661	6.2	soft mud; shell lens at 5.2	316408.8	3274789.4
22	662	6.2	soft mud; shell lens at 5.2	316412.1	3274785.9
22	663	6.3	soft mud; shell lens at 5.2	316411.9	3274792.4
22	664	6.3	soft mud; shell lens at 5.2	316421.1	3274792.4
22	665	6.3	soft mud; shell lens at 5.2	316417.9	3274789.2
22	-			316424.1	3274787.6
22	666	6.3	soft mud; shell hash lens at 4.8	316421.1	3274789
22	667		soft mud; shell hash lens at 4.9	316417.9	3274786.3
22	668	6.4	soft mud; shell hash lens at 4.9	316421.2	3274786.1
22	669	6.4	soft mud; shell hash lens at 4.9	316417.8	3274783
22	670	6.4	soft mud; shell hash lens at 4.9	316414.9	3274783.2
22	671	6.4	soft mud; shell hash lens at 4.9	316412.1	3274783.2
22	672	6.4	soft mud; shell hash lens at 4.9	316418	3274786.4
22	673	6.4	soft mud; shell hash lens at 4.9	316414.8	3274786.1
22	674	6.4	soft mud; shell hash lens at 4.9	316420.9	3274789.4
22	675	6.4	soft mud; shell hash lens at 4.9	316411.6	3274789.2
22	676	6.4	soft mud; shell hash lens at 4.9	316415	3274789.1
22	677	6.4	soft mud; shell hash lens at 4.9	316418	3274792.3
22	678	6.4	soft mud; shell hash lens at 4.9	316414.9	3274792.3
22	679	6.4	soft mud; shell hash lens at 4.9	316408.8	3274795.3
22	680	6.4	soft mud; shell hash lens at 4.9	316408.6	3274791.7
22	681	6.4	soft mud; shell hash lens at 4.9	316418.1	3274795.5
22	682	6.4	soft mud; shell hash lens at 4.9	316414.8	3274795.6
22	683	6.4	soft mud; shell hash lens at 4.9	316411.9	3274795.5
22	684	6.4	soft mud; shell hash lens at 4.9	316408.8	3274798.4
22	685	6.4	soft mud; shell hash lens at 4.9	316421.1	3274795.4
22	686	6.4	soft mud; shell hash lens at 4.9	316420.8	3274798.4
22	687	6.4	soft mud; shell hash lens at 4.9	316417.9	3274798.5
22	688	6.4	soft mud; shell hash lens at 4.9	316411.7	3274798.3
22	689	6.4	soft mud; shell hash lens at 4.9	316415	3274798.5

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
23	615	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316706	3275461.6
23	616	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316708.6	3275463.4
23	617	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316704.8	3275464.5
23	618	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316707.7	3275465.7
23	619	6.3	soft mud; shell lens at 1.3; shell at bottom of hole	316706.2	3275468.6
23	620	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316703.9	3275471.6
23	621	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316703.4	3275467
23	622	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316701.8	3275469.8
23	623	6.3	soft mud; shell lens at 4.3	316711.8	3275464.4
23	624	6.3	soft mud; shell lens at 4.3	316710.1	3275466.9
23	625	1.3	metallic object	316708.7	3275469.8
23	626	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316707.4	3275472.9
23	627	6.3	soft mud; shell lens at 4.3	316714.3	3275466
23	628	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316712.5	3275468.8
23	629	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316711.3	3275471.3
23	630	6.3	soft mud; shell lens at 4.3	316709.6	3275473.9
23	631	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316710.7	3275469.3
23	632	6.3	soft mud; shell lens at 4.3; shell at bottom of hole	316709.3	3275472
23	633	0.3	edge of metallic object	316708.2	3275467.9
23	634	0.3	metallic object	316707.1	3275470.9
23	635	0.3	metallic object	316707.3	3275470.2

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
24	711	7.7	soft mud; shell hash at bottom of hole	314429.5	3278628.9
24	712	7.7	soft mud; shell hash at bottom of hole	314426.4	3278628.9
24	713	7.7	soft mud; shell hash at bottom of hole	314423.4	3278628.7
24	714	7.7	soft mud; shell hash at bottom of hole	314420.1	3278628.7
24	715	7.7	soft mud; shell hash at bottom of hole	314417.3	3278628.8
24	716	7.7	soft mud; shell hash at bottom of hole	314414.2	3278628.8
24	717	7.7	soft mud	314411.2	3278628.7
24	718	7.7	soft mud	314408.1	3278628.8
24	719	7.7	soft mud	314405	3278628.8
24	720	7.7	soft mud	314405.1	3278631.9
24	721	7.7	soft mud	314408	3278631.8
24	722	7.7	soft mud	314411.1	3278631.8
24	723	7.7	soft mud	314414.1	3278631.9
24	724	7.7	soft mud	314417.2	3278631.9
24	725	7.8	soft mud; shell at bottom of hole	314420.1	3278631.8
24	726	7.8	soft mud; shell at bottom of hole	314423.4	3278632
24	727	7.8	soft mud; shell at bottom of hole	314426.3	3278631.9
24	728	7.8	soft mud; shell at bottom of hole	314429.4	3278631.9
24	729	7.8	soft mud	314405.1	3278634.9
24	730	7.8	soft mud	314408	3278634.9
24	731	7.8	soft mud	314411.4	3278634.8
24	732	7.8	soft mud	314414.2	3278634.8
24	733	7.8	soft mud	314417	3278634.9
24	734	7.8	soft mud; shell at bottom of hole	314420.3	3278635.1
24	735	7.3	soft mud; shell at bottom of hole	314423.4	3278634.9
24	736	7.3	soft mud; shell at bottom of hole	314426.4	3278634.8
24	737	7.3	soft mud; shell at bottom of hole	314429.5	3278634.8
24	738	7.3	soft mud; shell at bottom of hole	314405	3278638
24	739	7.8	soft mud	314408.2	3278637.9
24	740	7.8	soft mud	314411.6	3278638
24	741	7.8	soft mud	314414.1	3278637.9
24	742	7.8	soft mud; shell at bottom of hole	314417.1	3278638
24	743	7.8	soft mud; shell at bottom of hole	314420.3	3278637.9
24	744	7.8	soft mud; shell at bottom of hole	314423.3	3278637.9
24	745	7.8	soft mud; shell at bottom of hole	314426.3	3278638.1
24	746	7.8	soft mud; shell at bottom of hole	314429.4	3278637.9
24	747	7.8	soft mud	314405.3	3278641
24	748	7.8	soft mud	314408	3278640.9
24	749	7.8	soft mud	314411.1	3278640.9
24	750	7.8	soft mud	314414.2	3278641
24	-	7.8	soft mud	314414.2	3278640.9

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
24	751	7.9	soft mud; shell at bottom of hole	314417.5	3278640.9
24	752	7.9	soft mud; shell at bottom of hole	314420.3	3278641
24	753	7.4	soft mud; shell at bottom of hole	314423.2	3278641
24	754	7.4	soft mud; shell at bottom of hole	314426.4	3278640.8
24	755	7.4	soft mud; shell at bottom of hole	314429.3	3278641

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
25	605	7.1	soft mud	314166.5	3279670.5
25	606	9.1	soft mud	314157.4	3279669.4
25	607	8.6	soft mud	314157.3	3279672.2
25	608	8.6	soft mud	314154.9	3279669.3
25	609	9.0	soft mud	314154.1	3279672.5
25	610	9.0	soft mud	314164	3279670.1
25	611	9.0	soft mud	314160.9	3279669.7
25	612	9.0	soft mud	314166.7	3279673.3
25	613	9.0	soft mud	314163.7	3279673.2
25	614	9.0	soft mud; shell lens at 8	314160.7	3279672.8
25	756	8.7	soft mud	314154.1	3279675.1
25	757	8.7	soft mud	314157	3279675.5
25	758	8.8	soft mud	314160.3	3279675.8
25	759	8.8	soft mud	314163.2	3279676.1
25	760	8.8	soft mud	314166.1	3279676.4
25	761	8.8	soft mud	314153.9	3279678.3
25	762	8.9	soft mud	314156.8	3279678.6
25	763	8.9	soft mud	314160	3279678.8
25	764	8.9	soft mud; shell at bottom of hole	314162.9	3279679.1
25	765	8.9	soft mud	314166.1	3279679.3
25	766	8.9	soft mud	314153.7	3279681.2
25	767	8.9	soft mud	314156.5	3279681.6
25	768	8.9	soft mud	314159.9	3279681.8
25	769	8.9	soft mud	314162.7	3279682.1
25	770	8.9	soft mud	314165.7	3279682.2

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
26	579	8.1	soft mud	313112.5	3279542
26	580	9.1	soft mud	313109.6	3279542.1
26	581	9.1	soft mud	313106.3	3279542.3
26	582	9.0	soft mud	313103.4	3279541.9
26	583	9.0	soft mud	313100.4	3279545.2
26	584	9.0	soft mud	313115.6	3279545
26	585	9.0	soft mud	313112.3	3279545.1
26	586	8.5	soft mud; shell at bottom of hole	313109.4	3279545.2
26	587	9.0	soft mud	313106.5	3279545.1
26	588	9.0	soft mud	313103.5	3279545.1
26	589	9.0	soft mud	313100.5	3279547.7
26	590	9.0	soft mud	313115.7	3279548.1
26	591	9.0	soft mud	313112.6	3279548.1
26	592	9.0	soft mud	313109.5	3279548.1
26	593	9.0	soft mud	313106.4	3279548.2
26	594	9.0	soft mud	313103.1	3279548.4
26	595	9.0	soft mud	313100.4	3279551.5
26	596	8.9	soft mud	313115.3	3279551.2
26	597	8.9	soft mud	313112.5	3279551.3
26	598	8.9	soft mud	313109.3	3279551.4
26	599	8.9	soft mud	313106.3	3279551.3
26	600	8.9	soft mud	313103.3	3279551.1
26	601	8.9	soft mud	313112.4	3279554.3
26	602	8.9	soft mud	313109.5	3279554.3
26	603	8.9	soft mud	313103.4	3279554
26	604			313106.4	3279554.2

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
27	519	7.8	very soft mud	313103.5	3279466.5
27	520	7.8	very soft mud	313104.2	3279463.6
27	521	7.7	very soft mud	313100.6	3279465.6
27	522	7.7	very soft mud	313099.1	3279459.2
27	523	7.7	very soft mud	313097	3279455.5
27	524	7.7	very soft mud	313094.3	3279454.5
27	525	7.7	very soft mud	313101.6	3279462.7
27	526		very soft mud	313097.5	3279452.2
27	527	7.7	very soft mud	313102	3279460
27	528	7.7	very soft mud	313102.1	3279460.1
27	529	7.7	very soft mud	313095.4	3279461.3
27	530	7.6	very soft mud	313104.7	3279460.8
27	531	7.6	very soft mud	313102.8	3279456.9
27	532	7.6	very soft mud	313105.9	3279457.8
27	533	7.6	very soft mud	313106.8	3279454.9
27	534	7.6	very soft mud	313099.6	3279456.1
27	535	7.6	very soft mud	313100.7	3279453.2
27	536	7.6	very soft mud	313103.9	3279453.8
27	537	7.6	very soft mud	313103.9	3279453.8
27	538	7.5	very soft mud	313094.6	3279464.1
27	539	8.5	soft mud; shell at bottom of hole	313092	3279463.5
27	540	8.5	soft mud; light shell at 7.5	313088.7	3279462.5
27	541	7.4	soft mud	313090.5	3279456.8
27	542	7.4	soft mud; shell at bottom of hole	313096.3	3279458.6
27	543	7.4	soft mud; shell at bottom of hole	313098	3279452.6
27	544	8.4	soft mud; shell at bottom of hole	313097.6	3279464.9
27	545	8.4	soft mud; light shell at bottom of hole	313098.2	3279461.9
27	546	8.4	soft mud; light shell at bottom of hole	313092.6	3279460.7
27	547	8.4	soft mud; spongy at 3.4	313089.6	3279459.8
27	548	8.4	soft mud	313089.5	3279459.9
27	549	8.4	soft mud	313093.3	3279457.4
27	550	8.4	soft mud	313091.3	3279453.7
27	551	9.4	soft mud	313095	3279451.9
27	552	9.4	soft mud	313092.2	3279451.2

Anomaly	Probe ID	Feet Below Seafloor	Notes	X (UTM 15N, m)	Y (UTM 15N, m)
28	553	10.5	soft mud; shell hash lens at 5.5	312914	3279469.1
28	554	11.5	soft mud	312917.4	3279469.1
28	555	9.5	soft mud	312920.6	3279472.3
28	556	9.5	soft mud	312920.3	3279468.6
28	557	9.5	soft mud	312914.2	3279472.3
28	558	9.5	soft mud	312911.1	3279472.2
28	559	9.5	soft mud	312911	3279478.1
28	560	8.5	soft mud	312917.2	3279472.1
28	561	8.5	soft mud	312923.6	3279472
28	562	8.5	soft mud	312923.2	3279469
28	563	8.5	soft mud	312926.3	3279472.4
28	564	8.5	soft mud	312926.4	3279475.1
28	565	8.5	soft mud	312926.4	3279478.1
28	566	8.5	soft mud	312920.2	3279481.3
28	567	8.5	soft mud	312920.4	3279478.2
28	568	9.5	soft mud	312917.4	3279475.1
28	569	8.5	soft mud	312914.2	3279478.1
28	570	8.5	soft mud	312914.2	3279475
28	571	9.4	soft mud	312911.3	3279475.1
28	572	9.4	soft mud	312917.3	3279481.2
28	573	9.4	soft mud	312914.1	3279480.8
28	574	9.4	soft mud	312923.5	3279475.1
28	575	9.4	soft mud	312920.2	3279475.3
28	576	9.4	soft mud	312917.3	3279478.1
28	577	9.4	soft mud	312923.4	3279478.2
28	578	9.4	soft mud	312923.1	3279480.7

Appendix F: Texas Antiquities Permit 31570 and Agency Correspondence

From: Robert Gearhart
To: Jason Seitz
Cc: Courtney Gerken; Marisa Weber
Subject: Fwd: Bay Aquatic Beneficial Use Sites
Date: Friday, June 27, 2025 8:13:15 AM

Jason,
The THC has concurred with my archaeological findings and recommendations for the BABUS Project. My apologies for not forwarding their email sooner.

Bob

---------- Forwarded message ---------
From: <noreply@thc.state.tx.us>
Date: Wed, Jun 18, 2025, 11:26 AM
Subject: Bay Aquatic Beneficial Use Sites
To: <bob.hydrographics@gmail.com>, <reviews@thc.state.tx.us>, <Jerry.L.Androy@usace.army.mil>

Re: Project Review under Section 106 of the National Historic Preservation Act and/or the Antiquities Code of Texas
THC Tracking #202510550
Date: 06/18/2025
Bay Aquatic Beneficial Use Sites (Permit 31570)
Galveston Bay
Baytown,TX

Description: The BABUS Project will construct leveed Placement Areas for dredged material, totaling 4353 acres. Proposed PAs include 1187 acres, dredged to -70 ft, and 1659 acres filled over existing bay bottom.

Dear Robert L Gearhart:
Thank you for your submittal regarding the above-referenced project. This response represents the comments of the State Historic Preservation Officer, the Executive Director of the Texas Historical Commission (THC), pursuant to review under Section 106 of the National Historic Preservation Act and the Antiquities Code of Texas.

The review staff, led by Amy Borgens, has completed its review and has made the following determinations based on the information submitted for review:

Archeology Comments

- THC/SHPO concurs with information provided for the underwater project area.
- This draft report is acceptable. To facilitate review and make project information and

final reports available through the Texas Archeological Sites Atlas, we appreciate submission of tagged pdf copies of the final report including one restricted version with all site location information (if applicable), and one public version with all site location information redacted; an online abstract form submitted via the abstract tab on eTRAC; and survey area shapefiles submitted via the shapefile tab on eTRAC. For questions on how to submit these please visit our video training series at: https://www.youtube.com/playlist?list=PLONbbv2pt4cog5t6mCqZVaEAx3d0MkgQC Please note that these steps are required for projects conducted under a Texas Antiquities Permit.

We have the following comments: As part of the underwater investigation conducted by BOB Hydrographics, LLC, for the Bay Aquatic Beneficial Use Sites Project (Antiquities Permit No. 31570), 28 magnetic anomalies were recommended for avoidance. Probing of the seafloor demonstrated that the sources of the 28 magnetic anomalies are not buried shipwreck sites. The THC concurs with these results and with the recommendation that archeological monitoring occur for levee construction that uses material sourced from the San Jacinto or Trinity River paleo-valleys.

Consultation with the Texas State Historic Preservation Officer does not constitute consultation with Tribal Historic Preservation Offices, other Native American tribes, local governments, or the public, nor does it conclude the Federal Section 106 consultation process. If you have not already done so, please contact the U.S. Army Corps of Engineers as the responsible Federal agency regarding their Section 106 compliance. We look forward to further consultation with your office and hope to maintain a partnership that will foster effective historic preservation. Thank you for your cooperation in this review process, and for your efforts to preserve the irreplaceable heritage of Texas. If the project changes, or if new historic properties are found, please contact the review staff. If you have any questions concerning our review or if we can be of further assistance, please email the following reviewers: amy.borgens@thc.texas.gov.

This response has been sent through the electronic THC review and compliance system (eTRAC). Submitting your project via eTRAC eliminates mailing delays and allows you to check the status of the review, receive an electronic response, and generate reports on your submissions. For more information, visit http://thc.texas.gov/etrac-system.

Sincerely,

for Joseph Bell, State Historic Preservation Officer
Executive Director, Texas Historical Commission

Please do not respond to this email.

cc: Jerry.L.Androy@usace.army.mil

From: Robert Gearhart
To: Courtney Gerken
Cc: Marisa Weber
Subject: Fwd: Amendment Response for Permit #31570
Date: Friday, February 16, 2024 9:30:17 AM

The permit amendment has been approved.

---------- Forwarded message ---------
From: <noresponse@thc.state.tx.us>
Date: Fri, Feb 16, 2024, 9:19 AM
Subject: Amendment Response for Permit #31570
To: <bob.hydrographics@gmail.com>, <amy.borgens@thc.texas.gov>, <reviews@thc.state.tx.us>, <laney.fisher@thc.state.tx.us>

Amemdment for Permit for 31570

Dear Robert L Gearhart:

Your amendment for Permit 31570 has been approved by Amy Borgens on 2/16/2024 9:04:15 AM.

Sincerely,

October 6, 2024

Via email: Amy.Borgens@thc.texas.gov

Amy Borgens
State Marine Archaeologist
Texas Historical Commission
108 West 16th Street
Austin, Texas 78711

RE: Antiquities Permit 31570; Archaeological Assessment of the Bay Aquatic Beneficial Use Sites Project; request for 2nd amendment to revise the survey area and add probing of selected magnetic anomalies

Dear Ms. Borgens:

BOB Hydrographics, LLC (BOB) is requesting an amendment of Antiquities Permit 31570 for the purpose of refining the survey area and adding a task to probe selected magnetic anomalies. Please do not hesitate to contact me if you have any questions or concerns. I can be reached any time at 512-517-8564 or by email at BOB.hydrographics@gmail.com. I would appreciate your timely consideration of this request.

All my best,

Robert Gearhart
Owner

cc: Jason Seitz, ANAMAR Environmental Consulting, Inc.
Courtney Gerken, Lloyd Engineering, Inc.
Marisa Weber, Lloyd Engineering, Inc.

CHANGES TO THE SCOPE OF WORK

This is a second request to amend the scope of work for Permit 31570, the Bay Aquatic Beneficial Use Sites (BABUS) Project, located between Atkinson Island and the Mid-Bay Placement Area, on the east side of the Houston Ship Channel, in Galveston Bay. The BABUS Project is sponsored by the U.S. Army Corps of Engineers (SPONSOR). The SPONSOR proposes construction of one or more beneficial use sites. The survey area was increased to 5,736 acres by Amendment 1 of Permit 31570 in February of 2024 (Figure 1). Survey was completed over 2,307 acres of that area in March of 2024 (Figure 2, shaded blue). The currently proposed revision (Amendment 2) would reduce the total acreage to 5,151 acres (combined shaded area in Figure 2). The PROJECT includes portions of Galveston Bay State Mineral Lease Tracts 95-96, 116-118 127-131, 205-209, and 217-221.

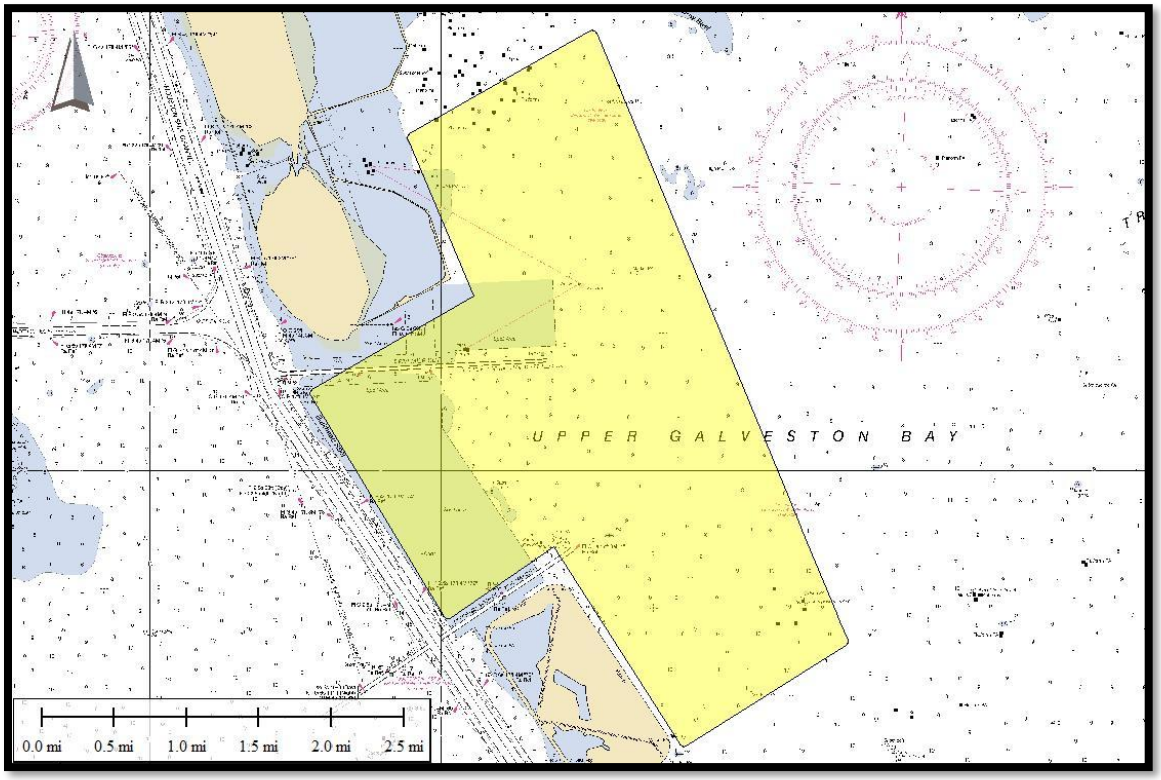

Figure 1: Amendment 1 Survey Area, approved February 16, 2024

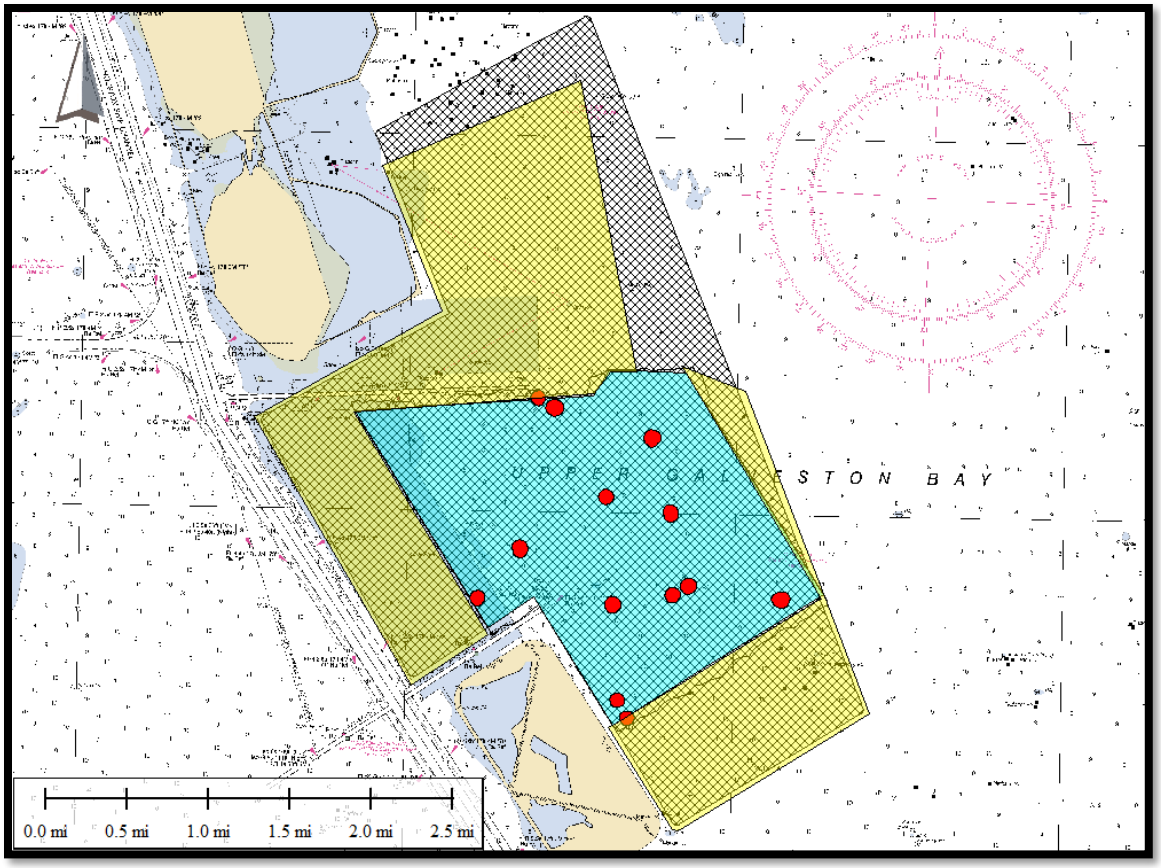

Figure 2: Proposed Amendment 2 Survey Area (combined shaded areas; blue is survey completed; yellow is additional survey proposed) and magnetic anomalies to be probed (red); Amendment 1 Area is cross hatched

The next phase of fieldwork would involve archaeological survey of additional BABUS areas, encompassing 2,977 acres (Figure 2, shaded yellow). The survey includes 50 meters (164 feet) beyond any potential seafloor disturbances. Probing of selected magnetic anomalies, recommended for archaeological avoidance, is proposed to follow the survey planned under Amendment 2. A total of 13 such anomalies (Figure 2, shaded red) were discovered during survey of in March of 2024. Discovery of additional anomalies, requiring probing, is anticipated during the next phase of survey. The purpose of probing would be to determine the presence/absence of buried shipwrecks.

METHODS

Geophysical Survey

BOB's survey methodology will meet or exceed the minimum requirements stipulated by the THC. No artifacts will be collected during the survey. Transects will be spaced consistent with THC requirements for archaeological survey, which call for a 20-meter interval for inland state waters. Additional survey transects may be necessary on geophysical targets deemed potentially significant. Sufficient additional transects will be surveyed, where necessary, to determine target significance.

Survey instrumentation will include side-scan sonar, magnetometer, recording fathometer and sub-meter GPS. Single-beam bathymetry data will be acquired using a recording echo sounder equipped with a 200-kHz transducer. Side-scan sonar data will be collected using a dual-frequency system with one channel operating at or above a frequency of 500 kHz. The sonar will be towed, where depths allow, at an altitude approximating 10 to 20 percent of the selected instrument range to optimize the image quality. Overlap of sonar data with adjacent transects will be sufficient to provide multiple views of potentially significant seafloor contacts. Magnetic data will be acquired using a magnetometer towed behind the survey vessel within 20 feet of the seafloor. Hypack software will be used for navigation and for logging of magnetometer and bathymetry data on the survey boat.

Probing

Sufficient probes will be placed on each selected anomaly to determine the presence/absence of buried wreckage. Additional probes may be required to delineate buried cultural features in the event an anomaly source is discovered. Locations selected for probes will be determined based on the size, shape, and orientation of each magnetic anomaly. Positions where probes are placed will be mapped using a sub-meter differential GPS/heading sensor and recorded in Hypack software.

Probes will be manually pushed into the seafloor with hydraulic assistance to a depth of 6 feet below the mudline or until refusal is reached. The required minimum depth of probing will be confirmed with the THC, prior to beginning work. Galvanized iron pipe will be used for probing. Water will be forced down the pipe using a pump to facilitate penetration of the seafloor to the required depth.

Probing will be conducted from a 20-foot work boat with enclosed cabin (shown below). The boat has a railing on the forward work deck, which provides support for the crew to work safely. The boat will be anchored to maintain position while the probe penetrates the seafloor. Probing of significant anomalies discovered by the magnetometer survey of new areas may be added to this scope of work as a subsequent Permit amendment.