CAMINADA HEADLAND BEACH AND DUNE RESTORATION INCREMENT II (BA-143)

APPENDIX F

SOUTH PELTO BORROW AREA GEOPHYSICAL / GEOTECHNICAL SURVEYS AND SEDIMENT ANALYSES REPORTS

LAFOURCHE & JEFFERSON PARISHES, LOUISIANA

STATE OF LOUISIANA
COASTAL PROTECTION AND RESTORATION AUTHORITY

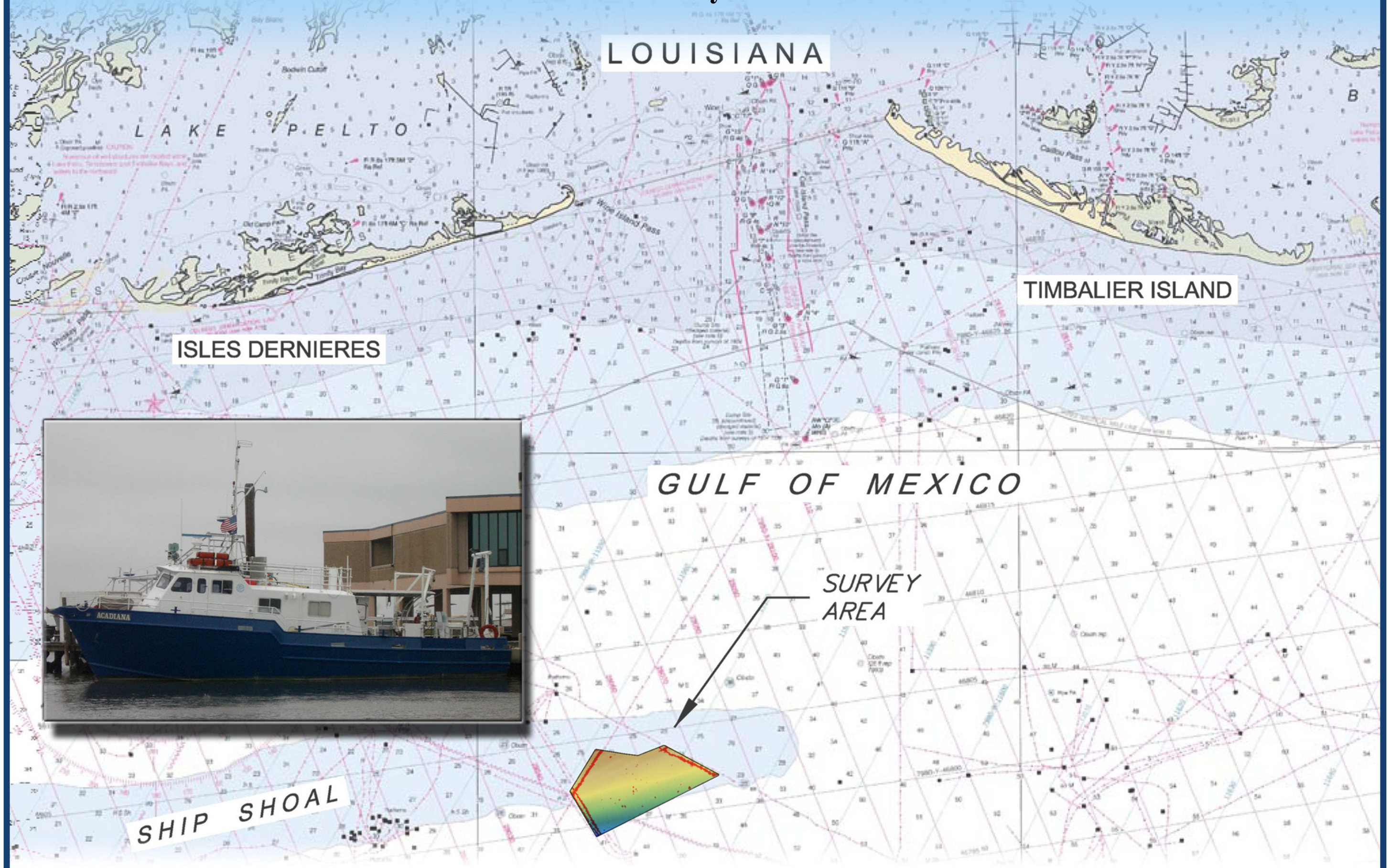
MARCH 2014

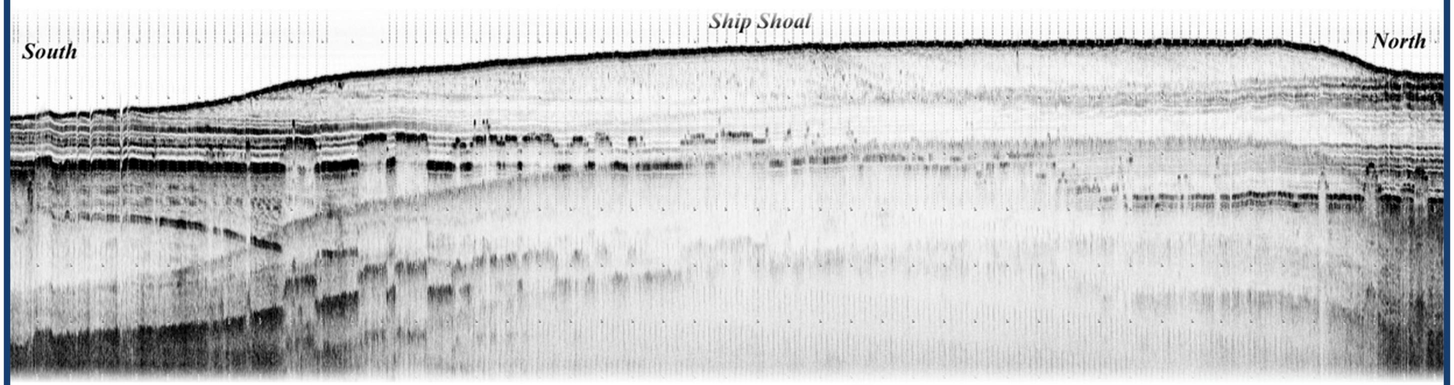
Final Report

Caminada Headland Beach And Dune Restoration Project (BA-45)
Gulf of Mexico, Louisiana

Geophysical and Geotechnical Surveys of Ship Shoal

OSI Report #11ES008-F
January 2012





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FINAL REPORT

GEOPHYSICAL INVESTIGATIONS & BORROW AREA SAMPLING
CAMINADA HEADLAND BEACH AND DUNE RESTORATION PROJECT
(BA-45)
GULF OF MEXICO, LOUISIANA

GEOPHYSICAL AND GEOTECHNICAL SURVEYS OF SHIP SHOAL

OSI REPORT NO. 11ES008-F

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GEOPHYSICAL AND GEOTECHNICAL SURVEYS
OF SHIP SHOAL

1.0 INTRODUCTION

During the periods 9-15 June 2011 and 10-14 October 2011, Ocean Surveys, Inc. (OSI) performed “Plans and Specifications” level detail geophysical and geotechnical surveys of Ship Shoal in the Gulf of Mexico (approximately 9 nm south of the Isles Dernieres, Louisiana) under subcontract to Coastal Engineering Consulting, Inc. (CEC) for the Louisiana Coastal Protection and Restoration Authority (CPRA) to support the Caminada Headland Beach and Dune Restoration Project (BA-45). The project includes restoring the western end of the Caminada Headland through beach and dune fill placement utilizing offshore sand resources from Ship Shoal within two Bureau of Ocean Energy Management (BOEM) lease areas: “South Pelto Lease Blocks 13 and 14” (Figure 1).

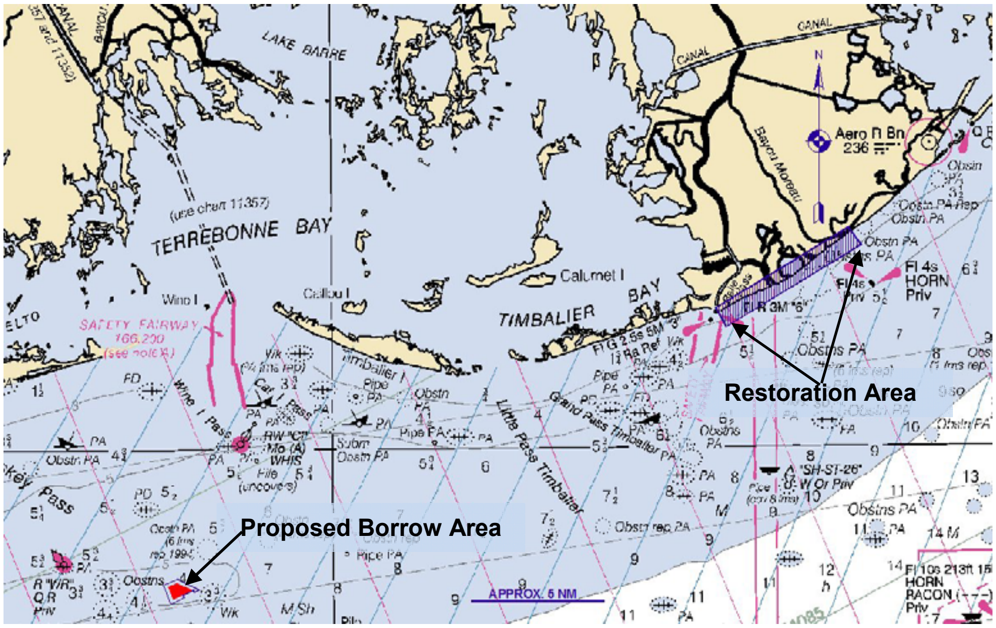

Figure 1. Location of Proposed Borrow Area (red) on Ship Shoal and restoration area along Caminada Headland in LaFourche Parish, Louisiana, (NOAA Nautical Chart 11340 in background).

2.0 PROJECT SUMMARY

2.1 Project Background and Objectives

The primary objective of the Caminada Headland Beach and Dune Restoration Project ("Project") is to protect and preserve the structural integrity of the barrier shoreline and provide for restoration of hydrologic conditions (CEC, 2011). The restoration will also help protect U.S. Highway 1, which serves as the only local hurricane evacuation route, and commercial infrastructure at Port Fourchon. A site on Ship Shoal, located approximately 27 nm southwest of the Project site, has been identified as a source of sand suitable for the project (CPE, 2005; CECI, 2011).

As part of the permitting process for the Project, BOEM in consultation with state and local level reviewers, requires compliance with Section 106 of the National Historic Preservation Act (NHPA) of 1966 as amended (36 CFR 800). The Section 106 process is coordinated at the state level by the State Historic Preservation Offices (SHPOs). Archaeological assessments based on the previous investigations identified several targets of potential archaeological significance within the current project area and recommended avoidance areas around those targets (C&C, 2003).

OSI has been subcontracted to perform several tasks in support of the restoration project. This report provides a summary of the detail geophysical and geotechnical surveys of Ship Shoal, LA. The objectives of these surveys include defining the sediment source available within the project site, as well as providing data needed to update the archaeological resource assessment of the area. The intent of the archaeological assessment is to reevaluate the previously identified target avoidance areas and identify any additional potential targets and recommend avoidance areas as needed. The archaeological assessment completed by Fathom Research, LLC is included in its entirety as Appendix 1 of this report.

2.2 Summary of Geophysical Survey and Equipment

The survey area on Ship Shoal is irregularly shaped with rough dimensions of 1.9 nautical miles (nm) by 1 nm covering approximately 1,580 acres. In accordance with BOEM guidelines, primary tracklines were spaced at 98-foot (30-meter) intervals with secondary tie lines oriented perpendicular to primary lines and spaced at 1000-foot intervals as shown in Figure 2.

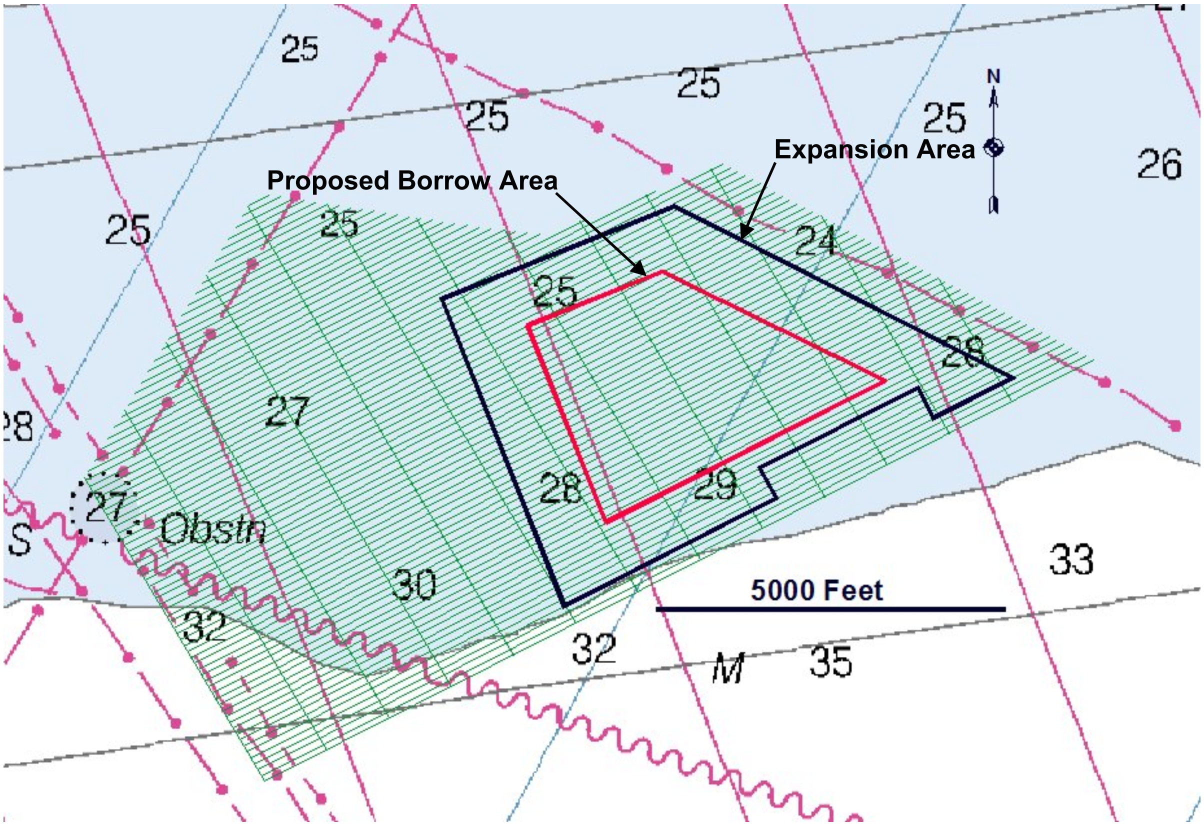

Figure 2. Proposed geophysical survey lines within the Ship Shoal Survey Area. Limits of Proposed Borrow Area (red) and Expansion Area (black) are highlighted. (NOAA Nautical Chart 11357 in background).

Survey operations were conducted from Louisiana Universities Marine Consortium's (LUMCON) vessel, the *R/V Acadiana* (Figure 3). This 58-foot vessel is powered by twin-diesel motors and outfitted with a generator, winches, a stern-mounted A-frame, davits and living accommodations needed to support an offshore operation. Geophysical investigations were conducted by an OSI survey crew consisting of a senior marine geologist/geophysicist and an electronics technician supported by a two-man LUMCON vessel crew (captain and mate). The following instruments were installed onboard the vessel to complete the investigation:

- *Trimble 212 Differential Global Positioning System (DGPS)*
- *Odom Dual-Frequency Echotrac Depth Sounder*
- *Klein 3000 100/500 kHz Dual-Frequency Digital Side Scan Sonar System*
- *Geometrics G882 Cesium Marine Magnetometer*
- *EdgeTech XStar Chirp Subbottom Profiling System equipped with SB512 Tow Vehicle*
- *EdgeTech Geostar Chirp Subbottom Profiling System equipped with SB216 Tow Vehicle*

Figure 3. Photograph of the *R/V Acadiana*.

The equipment was configured to optimize data quality, reduce ambient noise and cross talk, and maximize survey efficiency. Sensors were separated by as much space as possible to reduce acoustic interference and tow noise, as well as to minimize the possibility of entanglement during turns. Figure 4 illustrates the general equipment configuration aboard the *R/V Acadiana*. Vessel speed was maintained as high as possible without affecting the quality of the survey data, typically at 3-4 knots.

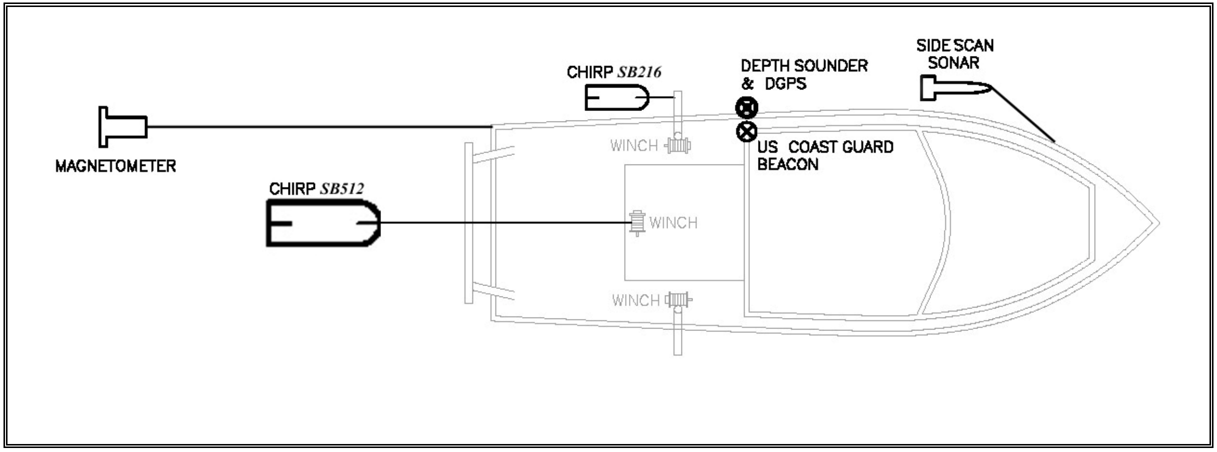

Figure 4. General equipment configuration and layout for the *R/V Acadiana*.

The dual-frequency depth sounder transducer was hard mounted to the port side of the vessel; the side scan sonar towfish was towed from the port bow; the Chirp SB216 was towed from a davit located approximately amidships on the port side of the vessel astern of the depth sounder; the magnetometer sensor was towed from the port quarter 100 feet behind the vessel (approximately 10 feet below the water's surface) and the Chirp SB512 was deployed astern of the vessel. The side scan sonar system employed a 165-foot (50-meter) sweep range to provide high-resolution imagery and over 200% coverage of the bottom. Refer to Appendix 2 for further discussion on equipment operations and procedures.

2.2.1 Horizontal and Vertical Control

Project horizontal reference is the LA State Plane Coordinate System, South Zone (1702), NAD 83 in US Survey Feet. The horizontal positioning of the survey vessel was accomplished using a DGPS interfaced with a computer running a version of HYPACK PC-based navigation and data logging software package. Navigation checks were performed to ensure the positioning system was functioning properly and delivering the horizontal accuracy required for the project.

Project vertical reference is the North American Vertical Datum of 1988 (NAVD88), in feet. Water depths were adjusted to the project datum based on NOAA predicted tides at Port Fourchon (station ID 8762075), which are referenced to Mean Lower Low Water (MLLW). CEC provided the conversion to NAVD88 based on an installed tide gauge at Port Fourchon: 0 feet MLLW = +0.48 feet NAVD88.

2.2.2 Chronology of Geophysical Survey Field Operations and Acquisition Summary

In excess of 130 nm of multi-sensor trackline data were acquired during the course of the field investigation. Table 1 provides a chronology of field operations, including vessel setup.

Table 1

Task	2011 Dates	Description
Mobilize vessel onsite	7 June	OSI crew arrive in Cocodrie, LA, begin R/*V Acadiana* mobilization
Finalize on-site mobilization and perform testing/calibration	8 June	Complete vessel mobilization, perform testing/calibration of equipment
Survey Operations	9-15 June	Conduct survey operations.
Demobilize vessel	18 June	Complete *R/V Acadiana* demobilization, crew departs Cocodrie, LA

2.2.3 Preliminary Data Review and Geotechnical Survey Plan

Following conclusion of the geophysical survey, the acquired data were reviewed to develop plans for a follow-up geotechnical (vibratory coring) investigation. The subbottom profile data were analyzed along with the historic core information (CPE, 2005) to develop a preliminary sand isopach map. Based on this preliminary review, CEC defined a proposed borrow and possible expansion area.

Within the borrow area and expansion area thirteen 20-foot length vibratory cores were proposed to groundtruth the geophysical data and document the sediment resource (Figure 5). All cores were located along geophysical survey tracklines to correlate sediment type with subbottom reflectors to gain a better understanding of the subbottom stratigraphy and to enable the best possible mapping of the sediment resources. Prior to conducting the vibratory coring investigation, a BOEM permit authorizing geological operations on the Outer Continental Shelf (OCS Authorization L11-016) was granted.

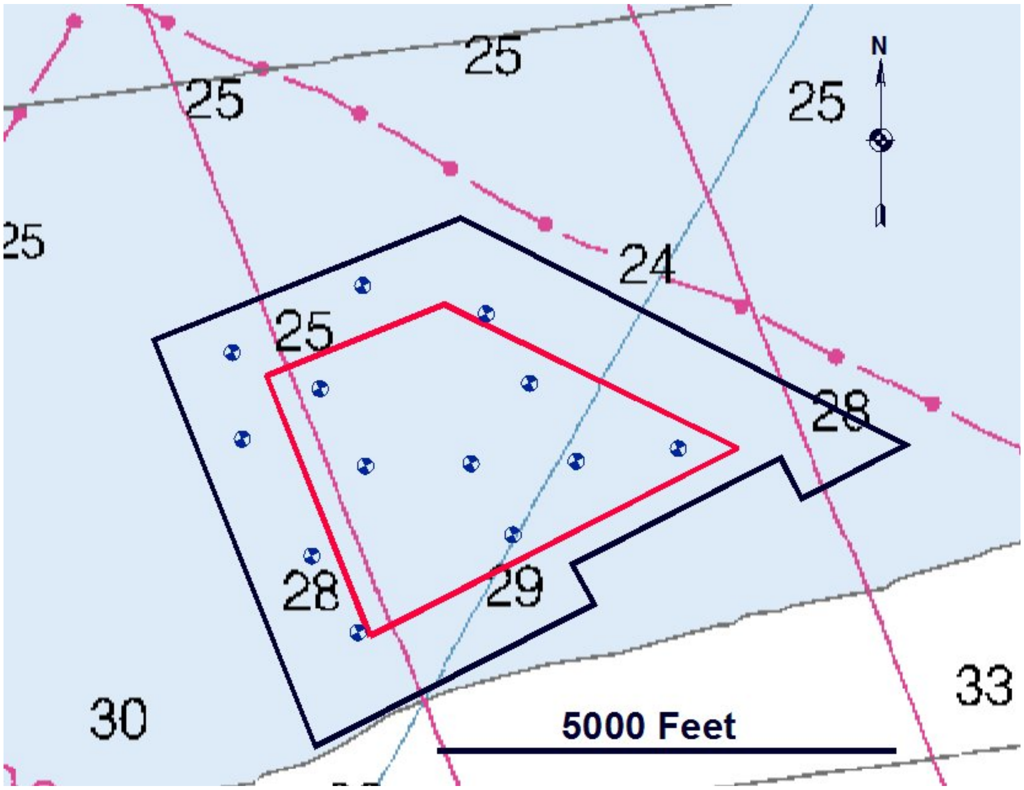

Figure 5. Proposed core locations with borrow area (red) and extension area (black) outlined (NOAA Nautical Chart 11357 in background).

2.3 Summary of Geotechnical Survey and Equipment

The coring operation was conducted from *AC Brown Elevator* a self-propelled liftboat from Elevating Boats, LLC (EBI) in Houma, LA. The vessel was equipped with three jack-up legs (72 feet in length), a crane, a fully enclosed cabin and living quarters, and a DGPS interfaced with a real-time positioning and digital logging computer. When jacked-up on station, the liftboat provided an extremely stable working platform and enabled the OSI crew to safely conduct sampling operations even during marginal weather conditions. Figure 6 provides two photographs of the liftboat and shows the vibratory coring rig used to complete the investigation.

Figure 6 - Photographs of EBI® liftboat. Right photo shows OSI crew recovering a core utilizing one of the stern-mounted cranes permanently installed on the vessel.

Coring was accomplished by an experienced OSI scientific and technical crew consisting of a geologist/project manager, a senior vibratory core operator and assistant. The OSI crew was supported by a two-man EBI liftboat crew (captain and mate). James Cohlmeyer, P.G. was CEC's onboard representative during the coring operations. The following instruments were installed onboard the vessel to complete the investigation:

- *Trimble Global Positioning System interfaced with a U.S. Coast Guard Differential Beacon Receiver*
- *HYPACK Navigation and Data Logging Software*
- *OSI Model 1500 Pneumatic Vibratory Corer equipped with a 30' long 4" ID core barrel*

The project horizontal reference is the LA State Plane Coordinate System, South Zone (1702), NAD 83 in US Survey Feet. Project vertical reference is NAVD88 in feet. Depth measurements at each coring station were converted to the project datum using adjusted water depths acquired during the geophysical survey.

Before departure to Ship Shoal, a project safety meeting was held onboard the liftboat at the dock. Discussions included potential hazards that exist from the vessel and equipment configuration, as well as the planned operations. The liftboat remained on Ship Shoal throughout the course of the investigation.

During coring operations, precision DGPS positioning and OSI navigation systems were used to guide the vessel to the coring locations. Navigation checks were performed at the beginning and end of the field program to ensure the positioning system was functioning properly and delivering the horizontal position accuracy required for the project. Once on station the vessel was jacked-up into position to begin coring operations. Core samples were acquired with an OSI Model 1500 pneumatic vibratory corer equipped with a 20' long 4" ID core barrel. The core barrel was fitted with a 3.5" Lexan liner in which a continuous sediment core was recovered. A crane was used to lower the coring apparatus to the bottom. Once the apparatus was safely on the bottom, a 20-foot core sample was attempted.

Fourteen vibratory cores were acquired at the thirteen proposed locations. Two cores were acquired at proposed station 2 because refusal was reached prior to achieving the 20 foot target depth during the first core attempt. At several core stations, expansion of sediment inside the core barrel was observed upon recovery. This expansion is not an uncommon phenomenon in vibratory coring and is noted on the core logs by recovery measurements that exceed penetration depths. To account for expansion in the cores, penetration of the core barrel was often halted before reaching the 20 feet target depth. Once on deck, cores were cut into manageable sections for storage and transportation.

Following the conclusion of this investigation, all core sections were analyzed by an OSI geologist. This analysis included splitting, visually describing, photographing, and subsampling. Subsamples were then analyzed for grain size. After the project is completed, the core sections will be archived at a CPRA facility.

3.0 DATA PROCESSING AND PRODUCTS

Following completion of the field investigation, the acquired data sets were processed and interpreted. For a discussion of processing and analysis methods, refer to Appendix 3. A series of project drawings were constructed to illustrate the results of the data analysis. Table 2 summarizes the data presented on each drawing. Drawings 1-4 present the entire survey area in plan view at a scale of 1 inch = 400 feet on (Arch E size) drawing sheets (30 by 42 inches). Drawing 5 (suitable sediment isopach map) and Drawing 6 (representative subbottom profiles, two sheets) present data within the proposed borrow area and expansion area at a horizontal scale of 1 inch = 200 feet, and vertical scale of 1 inch = 10 feet (Drawing 6 only). The drawings are presented separately in full size and in Appendix 4 in reduced format 11 by 17 inch.

Table 2

Drawing	Data Presented
1 – Tracklines	Includes all survey vessel tracklines.
2 – Hydrography	One-foot depth contours overlain on colorized image of modeled depth surface based on processed sounding data.
3 – Residual Magnetic Field Contours	Magnetometer anomalies and 10-gamma contours of the modeled residual magnetic field data.
4 – Side Scan Sonar Mosaic	Side scan sonar targets, magnetic anomalies, and isolated subbottom features overlain on side scan sonar mosaic.
5 – Sand Isopach	Two-foot contours of sediment thickness based on review of subbottom profiles correlated with vibratory coring results.
6 – Representative Subbottom Profiles	Three north-south and two east-west oriented chirp subbottom profile records, with core log data overlain.

Vibratory core logs are presented in Appendix 5 while grain size analysis and core photos are included in the digital appendix on the accompanying disc. Table 3 lists all of the appendices included in this report.

Table 3

Appendix #	Data Presented
1	Archaeological Assessment
2	Equipment Operations and Procedures
3	Data Processing Methods
4	Summary Tables of Magnetic Anomalies and Side Scan Sonar Targets, Target Images
5	Core Logs
6	Project Drawings in Reduced Format (11" by 17")
Digital Appendix	Final report file (PDF format), Project drawing files (AutoCad 2007 and PDF formats), core photographs taken at 1-foot intervals (jpg format), complete set of detailed grain size analysis tables

All raw digital data files acquired during the course of the survey (HYPACK, side scan sonar, and chirp subbottom profile) will be archived in-house and presented on digital media under separate cover to be submitted to BOEM.

4.0 DATA ANALYSIS AND DISCUSSION

The following sections discuss the results of the multi-sensor marine geophysical survey conducted in June 2011 and the geotechnical sampling program conducted in October 2011. Seasonal variations, storm events, and/or man’s influence since the time of the surveys may have altered conditions reported herein.

4.1 Hydrographic Data

Water depths range from less than 27 feet to greater than 41 feet below NAVD88. The seafloor dips toward the south, getting steeper further offshore. Both the depth surface generated from the hydrographic data and the side scan sonar mosaic show a relatively featureless bottom, with no large scale bedforms.

4.2 Magnetic and Side Scan Sonar Data

Analysis of magnetic data identified 98 individual magnetic anomalies in the survey area and four linear alignments of anomalies associated with pipelines along the perimeter of the survey area (two along the southwestern edge; one each along western and northeastern edges of the survey area). Most of the 98 magnetic anomalies identified are isolated and small (less than 15 gammas). Two clusters of anomalies, located approximately 2,400 feet southwest of the proposed borrow area, were deemed potentially archaeologically significant by the project archaeologist (see Appendix 1). Additionally, several clusters of anomalies were detected in the historic avoidance areas referred to as Areas 6, 8, and 9 (C&C, 2003). As documented in Appendix 1, the project archaeologist confirmed these areas should still be avoided during future activities in the site.

Analysis of side scan sonar imagery identified 79 sonar targets, only seven of which are located within the current proposed borrow area. Of these, only one, SS19, is correlated with a magnetic anomaly (M66). None of the anomalies or targets located within the proposed borrow area is interpreted as potentially archaeologically significant.

4.3 Subbottom Profile Data

Data from both chirp subbottom profiler systems were reviewed and generally achieved excellent resolution and penetration in the upper thirty feet of the subsurface. The Chirp 512 system tended to attain deeper penetration throughout the predominant sand body on the shoal and was relied on more heavily for data interpretation. Figure 7 shows a representative north-south oriented subbottom profile section and illustrates the type of subbottom data acquired. Two distinct sequences of seismic reflections were identified including an upper sequence of semi-transparent reflections and a lower sequence of less transparent, horizontal, sub-parallel reflections. Acoustic reflections within the upper sequence are lower amplitude in appearance, characteristic of predominantly sandy sediments, and show faint evidence of northward dipping bedding. This sequence thins to the south and east within the borrow area.

Higher amplitude, sub-parallel reflections identified in the lower sequence are characteristic of finer-grained silts and clays.

In general, as expected, subbottom data show surficial sandy sediments throughout the area underlain by a sequence of finer-grained deposits generally correlative with silts and clays. Although the entire project area appears to be a sand body overlying deeper finer-grained sediments, only minor paleo channels were detected in the shallow subsurface and none of these features were detected within the proposed borrow area or expansion area. As required by BOEM the location of these relict geomorphic features, which could present themselves as archaeologically significant have been mapped and are presented in plan view on Drawing 4 as an overlay to the sonar mosaic.

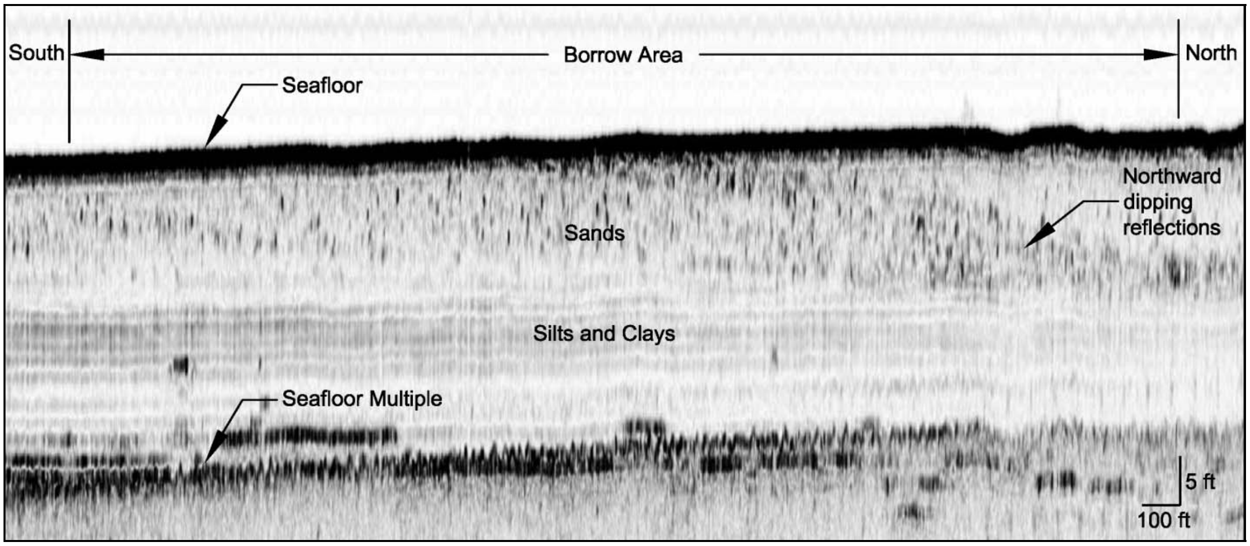

Figure 7. Representative chirp subbottom profile showing the two distinct sequences of seismic reflections identified within the borrow area. The upper sequence is typical of sands and the lower sequence is typical of silts and clays.

In addition to the mapping of sand thickness, subbottom data were analyzed for buried pipelines within the project area. As corroborated by the magnetometer, numerous parabolic features were detected in the subsurface related to buried pipelines bordering the project area but none were detected within the proposed borrow area or expansion area. These areas of pipeline detection are identified on project drawings.

4.4 Geotechnical Data

Vibratory core analysis was conducted by an OSI geologist at the University of New Orleans' Core Libratory in New Orleans, Louisiana. Cores were split longitudinally and laid on laboratory tables to perform the visual descriptions. In general, clean fine sand was observed overlaying silt and clay at depth. This coarsening upward package was found in nearly all cores described. The total thickness of sands and silty sands in the cores ranged from 14 to greater than 20 feet. Final core logs were prepared using the logging software suite *LogPlot. Logplot* is distributed by RockWare, Inc. Upon completion of the visual description process, one half of the core was photographed and prepared to be archived. Each core was digitally photographed in 1-foot intervals (Figure 8). These photographs are provided in the digital appendix.

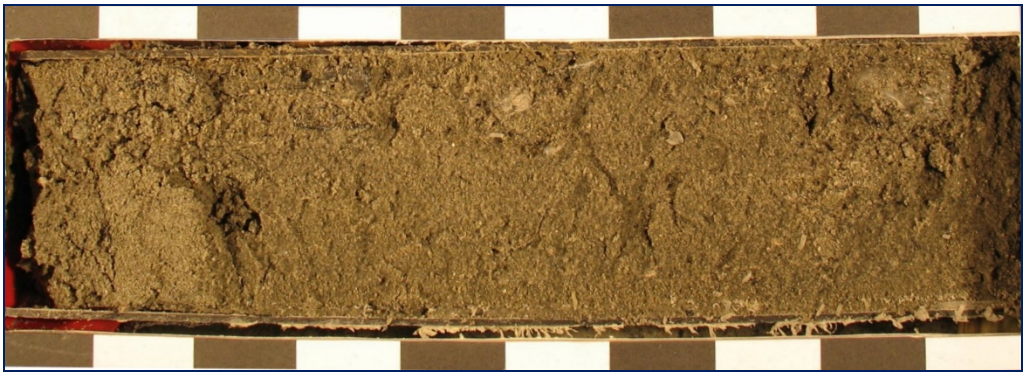

Figure 8. Example of 1-foot interval core photograph. Sample taken from CEC-11-VC-1 at 0-1 foot.

The remaining half of the core was sampled for grain size analysis at 2-foot intervals. Samples were also taken at the top and bottom of a change in sediment characteristic if they did not fall inside the 2-foot interval. Grain size analysis was performed on subsamples visually identified as containing mostly sand. Subsamples were then analyzed by mechanically sieving based on ASTM guidelines. Grain size data were entered into EXCEL spreadsheets and analyzed utilizing a custom MATLAB Version R2011b sieve analysis routine, specifically designed to generate grain size distribution cumulative probability curves and perform statistical analyses. These results are presented both in tabular and graphical formats in the digital appendix.

4.5 Summary of Potential Sediment Resources

Subbottom profile data were reviewed with the core logs, core photos and grain size results and indicated a general stratigraphy of clean fine sands (<1% fines) overlaying clayey/silty fine sands (<13% fines) and ultimately firm clays within the proposed borrow area and expansion area. Because silty/clayey sands contained less than 13% fines and were generally less than 5 feet thick (except CEC-11-VC-11, 6 ft), both surficial clean sands and underlying silty/clayey sands were deemed suitable sediment resources for the project (personal communication James Cohlmeyer, P.G., 12/8/11).

Figure 9 presents a section of a subbottom profiler record along an east-west oriented line with core data overlain. In several locations, depth to clay measurements based on the cores correlated to within a foot of the interpreted contact in the subbottom data (see for example CEC-11-VC-12 in Figure 8). In other locations the geophysical interpretations were observed to be within three feet (above and below) of measurements made in the cores (i.e. CEC-11-VC-9). In all cases the variance between core data and geophysical data was well within the expected levels for correlation between the two data sets given that many of the cores showed significant expansion upon recovery (as discussed earlier). Color-coded graphic representations of core logs and the subbottom reflector interpreted to be correlative with the contact between sand and finer sediments has been highlighted (dashed line) on the subbottom profile sections presented in Drawing 6.

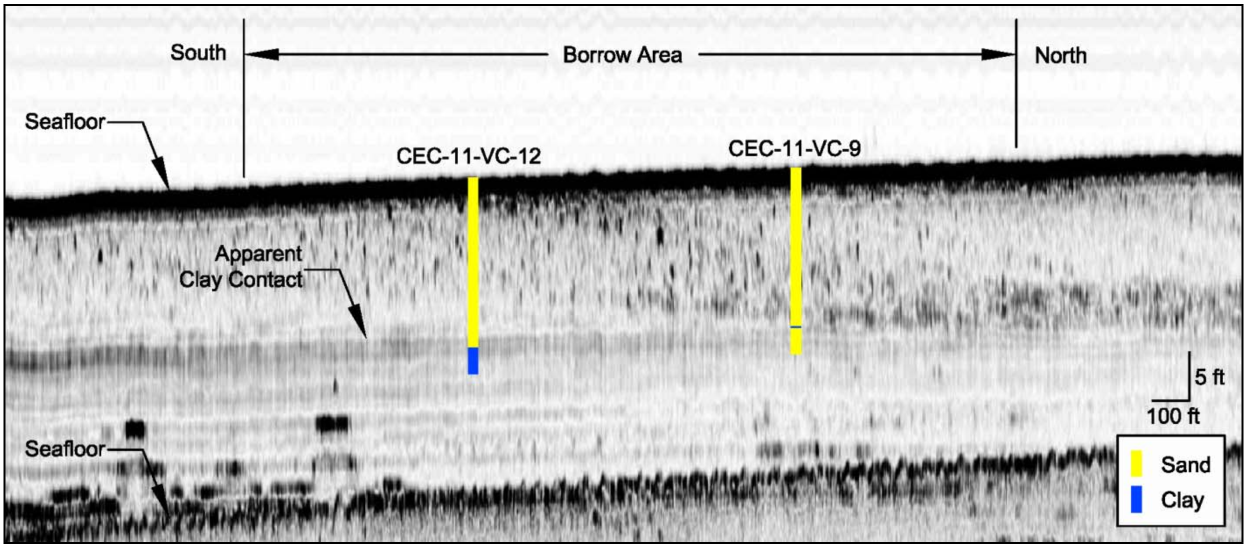

Figure 9. Representative chirp subbottom profile (line 87) including findings from vibracores collected along line.

In order to produce a conservative sediment isopach of surficial suitable sediments, the shallower of the two estimates of the sand/clay contact were used where the geophysical and geotechnical data sets differed. The resulting isopach of suitable surficial sediments is presented in Drawing 5. In general, the geology of proposed borrow area and expansion area is characterized by a relatively thick (9-19 feet) surficial layer of suitable sediments, which generally thickens to the north. Within the borrow area limits, suitable sediment thicknesses range from 13 feet in the south to 18 feet in the northern corner. Color-coded graphic representations of core logs have been overlain on the isopach map to better illustrate the sequence of sandy sediments in the upper subsurface.

Volume estimates have been calculated for both the proposed borrow area and the proposed expansion area using a surface modeling package. Volume estimates presented in Table 4 assume all suitable sediments identified in the areas are recoverable.

Table 4

Area	Surface Area (Million Square Feet)	Volume (Million Cubic Yards)
Proposed Borrow Area	9.6	5.6
Expansion Area	13.6	7.7
Combined Total	23.2	13.3

5.0 ARCHAEOLOGICAL ASSESSMENT

Fathom Research, LLC, the project's marine archaeological consultant, completed an assessment of the geophysical and geotechnical data of the 2011 survey area and proposed borrow and expansion areas. A report detailing the results of that assessment is included in Appendix 1.

In summary, Fathom Research, LLC's assessment resulted in the following:

- Concurred with the 2003 C&C survey findings regarding the generally high potential for the survey area to contain post-contact period shipwrecks and pre-contact period archaeological resources (i.e., isolated, out-of-context, durable pre-contact period artifacts distributed randomly throughout the sandy matrix of Ship Shoal);
- Confirmed the presence of the 2003 C&C survey-identified magnetic anomaly areas Clusters "6, 8, 9" (in this report's drawings);
- Identified two new magnetic anomaly clusters for avoidance or additional investigation (Areas "A" and "B" in this report's drawings) that were within the 2011 survey area, but well outside of the proposed borrow and expansion areas;
- Determined that there was no evidence in either the 2003 C&C survey data or the 2011 survey data indicating the presence of a submerged cultural resources within either the proposed borrow area or expansion area, and;
- Recommended no additional archaeological investigations be conducted within the proposed borrow and expansion areas and that an unanticipated discovery plan be followed during the implementation of the Project.

6.0 SUMMARY AND RECOMMENDATIONS

Current Louisiana Coastal Protection and Restoration Authority (CPRA) plans are to restore the beach and dune features along the Caminada Headland using sediment resources previously identified on Ship Shoal. The investigations described herein were two of several tasks that OSI has been subcontracted to perform to support the project. The geophysical and geotechnical surveying tasks focused on the characterization of site conditions and an archaeological assessment. The acquired data sets provide a framework for: defining the hydrographic and shallow stratigraphy; evaluating the suitability of sand resources; defining a project borrow area and possible expansion area; and identifying features present that might potentially impede the removal of sand including those deemed as being potentially archaeologically significant.

Hydrographic data acquired during the multi-sensor geophysical survey were analyzed to reveal a generally featureless seafloor, which gently dips southward in water depths ranging from less than 27 feet to greater than 41 feet below NAVD88 within the survey area. Side scan sonar imagery also show a relatively uniform surface, with no large scale bedforms. Side scan sonar data were also analyzed along with magnetometer data to identify 79 side scan sonar targets and 98 magnetic anomalies. None of the anomalies or targets located within proposed borrow area and expansion area is interpreted as potentially archaeologically significant.

Chirp subbottom profile data showed good correlation with core logs and grain size data and documented a surficial sand body underlain by clay. The subbottom data were analyzed with the geotechnical data to estimate thickness of suitable sediments based on suitability criteria set forth by CEC. The resulting isopach map illustrates the presence of a relatively thick sequence of sandy sediments throughout the proposed borrow area and extending to the limits of the expansion area. Estimated volume of suitable sediments within the borrow area is greater than 5.6 million cubic yards with an additional 7.7 million cubic yards in the expansion area surrounding the borrow area (total volume of suitable sediments over the entire proposed borrow area and expansion area is greater than 13.3 million cubic yards.). Suitable sand volume estimates are conservative, as a result suitable sand resources within the site may be somewhat more extensive than reported.

In dynamic environments such as ship shoal, active sediment transport is an ongoing process with surficial material constantly shifting. Actual volume of suitable sediment resources available at the time of dredging may differ from those reported here. Seasonal variations, storm events and/or man's influence subsequent to this investigation may alter the conditions reported herein.

7.0 REFERENCES

C&C Technologies, 2003. High resolution geophysical and archeological survey of the South Pelto area Block 13 vicinity of Ship Shoal. 37p. (Study prepared for the United States Environmental Protection Agency).

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NOAA Nautical Chart 11340, 72nd ed., July 2007.

NOAA Nautical Chart 11357, 39th ed., February 2007.

NOAA Nautical Chart 11358, 54th ed., February 2007.

NOAA Nautical Charts 11365, 20th ed., February 2008.

APPENDIX 1

ARCHAEOLOGICAL ASSESSMENT

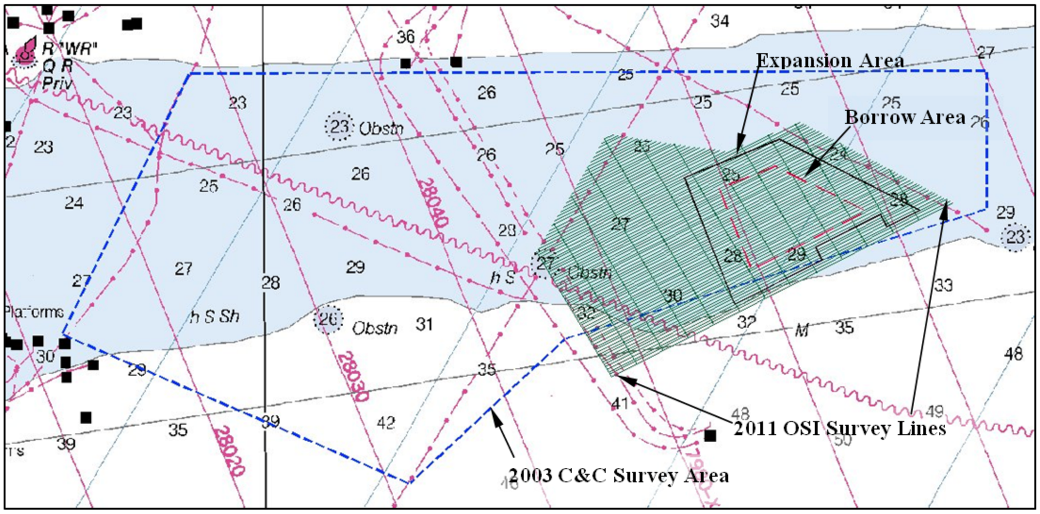
FINAL REPORT

Marine Archaeological Assessment of
Geophysical Survey and Geotechnical Sampling Data

Caminada Headland Beach and Dune Restoration Project (BA-45)
Ship Shoal Borrow Area and Expansion Area

South Pelto Area Lease Blocks 13 and 14, Gulf of Mexico, Louisiana

January 2012



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INTRODUCTION

This Report presents the results of the marine archaeological assessment of geophysical survey and geotechnical sampling data acquired in 2011 within the Caminada Headland Beach and Dune Restoration Project's (BA-45) (the "Project") Ship Shoal Borrow Area ("SSBA") and its surrounding Expansion Area ("SSEA"), referred to herein as the "study area." The study area is located approximately nine (9) nautical miles ("nm") south of the Isles Dernieres, Louisiana in the Bureau of Ocean Energy Management's ("BOEM") Gulf of Mexico, South Pelto Area, Lease Blocks 13 and 14, in water depths ranging from slightly less than 27 feet ("ft") to 41 ft (Figure 1). This assessment was performed for the Project by Fathom Research, LLC ("Fathom"), under a sub-contract with Ocean Surveys, Inc. ("OSI"), on behalf of Coastal Engineering Consultants, Inc. ("CEC") and the State of Louisiana's Coastal Protection and Restoration Authority ("CPRA"). CEC is working with OSI and Project team members Gulf Engineers & Consultants ("GEC"), GeoEngineers ("GEO"), and Picciola & Associates, Inc. ("Picciola") to assist CPRA with the planning, engineering and environmental permitting of the Project.

The Project involves restoration of the western end of the Caminada Headland through beach and dune fill placement utilizing an offshore sand resource identified previously at the far eastern end of the 4 mi long-x-2 to 6 mi wide Ship Shoal. The Project's entire 220-acre ("ac") (2,900 ft-x-2,050 to 4,450 ft wide-x-14 to 16 ft deep) Ship Shoal Borrow Area, and nearly all of its surrounding Expansion Area, are encompassed within the limits of a previously conducted program of high-resolution geophysical/archaeological survey (and geotechnical sampling) completed for the United States Environmental Protection Agency ("USEPA") in 2003 by C&C Technologies ("C&C") using BOEM's then-standard specified 50-meter ("m") (147 ft) shallow-water survey trackline spacing (Figure 2) (Braud-Samuel et al. 2003). The Project study area was resurveyed by OSI in 2011 at BOEM's request, because of the significant amount of time that had passed between the 2003 survey and the projected implementation of the Project in 2012, during which the Gulf Coast of Louisiana (including Ship Shoal) was impacted by the devastating hurricanes Katrina and Rita in 2005, and also because BOEM had reduced its standard shallow-water survey trackline spacing requirement from the specified 50 to 30 m (147 to 98 ft). OSI's geophysical field survey and geotechnical ("G&G") field sampling programs were completed aboard the R/V *Acadiana* and R/V *AC Brown Elevator* between June 9 and June 15, 2011 and October 10 and October 14, 2011, respectively. The 2011 OSI "survey area" refers to the area encompassed by the survey grid, which was much larger than the Project study area (i.e., the Borrow Area and its associated Expansion Area), and measured approximately 1-x-1.9 nm and covered approximately 1,580 ac (see Figure 2).

Given that this assessment is a review of more recently acquired and higher resolution geophysical and geotechnical survey and sampling data obtained from within an area already subjected to comprehensive archaeological investigation in 2003 by C&C (Braud-Samuel et al. 2003), the report from which includes fully developed discussions of the area's prehistoric and historic environmental and cultural backgrounds and site potentials for both periods, BOEM recommended that Fathom limit any redundancy of information in its report by focusing on addressing the 2011 data and present only new information resulting from the analysis of this data, as well as any new supplemental background information that may have been acquired during the investigation (Dr. Jack Irion, BOEM Gulf of Mexico Regional Historic Preservation Officer and Supervisor – Social Science Unit, BOEM-Gulf of Mexico Regional Office ["BOEM-GOMR"], personal communication with David Robinson, Fathom Principal Investigator, 2011). Dr. Irion's recommendation was reiterated and specific requirements regarding the contents and scope of this marine archaeological assessment report were confirmed by BOEM-GOMR's Senior Marine Archaeologist, Dr. Christopher Horrell, who gave Fathom permission to include this archaeological assessment report as an appendix in OSI's G&G report, as well as to reference the OSI report's relevant contents and that of the C&C (2003) report, as needed, to comply with BOEM's archaeological reporting guidelines outlined in Appendix 2 of the BOEM's Notice-to-Lessees ("NTL") No. 2005-G07 (personal communication with D. Robinson, January 19, 2012). Consequently, the reader is directed to refer to the contents of OSI's January 2012 *Final Report, Caminada Headland Beach and Dune Restoration Project (BA-45), Gulf of Mexico, Louisiana, Geophysical and Geotechnical Surveys of Ship Shoal (OSI Report #11ES008-F)* (OSI 2012) for detailed information regarding the specifics of the geophysical survey and geotechnical sampling's parameters and procedures, instrumentation and instrument settings, anomaly and target inventories, and post-processed data plots, and to the environmental and cultural context portions of C&C's 2003 report, the text of which is included herein as Appendix A.

STUDY GOALS AND OBJECTIVES

The phases of any marine archaeological investigation reflect the preservation planning standards for the identification, evaluation, registration, and treatment of cultural resources (National Park Service ["NPS"] 1983). The primary goals of this marine archaeological assessment were: 1) to review and identify anomalies or targets with the possibility of being submerged cultural resources or areas of prehistoric archaeological sensitivity; and 2) to provide management recommendations concerning the avoidance of possible submerged cultural resources or the need and scope of any additional marine archaeological investigation that may be warranted within the SSBA or SSEA based on the results of this assessment.

PROJECT AUTHORITY

As the overall Project requires review and permitting by several federal agencies, including, BOEM, it constitutes a federal "undertaking" for which compliance with Section 106 of the National Historic Preservation Act ("NHPA") of 1966, as amended (36 CFR 800), is required. Section 106 of the NHPA requires federal agencies take into account the effects of their undertakings on cultural resources listed or eligible for listing in the National Register of Historic Places ("NRHP") (36 CFR 60). The agency must also afford the Advisory Council on Historic Preservation the opportunity to comment on the undertaking. The Section 106 process is coordinated at the state level by the State Historic Preservation Offices ("SHPO"). The issuance of federal agency permits will depend, in part, on obtaining comments from the Louisiana SHPO ("LASHPO"), which operates within the Louisiana Department of Culture, Recreation & Tourism's ("CRT") Office of Cultural Development's Division of Archaeology ("LADOA") and Division of Historic Preservation ("DOHP"). This investigation was performed in accordance with the survey and reporting requirements outlined in BOEM's NTL No. 2005-G07 and its appendices, as well as the Secretary of Interior's *Standards and Guidelines for Archeology and Historic Preservation* (48 FR 44716 1983) and *Standards and Guidelines for Identification* (1983).

RESEARCH DESIGN AND METHODS

Results from the 2003 C&C marine archaeological investigation (see Appendix A) were reviewed and supplemental research was conducted for the small portion of the 2011 Project study area and survey area that extend outside the limits of the 2003 C&C survey area (see Figure 2). The objective of this review and research was to identify previously documented archaeological deposits within the Project study area and its vicinity and to assess the Project study area's potential to contain additional, previously undocumented, archaeological deposits. The overall goal of the review and research was to inform Fathom's interpretation and assessment of the

Project's 2011 geophysical and geotechnical survey data, and to assist Fathom in the formulation of management recommendations for the Project study area.

In addition to Fathom's review of the 2003 C&C report (Braud-Samuel et al. 2003), research performed for this assessment also included a review of:

- Cultural resource survey and archaeological site location index maps, reports, and archaeological site files held at the LADOA, Baton Rouge and the LADOA's online Louisiana Cultural Resources GIS database (http://kronos.crt.state.la.us/website/larchweb/viewer.htm);

- Historic maps archived in Tulane University's Howard-Tilton Memorial Library's Special Collections, New Orleans, as well as those available from the National Oceanic and Atmospheric Administration's ("NOAA's") Office of Coast Survey Historical Map and Chart Collection (http://historicalcharts.noaa.gov/);

- Regional and local historical, archaeological and geological background information contained in cultural resource survey technical reports, books, articles, and unpublished theses and reports held at LADOA, the Louisiana Collection of the Louisiana State Library, and in Special Collections of the Hill Memorial Library, Louisiana State University, Baton Rouge (e.g., Cuomo 1984; Davis 1984; Nowak et al. 2008; Sallenger 2009; Saucier 1994; Smith et al. 1983, etc.);

- NOAA navigation charts and on-line Automated Wreck and Obstruction Information System ("AWOIS");

- Berman's *Encyclopedia of American Shipwrecks* (1972);

Geophysical survey (the methods and results of which are described in detail in OSI's 2012 G&G survey report [see OSI 2012]) was performed at a 98 ft (30 m) primary survey trackline spacing with secondary tie lines oriented perpendicular to primary lines and spaced at 1,000 ft (300 m) intervals, and utilized a suite of instruments that included: an Odom Echotrac depth sounder; a Klein 3000 100/500 kHz dual-frequency digital sidescan sonar system; a Geometrics G882 cesium marine magnetometer; an EdgeTech 3100 CHIRP subbottom profiling system equipped with an SB512 tow vehicle; and an EdgeTech Geostar CHIRP subbottom profiling system equipped with an SB216 tow vehicle. Horizontal positioning of the survey vessel and data sets was accomplished using a Trimble 212 differential global positioning system. Geophysical data reproductions of relevant features in the area, as well as unidentified and identified magnetic anomaly tables, boat setback diagram, instrument settings, personnel, equipment descriptions and a copy of the daily survey and geophysical logs are included in OSI's 2011 report. The instrumentation and performance of the survey followed the specifications and requirements of BOEM NTL No. 2005-G07.

Post-processed geophysical data was provided to Fathom for review for evidence of submerged cultural resources. Inventoried sidescan sonar anomalies included any acoustic targets with distinct acoustic reflections relative to their ambient acoustic field, and/or those that were associated with a proximal magnetic anomaly or anomalies. Magnetic anomalies that were inventoried were those that appeared distinctly anomalous relative to the ambient magnetic field (alone or together in combination with other nearby magnetic anomalies). Sidescan sonar and magnetic anomalies caused by external sources (e.g., adjustments to sensor depths, passing vessels, known pipelines, etc.) were noted as such in the Daily Survey Log that was maintained by OSI field staff during the survey and eliminated from inclusion in the inventory.

Interpretation of the various types of survey data (both raw and post-processed) and selection of bathymetric targets, magnetic anomalies, sidescan sonar targets, and subbottom reflectors of potential archaeological interest relied on a combination of factors. These factors included the type of data being considered, onsite environmental conditions, predicted types of resources likely to be encountered, survey design parameters employed, and the experience of the archaeologist that reviewed and interpreted marine remote sensing data.

Consideration and interpretation of acoustic data produced by sidescan sonar and subbottom profiler systems is relatively straightforward. Acoustic targets in sidescan data appear as visual anomalies in the ambient visual field of the sea floor in either a photograph-like, high-angle oblique plan view (as in the case of a high-resolution sidescan sonar record) or in profile (as in the cases of subbottom profiler and single-beam depth sounder records). Sidescan sonar targets are selected as possible archaeological deposits based primarily on their appearance, that is, whether or not they appear to be vessel remains or areas of debris that could not otherwise be eliminated as a possible shipwreck. The sizes of targets, their relief above the bottom, and the relative density and spatial distribution of their constituent parts are all obtainable from the sonar record, particularly when data from adjacent lines is presented in a mosaic format, as it was for this study.

Subbottom profiler "reflectors" generally fall into two categories of archaeological interest: those that appear to be shallowly buried, discrete, anthropogenic deposits (e.g., shipwrecks, shell middens, ballast dumps, etc.), and those that appear to be buried geological deposits (e.g., paleolandforms). The former (i.e., shipwrecks) are often associated with corresponding "clusters" of magnetic anomalies and subtle, yet distinct, changes in bottom composition that are visible as differences in the acoustic reflectivity of the bottom in both the subbottom profiler and sidescan sonar records. Subbottom reflectors that are geological in nature and are buried beneath the sea floor result from changes in the sediment density caused by post-inundation marine sedimentation processes, inundation sequences, pre-submergence depositional events, fluvial erosional episodes or older geological processes. Some reflectors have characteristics that are readily identifiable relict elements of the pre-submergence paleolandscape, such as paleo-channel features, beach/shoreline features, upland terraces, etc., which, when found, can be correlated with results from geotechnical sampling (i.e., vibratory coring or deep borings).

Interpretation of magnetic data is less straightforward. Magnetic anomalies of archaeological interest can range from several to several thousand gammas in intensity, and extend tens or hundreds of feet or meters in duration, depending on the characteristics of their source and the source's distance from the point of measurement (i.e., the source-to-sensor distance). Even though a considerable body of magnetic signature data for shipwrecks is now available for comparison, it is impossible to positively associate any specific individual magnetic signature with a particular type or age of shipwreck, or any other archaeological feature. Variations in iron content, condition, and distribution of a vessel's wrecked remains, as well as the survey's design parameters (especially trackline interval and sensor altitude, which effect source-to-sensor distance) all combine to influence the intensity, duration and characteristics of the anomaly produced.

A more effective method of interpreting magnetic data is through the analysis of the spatial distribution of multiple anomalies across adjacent tracklines. Marine remote sensing archaeological surveys performed at conservative trackline intervals (e.g., 100 ft [30 m] or less) and at relatively consistent tow heights (less than 6 meters as mandated by BOEM) provide magnetic data that is more comprehensive in its coverage and, therefore, of greater resolution that allows for the discernment of patterns in the data that are indicative of potential shipwrecks, geological deposits, or isolated modern debris. By contrast, conducting a survey at a trackline interval greater than 100 ft (30 m) provides less than comprehensive coverage and, therefore, increases the chances for the magnetometer sensor to pass farther away from a magnetized source and possibly not detect its presence. Surveying at a trackline interval greater than 100 ft (30 m) also results in shipwreck-related magnetic anomalies that are generally lower in intensity, less complex in their signatures, may be detectable on just a single trackline (thereby minimizing the efficacy of anomaly pattern analysis across survey tracklines), or that may simply be missed altogether between lines. Recognizing these limitations of magnetometers, this survey was conducted using the 100 ft (30 m) trackline interval recommended by BOEM for high probability areas in waters 656 ft (200 m) deep or less.

Although no one signature of an individual magnetic anomaly can be attributed specifically to a shipwreck, shipwrecks often appear in magnetic data as a “complex” dipolar anomaly or as a cluster of multiple anomalies consisting of a larger and/or longer duration anomaly surrounded by smaller amplitude, shorter duration anomalies, which are detected across two or more adjacent tracklines. This spatial distribution of magnetic anomalies reflects a commonly encountered distribution of shipwreck debris on the seabed, which usually includes a centrally concentrated (sometimes buried) area of debris composed of the primary hull remains that is trailed or surrounded by a comparatively more diffuse distribution of smaller debris (e.g., displaced secondary hull elements, cargo, armament, etc.). Magnetic anomalies or anomaly clusters associated with shipwrecks are also accompanied often by correlating sidescan sonar and/or subbottom profiler anomalies. In contrast, magnetic anomalies associated with seabed infrastructure, such as pipelines, are often distributed in regular patterns extending over long areas of the bottom, while those associated with modern isolated debris can exhibit high-intensity magnetic signatures, but that are usually only detected for brief durations on just a single trackline. In all cases, remote sensing data interpretation and the target selection processes are significantly enhanced by the ability to cross-correlate data collected simultaneously from multiple instruments with different detection capabilities and by examining data from adjacent tracklines.

Rather than select potential cultural targets from a single data set or individual trackline, all of the geophysical data recorded for this investigation were reviewed simultaneously after post-processing for the presence of any correlations between data sets and across multiple tracklines for clues regarding the possible identity of individual targets. The remote sensing data recorded during this survey were also considered and interpreted within the context of the 2003 C&C survey, background research results, and the results from the geotechnical sampling program, to identify and differentiate targets representing potential archaeological deposits and sensitive areas from those that were not. Recommendations regarding the avoidance of Project impacts to, and/or the performance of additional archaeological investigation of, anomalies comprising discrete targets or archaeologically sensitive geological features, were made based on the results of these analyses.

Geotechnical sampling (i.e., vibratory coring) was performed by OSI following conclusion of the geophysical survey. The methods and results of the geotechnical sampling program are described in detail in OSI’s 2012 G&G survey report (see OSI 2012). Thirteen, 20-ft long cores were proposed to document the sediment resource and “ground-truth” the acquired geophysical data. Prior to conducting the coring operations, a sampling permit was obtained by OSI through BOEM. The coring operations were conducted from the lift-boat R/V *AC Brown Elevator.*

Horizontal positioning of the vessel and core locations was accomplished using a Trimble 212 differential global positioning system. The vibratory coring system consisted of an OSI Model 1500 pneumatic vibratory corer equipped with a 20-ft long-x- 4-inch ("in") (inner diameter) core barrel. The core barrel was fitted with a 3.5-in hard-plastic liner within which a continuous sediment core was recovered. Following recovery, all core sections were split, photographed, analyzed, sampled, and logged by an OSI geologist. The core photographs and logs were provided to Fathom for review for evidence of submerged cultural resources or contextually intact, formerly subaerial, paleo-landscape features with archaeological sensitivity for containing pre-contact period ancient Native American archaeological deposits.

RESULTS

Research

South Pelto lease blocks 13 and 14 are identified by BOEM as high probability areas relative to their potential for containing pre-contact period ancient Native American archaeological deposits; South Pelto Lease Block 14 is identified by BOEM as having a high probability for containing submerged shipwrecks. Comprehensive descriptions of the pre- and post-contact period cultural chronologies and respective archaeological sensitivities of the Project study area and its vicinity summarized here are provided in the text of the 2003 C&C report included as Appendix A.

Pre-Contact Period

The Project study area is underlain by a 125 to 150 ft thick deposit of Holocene sediments that were deposited over the last 10,000 years onto a weathered Pleistocene-age "Prairie terrace" sediment sequence representing the floodplain and deltaic sediments deposited between 120,000 and 20,000 years ago (Saucier 1994; Braud-Samuel et al. 2003). Large expanses of the Prairie terrace deposit forming today's continental shelf in the region were exposed when sea level was 300 to 400 ft lower than today as a result of advances of the Wisconsin glaciaction that trapped large amounts of the earth's water as polar ice (Braud-Samuel et al. 2003). This exposed Prairie terrace deposit was incised, in some cases deeply, by an extensive network of stream and river channels, some of which have been identified deeply buried in the general area around the Project study area and are believed to be associated with an ancestral Mississippi River course (Braud-Samuel et al. 2003; Moore et al. 1978).

Beginning at about 18,000 years before present ("B.P."), sea level has risen and the Pleistocene surfaces of the Prairie terrace deposit were progressively drowned and/or buried by marine or Holocene-age deltaic sediments (Braud-Samuel et al. 2003). Prior to their inundation by eustatic sea level rise, the Project study area would have been situated in an area that once consisted of environments suitable and attractive for human habitation and utilization (i.e., streams, river valleys, natural levees, point bars, river and coastal terraces, etc.) (Pearson 1986). Sea level data presented in Saucier (1994) and cited by Braud-Samuel et al. (2003), indicates that the Prairie terrace surface in the vicinity of the Project study area would have been subaerial about 27,000 to 10,000 B.P., after which time it was inundated by a rising sea. Given the generally accepted theory that human populations arrived to the region circa ("ca.") 12,000 B.P., it is possible that human habitation occurred and archaeological evidence of dating from the earliest period of this habitation exists within preserved elements of the deeply buried Prairie terrace surface (Braud-Samuel et al. 2003).

Holocene sediment deposits overlying the Pleistocene Prairie terrace deposit consist of two geological units: a thick lower unit composed of a sequence of deltaic sediments associated with the drowned portions of the Mississippi River's regressive ancestral deltas (i.e., most likely the Maringouin Delta Complex [active ca. 7,500 to 6,000 B.P.], which extended south of the present position of Ship Shoal) that prograded out onto the inner continental shelf in the general area after ca. 10,000 B.P., and the overlying, sand-rich Ship Shoal unit - a submerged, transgressive feature formed from sediments that eroded from distal ends of deltaic features formerly extending across this portion of the inner continental shelf (Braud-Samuel et al. 2003) (Figure 3). The Maringouin Delta deposited the typical stratified sequence of deltaic sediments (i.e., the lower unit) in the area (i.e., pro-delta channel, natural levee, backswamp, lake and marsh environments) up until about 6,000 B.P., when water flow through the system began to decline, deltaic expansion ended, and a cycle of deterioration commenced (Braud-Samuel et al. 2003). Subsidence and the submersion and reworking of the delta's matrix associated with the marine transgressive process would have been the dominant geological regimes that drove the deterioration of the delta and transformed its margin from an erosional headland with flanking barriers to a transgressive barrier island arc, and, finally, to a subaqueous inner shelf shoal (e.g, the Ship Shoal unit) (Nowak et al. 2008; Penland et al. 1985).

At around 6,000 B.P. and immediately prior to inundation, the Maringouin Delta Complex's environment forming the lower unit deposit would have consisted of the same landforms characterizing today's Mississippi River deltaic complexes - distributary systems associated with natural levees and back swamps, fresh and brackish water ponds and lakes, brackish and saline bays, and beach ridges at the Gulf of Mexico margin (Braud-Samuel et al. 2003). Archaeological research conducted to date indicates that deltaic settings such as these were especially attractive to early human inhabitants in the region, as they were among the most abundant in predictably available resources, and their waterways provided easy access to inland and coastal waterborne transportation corridors. The types of pre-contact period sites that are found in these deltaic environments include shell middens, earth middens, beach deposits, shell mounds and earth mounds (Weinstein and Gagliano 1985).

Application of Penland et al.'s (1985) sea level rise model for the region indicates that the lower unit's deltaic surface within the entire Project study area was inundated by ca. 6,200 B.P. (Braud-Samuel et al. 2003). This means that human habitation of the lower unit Holocene deltaic deposit would have likely been limited to the period between about 7,000 B.P., when deltaic landforms suitable for human habitation may have first prograded into the area and a subaerial deltaic plain was established, and about 6,200 B.P., when the area was inundated (Braud-Samuel et al. 2003).

As the plain expanded over time and its biological diversity and productivity increased, occupation and human usage would have intensified as well. During this period in the life of a major river delta, human habitation sites and the archaeological deposits they left behind are most usually situated above the deltaic wetlands on the natural levees and at the junctions of distributary channels fanning across the deltaic lobe (Waters 1992). The period between 7,000 and 6,200 B.P. roughly coincides with Louisiana's Middle Archaic period (ca. 7,000 to 5,000 B.P.), for which little archaeological evidence has been found to date within the state's coastal region, presumably because the matrices of region's currently subaerial deltaic features are too young to contain them, and because any sites associated with the period are deeply buried. Inland riverine sites dating from the Middle Archaic in Louisiana indicate that shellfish harvesting was a significant focus of hunting-and-gathering activities at that time. It is reasonable to expect that deltaic and coastal Middle Archaic populations of the period were also engaged in shellfish harvesting.

While environmental variables are an important element in the selection of suitable locations for human habitation, they also play a key role in site formation processes, and are equally relevant to the preservation and distribution of archaeological sites within a given area. The deposition of underwater archaeological sites along the south coast of Louisiana results from two primary causes – watercraft sinking or formerly terrestrial sites becoming submerged through inundation as a result of land subsidence and eustatic sea level rise. This latter form of submergence occurs through one of two marine transgressive processes: "shore-face" retreat, when the coastline slowly regresses inland; or "stepwise" retreat, when in-place drowning of coastal features occurs (Waters 1992). Generally speaking, episodes of marine transgression are essentially periods of erosion, a destructive process that creates less than ideal depositional sequences from an archaeological perspective.

Shore-face retreat describes the erosion of previously deposited sediments by wave and current processes as the shoreline transgresses. It is the dominant inundation regime during the marine transgression process (Waters 1992). As sea level rises, beach-face and shore-face erosional zones, offshore of the present Louisiana coastline, have sequentially passed across the subaerial portions of the relict and current Mississippi River deltaic plains. Older sediments that had been deposited in coastal and terrestrial environments inland of the earlier shoreline get reworked, first by the swash and backwash processes of beach face and then by the waves and currents associated with the upper shore-face breaker and surf zones. The erosion associated with the continuous transgression of the sea reworking these deposits into a thin unconformable geological unit of transgressive lag (i.e., gravel and coarse sand deposits) forms the top of a time-transgressive geological unit known as a "marine unconformity" (i.e., the surface defined by the top of the buried paleosol and the base of the overlying marine deposit). Reworking terrestrial and coastal sediments are referred to as "palimpsest sediments," and the erosional surface marked by the depth of the maximum disturbance by transgression is called the "ravinement" surface. This ravinement surface often shows up quite clearly in subbottom profiler data and can be a useful indicator for the presence of relict paleolandforms (Waters 1992).

Shore-face retreat would have probably been the prevailing marine transgressive regime in the unprotected portions of barrier shorelines within the Ship Shoal area, especially since the regional rate of sea level rise appears to have been slowing considerably at around the same time that the Maringouin Delta Complex was being inundated. As the shoreface moved landward with its shoreline, the upper 15 to 30 ft of the delta complex's depositional units would have been eroded. Material eroded from the headland would be redistributed by longshore currents, which would in turn create barrier islands on the flanks of either side of the deltaic margin's headland. As sea level continued to rise, the deltaic margin's headland would be transformed into a barrier island arc, and then, finally, a inner shelf shoal, such as Ship Shoal (Figure 4) (Cuomo 1984).

Alternatively and to a lesser extent, marine transgression also occurs by the process of stepwise retreat, which is the sudden inundation or in-place drowning of coastal landforms and sediments - a process that has been shown to preserve inundated sites (Waters 1992). Stepwise retreat most commonly occurs at times and in areas of rapidly rising sea level, where the coast is quickly subsiding and the gradient of the transgressed surface is shallow. In the stepwise retreat process, instead of the waves and currents of the shore- and beach-face sequentially reworking older sediments during transgression, the breaker and surf zones jump from the active shoreline to a point farther inland, submerging the older coastal landforms and sediments in an area seaward of the more destructive breaker and surf zones. The surf and breaker zones then stabilize and develop a new shoreline farther inland (Rees 2010; Waters 1992).

In order for stratified, formerly terrestrial archaeological deposits to be preserved underwater in meaningful contexts, intact elements of the paleo-landsurface in which they were deposited must be present. Such deposits would need to have survived the marine transgression process and the subsequent disturbances from modern marine or fluvial processes and/or human activities.

The sandy deposit comprising the present inner shelf shoal that is Ship Shoal consists of transgressive sediments, which were deposited during the past 7,000 years from the eroded distal ends of the Maringouin Delta Complex and have been churned, reworked, and redeposited by wave and current regimes for several thousands of years (Braud-Samuel et al. 2003) (see Figure 4). While Braud-Samuel et al. (2003) note that no archaeologically sensitive paleochannel features were found within the 2003 C&C survey area, relict Holocene paleochannel features dating from between about 6,200 and 7,000 B.P. have been found preserved in the vicinity of Ship Shoal during other surveys.

Since it is likely that the Maringouin Delta Complex was inhabited by people during much of the Middle Archaic period, it is possible that displaced heavy, durable artifacts (e.g., stone projectile points and grinding stones), as well as shellfish remains, associated with eroded and reworked Middle Archaic archaeological deposits and shell middens, would be incorporated into the matrix of sandy sediments now forming Ship Shoal. Any pre-contact period ancient Native American archaeological materials now existing within Ship Shoal's sand will have been removed from their original depositional context by the many years of wave- and current-driven erosion and reworking, and, thus, would have little or no possibility of possessing the necessary contextual integrity for National Register eligibility.

Post-Contact Period

The history of post-contact period navigation of coastal Louisiana's waters spans nearly 500 years, as watercraft have served as the principal means of transportation throughout the region. This long period of maritime activity and the navigational hazard that Ship Shoal (which was "Ship Island" prior to ca. 1816, when the last subaerial vestige of the island was submerged [Figure 5]) has represented to mariners and their vessels across the centuries have combined to result in a large number of vessel casualties in the area around Ship Shoal. Consequently, Ship Shoal and the Project study area possess a high probability for containing shipwrecks (Braud-Samuel et al. 2003).

Early sailing routes typically followed the coast, as overland travel in southeastern Louisiana's marshes and swamps was limited (Braud-Samuel et al. 2003). Open ocean waters of the Gulf and around Ship Shoal were navigated during the earlier post-contact period primarily in sloops, schooners, brigantines and barks (Nowak et al. 2010). Vessels typically carried merchandise, foodstuffs, sugar, cotton, and manufactured goods between New Orleans and Brashear City (Morgan City), Galveston, Texas, and the region's smaller ports.

Passenger trade between New Orleans and Texas increased during the 1820s as emigration and settlement of the region expanded. Growth in vessel traffic intensified further in the middle 1800s, as settlement and agricultural production around the lower Bayou Teche town of Franklin grew and the town developed into an important local port for coastal and oceanic vessel traffic (Braud-Samuel et al. 2003). In the years before the Civil War, significant advances were made in ship design and construction. Swifter sailing vessels and the use of steam power were increasing, as vessels navigating the waters around Ship Shoal included everything from small coastal vessels to large clippers, full-rigged ships, and steamships. Iron and steel components were also seeing increasing use in ship construction (Nowak et al. 2010). This increasing vessel traffic and recognition of the dangers posed by Ship Shoal led to the stationing of the lightship Pleasonton (formerly the Revenue Cutter McLane) at the shoal in the late 1840s. The lightship was replaced by the 125 ft tall, iron, screw-pile-type Ship Shoal Lighthouse, which was erected at the west end of the shoal. The lighthouse remained operational until the 1970s, and was still standing at the time of the C&C survey in 2003 (Braud-Samuel et al. 2003).

Southern Louisiana is among the most productive natural areas in the United States and the world (Pitre 1983). Therefore, it's not surprising that many in the region turned to fishing for a living after the Civil War, working within the growing shrimp and oyster fisheries, which expanded with the advent of canning in the region in the late 1860s. Until ice became economically feasible late in the nineteenth century, distance and heat restricted access to markets and commercial fishing was limited to small-scale operators who lived off their catch (Pitre 1983). The most commonly employed ships in these fisheries were 20 to 40 ft luggers or "canots," which were a distinctive Acadian vessel powered by red lateen sails tanned with bark. The canot resembled a gaff-headed sloop, with an outboard rudder, open cockpit, and a closed forecastle with a hatch. Other small-craft frequenting southern Louisiana's coastal waters in use at the time included sloops, cat boats, and schooners, which were used for recreational excursions, fishing and bird hunting, although few of these smaller vessel types would have frequented the waters as far off shore as Ship Shoal (Nowak et al. 2010).

Following the removal of the Union blockade of southern ports, commercial shipping resumed along the Gulf Coast, although the American merchant marine never regained its antebellum status due to lost markets and increased costs related to insurance, crews and shipbuilding. The new traffic that moved along coastal Louisiana and along new traffic patterns to Gulf ports and ports all over the world (e.g., the Caribbean, the East Coast of the U.S.; Europe, and South America) was increasingly controlled by foreign interests. Steamers hauled freight and towed barges in the Gulf and on the bays, rivers and bayous (Nowak et al. 2010).

The significant contribution of shipping and fishing to the economy of southern Louisiana continued and increased into the middle and late twentieth century. Development of the "otter trawl" in the 1920s ushered in the shrimp fishery's growth into one of the region's most economically important industries. By the middle of the twentieth century, shrimp trawlers had become the most common vessel type on the Gulf waters of Louisiana and the waters around Ship Shoal (Braud-Samuel et al. 2003).

Two new commodities (oil and natural gas) discovered during the late nineteenth and early twentieth centuries quickly became the dominant forces in not only Louisiana's economy, but in the world economy. The discovery of these energy resources off of the southern shore of Louisiana in the late 1940s ushered in a new era in the history of human settlement and activity in the region, and brought with it a variety of new vessel types (e.g., crew and supply boats, drilling rigs, jack-up barges, etc.). Numerous enterprises have explored Louisiana's Gulf waters in search of oil and natural gas, building numerous permanent offshore wells, platforms, pipelines and facilities in the immediate vicinity of the Project area.

Oil and gas production, as well as fishing (shrimping in particular), remain the region's principal economic activities. Modern navigation improvements, like the advent of radar and GPS, have greatly reduced the chance for shipwrecks to occur, although numerous fishing and recreational watercraft, as well as barges, tugboats, and work boats have all been lost in Louisiana's coastal Gulf waters in vicinity of Ship Shoal, some as a result of the region's numerous hurricanes and tropical storms (e.g., the hurricanes of 1909, 1915, 1920, 1928, 1934, 1949, 1956, 1957 (*Esther*), 1965 (*Betsy*), 1974 (*Carmen*), 1977 (*Babe*), 1979 (Bob), 1985 (*Juan*), 1992 (*Andrew*), 1998 (*Hermine*), and 2005 (*Katrina* and *Rita*) (Nowak et al. 2010). Braud-Samuel et al. (2003) include a list of 20 vessel casualties and unidentified obstructions reported for the waters within a five-mi radius of the 2003 C&C survey area, as documented in a study completed by Panamerican Consultants, Inc. ("Panamerican") (2003). Six of the vessel casualties/obstructions, all of unknown dates, are reported within South Pelto Lease Block 14 (see Braud-Samuel et al. 2003:23).

Although the region's post-contact history of maritime activity spans nearly five centuries, documented shipwrecks in the area included in the Panamerican (2003) inventory are exclusively those dating from second half of twentieth century. Rather than being a conclusive indicator of a low potential for earlier, undocumented wrecks to be present, this may be seen more as a function of the relatively greater number and size of vessels that navigated the region's waters during this later period, improved communications, and the relatively greater preservation one might expect of vessels deposited more recently into the archaeological record. Simply put, the more recent a ship's loss, the better will be the documentation of that loss, and the more intact and easier to find will be its remains. Conversely, it is the older, less-well documented or undocumented vessels, whose more degraded, buried, wooden-hulled remains, such as those of early colonial vessels, which, if found during the course of a survey, would be more likely to qualify as a National Register-eligible historic property upon evaluation.

The extent to which any vessel lost in the Project study area will be preserved is dependent upon multiple factors, which include the age of the shipwreck, the vessel's size and the materials used in its construction (i.e., wood versus iron or steel), the cause of loss (i.e., fire, explosion, grounding, foundering, etc.), the type of cargo it was carrying at the time of loss, and the prevailing environmental conditions at the shipwreck site (includes both natural conditions and post-depositional anthropogenic disturbances). As Braud-Samuel et al. (2003) note, the waters on and around Ship Shoal represent a high-energy environment in which waves, especially those produced during strong storms (i.e., hurricanes), disturb and churn the sediments comprising the upper portion of Ship Shoal's stratigraphy.

This wave action and Ship Shoal's mobile sediment matrix would not be generally conducive to the preservation of intact shipwreck sites, especially in the Shoal's shallower, higher-energy areas. This is particularly true of wooden-hulled vessels, the remains of which would be more likely to be more rapidly broken up, dispersed, and buried beneath Ship Shoal's shifting sands, than would the remains of an iron- or steel-hulled vessel. The Shoal's shifting sands would also likely result in shipwreck remains becoming periodically exposed and reburied. As a consequence of Ship Shoal's high-energy environmental conditions, detection of undocumented shipwrecks in the Project study area could be relatively difficult, with a magnetometer (rather than a sidescan sonar) and the identification of clusters of multiple anomalies of varying amplitudes distributed across adjacent survey tracklines potentially serving as the most effective instrument and technique of archaeological detection and presence/absence determination.

Geophysical Data Assessment

Assessment of OSI's 2011 geophysical survey data is presented here. Specific information regarding the method and results of the geophysical survey, as well as data plots, representative examples, survey logs, and magnetometer anomalies and sidescan sonar target inventories derived from the data, and developed and presented in compliance with the guidelines outlined in BOEM NTL No. 2005-G07, are included in OSI's 2012 G&G survey report, to which the reader is referred for more detailed information associated with this archaeological assessment.

Assessment of Bathymetry Records

Water depths recorded by OSI during the 2011 survey ranged from less than 27 ft to greater than 41 ft below NAVD88 (OSI 2012). The seafloor within the survey area slopes downward toward the south, with the slope increasing further offshore. Post-processing and contouring of the depth surface generated from the hydrographic data and the side scan sonar mosaic depict a relatively featureless bottom without any large-scale bedforms or bathymetric areas suggestive of an intact shipwreck or scattered shipwreck materials extending above the seafloor (OSI 2012).

Assessment of Magnetometer Records

Analysis of the magnetometer data identified a total of 98 inventoried magnetic anomalies (OSI Project Drawing 3, Magnetic Anomaly Summary Table – Appendix 4 OSI Report 11ES008-I), as well as four linear alignments of anomalies that correlate with charted pipelines located outside of the proposed Borrow Area limits (i.e., two along the southwestern edge, one along the western edge, and one along the northeastern edge of the survey area). Most (59) of the magnetic anomalies are small, less than 15 gammas, isolated, and scattered throughout the area. These anomalies are indicative of small, isolated ferrous objects for which avoidance is not recommended. Of the remaining 39 magnetic anomalies, four are distributed in two clustered anomaly pairs (M64/M67 and M70/M73) identified as potential shipwrecks/shipwreck materials. Although these anomalies are located over 2,400 ft southwest and outside of the proposed Borrow Area, avoidance using a 500-ft radius buffer zone centered on each anomaly pair, or additional archaeological investigation to ascertain the sources of each anomaly pair cluster, is recommended. These anomaly pairs and their associated buffer zone are designated as Avoidance Area 'A' in OSI's 2012 report's project drawings. The remaining 35 inventoried magnetic anomalies either correlate with the locations of anomalies previously identified by the 2003 C&C survey in Braud-Samuel et al. (2003) as buffer zones "6", "8" and "9," for which continued buffer zone maintenance is recommended, or they have characteristics that are suggestive of isolated ferrous objects/modern debris, rather than shipwrecks or shipwreck materials, for which avoidance (for historic preservation purposes, alone) is not recommended.

Assessment of Sidescan Sonar Data

Analysis of the sidescan sonar data acquired and post-processed by OSI in 2011 identified a total of 79 acoustic targets on the seafloor surface (see OSI 2012). Most (61) of the side scan sonar targets are very small (less than 10 ft long) and appear to be isolated debris. Fifteen (15) of the targets are associated with magnetic anomalies. One of the acoustic targets (SS20) lies within Avoidance Area A and appears to be associated with the magnetic anomaly pair cluster M64/M67. The remaining acoustic targets have no associated magnetic anomalies and are all considered to be single non- or low-ferrous objects, cable, pipe or geological features that are not recommended for avoidance.

Assessment of Subbottom Profiler Data

Analysis of the subbottom profiling data identified no evidence of relict channels or other archaeologically sensitive buried paleo-landforms in the survey area, as illustrated in OSI project drawings included in their 2012 report.

Geotechnical Data Assessment

Analysis of logs and color photographs of the vibratory cores acquired, split, and prepared in support of the project documented fine sand overlaying silt and clay at depth in all of the cores.

The total thickness of sands and silty sands in the cores ranged from 14 to 20-plus ft. No evidence of archaeologically sensitive buried paleosols were observed in any off the cores. Based on these results, no additional geotechnical sampling to identify archaeological paleosols is recommended.

SUMMARY AND RECOMMENDATIONS

Research indicated that the sands within the vertical and horizontal limits of the Ship Shoal Project study area are part of a dynamic, high-energy, contextually disturbed environment that derives from an archaeologically sensitive landform that was subaerially exposed between ca. 7,000 and 6,200 B.P., with a small portion of the shoal's western end remaining exposed at low water up until the early nineteenth century. South Pelto Lease Blocks 13 and 14, in which the Project study area is located, have a high sensitivity for contacting out-of-context, pre-contact period, ancient Native American archaeological deposits dating from its time of exposure (i.e., ca. 7,000 to 6,200 B.P.). South Pelto Lease Block 14 was identified as having a high sensitivity for containing submerged post-contact period shipwrecks. Research also indicated that there were no previously identified pre- or post-contact period archaeological deposits within the Project study area. Archaeological assessment of the geophysical and geotechnical survey data acquired for the Project in 2011 indicated that there are no bathymetric targets, magnetic anomalies, side scan sonar targets or subbottom profiler reflectors that appear to be submerged cultural resources within the Project study area (i.e., the Borrow Area or Expansion Area). ***Consequently, no additional archaeological investigation is recommended for the Ship Shoal Project study area (i.e., the Borrow and Expansion areas).***

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FIGURES

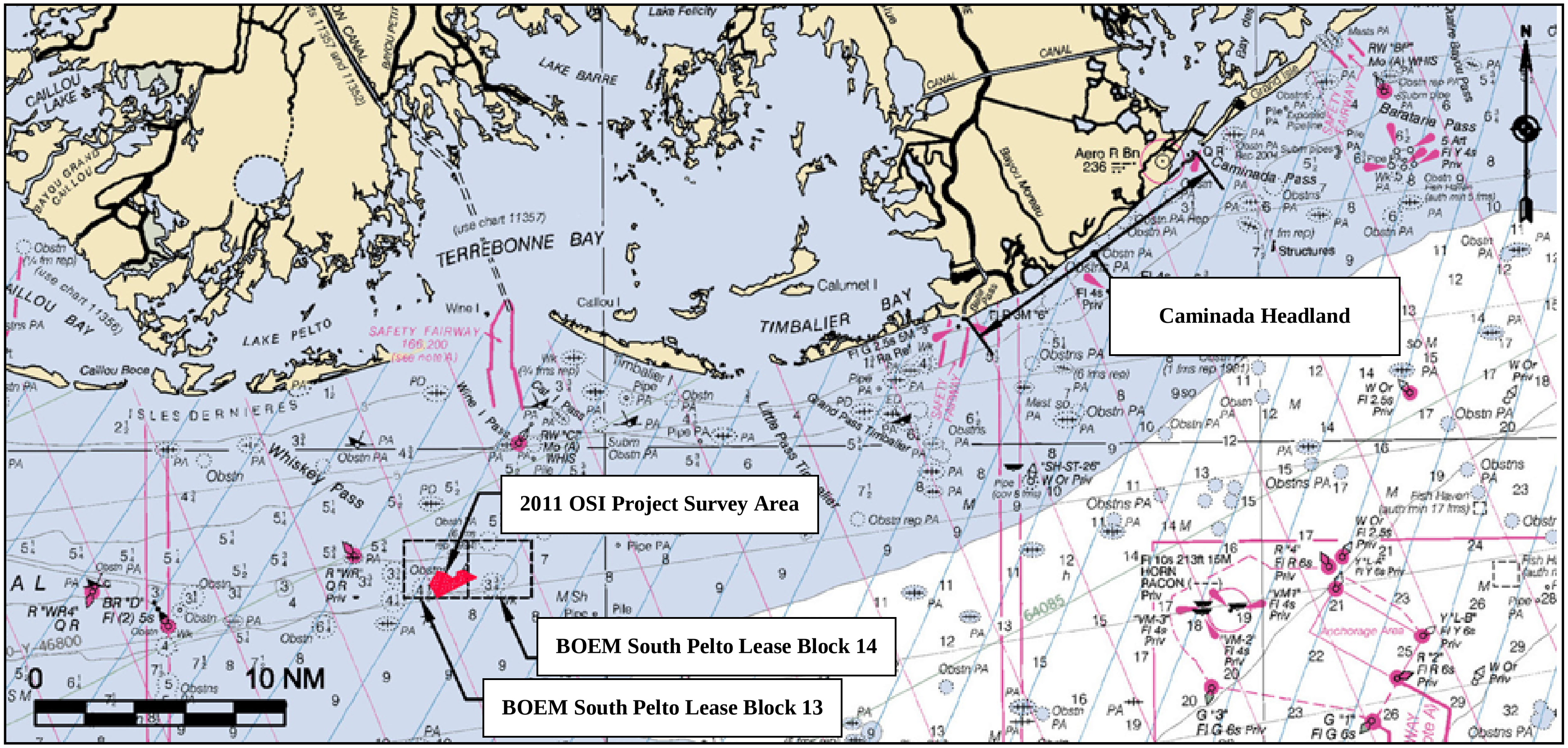


Figure 1. Location of the 2011 OSI Project Survey Area within BOEM South Pelto Lease Blocks 13 and 14 relative to the Caminada Headland (source: after OSI 2011).

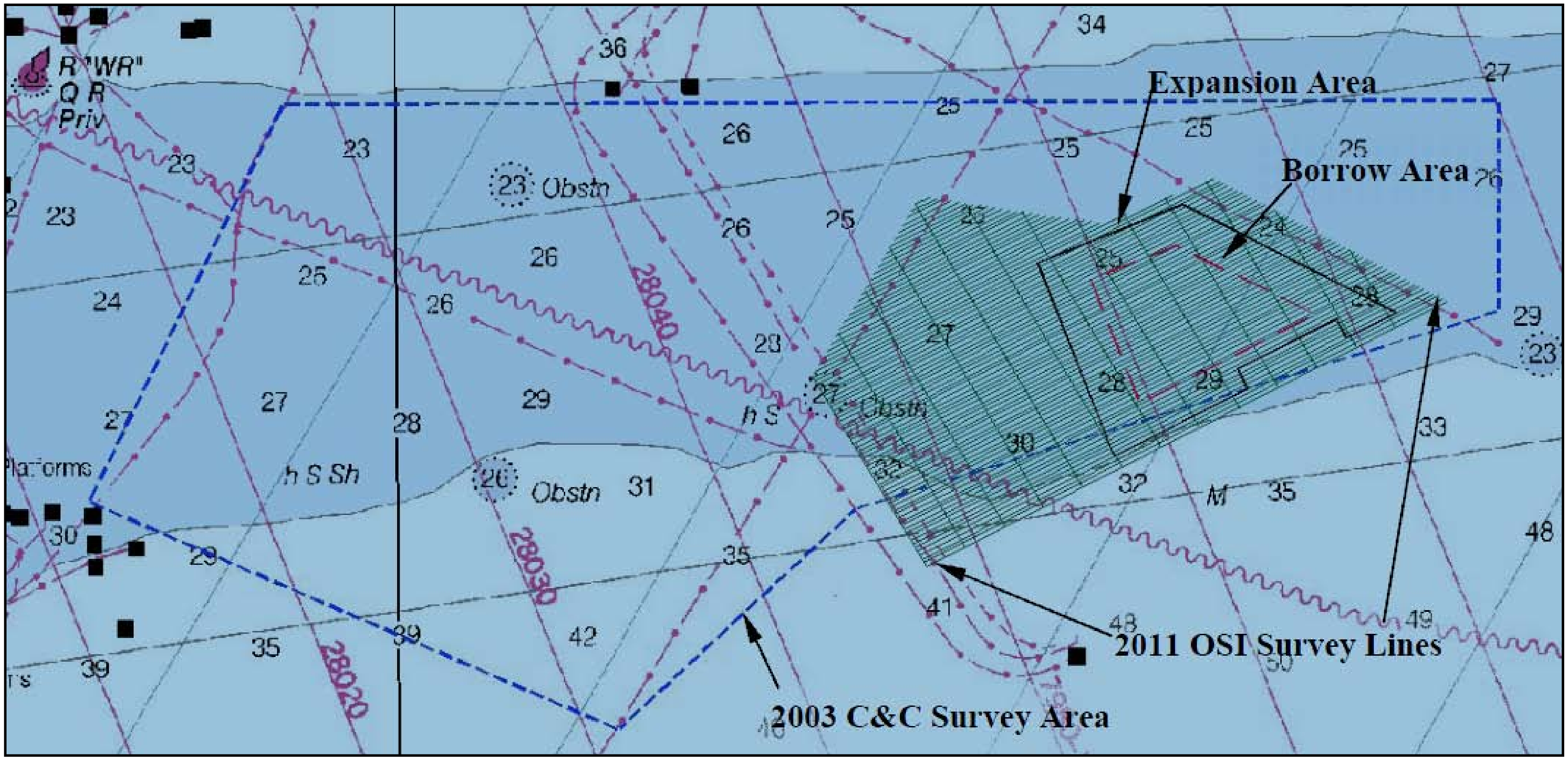
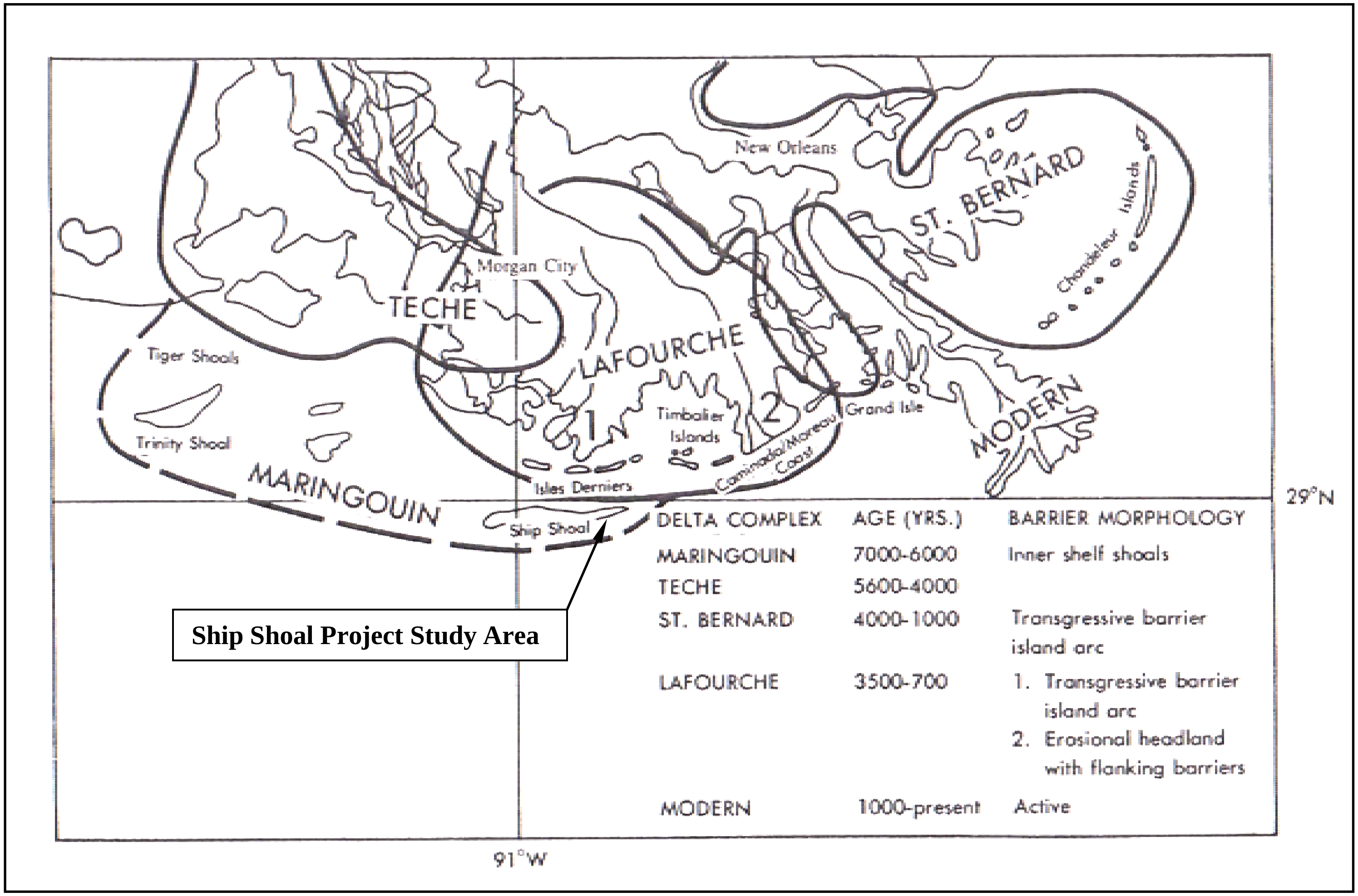


Figure 2. Location of the Project Borrow Area and Expansion Area within the 2011 OSI Survey Area and 2003 C&C Survey Area (image source: OSI).



DELTA COMPLEX	AGE (YRS.)	BARRIER MORPHOLOGY
MARINGOUIN	7000-6000	Inner shelf shoals
TECHE	5600-4000	
ST. BERNARD	4000-1000	Transgressive barrier island arc
LAFOURCHE	3500-700	1. Transgressive barrier island arc 2. Erosional headland with flanking barriers
MODERN	1000-present	Active

Figure 3. Development of the Mississippi River deltaic plain over the last 7,000 years, showing the location of Ship Shoal and the Project Study Area relative to the ca. 7,000 to 6,000 B.P. Maringouin Delta Complex (source: Cuomo 1984).

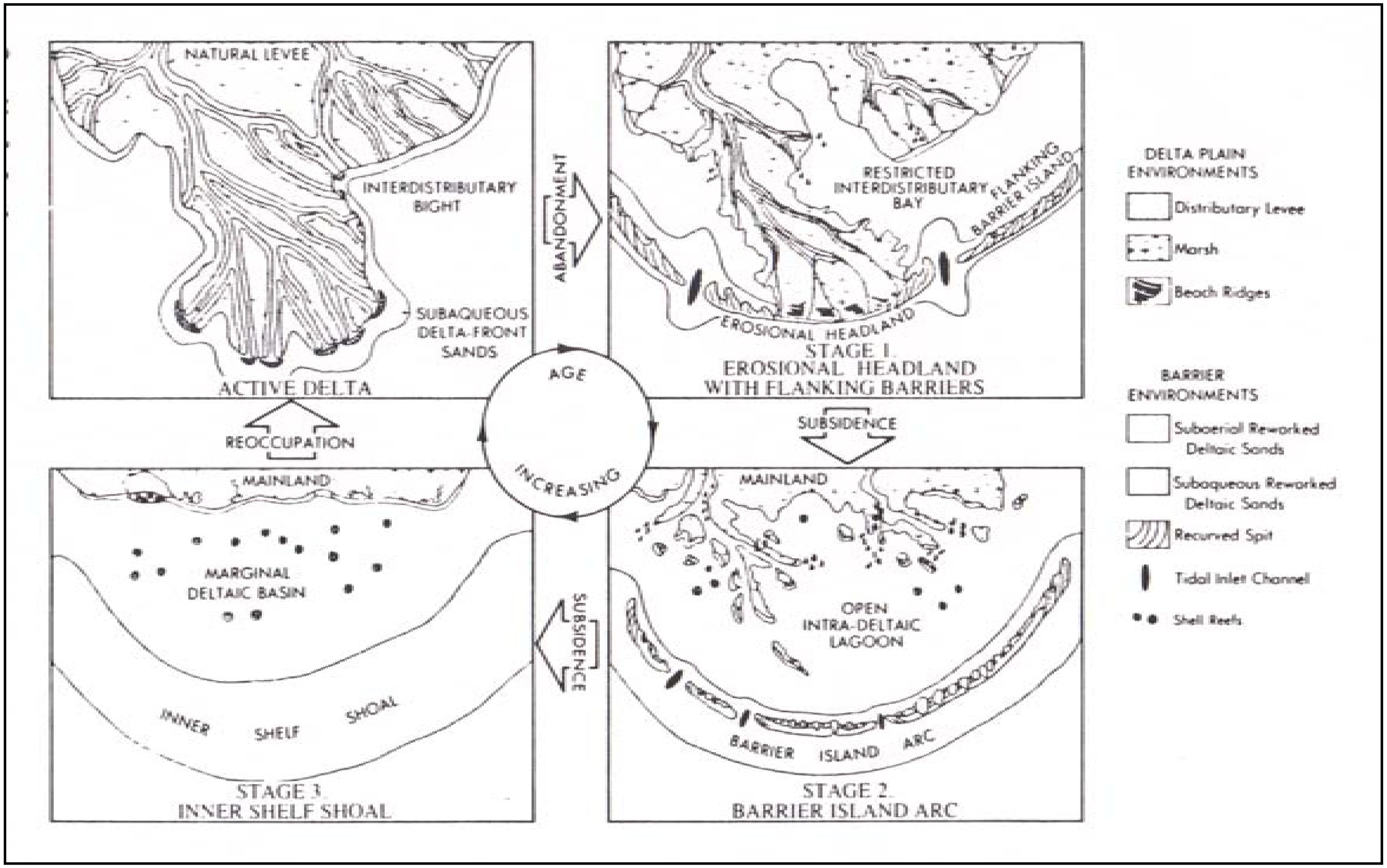


Figure 4. Model for coastal development in Louisiana showing the stages in the formation of an Inner Shelf Shoal, such as Ship Shoal (source: Cuomo 1984).

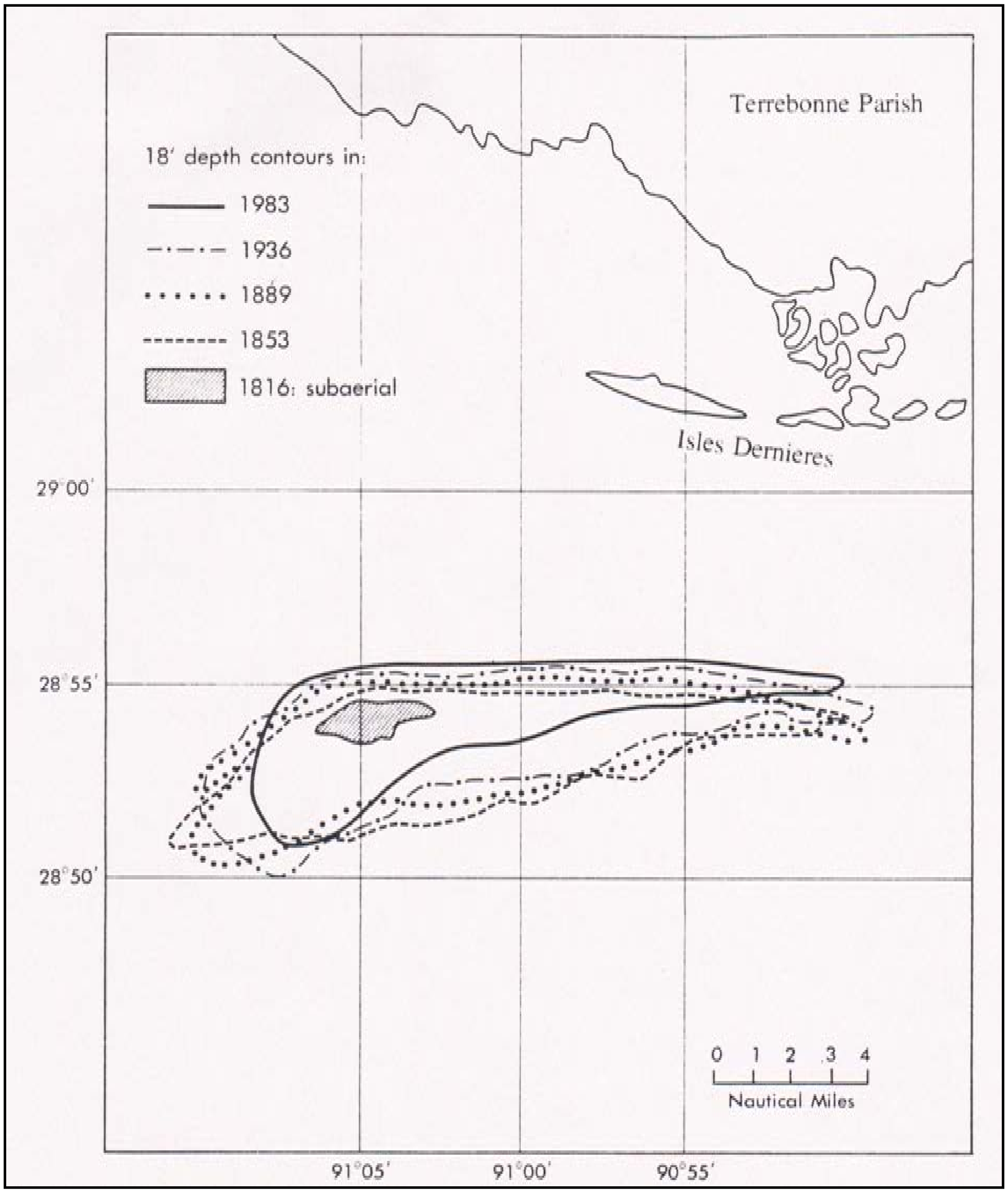


Figure 5. Chronological sequence of changes in the shape and position of Ship Shoal along the 18 ft depth contour (ca. 1816 to 1983) demonstrating the dynamic nature of the deposit. Sequence is based on historic charting (note: the subaerial exposure of a small area of the shoal's northwest portion ca. 1816. This exposure corresponds to contemporary references to the shoal as "Ship Island" in the early 1800s [Cuomo 1984; Dixon 2009; Sallenger 2009]) (source: Cuomo 1984).

APPENDIX A

STUDY PREPARED FOR

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

New Cut Dune/Marsh Restoration Project
Using Ship Shoal Sediment
Coastal Terrebonne Parish, Louisiana

High Resolution Geophysical and Archaeological Survey of the South Pelto Area Block 13 Vicinity of Ship Shoal

By

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EPA 68-W-02-009
Work Assignment 1-02
CEI Job # 23028
C&C Project # 4037-4040 (South Pelto 13)

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ENCLOSURES

EXECUTIVE SUMMARY

- C & C Technologies, Inc. performed a geophysical subbottom profiling and mapping survey offshore of coastal Terrebonne Parish, Louisiana on a portion of the Ship Shoal sand body in South Pelto Area Blocks 12, 13, 14, 18 and 19.

- This work was performed under EPA Contract No. 68-W-02-009 for the New Cut Dune/Marsh Restoration Project, a portion of Work Assignment No. 1-02.

- The purpose was to complete a Minerals Management Service (MMS) archaeological and hazard evaluation and to identify the thickness of the Ship Shoal sand body within the study area.

- Seafloor depths range from -26 to -48 feet Mean Lower Low Water (MLLW) across the survey area.

- The seaward side of Ship Shoal dips to the south-southeast at a maximum gradient of about 0.3°, and the landward side dips to the north-northwest at a maximum gradient of about 0.7°.

- Isopach values of sand comprising the linear Ship Shoal sand feature indicate thickness varies from 10 feet in the northern region to 2 feet in the southern region, with 18 feet maximum in the central region.

- Twelve sonar targets were detected by the side scan sonar system. One of the targets is a debris zone with multiple small targets.

- Eight existing pipelines traverse across the survey area, and seven more exist on the outskirts.

- Six production platforms and two wells also exist just outside the bounds of the survey area.

- Eleven identified magnetic clusters and three associated sonar contacts are recommended for avoidance based upon archaeological potential.

- Dredging, anchoring, and coring activities should take note of and avoid the locations of all sonar targets, pipelines, and other man-made infrastructure.

GEOHAZARD ASSESSMENT

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA), Region 6 serves as a member of the Federal Task Force created by the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), P.L. 101-646, to carry out wetlands restoration projects in coastal Louisiana. The EPA is designated to implement several of these restoration projects in Louisiana, including the New Cut Dune/Marsh Restoration project located in coastal Terrebonne Parish. The New Cut project site is located between East Island and Trinity Island of the Isles Dernieres barrier island chain in southern Terrebonne Parish. The EPA proposes to excavate sand from the eastern portion of the offshore sand body known as Ship Shoal and transport the dredged material to New Cut to restore dunes and marsh. The area from which sand is to be dredged for this project lies in Federal waters of the Gulf of Mexico approximately 9.5 miles south of Isle Dernieres. This offshore area is defined as the "study area" for the present project and contains 10.37 square miles of area encompassing portions of five lease blocks (12, 13, 14, 18 and 19) in the South Pelto Area. The specific locations from which sand will be dredged within the study area will be delineated on the basis of environmental, engineering, and archaeological investigations, including the present study.

Coastal Environments, Inc. of Baton Rouge, Louisiana subcontracted C&C Technologies, Inc. to perform an Archaeological and Hazard Study under the EPA Contract No. 68-W-02-009 for the New Cut Dune/Marsh Restoration Project (a portion of Work Assignment No. 1-02). The purpose of the high-resolution geophysical survey was to determine the thickness of the Ship Shoal sand body, identify any potential hazards or engineering constraints to dredging and mooring activities, determine the water depths and seafloor and subbottom conditions, and assess cultural resource potential. The survey was conducted in compliance with the latest Minerals Management Service guidelines as defined in Notice to Lessee (NTL) No. 2002-G01, dated March 15, 2002 and entitled *Notice to Lessees and Operators of Federal Oil, Gas, Sulphur, and Salt Leases and Pipeline Right-of-Way Holders in the Outer Continental Shelf, Gulf of Mexico OCS Region* (U.S. Department of Interior, Minerals Management Service 2002). In the following discussions the "survey area" refers to the area encompassed in the survey grid, which was slightly larger than the study area as defined above.

Field operations were conducted aboard the R/V *Ocean Surveyor* between July 31 and August 7, 2003. Sea state ranged from 1 to 5 feet and the data quality was adequate for the geophysical interpretation. The average speed during the survey was 3.5 knots. The survey was conducted on a 24-hour, round the clock basis, except during brief periods of down time due to weather conditions or instrument problems. Complete coverage of the study area was achieved by conducting the survey on a 50-meter grid as specified by NTL No. 2002-G01. This grid consisted of a total of eighty-eight (88) east-west primary tracklines (Line Nos. 1 to 88) spaced 50 meters (164.05 feet) apart and eleven (11) north-south tie lines (Line Nos. 89 to 99) spaced 900 meters (2,952.9 feet) apart. Lines Nos. 100 to 102 were acquired for the correlation of subbottom data to borings done in previous studies (Kulp et al. 2001). A total of 410.55 line miles of survey were conducted in the study area. Geophysical instruments utilized for the survey included an EdgeTech 500 kHz Side Scan Sonar, Odom Echotrac DF 3200 Bathymetric System, Geometrics 880 Cesium Magnetometer and SB-0512 Subbottom Profiler. Horizontal positioning of the survey vessel was accomplished using the C-Nav globally corrected GPS system. A Coast Guard beacon was monitored as a secondary source of differential corrections. Brief descriptions of the survey protocol and instruments used are provided below; specific information on these instruments and their deployment, settings, calibrations and performances are provided in the appendices.

WinFrog integrated navigation software, run on a Windows operating system, was used for all navigation and to integrate all of the various data collection systems used. The WinFrog navigation system used DGPS positioning to ensure ± 16-feet accuracy. The magnetometer used was a Geometric Model 880 Cesium Magnetometer. The magnetometer sensor was fitted with a depth gauge and was towed no more than 19.6 feet above the seafloor and 300 feet aft of the survey vessel to eliminate magnetic interference. The magnetometer sensitivity was maintained at one gamma or less, the sampling interval did not exceed one second and the background noise level did not exceed ± 3 gammas. The side scan sonar used was an EdgeTech Model 260, dual-channel, dual frequency system that provided continuous planimetric images of the seafloor. The side scan sonar was operated in a frequency range of 500 kHz and at a swath width of 164.05 feet to ensure 100 percent coverage of the study area.

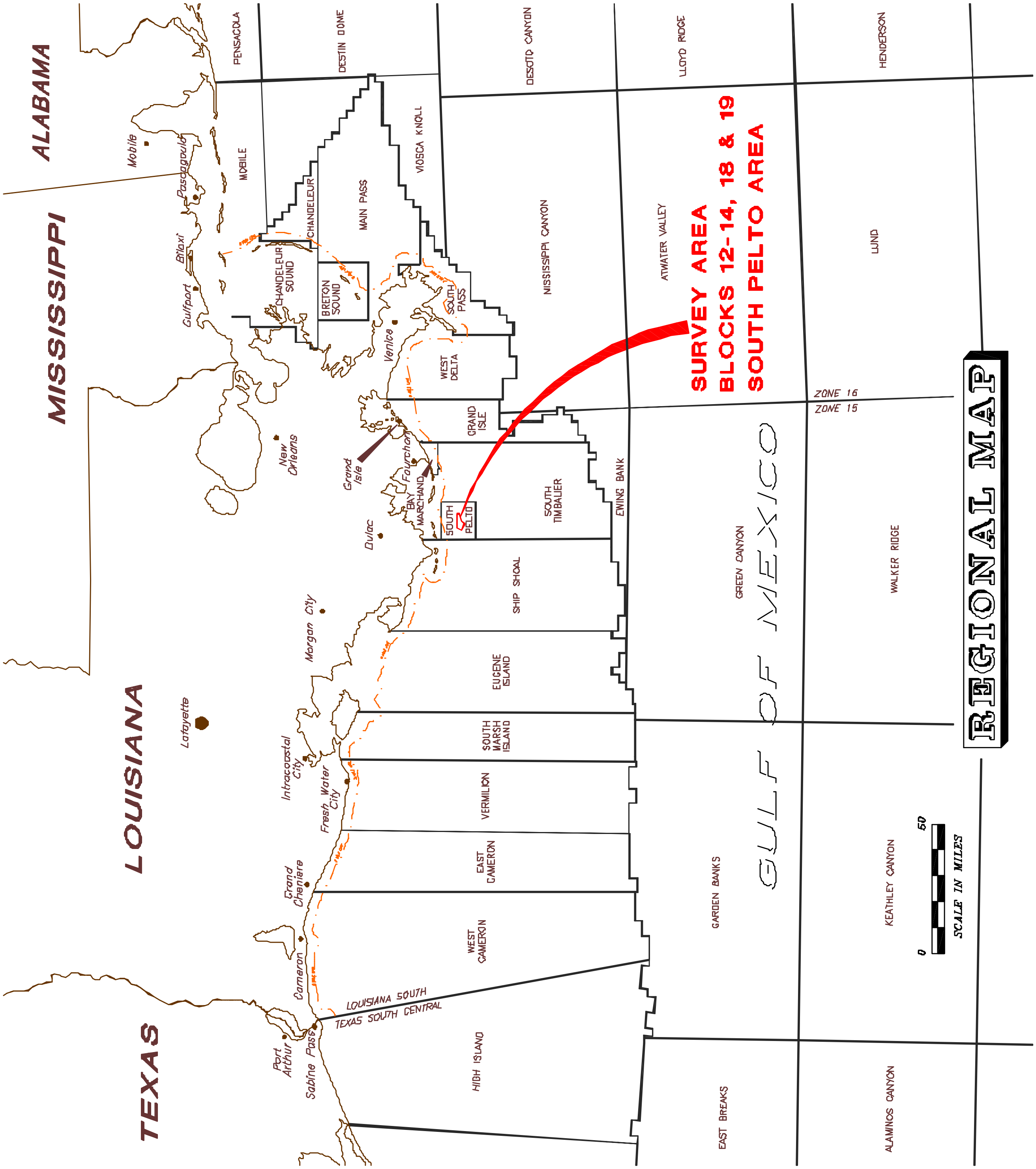
The Edgetech Geostar Model SB-0512 (CHIRP) Subbottom profiler was used to obtain subbottom data. The system was towed behind the survey vessel and was operated at a frequency of 2-to-10 kHz over 20 milliseconds. These operating parameters were selected after several tests to determine which frequency settings provided optimum subbottom data. A hull mounted, high frequency, narrow beam Odom Echotrac DF 3200 Bathymetric System was used to obtain bathymetric data. To ensure accuracy in water depth measurements, the water column sound velocity was calibrated at the start and end of the survey using a Seabird CID-19 velocimeter.

All of the remote-sensing data were displayed visually during the survey and monitored on a continuous basis. All data were also recorded digitally for later processing and analysis.

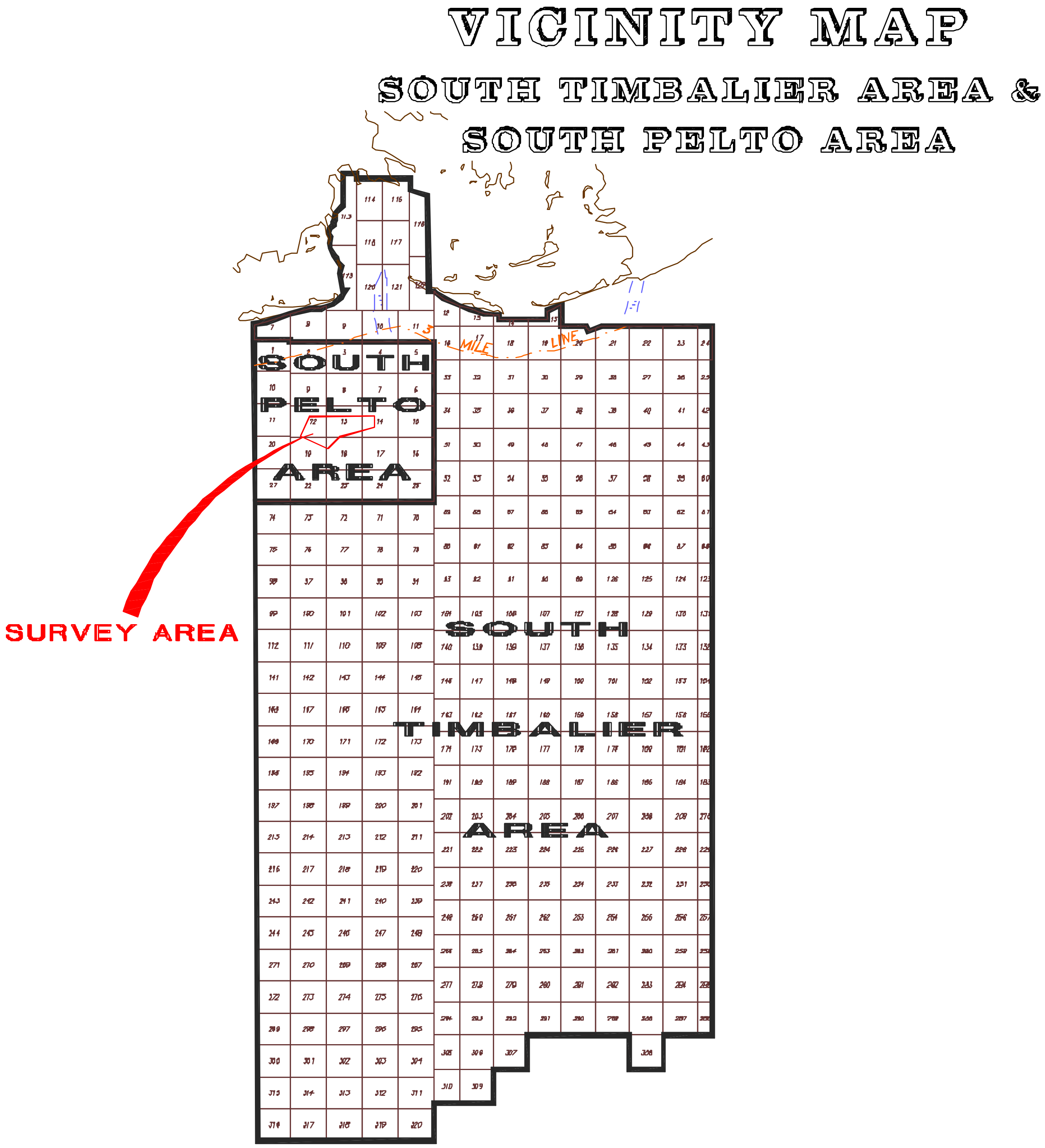
Geophysical data reproductions of pertinent features in the area may be observed in Appendix A. Magnetic Anomaly Tables and a nomogram for estimating the size of ferrous sources are included in Appendix B. A personnel list, boat setback diagram, a copy of the daily survey logs, instrument settings, and equipment descriptions are provided in Appendix C. Appendix D contains the tide curves and sound velocity data used to correct the bathymetric data used to construct the Bathymetry Map (Sheet 1). Appendices E, F and G contain the daily progress reports, bore logs and reduced study maps, respectively.

Geophysical data collected from the remote sensing systems were reviewed for geologic interpretation and evidence of potential hazards to dredging and mooring activities. The survey results are projected on the Archaeological and Hazard Map (Sheet 2). Isopach thicknesses are presented as contours on the Sand Isopach Map (Sheet 3). The following written text is intended to be viewed in conjunction with the study maps to provide a comprehensive explanation of the seafloor and subsurface features within the study area. Regional and Vicinity Maps are included on the following two pages (Pages 4 and 5).

GEOHAZARD ASSESSMENT



GEOHAZARD ASSESSMENT



2.0 REGIONAL GEOLOGIC SETTING

The New Cut Dune/Marsh Restoration Project offshore study area is located on the Inner Continental Shelf in the Gulf of Mexico in a region that has been influenced by two principal geological processes throughout the late Pleistocene and the Holocene (10,000 years ago to present). The first process is the cyclical marine regression-transgression sequences that have resulted from fluctuating sea levels operating in response to episodes of Pleistocene glaciation and deglaciation. The second process is the deltaic processes of the sediment-dominated Mississippi River.

Most of the seafloor beneath the New Cut study area consists of a large, submarine sand body known as Ship Shoal. A considerable amount of research has been conducted on the geology, geomorphology and sediment character of Ship Shoal, particularly in relationship to its potential as a source of sand for restoring portions of Louisiana's rapidly eroding coastline (see particularly Kulp et al. 2001; Penland et al. 1985, 1986; Stone 2001; Suter et al. 1985; Williams et al. 1989). Underlying and adjacent to the Ship Shoal region is a 125- to 150-foot-thick wedge of deltaic sediments deposited by the Mississippi River over the past 10,000 years or so. As with Ship Shoal, the processes of the Mississippi River Delta formation and their sequences have been intensively studied and are reasonably well known (Coleman and Gagliano 1996; Frazier 1967; Saucier 1994). These sources on Ship Shoal and Mississippi River deltaic geology have been extensively relied upon in the following geologic synthesis. In addition, information has been drawn from reports of several geophysical studies that have been conducted in the vicinity of the study area. These studies were conducted relative to oil and gas production activities in the region and they provide information on the shallow subsurface geology derived from seismic instrument surveys.

The sand-rich feature known as Ship Shoal comprises most of the seafloor in the study area. Ship Shoal is the largest and easternmost of a series of sand shoals that have developed on the Inner Continental Shelf of Louisiana as a result of deltaic abandonment and marine transgression (Kulp et al. 2001). The elongated shoal lies parallel to the coast approximately 8 to 12 miles off of coastal Terrebonne Parish, and measures approximately 30 miles long in an east-west direction. The central portion of the shoal ranges between 2.5 and 5 miles wide, while at its eastern and western ends, width ranges between 3 and 6.2 miles.

Ship Shoal is a transgressive sedimentary feature formed in the past 7,000 years or so from sediments eroded from the distal ends of deltaic features associated with an early Mississippi River Delta system known as the Maringouin Delta Complex. The Maringouin Complex was formed when the Mississippi River occupied the western portion of its valley in lower Louisiana from about 6,000 to 7,500 years before present (B.P.) (Frazier 1967; Saucier 1994). Saucier (1994) suggests that Maringouin Delta Complex development began when sea level was perhaps 25 feet lower than at present. At its maximum extent, the Maringouin Delta Complex projected onto the inner shelf off Louisiana to a point seaward of the present position of Ship Shoal; although exactly how far seaward is unknown. As it prograded into this area, the Maringouin Complex deposited the typical stratigraphic sequence associated with deltaic systems which includes sediments associated with prodelta, channel, natural levee, backswamp, lake and marsh environments. The position of the main distributary of the Maringouin Complex is not known, but relict subjugate distributary channels associated with Maringouin Delta surfaces have been identified in subbottom profiler records collected in the central and western areas of Ship Shoal (Gulf Ocean Services 2001; Intersea Research, Inc. 1985; Penland et al. 1985; Thales GeoSolutions 2002).

Frazier (1967) argued that the Maringouin Delta Complex was the earliest Holocene Mississippi River deltaic feature extending into the offshore waters of central Louisiana. However, Penland et al. (1988), relying on seismic and vibracore data, maintain that an earlier Holocene deltaic feature underlies the Maringouin Complex in offshore central Louisiana. They designate this earlier delta the Outer Shoal Delta Complex and others have suggested that it dates between 9,200 and 8,200 years B.P. (Saucier 1994). The top of the Outer Shoal Delta Complex is a ravinement surface that occurs at a depth of 45 to 75 feet along the central Louisiana coastline. No definitive information on the aerial extent of this postulated early delta complex is available and it is unknown if it extended into the South Pelto lease area or the vicinity of the present study area.

Frazier (1967) and others have argued that about 6,000 years B.P. the main course of the Mississippi River shifted to the east, abandoning the distributaries of the Maringouin Delta Complex and starting new deltaic deposition in southeastern Louisiana. This view holds that the Mississippi did not shift back to the west and begin another cycle of delta building off the central Louisiana coast until about 3,800 years B.P. with the establishment of what is termed the Teche Delta Complex. However, recently Saucier (1994) has proposed that the abandonment of the Maringouin Delta Complex was because of sea level rise, not because the Mississippi River shifted to the east. Saucier (1994) argues that continued sea level rise after about 6,000 years B.P. submerged large portions of the Maringouin Delta Complex, causing erosion, abandonment of distributaries and subsidence, all of which resulted in a shift of the loci of deltaic sedimentation farther inland. Subsequently, beginning about 4,500 years B.P. new distributary courses formed in the same area as the earlier Maringouin main channel and new deltaic sedimentation began to extend onto the older, now eroded and subsided Maringouin surface. This new delta feature is known as the Teche Delta Complex.

Regardless of the mechanism, once the fluvial sediment supply into the Maringouin Delta Complex distributaries began to be eliminated about 6,000 years ago, deltaic expansion ended and a period of deterioration began. The loosely consolidated sediments and organic deposits within the Maringouin Delta compacted, leading to subsidence. Subsidence, coupled with actual sea level rise, resulted in a rapid relative sea level rise. Some have estimated relative sea level rise in central coastal Louisiana to have been on the order of 0.40 to 0.54 inches per year (Penland et al. 1985); although others suggest a much lesser rate (Saucier 1994). Rising sea level, together with cessation of delta growth, led to erosion of deltaic headlands, landward migration of the shoreline and, ultimately, to transgression of the Maringouin Delta sediments by marine waters.

During transgression, marine processes reworked marginal deltaic landforms, removing fine-grained material and leaving behind heavier, sandy sediments such as those found in channels and distributary mouth bars. These sandy sediments initially formed into an erosional headland with flanking headland barriers and recurved spits that were transformed over time into a barrier island arc separated from the continually eroding mainland as relative sea level rise continued. These barrier island features represent the progenitors of what was to become Ship Shoal as well as two other coastal Louisiana submerged features, Trinity and Tiger shoals (Penland et al. 1985).

During this period, estuarine and marine lagoon environments, similar to those seen in modern-day Terrebonne Bay, developed between the barrier islands and the retreating mainland shoreline. Fine-grained sediments associated with these lagoonal environments form a thin veneer over portions of the deltaic sediments beneath Ship Shoals. The extent and configuration of this lagoonal stratum have not been fully defined, but Penland et al. (1985) note these lagoonal deposits are "only found under the western end of Ship Shoal." These lagoonal sediments represent the earliest of the transgressive depositional facies in the study area (Penland et al. 1985). Vibracore data indicate that these deposits range from 1.6 to 5 feet thick and consist of a “uniform sequence of silty clay containing parallel laminations, starved ripples, asymmetrical ripple laminations, and shell” (Penland et al. 1985).

Ultimately, continued sea level rise and reworking of the barrier island features by marine processes produced a completely submerged, sand-rich marine shoal; today known as Ship Shoal (Kulp et al. 2001). The sandy spits and barrier islands that formed at the distal end of the Maringouin Delta Complex were located somewhat seaward of the present position of Ship Shoal. Over time, these sand deposits slowly migrated landward, burying the underlying, transgressive lagoonal sediments and the earlier, regressive deltaic deposits (Kulp et al. 2001). Available evidence indicates that Ship Shoal continues to slowly migrate landward to the northwest (Penland et al. 1985).

3.0 BATHYMETRY, MORPHOLOGY AND SEAFLOOR FEATURES

3.1 Bathymetry

The EchoTrac data were utilized to determine water depths across the survey area (Appendix A, Figure No. 1). The recorded two-way travel times were converted to depths in feet by applying the harmonic mean sound velocity. A constant offset was automatically added in the field to compensate for transducer depth. Predicted tides from the Wine Island tide station were applied to reference the depth values to MLLW. The resulting depths are shown as smoothed contours at a two-foot contour interval on the Bathymetry Map.

The New Cut Project offshore study area is located near the eastern end of Ship Shoal where the relief of the sand body is relatively low. Relief of Ship Shoal above the surrounding shelf is about 10 feet in the South Pelto Area. Water depths over the shoal within this area range from as little as 26 feet in the northwestern corner of the study area to over 48 feet at the southern most point in the study area. However, the main body of Ship Shoal does not extend into the southern portion of the study area.

No scarps, banks, outcrops or other bathymetric features were identified on the high-resolution geophysical data within the surveyed area for the New Cut Project.

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3.2 Morphology

The morphology and stratigraphy of Ship Shoal have been extensively studied and are well described. The "crest" of the shoal is on its landward, or northern side, where the slope down to the surrounding seafloor is relatively steep in comparison to the surrounding seafloor. The northern edge of the shoal with its steep grade was obvious along the northwestern edge of the study area where the top of the shoal sloped from a water depth of 24 feet to a depth of 34 feet over a distance of just 1300 feet (0.7°). On its seaward, or southern side, the shoal slopes gradually from the crest down to the seafloor, at a gradient of approximately 0.3°. Seaward of the shoal is a broad, level platform 9 to 12 miles wide that slopes very gradually toward the south, south of the study area.

3.3 Seafloor Features

Kulp et al. (2001) cite previous studies that indicate Ship Shoal surficial sediments are composed of 75 – 100% sand. As concluded by Krawiec (Kulp et al. 2001), through compositional and grain size analysis of grab samples taken on Ship Shoal and the vicinity, the surficial sediments are composed of fine-grained quartz sand. Combining previous datasets, Williams found that Ship Shoal contained 90 to 99% quartz sand (Kulp et al. 2001). Sonar imagery revealed a mottled seafloor of moderate reflectivity (Sonar Mosaic Map; Appendix A, Figure Nos. 5 to 16), which is consistent of fine-grained sandy sediments. Available data on previous core samples taken within the area are located in Appendix F (M. Kulp, personal communication 2003) and the locations of these are annotated on the Archaeological and Hazard Map (Sheet 2).

Several zones of increased seafloor reflectivity were noted within the study area. One of these, in the northwestern corner, has sonar characteristics resembling sediment of increased grain size and/or a change in composition, as in carbonate sediments. Based on its location and orientation in relation to isopach and bathymetry values, it is possible that this feature represents the active shoal crest accumulation surface. Kulp et al. (2001) describe the “shoal crest environment as a shore-parallel accumulation of sand and shell that has been deposited in response to reworking by wave and tidal currents.” No known core samples were taken within this zone, therefore it is uncertain as to the precise reason for this signature.

Two small zones of increased seafloor reflectivity were noted in the western and southeastern regions of the study area. Sonar characteristics of these two zones resemble only small variations of surficial sediments, such as a slightly localized increase in sand percentage.

Where the shoal sediments disappear in the southern portion of the study area, a subtle distinction can be seen in the sonar signature of the surface sediments. This signature marks the change in surficial sediment character from the shoal sand in the north, to the exposure of the underlying Maringouin Delta sediments in the south, although a thin veneer of shoal sand is likely to cover this area.

No other significant, naturally occurring seafloor features were found within the study area.

4.0 STRATIGRAPHY AND ISOPACH INTERPRETATION

4.1 Stratigraphy of Ship Shoal

Ship Shoal consists of an upper section, defined as the “shoal crest,” a central section comprising most of the body of the shoal called the “lower shoal,” and a thinner basal section called the “back shoal” (Penland et al. 1985). The shoal crest facies occupies the uppermost portion of Ship Shoal and ranges from 2 to 5 feet thick. This stratum represents high-energy deposition on the shoal and is composed of “clean, well-sorted, fine-to-medium sand” (Penland et al. 1985). The shoal crest contains whole and reworked modern shell, as well as relict *Rangia* and *Crassostrea* shells. The latter are presumably mainly derived from estuarine and marine lagoonal environments that once existed shoreward of the original barrier spits and islands that formed at the distal margin of the Maringouin Delta Complex. However, it is conceivable that some of these shells are derived from greater than 6,000-year-old aboriginal shell middens that may have once existed on Maringouin Delta Complex landforms.

The lower shoal ranges from 5 to 10 feet thick and consists of “moderately sorted fine- to very fine-grained sand" (Penland et al. 1985). The lower shoal reflects a lower-energy environment of deposition than the shoal crest and is extensively burrowed. It contains occasional horizontal and sub-horizontal laminations; and whole and reworked modern and relict shell similar to that in the shoal crest. The back shoal facies is a relatively thin stratum that represents “the advancing edge of the landward depositional surface of Ship Shoal” (Penland et al. 1985). It is “characterized by interbedded layers of silty clay and lenticular to wavy bedded, poorly sorted, very fine sand" (Penland et al. 1985).

Underlying these sandy strata beneath portions of Ship Shoal is a 1.6-to-5-foot-thick stratum of silty clay, lagoonal sediments. These lagoonal sediments constitute the deepest transgressive facies at Ship Shoal and represent sedimentation that occurred in the relict back barrier environment shoreward of the barrier arc shoreline.

All of these transgressive features of Ship Shoal have been deposited within the past 7,000 years or so. The sand-rich facies (shoal crest, lower shoal and back shoal) represent sandy sediments derived from the erosion of deltaic shorelines associated with the Maringouin Delta Complex. Some of the finer-grained lagoonal sediments at the base of the transgressive section are likely to have been derived from the erosion of Maringouin Delta sediments. However, some of these sediments may have originated with other early Mississippi River deltas that prograded into the region long after the Maringouin Delta had entered its cycle of deterioration.

The available evidence indicates that the majority of the 150-or-so feet of Holocene sediments underlying the study area is associated with the Maringouin Delta Complex and has been deposited in the past 7,500 years or so. These thick Holocene deposits rest on weathered, Pleistocene-age, Prairie terrace deposits that represent floodplain, deltaic and open shelf sediments deposited between about 120,000 and 20,000 years B.P. (Frazier 1974; Saucier 1994). During periods of lower sea level, large expanses of these Pleistocene surfaces were subaerially exposed (e.g. the present outer continental shelf) and streams extended an extensive network of channels across them. Several relict channels trending northwest to southeast have been identified incised into this deeply buried Pleistocene surface in the vicinity of the study area. These relict channels terminate at the head of Mississippi Canyon and they are believed to represent channels of an ancestral Mississippi River course (Moore et al. 1978). Approximately 18,000 to 20,000 years B.P., sea level was near the present edge of the Outer Continental Shelf, approximately 300 feet lower than at present. Since that time, sea level has gradually risen and Pleistocene surfaces have been drowned and/or buried by marine or Holocene-age deltaic sediments.

4.2 Subbottom Data and Isopach Interpretation

An Edgetech Geostar SB-0512 Subbottom Profiler was used to assess subsurface conditions beneath the New Cut offshore study area. The subbottom profiles resolved approximately 35 to 50 feet of shallow deposits across the study area; and data examples provided in Appendix A illustrate the seismic character of these sediments. Although several surface multiples exist within the seismic data, adequate penetration allowed for the contouring of isopach values of Ship Shoal sediments within the area. A constant velocity of 5,000 feet per second was used to convert time values to depth/thickness values.

The New Cut study area is oriented on the easternmost portion of the transgressive Ship Shoal sand body. The orientation provides survey coverage of the subsurface within the shoal crest, beneath the shoreward and seaward faces, and within the eastern flank of the shoal. Extensive work has been done previously on the sedimentary facies of Ship Shoal and underlying sediments. Results from three University of New Orleans/United States Geological Survey (USGS) cores examined in 2000 and one Louisiana Geological Survey/USGS core examined in 1986, were made available for this report (Kulp, personal communication 2003). These cores are listed in the following table, and their complete description logs are located within Appendix F. The representative stratigraphic log below was derived from these and other previous works done on Ship Shoal (Kulp et al. 2001).

Ship Shoal Cores Within Study Area

Core ID	Lat. (dec.deg.)	Long. (dec.deg.)	Water Depth (ft)	Core Length (ft)	Short ID
BSS00 SS-02	28.915933	-90.615950	27.59	6.79	00-2
BSS00 SS-03	28.912150	-90.654083	26.90	6.27	00-3
BSS00 SS-05	28.909117	-90.614033	30.81	3.67	00-5
SS-86-25	28.925022	-90.629975	25.00	43.54	86-25

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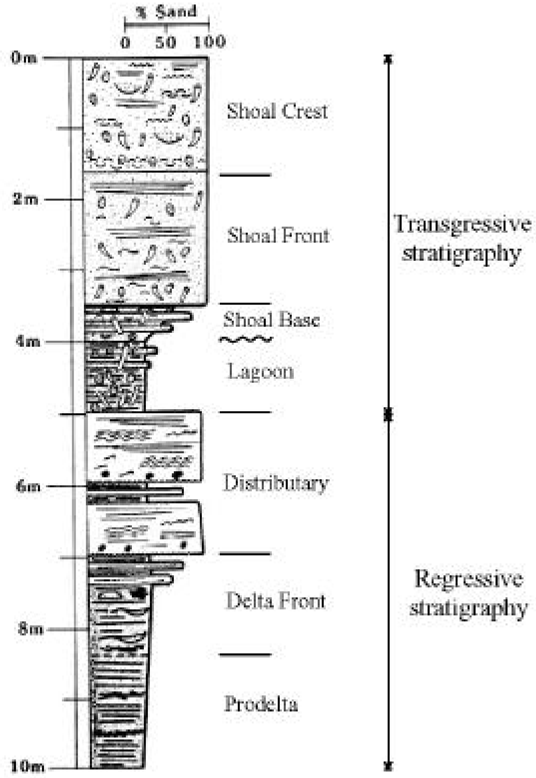

Although as mentioned above, several seafloor multiples existed and obscured some of the seismic response, the shoal base, lagoon, and delta sediments were distinguishable within the seismic records (Appendix A, Figure Nos. 2 to 4).

In the central and western sections of the study area, the nature of the contact between the fine grained lagoonal muds and the sandy back shoal sediments supplied a distinctive, well-defined reflector that was used for isopach generation throughout most of the area. These sections of the study area, which include the shoal crest, shoal front and back shoal facies, exhibited the greatest isopach values throughout the study area, ranging from 14 to 18 feet, thickening from the center of the area to the west.

In the eastern portion of the study area, where lagoonal deposits were minimal, a moderately well stratified sequence of parallel, medium- to high- amplitude reflectors existed. These reflectors eventually pinch out toward the center of the study area beneath Ship Shoal. This seismic stratigraphy resembles the typical rapidly accumulated cycles of Mississippi River sedimentation on the continental shelf. This configuration is probably associated with the lack of lagoonal deposits on the eastern flank of the shoal. Isopach values were derived from the base of the highly reflective, massive sand unit above these alternating reflectors. Unlike thickness values in the western area, isopach values range from 10 to 14 feet, thinning to the east.

In the north, the survey area did not provide coverage over the present-day back shoal environment. Isopach values go from 14 feet down to 6 feet in this area and thin to the north. However, to the south, the survey area did provide coverage of the seaward extent of the main shoal sediments. Lagoonal and back shoal sediments appear to pinch out southward beneath the shoal front deposits and Ship Shoal sand is sitting directly upon the Maringouin Delta sediments in the southernmost portions of the study area (Appendix A, Figure Nos. 2 to 4). Sand thickness values thin from 14 feet to zero in this area.

Overall, isopach values ranged from zero to 18 feet in the study area. These contours are presented on the Ship Shoal Isopach Map (Sheet 3).

One small relict channel was noted in the center of the study area. This feature is a remnant piece of eroded channel exposed at the seafloor within the Ship Shoal sand body and lacks significant lateral extent. This channel extends into the subsurface approximately 5 feet.

Upper Maringouin Delta deposits below the Ship Shoal body were seismically imaged across the study area. Although obscured by seismic multiples, no channels appeared to exist incising these deposits. Several areas of gas saturation were seen within the Maringouin Delta deposits but do not appear to inundate the shoal deposits above and no gas saturation was noted within the Ship Shoal sand body itself.

5.0 EXISTING INFRASTRUCTURE

Public and company file information were reviewed in conjunction with the acquired geophysical data to confirm the presence of existing pipelines, platforms and wells within the study area. Eight existing pipelines traverse the study area, and seven more exist on the outskirts. Six production platforms and two wells also exist just outside the bounds of the study area. These are outlined in the following tables. It is recommended that these pipelines and structures be avoided by 500 feet on all sides.

Existing Pipelines Within the Study Area

Pipeline	Segment	Blocks Crossed within Study Area	Overall Bearing	Approx. Length within Study Area
Chevron 10"	S-5013	South Pelto 13 & 14	S63°00'45"E	11,127.20'
Equilon 20"	S-4006	South Pelto 13 & 18	S32°16'09"W	16,859.80'
Texaco 4"	S-6173	South Pelto 13	S31°40'17"E	10,489.57'
ANR 8"	S-6286	South Pelto 13	S31°31'01"E	10,587.03'
Energy 6"	S-12030	South Pelto 12 &13	S34°48'34"E	11,299.54'
Vastar 8"	S-5408	South Pelto 12 &13	S67°00'04"E	14,068.95'
Comstock 8"	S-8017	South Pelto 12	S26°00'E	7,856.11'

Existing Pipelines Outside of Study Area, Within Survey Grid

Pipeline	Segment	Block	Distance from Study Area
El Paso 4" & 2"	S-10156 & S-10154	South Pelto 13	216' North
El Paso 2", 4" & 4"	S-10792, S-10791 & S-10790	South Pelto 13	476' North
Murphy 4"	S-5955	South Pelto 12	183' Southwest
Murphy 4"	S-6237	South Pelto 19	464' Southwest

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Other Existing Infrastructure				
Structure	**Block**	**X-Coordinate (LA So. 1702)**	**Y-Coordinate (LA So. 1702)**	**Water Depth**
PL13 "7" Platform	South Pelto 13	2,218,242.89'	95,515.97'	31.0'
PL13 "9" Platform	South Pelto 13	2,219,948.16'	95,577.07'	31.0'
Well #G-1 (OCS-00072)	South Pelto 12	2,206,045.92'	87,707.46'	27.9'
PL12 "29" Platform	South Pelto 12	2,205,544.91'	85,742.34'	30.0'
PL12 "34" Platform	South Pelto 12	2,206,438.09'	85,747.36'	30.0'
PL19 "35" Platform	South Pelto 19	2,206,460.08'	84,741.23'	31.5'
PL19 "37" Platform	South Pelto 19	2,207,359.92'	85,043.42'	31.5'
Well #36 (OCS-00073)	South Pelto 19	2,208,345.05'	84,415.51'	33.0'

6.0 UNIDENTIFIED MAGNETIC ANOMALIES AND SONAR CONTACTS

The magnetometer recorded seven hundred seventy three (773) magnetic deflections in the study area (Appendix A, Figure No. 17). The majority of these can be associated directly with the eight pipelines crossing the area and the several well sites and platforms located in the southwestern corner of the study area, or with objects immediately adjacent to these oilfield structures that represent debris associated with their construction, use or maintenance. Three hundred fifty six (356) magnetic anomalies were recorded that could not be reliably associated with identified oilfield structures and remain unidentified. These unidentified anomalies are widely scattered across the study area and are shown with reference numbers on the Archaeological and Hazard Map (Sheet 2). They are included in a table on the map and in Appendix B.

Most of these unidentified magnetic targets produce low amplitude deflections of less than 25 gammas or so, were recorded on only a single survey line, and the deflections covered an area ("duration") of less than 150 feet along that line. These types of magnetic signatures are typically related to single, individual ("point source") ferrous objects of varying sizes. It is impossible to identify the sources of these anomalies with certainty, but in most cases, these objects can be classified as modern objects or debris. Numerous studies have shown that quantities of modern debris can be expected in settings where commercial boat traffic or oil extraction activities have been intensive or long term and that this debris typically appears as scattered, single point source magnetic anomalies, just as is observed in the study area. This phenomenon is particularly characteristic of older offshore lease blocks where well or pipeline construction occurred prior to the mid-1970s when more stringent regulations concerning the disposal and dumping of materials in marine waters were enacted. Development began in all of the lease blocks in the study area prior to the 1970s and there is no doubt that a variety of large objects, such as pieces of pipe, rig and platform elements, and steel cable, as well as small items ranging from nuts and bolts to worn out tools, have been purposefully thrown or accidentally lost in the study area. These items are believed to represent the sources for most of the unidentified magnetic anomalies recorded.

Eleven clusters of magnetic anomalies were identified within the study area that have characteristics similar to those associated with shipwreck sites or might represent hazards to the proposed sand dredging. It is recommended that all eleven clusters be avoided due to their hazard and archaeological potentials. For a list of these avoidance areas and an analysis of the anomalies, see the Archaeological Assessment portion of this report.

Twelve sonar targets were also detected within the study area by the side scan sonar system. One of these targets, Sonar Contact No. 9, is identified as a debris zone with multiple small targets on the surface. The subbottom profiler recorded this target as well and there appears to be a significant amount of very dense material at this location (Appendix A, Figure Nos. 5 to 16). Sonar Contact Nos. 2 and 6 occur in association with clusters of magnetic anomalies. These three sonar contacts are recommended for avoidance based on their archaeological potential as well as the possibility that they might represent hazards to the proposed sand dredging. All sonar contacts are shown with index number on the Archaeological and Hazard and Side Scan Sonar Mosaic Maps (Sheets 2 and 4) and are listed with their location and dimensions in a table on the Archaeological and Hazard Map and in section 5.3 of the Archaeological Assessment portion of this report.

The locations of all unidentified magnetic anomalies and sonar contacts should be avoided or investigated and documented prior to dredging and mooring activities.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The high-resolution geophysical data collected by C & C Technologies, Inc. during the August, 2003 survey under EPA Contract No. 68-W-02-009 were suitable for the delineation of man-made and shallow geologic hazards and for mapping the thickness of a portion of the Ship Shoal sand body. The data were also suitable for performing an archaeological assessment of cultural resource potential in the study area, which encompasses portions of South Pelto Lease Blocks 12, 13, 14, 18 and 19.

Water depths in the study area, determined using an Echotrac DF 3200 fathometer and referenced to MLLW using predicted tides from the Wine Island tide station, ranged from slightly less than 26 feet to just over 48 feet. The maximum seafloor gradient is approximately 0.7° where the landward side of Ship Shoal dips to the north-northwest through the study area.

The subbottom profiler data, in conjunction with previously collected core data, were used to map the sand rich facies that varies in thickness from 2 to 18 feet as depicted by isopach contours on the enclosed Isopach Map (Sheet 3). This sand rich facies is the body of the transgressive feature known as Ship Shoal, which is composed of sediments eroded from the distal ends of the Maringouin Delta Complex of the ancestral Mississippi River.

Eight existing pipelines traverse the study area, and seven more exist on the outskirts. Six production platforms and two wells also exist just outside the bounds of the study area. It is recommended that these pipelines and structures be avoided by at least 500 feet.

Eleven identified magnetic clusters and three associated sonar contacts are recommended for avoidance based upon their archaeological and hazard potentials.

ARCHAEOLOGICAL ASSESSMENT

1.0 INTRODUCTION

The New Cut Dune/Marsh Restoration Project offshore study area is located in Federal waters of the Gulf of Mexico approximately 9.5 miles south of Isle Dernieres, Louisiana. The proposed study locale contains 10.37 square miles of area encompassing portions of Lease Blocks 12, 13, 14, 18, and 19, South Pelto Area (See Regional and Vicinity Maps, pages 4 & 5). The field geophysical survey of the study area was conducted aboard the R/V *Ocean Surveyor* between August 1 and August 7, 2003. Geophysical instruments utilized for the survey included an Edgetech 500 kHz Side Scan Sonar, Odom Echotrac DF 3200 Bathymetric System, Geometrics 880 Cesium Magnetometer and SB-0512 Subbottom Profiler. Horizontal positioning of the survey vessel was accomplished using the C-Nav globally corrected GPS system. A Coast Guard beacon was monitored as a secondary source of differential corrections. Geophysical data reproductions of pertinent features in the area may be observed in Appendix A. The unidentified and identified magnetic anomaly tables and a nomogram for assessing ferrous mass are included in Appendix B. Boat setback diagram, instrument settings, personnel, equipment descriptions and a copy of the daily survey and geophysical logs are provided in Appendix C. Appendix D contains the tide curves and velocity curves used to correct the bathymetric contours shown on the Bathymetry Map (Sheet 1). The instrumentation and the conduct of the survey followed the specifications and requirements of Notice to Lessee (NTL) No. 2002-G01, dated March 15, 2002 and entitled *Notice to Lessees and Operators of Federal Oil, Gas, Sulphur, and Salt Leases and Pipeline Right-of-Way Holders in the Outer Continental Shelf, Gulf of Mexico OCS Region* (U.S. Department of the Interior, Minerals Management Service, 2002).

All of the lease blocks in the study area are identified by the Minerals Management Service (MMS) as high probability areas relative to prehistoric archaeological site potential and one (South Pelto 14) is identified as a high probability block relative to historic shipwreck potential. The archaeological requirements of NTL No. 2002-G01 mandate that survey coverage of the study area be conducted along lines spaced at 50-meter intervals. Coverage of the study area was achieved with eighty-eight (88) survey tracklines spaced 50 meters (164.05 feet) apart and oriented in an east-west direction. Additional survey coverage was obtained along eleven (11) north-south "tielines" spaced at 900-meter (2,952.9-foot) intervals across the study area and three (3) survey tracklines connecting previously collected vibracore locations. These last three lines were run to specifically collect subbottom geological data for correlation with the vibracore interpretations. Navigation fixes for the vessel are annotated on the recorded geophysical data at 150-meter (492.15-foot) intervals.

Geophysical data collected from the remote sensing systems were reviewed for evidence of submerged cultural resources. The survey results are projected on the Archaeological and Hazard Map (Sheet 2). A Side Scan Sonar Mosaic Map (Sheet 4) was constructed as part of the archaeological requirements. The following written text provides a framework for understanding the cultural resources potential of the study area and is to be viewed in conjunction with the study maps to provide a comprehensive explanation of the seafloor and subsurface features identified within the study area.

ARCHAEOLOGICAL ASSESSMENT

2.0 PREHISTORIC BACKGROUND AND SITE POTENTIAL

Underlying the study area are approximately 125 to 150 feet of Holocene sediments that have been laid down in the past 10,000 years or so. These Holocene deposits rest on weathered, Pleistocene-age, Prairie terrace deposits that represent floodplain and deltaic sediments laid down between about 120,000 and 20,000 years B.P. (Saucier 1994). Between about 60,000 and 50,000 years before present (B.P.) and again between 24,000 and 20,000 years B.P. Wisconsin period glacial advances trapped large amounts of the earth's water as polar ice (Coleman et al. 1991). As the glaciers advanced, ocean levels around the world were lowered by as much as 400 feet (Fisk and McFarlan 1955). As sea level fell, large expanses of Prairie terrace deposits, now forming the Continental Shelf, were exposed. Approximately 18,000 to 20,000 years B.P., sea level was approximately 300 feet lower than at present, near the present edge of the Outer Continental Shelf. Streams extended an extensive network of channels across the Pleistocene surface; some of them deeply entrenched. Several relict channels trending northwest to southeast have been identified incised into this deeply buried Pleistocene surface in the vicinity of the study area. These relict channels terminate at the head of Mississippi Canyon and they are believed to represent channels of an ancestral Mississippi River course (Moore et al. 1978). Beginning about 18,000 years B.P., sea level has gradually risen and Pleistocene surfaces have been drowned and/or buried by marine or Holocene-age deltaic sediments.

Before its inundation by rising sea level, much of the Continental Shelf, including those portions under the study area, would have supported environments suitable for human habitation, such as where streams run into river valleys, near natural levees and point bars, and along river and coastal terraces (Pearson et al. 1986). Sea level curve data presented by Saucier (1994) suggest that the Prairie terrace surface beneath the study area was subaerially exposed from about 27,000 years B.P. to about 11,000 years B.P. when it was inundated by rising seas. Under the generally accepted assumption that human populations arrived in the region by or shortly before approximately 12,000 years B.P., it is possible that human use or settlement of this Prairie surface occurred during the very earliest phase of human occupation of the New World. The potentials for preservation of archaeological materials on this surface in the face of the impacts of transgressive seas are not well known, but it is believed that most cultural remains that might have existed on the Prairie terrace were destroyed or seriously disturbed during the early stages of inundation. Studies have shown, however, that cultural remains can survive the impacts of transgression if they occur in specific settings, such as in the topographic lows of incised river channels that have been filled by estuarine and riverine sediments prior to transgression (Belknap and Kraft 1981, 1985; Pearson et al. 1986). Archaeological remains in these settings can become buried through subsidence and sedimentation and, if they remain below the erosive affects of marine transgression, can be preserved. Thus, early prehistoric sites or materials might be preserved within incised channels, or similar settings, on the Prairie terrace below the study area. However, any such materials are now covered by roughly 150 feet of Holocene sediment and are so deeply buried that they will not be impacted by the proposed sand removal.

The Holocene sediments resting above the Pleistocene-age, Prairie terrace consist of two geologic units. The lower unit is a thick sequence of deltaic sediments representing drowned portions of ancestral deltas of the Mississippi River that prograded onto the inner shelf in this area after about 10,000 years B.P. In the study area, these regressive deltaic deposits extend from about 34 feet below sea level to the top of the Pleistocene surface, at about 155 to 180 feet below sea level. Resting on top of these deltaic deposits throughout most of the study area is the other Holocene-age geologic unit, the sand body known as Ship Shoal. Ship Shoal is a sand-rich, submerged, transgressive feature formed from sediments derived from the erosion of the distal ends of those deltaic features that formerly extended onto this portion of the shelf. Each of these major geologic units has a distinctive geomorphic history and each provides differing potentials for prehistoric site preservation, as is discussed below.

The majority, and possibly all, of the remaining regressive Holocene deltaic sediments underlying the study area are associated with the Maringouin Delta Complex, which was active from about 6,000 to 7,500 years B.P. It is possible that the basal portions of these over 100-foot-thick deltaic deposits are associated with the Outer Shoal Delta Complex, a deltaic system identified by some researchers that is believed to date between approximately 9,200 and 8,200 years B.P. (Penland et al. 1989; Saucier 1994). Presently, there is no definitive information on the area extent of this postulated early delta complex and it is unknown if it extended into the vicinity of the present study area.

At its maximum extent, the Maringouin Delta projected onto the inner shelf off Louisiana to a point south of the present position of Ship Shoal; although exactly how far to the south is unknown. As it prograded into this area, the Maringouin Delta deposited the typical stacked sequences of sediment suites associated with deltaic systems, including sediments associated with prodelta, channel, natural levee, backswamp, lake and marsh environments. Beginning about 6,000 years B.P. water flow through the distributaries of the Maringouin Delta system began to decline, possibly because of sea level rise and a shifting of the loci of sedimentation farther inland (Saucier 1994). When the fluvial sediment supply was eliminated, deltaic expansion ended and a cycle of deterioration began. The loosely consolidated sediments and organic deposits within the Maringouin Delta compacted, leading to subsidence. This, coupled with rising sea level, lead to erosion of deltaic headlands, landward migration of the shoreline and, ultimately, to inundation and transgression of the Maringouin Delta by marine waters.

Subbottom records collected during this and previous studies, plus a variety of core data, indicate that the top of intact Maringouin Deltaic deposits lies between about 34 and 48 feet below sea level in the study area. Relying on a best-fit relative sea level curve for the Holocene Mississippi River Delta Plain published in Penland et al. (1985), it appears that inundation of the Maringouin Delta by marine waters began approximately 6,700 years B.P. and by about 6,200 years B.P. the deltaic surface in the study area was entirely submerged. Prior to deterioration and submergence, the Maringouin Delta Complex would have existed as a typical delta plain, containing characteristic deltaic landforms, such as distributary systems with associated elevated natural levees and back swamps, as well as fresh and brackish ponds and lakes, brackish to saline bays, and beach ridges along the deltaic margins at the Gulf of Mexico. All of these various landforms presumably existed at the surface of the Maringouin Delta Complex Plain immediately prior to inundation. Additionally, many of these landform features developed and became buried through subsidence and sedimentation as the delta advanced and now exist as stacked sequences within, at least, the upper portions of Maringouin Delta sediments beneath the study area.

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An abundance of archaeological research in deltaic settings in Louisiana and elsewhere has demonstrated that delta habitats presented prehistoric (and historic) populations with a rich and diverse environment, containing an abundance of easily exploited food resources. Particularly important were shellfish and fish species found throughout the year in the various water habitats, but elevated landforms, particularly natural levees, also supported an abundance of animal and plant food species. This archaeological research in deltaic Louisiana has also indicated a high correlation between prehistoric site locations and particular landforms. Specifically, prehistoric sites are found on elevated landforms that provided suitable habitation locales in an otherwise low and wet environment. Most commonly, prehistoric settlement occurred along the elevated natural levees of distributaries, although sites are also known from other elevated features, such as beach ridges. Today, thousands of archaeological sites are known from natural levee settings in south Louisiana and there is every reason to believe that similar utilization of earlier deltaic systems, like the Maringouin Delta Complex, occurred.

Based on available sea level data, it is believed that human occupation of Maringouin Delta Complex landforms beneath the study area would have ended about 6,200 B.P. when inundation occurred. This means that occupation of the Maringouin Delta in the study area would have taken place between 6,200 years B.P. and, possibly as early as about 7,000 B.P. when deltaic landforms suitable for human habitation may have first prograded into this area. Presumably, landforms associated with the earlier period will be buried beneath the present surface of the Maringouin Delta, while the later, circa 6,200-year-old landforms will be located at or near the present surface of the delta. This means that these landforms were available for occupation and use during the archaeological period known as the Middle Archaic (circa 7,000 to 5,000 years B.P.). In coastal Louisiana, little evidence of the Middle Archaic period has been found, principally because the deltaic features that cover much of the region are too young and any sites associated with Middle Archaic occupation are now deeply buried. Middle Archaic sites, however, are well known from elevated Pleistocene uplands bordering these deltaic features to the north, and from Avery Island, an elevated salt dome feature in the deltaic plain in Vermilion Parish (Gagliano 1967; Brown and Lambert-Brown 1978; Weinstein and Kelley 1992). One characteristic of the Middle Archaic was the extensive exploitation of shellfish, as seen on inland riverine sites. There is every reason to believe that Middle Archaic populations in deltaic and coastal settings placed similar reliance on the vast shellfish (particularly *Rangia* and *Crassostrea*) resources found in these environments. Thus, it is presumed that Middle Archaic populations used and settled Maringouin Delta Complex landforms and that evidence of this exists in the form of shell middens, as well as other types of cultural materials.

As noted, archaeological research has demonstrated that certain deltaic landforms, particularly the elevated natural levees of distributary systems as well as elevated beach ridges and barrier islands, provided optimum locales for settlement and today natural levees contain the vast majority of known archaeological sites in delta settings. Subbottom profiler and core data have recorded the presence of several filled, fluvial channels incised into the surface of the Maringouin Delta Complex deposits in the vicinity of the study area. These features represent distributary pathways associated with the later stages of the Maringouin Delta. One large paleochannel, oriented roughly north-south and extending through lease blocks Ship Shoal 89 and 94, just a few miles west of the study area, has been identified (Intersea Research, Inc. 1985; Thales GeoSolutions, Inc. 2002).

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The top of this large channel is at or within a foot or so of the surface of the old Maringouin Delta and extends beneath the sand of Ship Shoal. Relying on subbottom seismic data and vibracores, Penland et al. (1985) identified large distributary features incised into delta deposits beneath transgressive sand in the western portion of Ship Shoal, several miles west of the study area. Additionally, Penland et al. (1989) identified a "distributary zone" extending north from Lease Blocks 88 and 89, Ship Shoal Area as part of a delineation of sand resources along the central Louisiana coast. This identification, apparently, relied on collected seismic and core data. Similar, but smaller channels incised into the upper surface of the Maringouin Delta have been recorded during other geophysical surveys in the vicinity of Ship Shoal (Gulf Ocean Services 2001).

The available evidence indicates that Holocene paleochannel features dating to between about 6,200 years B.P. and 7,000 years B.P. are preserved in the vicinity of the study area. The natural levees associated with these relict Maringouin Delta distributaries represent high probability locales relative to Middle Archaic period site occurrence. However, no paleochannel features associated with Maringouin Delta deposits that might be interpreted as high probability locales were observed in the study area.

The sandy deposits that form Ship Shoal represent transgressive sediments deposited in the past 7,000 years or so from sediments eroded from the distal ends of Maringouin Delta Complex features. These deposits have been churned, reworked and redeposited by wave and current action over the past several thousand years, and continue to be so. As discussed, it is believed that archaeological sites associated with the Middle Archaic period were established on the Maringouin Delta Complex. During the course of deltaic deterioration and marine transgression, some of these sites are certain to have been eroded and incorporated into the material forming Ship Shoal. The reworking of site materials by wave erosion probably removed and winnowed out or destroyed small, light and fragile items, but heavy and durable cultural objects could have become incorporated into the sandy sediments now forming Ship Shoal. In particular, it is anticipated that stone artifacts, such as projectile points, grinding stones, etc., which are very characteristic of Middle Archaic artifact assemblages, could have become incorporated into Ship Shoal sediments and remain there. Additionally, shellfish remains from Middle Archaic shell middens, assuming they existed, could, also, now exist within Ship Shoal sand. The presence of numerous reworked brackish water *Rangia* and *Crassostrea* shells within the body of Ship Shoal indicates some support for this contention. Penland et al. (1985) suggest that these shells are mainly derived from estuarine and marine lagoonal environments that once existed shoreward of the original barrier spits and islands that formed at the margins of the Maringouin Delta Complex. However, it is conceivable that some of these shells are derived from greater than 6,000-year-old aboriginal shell middens that once existed on Maringouin Delta Complex landforms. Even if these shells are from natural beds, their presence shows that large items can survive several thousand years of reworking within the body of Ship Shoal. Presumably, other durable items, such as stone tools and, possibly, bone, will, also, survive. In fact, the survival of bone items within Ship Shoal sediments is evidenced by the discovery of a deer tooth in a shallow core taken on Ship Shoal (S. Gagliano personal communication 2003).

Most of the seafloor beneath the offshore study area consists of Ship Shoal sand, deposits that have a probability for containing archaeological materials dating from the Middle Archaic period. Any archaeological materials now existing within this Ship Shoal sand will have been removed from their original depositional context by many years of wave and current erosion and reworking; no in situ site material will exist. However, the occurrence of even isolated, out-of-context artifacts within the body of Ship Shoal is extremely important because they will provide unique evidence of early human occupation on now submerged deltaic features.

3.0 HISTORIC BACKGROUND

The study area is in a high probability zone for the occurrence of historic shipwrecks, principally because the shallow waters of Ship Shoal have constituted a hazard to coastal shipping. In fact, the name of the shoal itself is apparently derived from the dangers it presented to vessels. Waterborne transportation and commerce have been of great importance to this area of coastal Louisiana since the early historic period, beginning in the sixteenth century when Spanish vessels first traveled along the northern coast of the Gulf of Mexico. Early sailing routes typically hugged the coast, meaning that vessels sailing in the Gulf of Mexico during the early historic period often traversed the area of Ship Shoal. Specific information on vessel losses in the region prior to the nineteenth century is uncommon, but one vessel lost off Cameron Parish west of the Ship Shoal area was the Spanish merchantman *El Nuevo Constante*, sunk in 1766. Archaeological research on *El Nuevo Constante* revealed the presence of well-preserved vessel components and cargo items (Pearson and Hoffman 1995).

Although vessels were sailing along the coast in the vicinity of Ship Shoal from an early period, settlement of coastal Louisiana west of the Mississippi River remained relatively sparse until the later part of the eighteenth century. Overland travel in this region of vast swamps and marshes was difficult and the movement of goods and people was principally by water. Much of the early vessel traffic in the region passed along inland waterways, but some coastal traffic occurred. By the second decade of the nineteenth century, small trading vessels, principally sloops and schooners, were regularly sailing along the central Louisiana coast in the vicinity of Ship Shoal. Most of this trade centered on New Orleans and these vessels typically carried merchandise, foodstuffs and manufactured goods out from New Orleans to smaller ports and communities in coastal Louisiana and Texas, such as Brashear City (now Morgan City) and Galveston, and returned to New Orleans with agricultural products, such as sugar and cotton. Passengers also were carried by these small coasting vessels, particularly after the mid-1820s when Americans began to travel from New Orleans to Texas in increasing numbers to take up settlement.

Vessel traffic through Atchafalaya Bay and along the coast near the Ship Shoal area increased as settlement and agricultural production expanded along Bayou Teche and into the interior. By 1840, the town of Franklin on lower Bayou Teche had developed into a locally important port for coastal as well as ocean-going vessels. By this time a large number of steamboats were traveling the interior waters of south Louisiana and some were steaming along the coast, following the same routes as the small sailing vessels. The growth in maritime activity led to a proportionate increase in ship losses.

In 1857, The New Orleans, Opelousas, and Great Western Railroad was completed from Algiers on the Mississippi River opposite New Orleans to the east bank of the Atchafalaya River on Berwick Bay. At the termination of the railroad was the small town of Brashear City, which soon developed into a thriving port for river vessels as well as ocean-going craft sailing through Atchafalaya Bay. Brashear City became the principal port for the steamers operated by Charles Morgan between Louisiana and Texas. The importance of the Morgan Line to the economy of the region led the Louisiana legislature to change the name of Brashear City to Morgan City in 1873. By this time, 17 Morgan Line steamers were calling at the port (Pearson and Simmons, 1995). These, and other steam vessels, were traveling into and out of Atchafalaya Bay and in the vicinity of Ship Shoals.

Increasing vessel traffic and recognition of the dangers posed by Ship Shoals led to the stationing of a lightship at Ship Shoal in the late 1840s. This vessel was the former Revenue Cutter *McLane*, re-christened *Pleasonton* after conversion to a lightship. In 1859, the *Pleasonton* was replaced by the Ship Shoal Lighthouse, a 125-foot tall, iron, screw pile structure erected near the western end of the shoals (Cipra 1997). This lighthouse was discontinued in the 1970s, but is still standing.

In the late nineteenth century, fishing and oystering began to develop into important commercial activities along central coastal Louisiana. A variety of small vessels were used in these endeavors, many of which were locally constructed. The vast majority of the small vessels involved in these industries worked in coastal bays and rivers or along inshore gulf waters; only occasionally did they venture as far offshore as the study area. However, beginning in the 1920s, after the development of the otter trawl, shrimping became an important aspect of the regional fishing economy. Soon, gasoline and, later, diesel-powered shrimp trawlers were venturing farther offshore in the Gulf of Mexico, including into the area of Ship Shoal. By the middle of the twentieth century, shrimp trawlers had become the most common type of vessel sailing in the waters around Ship Shoal.

In the 1940s, the Louisiana oil industry expanded offshore, and by the 1950s production had begun in the vicinity of Ship Shoal. The development of the offshore oil industry brought with it a variety of new types of vessels ranging from crew and supply boats, to drilling rigs and jack-up barges. In addition, the infrastructure of oil and gas production became a permanent presence in the offshore waters and today numerous wells, platforms, and pipelines are located in the Ship Shoal Area and several pipelines cross the study area. Oil and gas production and fishing, particularly shrimping, remain the principal economic activities of the region.

4.0 HISTORIC POTENTIAL

The long period of relatively intense vessel traffic along coastal Louisiana in the historic period, coupled with the hazard presented by Ship Shoal, has resulted in a large number of vessel losses in the region. Typically, accounts of historic, and even relatively recent, vessel losses are imprecise or incomplete such that there are questions about the exact location of loss, making it difficult to determine what vessels were actually lost in the study area. A recent study (Panamerican Consultants, Inc. 2003) reports twenty (20) known and unknown vessels and unidentified objects and obstructions that could represent vessels within a five-mile radius of the study area. The shipwreck and unidentified object table below provides the following information about each of

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these objects or obstructions:

- **Number:** The number assigned to the vessel or object in the Panamerican Consultants, Inc. (2003) report.
- **Vessel/Object**: The name of the vessel if known.
- **Location Reliability**: A numerical value placed on the reliability of the reported location of the vessel ranging from 1, very reliable, to 4, very unreliable.
- **Vessel Type**: The type of vessel if known.
- **Year Lost**: The year the vessel was lost, if known.
- **Year Built**: The year the vessel was built if known.
- **Lat. NAD27**: The latitude of the vessel in decimal degrees, NAD 27.
- **Long. NAD27**: The longitude of the vessel in decimal degrees, NAD 27.
- **Lease Block**: The offshore lease block in which the vessel or object falls.

Shipwrecks and Unidentified Objects Within Five Miles of the New Cut /Marsh Restoration Offshore Study Area

Number	Vessel / Object	Location Reliability*	Vessel Type	Year Lost	Year Built	Lat. NAD27	Lon. NAD27	Lease Block
378	Unknown Vessel	1	Unknown	-	-	28.939980	-90.725342	PL 11
379	Miss Natalie (?)	1	Tugboat	1983	-	28.911819	-90.717430	PL 11
380	Unknown Wooden Vessel	1	Unknown	-	-	28.910810	-90.584770	PL 14
1003	Coral Tide	2	Crew boat	1966	-	28.915239	-90.686752	PL 12
528	Allegro	2	Pleasure craft	1962	1953	28.893326	-90.723328	PL 20
529	**Carl Tide**	**2**	**Unknown**	**1965**	**1957**	**28.900000**	**-90.666656**	**PL 19**
530	Crane	3	Unknown	-	-	28.883333	-90.716660	PL 20
1186	Mellow Max	3	Unknown	1970	1955	28.959999	-90.629997	PL 8
1380	H. G. Newberry	2	Unknown	1992	-	28.928055	-90.692780	PL 12
1393	Jack-up rig	2	Unknown	1985	-	28.924999	-90.561668	PL 14
1437	Sargent	3	Motor vessel	1985	-	28.963333	-90.631668	PL 8
11981	Object	1	Unknown	-	-	28.913334	-90.571945	PL 14
12507	Obstruction	4	Unknown	-	-	28.913568	-90.572029	PL 14
14235	Unknown Vessel	4	Unknown	-	-	28.925234	-90.561752	PL 14
14236	Unknown Vessel	4	Unknown	-	-	28.883570	-90.716759	PL 20
14237	**Obstruction**	**4**	**Unknown**	**-**	**-**	**28.921741**	**-90.658035**	**PL 12**
14238	Obstruction	4	Unknown	-	-	28.896902	-90.708977	PL 20
14464	Obstruction	4	Unknown	-	-	28.938286	-90.589066	PL 14
14717	Obstruction	4	Unknown	-	-	28.884623	-90.713455	PL 20
14719	**Obstruction**	**4**	**Unknown**	**-**	**-**	**28.903315**	**-90.659630**	**PL 12**

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Shipwrecks and Unidentified Objects Within Five Miles of the New Cut /Marsh Restoration Offshore Study Area

Number	Vessel / Object	Location Reliability*	Vessel Type	Year Lost	Year Built	Lat. NAD27	Lon. NAD27	Lease Block

1 equals highest and 4 equals lowest reliability (source: Panamerican Consultants, Inc., 2003). (Note: Bolded items are within Study Area.)

It is important to recognize that not all of the vessels in this list necessarily fall in this area, because the reported locations of loss of many are unreliable. Additionally, there may by other discrepancies in the table because of the often inconsistent or confusing information available on shipwrecks. For example, the vessels named *Carl Tide* and *Coral Tide* may very well be the same craft that appears under slightly different names in different sources of information. Also, these sources provide different locations and dates of loss for these similarly named vessels.

Several sunken vessels have been identified during previous remote-sensing surveys in the near vicinity of the study area. One such wreck, tentatively identified as the tugboat *Miss Natalie*, was documented in Block 11, South Pelto Area, just to the west of the study area (Fugro, John E. Chance & Associates, Inc. 1995).

The previous table includes only vessels that have been reported in the readily available literature or are included in databases of shipwrecks maintained by various governmental agencies. It can be assumed that some presently unknown number of vessels has been lost on Ship Shoals and never reported. This would be particularly true of vessels lost during the early historic period when reporting of losses was often haphazard and incomplete and of small vessels whose losses are often not reported, even in fairly recent times. Despite problems with the historical record on vessel losses, the information presented here indicates the relatively high potential that the study area and Ship Shoal as a whole have for containing historic shipwrecks.

The potential for preservation of any vessels lost in the study area will be related to a variety of phenomena, including the type of vessel, the nature of the loss event, and the post-wreck environmental setting. In general, the relatively shallow waters of the study area represent a high-energy environment; an environment that is not generally conducive to the preservation of shipwreck remains. Waves, particularly those produced during strong storms such as hurricanes, disturb and churn the upper portions of Ship Shoal, and they would similarly act to breakup and disperse a sunken vessel. This would be particularly true of wooden-hulled vessels. Iron or steel-hulled vessels are more likely to withstand the battering from waves, but over time even these vessels are likely to be broken up and scattered widely. Heavy and durable portions of either type of vessel could become buried within the sand of Ship Shoal and remain in or near their original loss position for a considerable period of time. Even so, the constant reworking of the shoal sand would probably, over time, move, re-expose and rebury even large objects. Thus, it is anticipated that vessels lost in the shallower waters of the study area will become widely scattered and dispersed and many if not most, vessel pieces will be periodically buried and exposed. Side scan sonar, therefore, may or may not be useful in detecting these vessels, depending upon the distinctiveness of any portion of the wreck exposed on the surface. The magnetic signature of wrecks in this setting would generally consist of a "cluster" of individual anomalies of varying amplitudes (Arnold 1982; Garrison et al. 1989; Saltus 1982). Garrison et al. (1989) suggest that vessel debris in high-energy settings will be scattered over an area greater than 100,000 square feet. Although this proposition has not been verified, it is likely that the pattern and area of dispersal of wreckage will vary considerably among vessel types and environments of sinking.

Vessels or portions of vessels are less likely to be impacted by wave forces in the deeper waters of the study area, such as along the southern edge of Ship Shoal (Garrison et al. 1989). However, beneath the study area, these areas contain a relatively thin layer of sand and other loose sediments on top of moderately stiff deltaic clay, where the potentials for burial are somewhat lessened. Wooden materials coming to rest in this setting are likely to deteriorate fairly rapidly, if they remain unburied. Metal-hulled vessels can remain intact in these settings for a longer period of time, as indicated by the discovery of the apparently reasonably well preserved vessel, tentatively identified as the tugboat *Miss Natalie* in South Pelto 11, just to the west of the study area (Fugro, John E. Chance & Associates, Inc. 1995). The *Miss Natalie* was lost in 1983.

5.0 ASSESSMENT OF DATA

5.1 Bathymetry Record and Surface Features

Water depths in the survey area, determined using an Echotrac DF 3200 fathometer and referenced to MLLW using predicted tides from the Wine Island tide station, ranged from slightly less than 26 feet to just over 48 feet. The shallowest depths are in the extreme northwestern corner of the study area and the deepest are at the southern tip. The northern, or inshore, edge of the shoal with its steep slope is obvious along and just outside of the northwestern edge of the study area. Here the top (crest) of the shoal slopes from a water depth of 24 feet to a depth of 34 feet over a distance of 1300 feet, a gradient of 1:130. Elsewhere in the study area, the surface of the shoal above 28 feet MLLW is relatively flat, showing a slight slope toward the south-southeast. Below 28 feet MLLW, the gradient of this slope increases slightly.

5.2 Assessment of Magnetometer Records

Seven hundred seventy-three (773) magnetic anomalies were recorded in the study area. The majority of these can be associated directly with the eight pipelines crossing the area and the several well sites and platforms located in the southwestern corner of the study area, or with objects immediately adjacent to these oilfield structures that represent debris associated with their construction, use or maintenance. Three hundred fifty six (356) magnetic anomalies were recorded that could not be reliably associated with identified oilfield structures and remain unidentified. As shown on the Archaeological and Hazard Map (Sheet 2) these magnetic anomalies are scattered widely over the study area. Most of these magnetic targets produce low amplitude deflections of less than 25 gammas or so, were recorded on only a single survey line, and their signature covered an area (e.g. "duration") of less than 150 feet along that line. These types of magnetic signatures are commonly related to single, individual ("point source") ferrous objects of varying sizes. It is impossible to identify the sources of these "point source" anomalies with certainty, but in most cases, these objects can be classified as modern objects or debris. Numerous studies have shown that quantities of modern debris can be expected in settings where commercial boat traffic or oil extraction activities have been intensive or long term and that this debris commonly appears as scattered, single source magnetic anomalies, just as is seen in the study area. This phenomenon is particularly characteristic of older offshore lease blocks where well or pipeline construction occurred prior to the mid-1970s when more stringent regulations concerning the disposal and dumping of materials in marine waters were enacted. Development began in all of the lease blocks in the study area prior to the 1970s and there is no doubt that a variety of large objects, such as pieces of pipe, rig and platform elements, and steel cable, as well as small items ranging from nuts and bolts to worn out tools, have been purposefully thrown or accidentally lost in the study area. These items are believed to represent the sources for most of the unidentified magnetic anomalies recorded.

It is impossible to positively associate any specific magnetic signature with a shipwreck, but the size and characteristics of a magnetic signature does provide a starting point for distinguishing between shipwrecks and modern debris. Generally, shipwrecks that have been scattered and dispersed, as is anticipated in most of the study area, will appear as a closely-spaced cluster of magnetic anomalies of varying amplitudes covering an area of greater than 100,000 square feet (Garrison et al. 1989). However, Garrison et al (1989) also show that individual pieces of ship wreckage may produce a magnetic anomaly that measures only 135 to 150 feet across. Typically, larger pieces of wreckage or large items from vessels will produce magnetic amplitudes of moderate to high intensity (>50 gammas) when the magnetometer sensor is within 75 or 80 feet or so, the distance the sensor would have been from any object in this survey. Relying on these findings and assumptions, criteria were established for identifying those magnetic anomalies (actually groups or clusters of anomalies) that might represent scattered vessel remains. These are closely spaced clusters of magnetic anomalies that displayed amplitudes greater than 50 gammas and covered an area greater than 150 feet in all directions. This means that these consist of groups of magnetic anomalies that extended more than 150 feet along a single survey line and appeared as adjacent anomalies on more than one survey line and contain at least one individual anomaly producing a magnetic deviation of greater than 50 gammas on one of the lines. Individual magnetic anomalies with amplitudes of greater than 50 gammas and durations of greater than 150 feet along only a single survey line are not included, because it is believed that these types of signatures are most likely to be associated with single, point source objects. Although these clusters of magnetic anomalies might represent shipwreck remains, this cannot be verified without physical examination. Even if these magnetic clusters do not represent wreckage, they probably reflect pieces or concentrations of ferrous debris of sufficient size to constitute a hazard to the proposed sand dredging.

Eleven clusters of magnetic anomalies are identified in the study area that meet these criteria for vessel wreckage or potential hazard. A description of these clusters is provided and summary information on the clusters is provided in the Cluster of Magnetic Anomalies Table below. Cluster No. 1 is located near the north-central boundary of the study area. It is comprised of six anomalies producing magnetic deflections ranging from 4 to 79 gammas. Anomaly No. 31 is the largest anomaly in this cluster at 79 gammas and a duration of 120 feet. Cluster No. 1 may be associated with Sonar Contact No. 6. Cluster No. 2 is located near the northwest margin of the study area. It is made up of three anomalies ranging in magnetic intensity from 4 to 654 gammas. Anomaly No. 59 is the largest with a deflection of 654 gammas and a duration of 255 feet. Cluster No. 3 is also in the northwest portion of the study area. It is comprised of seven anomalies ranging in intensity from 8 to 2,467 gammas. Anomaly No. 79 (2,467 gammas with a duration of 498 feet) and Anomaly No. 70 (1,674 gammas with a duration of 780 feet) are the two largest anomalies in this cluster. Cluster No. 3 is associated with Sonar Contact No. 9, which is identified as a debris field (See Clusters of Magnetic Anomalies table below) and correlates to the position of a previously reported obstruction (See Shipwrecks and Unidentified Objects table above, Reference No. 14237). Cluster No. 4 is near the eastern margin of the study area. It is comprised of six anomalies that produced magnetic intensities ranging from 3 to 54 gammas. The largest deflection is seen in Anomaly No. 75 (54 gammas with a duration of 253 feet). This cluster is associated with Sonar Contact No. 2, identified as a 15-by-11-foot piece of unidentified debris (see Clusters of Magnetic Anomalies table below). Cluster No. 5 is located just to the south of Cluster No. 4 and could be associated with that cluster. Cluster No. 5 is a grouping of three anomalies that produced magnetic deflections ranging from 21 to 113 gammas. Anomaly No. 105 (113 gammas with a duration of 141 feet) is the largest of the anomalies in this cluster. Cluster No. 6 consists of two anomalies and is located in the east-central portion of the study area. Anomaly No. 115 is the larger of the two anomalies with a deflection of 511 gammas and a duration of 462 feet. The second anomaly in this group, Anomaly No. 120, has a deflection of 12 gammas and a duration of 659 feet. Cluster No. 7 is located near the west-central boundary of the study area and is the largest cluster of anomalies identified during the survey. Eleven anomalies ranging in magnetic intensity from 5 to 1,932 gammas make up this north-to-south oriented cluster. The largest is Anomaly No. 189 with a deflection of 1,932 gammas and a duration of 1,174 feet. There are no sonar contacts associated with Cluster No. 7. Cluster No. 8 is located near the southeastern margin of the study area and is composed of three anomalies. The three anomalies produced magnetic deflections ranging from 5 to 49 gammas with Anomaly No. 198 (49 gammas with a duration of 333 feet) being the largest. Cluster No. 9 is located southwest of Cluster No. 8 along the southeastern margin of the study area. It is comprised of two anomalies, Anomaly No. 208 (53 gammas with a duration of 252 feet) and Anomaly No. 223 (2 gammas with a duration of 211 feet). Cluster No. 10 is located in the south-central part of the study area and contains three anomalies. The anomalies range in size from 6 to 996 gammas with the largest being Anomaly No. 302 (996 gammas with a duration of 614 feet. Finally, Cluster No. 11, located in the southwestern part of the study area approximately 1, 968 feet south of Cluster No. 7, is composed of five anomalies ranging in size from 10 to 76 gammas. Anomaly No. 347 (76 gammas with a duration of 238 feet) is the largest anomaly in this cluster.

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Clusters of Magnetic Anomalies that Exhibit Characteristics of Shipwrecks.

Cluster	Magnetic Anomalies and Amplitude (gammas)	Comments
Cluster 1	31 (79 gammas); 22 (6 gammas); 14 (4 gammas); 338 (2 gammas); 2 (4 gammas); 10 (3 gammas)	
Cluster 2	59 (654 gammas); 49 (4 gammas); 44 (4 gammas).	
Cluster 3	70 (1674 gammas); 65 (16 gammas); 79 (2467 gammas); 88 (8 gammas); 89 (11 gammas); 93 (5 gammas); 94 (48 gammas).	Side scan Target 9, identified as "Debris Zone," correlates with Anomaly 70. This cluster correlates with the previously reported position of an "Obstruction" (see Number 14237 in previous Shipwrecks and Unidentified Objects table).
Cluster 4	75 (54 gammas); 86 (7 gammas); 76 (18 gammas); 68 (17 gammas); 62 (3 gammas); 55 (5 gammas	Side scan Target 2, identified as 15.1 by 11.2-foot object correlates with Anomaly 75.
Cluster 5	105 (113 gammas); 97 (11 gammas); 108 (21 gammas)	Possibly part of Cluster 4
Cluster 6	115 (511 gammas); 120 (12 gammas)	
Cluster 7	180 (147 gammas); 179 (33 gammas); 170 (19 gammas); 169 (6 gammas); 168 (8 gammas); 171 (5 gammas); 188 (363 gammas); 189 (1932 gammas); 203 (72 gammas); 204 (15 gammas); 214 (9 gammas)	
Cluster 8	198 (49 gammas); 332 (10 gammas); 197 (5 gammas)	
Cluster 9	208 (53 gammas); 223 (2 gammas)	
Cluster 10	302 (996 gammas); 298 (9 gammas); 305 (6 gammas)	
Cluster 11	347 (76 gammas); 271 (38 gammas); 278 (10 gammas); 348 (30 gammas); 283 (10 gammas)	This cluster is in the near vicinity of the reported location of loss of the vessel *Carl Tide* (see Number 529 in Shipwrecks and Unidentified Objects table)

Several of these clusters are long, linear features oriented in a generally north-south direction. This is particularly evident in Clusters 4, 5 and 7. This could be a result of wave-induced patterns of dispersal or it could simply mean that the source object or objects are elongated in shape, such as cable or pipe.

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5.3 Assessment of Side Scan Sonar Records

Side scan sonar records display several identified man-made features and twelve (12) unidentified sonar contacts along the bottom surface (Appendix A, Figure Nos. 5 to 16). Five of the unidentified sonar contacts correlate with magnetic anomalies. Sonar Contact No. 2 may be associated with Anomaly No. 75 (Cluster No.4). Sonar Contact No. 3 may be associated with Anomaly No. 106. Sonar Contact No. 4 may be associated with a point source Anomaly No. 137. Sonar Contact No. 6 appears to correlate with Anomaly No. 3 or possibly Cluster No. 1, and Sonar Contact No. 9 is likely associated with Anomaly No. 70 (Cluster No. 3). None of the sonar contacts could be identified as sunken vessels or parts of sunken vessels and most appear to be pieces of debris. The Unidentified Sonar Contacts table below provides a description of the unidentified sonar contacts and they are displayed on the Archaeology and Hazard Map.

Unidentified Sonar Contacts

No.	Line	Shot Point	Dimensions (ft)	Description	Sensor Height (ft)	Block Area	Louisiana South	
							X-Coord.	Y-Coord.
1	7	62	13x6x0	Debris	16	PL14	2,235,669'	94,115'
2	12	63	15x11x0	Debris	16	PL14	2,236,258'	93,456'
3	17	64-65	15x9x0	Debris	16	PL14	2,236,258'	93,456'
4	24	49	4x2x0	Debris	16	PL13	2,229,552'	91,473'
5	1	39-40	14x3x0	Debris	16	PL13	2,224,546'	94,960'
6	1	36-37	15x2x0	Debris	16	PL13	2,223,120'	95,239'
7	8	33	7x2x0	Debris	16	PL13	2,221,511'	93,847'
8	46	35-36	17x15	Debris	16	PL13	2,222,613'	87,637'
9	13	22-23	Debris Zone	Debris Zone	16	PL12	2,216,142'	93,250'
10	61	4-5	16x17x0	Debris	16	PL19	2,207,418'	85,184'
11	62	4-5	9x13x0	Debris	16	PL19	2,207,345'	85,035'
12	58	2-3	Debris Zone	Debris Zone	16	PL19	2,206,418'	85,717'

5.4 Assessment of Subbottom Records

Subbottom profiler data were used to examine the near-surface subbottom features (Appendix A, Figure Nos. 2 to 4). The subbottom profiler record shows a cross sectional view of the subbottom strata within the survey area. Visual No. 3 (dated 1983) (U.S. Department of the Interior, Minerals Management Service 1996) indicates that general seafloor sediments in this portion of the South Pelto Area are primarily silty clay. However, the subbottom profiler record from the immediate study area indicates the acoustic characteristics of the upper sediments are more typical of sand. The subbottom data did not show extensive relict channels in the area. In fact, only one portion of a channel was seen in the data (See Archaeological and Hazard Map, Sheet 2) in the central portion of the survey area. This channel was relatively close to the surface within Ship Shoal sand and exhibited extensive truncation along the upper portions. It is believed that this channel formed subaqueously.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The assessment of the data from the survey area revealed the partial remains of a relict channel within Ship Shoal sand. The location of the channel within the body of Ship Shoal suggests that it is a submarine channel possibly produced by marine currents or waves, making it impossible to determine the age of the channel. Since the channel was probably formed subaqueously, it has no relationship to potential human occupation of the area, and no potential for containing prehistoric archaeological sites. This channel is not recommended for archaeological avoidance.

Eleven clusters of magnetic anomalies were identified within the study area that have characteristics similar to those associated with shipwreck sites. As discussed, the identity of the sources of these clusters of magnetic anomalies cannot be determined without additional examination, but they do present magnetic signatures that are characteristic of shipwrecks, specifically vessels that have been broken up and dispersed as would be anticipated in the high-energy environment found on Ship Shoals. It is recommended that all eleven clusters be avoided due to their archaeological potential. A list of the avoidance areas is provided in the Archaeological Avoidance Areas table presented below. Avoidance distances are based on the characteristics of the anomaly cluster (size, orientation, etc.) and the nature of activity this project involves. The avoidance distances also reflect the premise that the removal of several feet of sand from Ship Shoal will result in the displacement of surrounding sand deposits as they flow into the area excavated. Presumably, some of this displacement will occur during the sand removal process itself, but it will also continue for some time after the dredging is completed as waves and currents act to fill the excavated areas. Presently, it is impossible to determine how far away from any excavation sand stability will be affected. This is dependent upon a variety of factors, such as the lithology and content of the sand deposits and the depth of dredging; factors that require engineering assessments beyond the scope of the present study. Therefore, it is recommended that these factors be considered prior to excavations and that all identified magnetic anomaly clusters be avoided by a distance sufficient to ensure that the sediments at the clusters will not be displaced by dredging. These same factors have to be considered when excavations are conducted in the vicinity of pipelines and other oilfield features. These features must be avoided by a sufficient distance to ensure that the movement of sand resulting from the excavations will not uncover, undermine, or otherwise impact their structural integrity.

Twelve (12) unidentified sonar contacts were also noted in the study area. The majority of these are interpreted as modern debris and are not recommended for avoidance based on archaeological potential. However, three (Sonar Contact Nos. 2, 6, and 9) are associated with anomaly clusters and are recommended for avoidance on the basis of archaeological potential.

If the eleven identified magnetic clusters and associated sonar contacts cannot be avoided by the proposed operations, then they will have to be physically examined to determine their identity, potential significance and National Register eligibility. This will require dive investigations and these should follow the procedures established by the Minerals Management Service for such studies.

Archaeological Avoidance Areas

Magnetic Anomalies							
Ref. No.	Line No.	Shot Point	Gamma/ Duration (ft)	Area/ Block	Louisiana South		Avoidance Criteria
					X Coord.	Y Coord.	
31	5	36.6	79/120 Dipole	PL13	2,223,256'	94,450'	With 2,10,14,22, & 338 1000' x 500' minimum, Sheet No. 2
59	10	13.2	654/255 Dipole	PL12	2,211,740'	93,587'	With 44 & 49 750' minimum, Sheet No. 2
79	13	22.22	2467/498 Dipole	PL12	2,216,176'	93,110'	With 65,70,88,89,93, & 94, Sonar No. 9 1000' minimum, Sheet No. 2
75	12	63.08	54/253 Dipole	PL14	2,236,293'	93,351'	With 55,62,68,76, & 86 Sonar No. 2 1000' minimum, Sheet No. 2
105	16	62.6	113/141 Dipole	PL14	2,236,059'	92,695'	With 97 & 108 Avoidance distance designated on 500' minimum, Sheet No. 2
115	18	43.82	511/462 Dipole	PL13	2,226,816'	92,327'	With 120 500' minimum, Sheet No. 2
189	36	10.58	1932/1174 Dipole	PL12	2,210,470'	89,323'	With 168,169,170,171,179,180, 188,203,204, & 214 1000' minimum, Sheet No. 2
198	37	59.5	49/333 Dipole	PL14	2,234,538'	89,244'	With 197 & 332 500' minimum, Sheet No. 2
208	39	57.18	53/252 Monopole	PL14	2,233,398'	88,908'	With 223 500' minimum, Sheet No. 2
302	60	22.09	996/614 Dipole	PL19	2,216,146'	85,407'	With 298 & 305 500' minimum, Sheet No. 2
347	98	19.33	76/238 Monopole	PL12	2,210,971'	86,804'	With 271,278,283, & 348 500' minimum, Sheet No. 2

As discussed previously, the Ship Shoal deposits have the potential for containing cultural remains dating to the Middle Archaic period (circa 7,000 to 5,000 years B.P.). The present evidence indicates that Ship Shoal deposits have been churned, reworked and extensively burrowed over the past several thousand years (Penland et al. 1985), such that any cultural remains contained in them have been disturbed and will not be *in situ*. Despite this, these cultural remains are considered significant items because they can provide evidence of pre-5,000-year-old human occupation of deltaic and coastal settings in the region; evidence that is unique and has not been found elsewhere. Therefore, it is recommended that some attempt be made to examine the excavated Ship Shoal sediments for the presence of Middle Archaic artifacts and ecofacts. The techniques to be used in sand removal and placement onshore have not been finalized, so the recommendations for examining the excavated material presented here may have to be altered to fit the dredging techniques ultimately employed. At a minimum, it is recommended that the excavated sand be visually monitored by an archaeologist. Monitoring can probably be most efficiently conducted by examining the sediments after they are placed onshore where it may be easier to locate and identify possible artifacts. Monitoring should be intensive and systematic. Under the assumption that sediments will be pumped ashore, and that the outflow pipe will be periodically shifted to distribute the sediments, it is recommended that archaeologists examine the "fan" or "cone" of sediments produced at each location where sediments are pumped, after the outflow pipe has been shifted to another position. Experience at other locations, has shown that when dredged material flows onshore it often produces a fan- or cone-shaped pile of sediment that is partially size-graded (S. Gagliano personal communication 2003). This grading phenomenon tends to spatially concentrate items of similar size and mass, helping to sort any cultural materials that might be present. In this procedure it is important that the dredge outflow be shifted periodically to produce spatially distinct areas of disposed material. Additionally, it is important that the locations in Ship Shoal where individual piles of sediment are derived are recorded to the extent possible. This will be critical to ascertain if any spatial patterns exist in artifact distributions. It should be possible to mark individual outflow locations with flags that record where in Ship Shoal they were dredged, or record the locations using a GPS and link the onshore disposal location with the offshore dredge location. This would allow archaeologists to periodically visit the disposal locale to examine the material that has been deposited since a previous visit.

If heavy equipment (i.e. bulldozers, graders, etc.) is going to be used to distribute and form sediments after they are pumped ashore, we recommend that monitoring include a pedestrian survey of the entire onshore disposal area after this has been done. This survey should be conducted after some rain has fallen or the area has been sprayed with water, which should help expose any artifacts at or near the prepared surface.

The type of monitoring described above will not discover all of the artifacts that may exist within the Ship Shoal sand that is deposited at the New Cut onshore project location. It will serve only as a gross examination and it may be that a more intensive assessment of sediments will be required to adequately assess their cultural content. Specifically, it is recommended that some portion of the sand outflow be examined in detail, if the initial stages of monitoring suggest this is necessary. For example, if the monitoring recovers large numbers of artifacts and/or ecofacts of various sizes, then it may not be necessary to undertake any additional examination of the dredged material. Some options for undertaking additional examination of the dredge material can be discussed now, but specific recommendations on techniques cannot be made until the dredging procedures are finalized. One option is that screening be conducted onshore using the outflow material, assuming this will be the technique used for sediment placement and assuming that it will be possible to determine the location in Ship Shoal where outflow sediments are derived. Ideally, the screening mechanism could be incorporated into the outflow stream. If this is not possible, then the outflow could be periodically diverted into a stationary screen set up near the point of discharge. This would involve using a large, industrial screen (or screens) of the type typically used by the sand and gravel industry to sort aggregate. A mesh size of about one-half inch should be large enough to let sand easily pass through, but small enough to capture cultural remains of interest. The objective would be to screen only a very small portion of outflow material; for instance, it may be necessary to divert outflow into the screen for only a few minutes a day, or possibly only every few days. A water pump would be required to wash sediments through the screen. The amount of material that can be screened within a reasonable amount of time and effort will have to be determined through field trials. Similarly, the amount of material that will have to be screened to obtain information on artifactual content is presently unknown. However, the objective would be to screen only a sufficient portion of the dredged material to develop some idea of its cultural content.

A second option would be to use a sluice box system on the onshore materials rather than a screen to separate the heavier artifacts from the lighter dredged material. A water pump or dredge would be used to provide the water supply to the sluice to assist in the separation of materials and a screen at the end of the sluice would ensure that any artifacts not caught by the sluice would be retained. Both of these options are flexible in that either could be conducted onshore as well as on the barge or other vessel to be used as the sand is being dredged from the bottom. However, conducting the screening or sluicing on the barge during excavation may face logistical and safety problems that would not be encountered if the work is done at the onshore location.

It is possible that directly screening the dredge flow or diverting that flow into a screen will produce unacceptable delays or inconveniences in the dredging activity. If so, it is recommended that the Ship Shoal sediments be screened after they have been deposited onshore. In light of the amount of material that needs to be screened, it would be inefficient to try to dig sediment for screening by hand. More effective would be to use a front-end loader or a similar piece of equipment to dig up material after it has been pumped ashore and dump it into a stationary screen. A water pump would be required to water screen the material. This approach would allow archaeologists to undertake the screening without serious interruptions to the dredging process.

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APPENDIX 2

EQUIPMENT OPERATIONS AND PROCEDURES

Trimble DSM 212 Differential Global Positioning System
HYPACK Navigation Software
ODOM Echotrac Depth Sounder
Klein Dual-Frequency Digital Side Scan Sonar System
Geometrics G882 Cesium Marine Magnetometer
EdgeTech 3200-XS 2-16 kHz “Chirp” Subbottom Profiler
EdgeTech GEOSTAR 4-24 kHz “Chirp” Subbottom Profiler

EQUIPMENT OPERATIONS AND PROCEDURES

Trimble DSM 212 Differential Global Positioning System

A Trimble DSM 212 differential global satellite positioning system (GPS) provides reliable, high-precision positioning and navigation for a wide variety of operations and environments. The unique feature of this system is its integration of a standard 12-channel GPS receiver with a U.S. Coast Guard beacon receiver all in one package. Both antennas are combined in a single housing and the receiver electronics are similarly contained within one topside control box. The complete system includes the topside control unit, a GPS volute antenna and cable, RS232 output and input data cables, and a 12-volt DC power cable. The proprietary MSK beacon receiver used in the system has been designed to provide enhanced signal reception at large distances from the reference station and under inclement weather conditions. The low noise MSK receiver is also an automatic, dual-channel system providing seamless switching between multiple beacons when necessary. The DSM 212 outputs one position per second to the HYPACK navigation computer. The manufacturer reports submeter accuracy of the system under suitable operating conditions.

HYPACK Navigation Software

Survey vessel trackline control and position fixing were obtained by utilizing an OSI computer-based data logging package running HYPACK navigation software. The computer is interfaced with the DGPS system onboard the survey vessel. Vessel position data from the DGPS were updated at 1.0-second intervals and input to the HYPACK navigation system which processes the geodetic positions into State Plane coordinates used to guide the survey vessel accurately along preselected tracklines. The incoming data are logged on disk and processed in real time allowing the vessel position to be displayed on a video monitor and compared to each pre-plotted trackline as the survey progresses. A nautical chart background shows the shoreline, general water depths, and locations of existing structures, buoys, and control points on the monitor in relation to the vessel position. The OSI computer logging system combined with the HYPACK software thus provide an accurate visual representation of survey vessel location in real time, combined with highly efficient data logging capability and post-survey data processing and plotting routines.

Odom Echotrac DF3200 MKII Digital Dual-Frequency Depth Sounder

Precision water depth measurements were obtained by using an Odom Echotrac MKII depth sounder capable of recording water depths up to 600 feet (using 200 kilohertz frequency) at a resolution of 0.1 foot. The Echotrac system can be used as a single- or dual-frequency system, typically operated at 200 kilohertz (3° or 8° beam transducer) and/or 24 kilohertz. The MKII recorder has a high-resolution thermal print head which can generate up to 16 gray scales, with enhanced bottom tracking capabilities through use of a Digital Signal Processing feature. Digital data are output through any of its four bi-directional RS-232 serial ports. The MKII incorporates tide and draft corrections plus a calibration capability for local water mass sound speed. A port is also provided for direct interface to an external TSS heave sensor for removing boat motion from the data in real time.

Operated in dual-frequency mode with a 24-kilohertz transducer, the system is capable of nearsurface subbottom penetration through generally finer grained sediments. Depending on site conditions, the high-frequency signal reflects off the sediment-water interface while the lower-frequency signal may penetrate below the bottom and reflect off the first compact layer encountered. Both traces are recorded digitally by the HYPACK navigation computer as well as printed on the thermal paper.

Geometrics Model G-882 Cesium Vapor Marine Magnetometer

Total magnetic field intensity measurements are acquired along the survey tracklines using a Geometrics G882 cesium magnetometer which has an instrument sensitivity of 0.1 gamma. The G882 magnetometer system includes the sensor head with a coil and optical component tube, a sensor electronics package which houses the AC signal generator and mini-counter that converts the Larmor signal into a magnetic anomaly value in gammas, and a RS-232 data cable for transmitting digital measurements to a data logging system. The cesium-based method of magnetic detection allows a center or nose tow configuration off the survey vessel, simultaneously with other remote sensing equipment, while maintaining high quality, quiet magnetic data with ambient fluctuations of less than 1 gamma. The G882 outputs magnetic intensity readings at a 10-hertz sampling rate which were recorded on the OSI data logging computer by the HYPACK software. A key feature of the G882 is an altimeter under the nose of the towfish that measures height of the sensor above the bottom and it also has a pressure sensor to record depth below the water surface.

The G882 magnetometer acquires information on the ambient magnetic field strength by measuring the variation in cesium electron energy level states. The presence of only one electron in the atom's outermost electron shell (known as an alkali metal) makes cesium ideal for optical pumping and magnetometry.

A beam of infrared light is passed through a cesium vapor chamber producing a Larmor frequency output in the form of a continuous sine wave. This radio frequency field is generated by an H1 coil wound around a tube containing the optical components (lamp oscillator, optical filters and lenses, split-circular polarizer, and infrared photo detector). The Larmor frequency is directly proportional to the ambient magnetic intensity, and is exactly 3.49872 times the ambient magnetic field measured in gammas or nanoteslas. Changes in the ambient magnetic field cause different degrees of atomic excitation in the cesium vapor which in turn allows variable amounts of infrared light to pass, resulting in fluctuations in the Larmor frequency.

Although the earth's magnetic field does change with both time and distance, over short periods and distances the earth's field can be viewed as relatively constant. The presence of magnetic material and/or magnetic minerals, however, can add to or subtract from the earth's magnetic field creating a magnetic anomaly. Rapid changes in total magnetic field intensity which are not associated with normal background fluctuations mark the locations of these anomalies.

Determination of the location of an object producing a magnetic anomaly depends on whether or not the magnetometer sensor passed directly over the object and if the anomaly is an apparent monopole or dipole. A magnetic dipole can be thought of simply as a common bar magnet having a positive and negative end or pole. A monopole arises when the magnetometer senses only one end of a dipole as it passes over the object. This situation occurs mainly when the distance between opposite poles of a dipole is much greater than the distance between the magnetometer and the sensed pole, or when a dipole is oriented nearly perpendicular to the ambient field thus shielding one pole from detection. For dipolar anomalies, the location of the object is at the point of maximum gradient between the two poles. In the case of a monopole, the object associated with the anomaly is located below the maximum or minimum magnetic value.

Klein 3000 Dual-Frequency Side Scan Sonar System

Side scan sonar images of the bottom are collected using a Klein 3000 dual frequency, high-resolution sonar system operating at frequencies of 100 and 500 kilohertz. The system consists of a topside computer, monitor, keyboard, mouse, tow cable, and sonar towfish. All system components are interfaced via a local network hub and cable connections. The system contains an integrated navigational plotter which accepts standard NMEA 0183 input from a GPS system. This allows vessel position to be displayed on the monitor and speed information to be used for controlling sonar ping rate. Sonar sweep can also be plotted in the navigation window for monitoring bottom coverage in the survey area.

The hardware is interfaced to the Klein SonarPro data acquisition and playback software package which runs on the topside computer. All sonar images are stored digitally and can be enhanced real-time or post-survey by numerous mathematical filters available in the program software. Imagery is displayed in a waterfall window in either normal or ground range (water column removed) formats. Other software functions that are available during data acquisition include; changing range scale and delay, display color, automatic or manual TVG (time variable gain), speed over bottom, multiple enlargement zoom, target length, height, and area measurements, logging and saving of target images, and annotation frequency and content. The power of this system is its real-time processing capability for determining precise dimensions of targets and areas on the bottom.

As with many other marine geophysical instruments, the side scan sonar derives its information from reflected acoustic energy. A set of transducers mounted in a compact towfish generate the short duration acoustic pulses required for extremely high resolution. The pulses are emitted in a thin, fan-shaped pattern that spreads downward to either side of the fish in a plane perpendicular to its path. As the fish progresses along the trackline this acoustic beam sequentially scans the bottom from a point directly beneath the fish outward to each side of the survey trackline.

Acoustic energy reflected from any bottom discontinuities is received by the set of transducers in the towfish, amplified and transmitted to the survey vessel via the tow cable where it is further amplified, processed, and converted to a graphic record by the side scan recorder. The sequence of reflections from the series of pulses is displayed on a video monitor and/or dual-channel graphic recorder on which paper is incrementally advanced prior to printing each acoustic pulse. The resulting output is essentially analogous to a high angle oblique "photograph" providing detailed representation of bottom features and characteristics. This system allows display of positive relief (features extending above the bottom) and negative relief (such as depressions) in either light or dark opposing contrast modes on the video monitor. Examination of the images thus allows a determination of significant features and objects present on the bottom within the survey area.

EdgeTech 3200-XS 0.5-12 kHz "Chirp" Subbottom Profiler

Information concerning subsurface stratigraphy was explored through use of an EdgeTech 3200-XS "Chirp" Subbottom Profiler system operating at frequencies of 0.5 to 12 kilohertz. The subbottom profiler consists of three components: the deck unit (XStar topside computer, amplifier, monitor, keyboard, and trackball), an underwater cable, and a Model SB512 towed vehicle housing the transducers. Data are acquired, logged, and displayed using the Discover Subbottom software.

The 3200 XS Chirp sonar is a versatile subbottom profiler that generates cross-sectional images and collects normal incidence reflection data over many frequency ranges. The system transmits and receives an FM pulse signal generated via a streamlined towed vehicle (subsurface transducer array). The outgoing FM pulse is linearly swept over a full spectrum range of 0.5-12 kHz for a period of approximately 20 milliseconds. The acoustic return received at the hydrophone array is cross-correlated with the outgoing FM pulse and sent to the deck unit for display and archiving, generating a high-resolution image of the subbottom stratigraphy. Because the FM pulse is generated by a converter with a wide dynamic range and a transmitter with linear components, the energy, amplitude, and phase characteristics of the acoustic pulse can be precisely controlled and enhanced.

During data acquisition, all records were annotated with relevant supporting information, field observations, line number, run number, navigation event marks and numbers for later interpretation and correlation with vessel position data.

EdgeTech GeoStar 2-16 kHz "Chirp" Subbottom Profiler

The EdgeTech GeoStar "Chirp" Subbottom Profiler system operates at frequencies of 2-16 kilohertz. The subbottom profiler consists of three main components: the deck unit (Pentium processor, amplifier, monitor, keyboard, and trackball), an underwater cable, and a Model

SB216 towed vehicle housing the transducers. Data are displayed on a monitor while being logged on the topside control computer.

The GeoStar "chirp" profiler is a versatile subbottom system that generates cross-sectional images and collects normal incidence reflection data over many frequency ranges. The system transmits and receives an FM pulse signal generated via a streamlined towed vehicle (subsurface transducer array). The outgoing FM pulse is linearly swept over a full spectrum range of 2-16 kilohertz for a period of approximately 20 milliseconds. The acoustic return received at the hydrophone array is cross-correlated with the outgoing FM pulse and sent to the deck unit for display and archiving, generating a high-resolution image of the subbottom stratigraphy. Because the FM pulse is generated by a converter with a wide dynamic range and a transmitter with linear components, the energy, amplitude, and phase characteristics of the acoustic pulse can be precisely controlled and enhanced.

During data acquisition, all records were annotated with relevant supporting information, field observations, line number, run number, navigation event marks and numbers for later interpretation and correlation with vessel position data.

APPENDIX 3

DATA PROCESSING AND ANALYSIS METHODS

Navigation Data
Hydrographic Data
Magnetometer Data
Side Scan Sonar Data
Subbottom Reflection Data

DATA PROCESSING AND ANALYSIS METHODS

Navigation Data

During the field investigation, vessel navigation files were continuously processed and entered into AutoCAD drawings to verify survey coverage and assist with the onsite review of geophysical data. Upon completion of the field work, vessel tracklines were exported utilizing the HYPACK software as a DXF file and entered into the AutoCAD drawing files to show survey coverage.

Hydrographic Data

Upon completion of the field work, the single beam data were processed using HYPACK single beam editor. Digital depth data were first checked against the graphic sounding records for verification of depth quality. Erroneous digital depths caused by floating and drifting debris, air bubbles from passing ship's wake, or fish in the water column were filtered out of the data. The editing process is performed with care to eliminate points attributed to objects in the water column (fish, floating line, etc.) while preserving small features important to the project (potential obstructions). The digital files containing vessel position and hydrographic data were then processed to correct for field calibrations and adjust the sounding data to the required datum.

Depth data points were exported out of HYPACK and used to generate surface models that placed the depth data into cell bins of a sufficient size to preserve the features of interest. Shaded rendering maps were generated within the software program Global Mapper, Version 10. The processed x, y, z data for the survey areas were then contoured at an appropriate interval using Quicksurf operating within AutoCAD (Autodesk).

Magnetic Intensity Measurements

The objective of the magnetic survey was to locate any ferrous objects lying on or buried beneath the seafloor within the project site. Anomalies of man-made origin typically have short wavelengths and high amplitudes. In contrast, most geological features generate anomalies that are large in amplitude and often cover a much greater area. Magnetometer data were initially processed with HYPACK software package Single Beam Editor and then contoured utilizing the Geometrics' software package MagPick (V. 3.2). Magnetic anomaly tables were constructed based on a review of the processed data.

For discrete anomalies, determination of the location of the anomaly-producing object depends upon whether the anomaly is an apparent monopole or dipole and upon whether or not the magnetometer passed directly over the object. A magnetic dipole can be thought of in terms of a common bar magnet having a positive and a negative pole. Monopoles arise when the magnetometer senses only one pole of a dipole. This situation most commonly arises when the distance between opposite poles of a dipole is greater than the distance between the magnetometer sensor and the sensed pole or when a dipole is oriented nearly perpendicular to the ambient field thus shielding one pole from detection. For dipolar anomalies, the closest point of detection of the related object is determined to be at the point of maximum gradient between the two poles. Whereas the closest point of detection for objects which exhibit monopolar characteristics is typically the peak of maximum fluctuation.

Side Scan Sonar Imagery

Side scan sonar mosaics were created using Chesapeake Technologies, Inc. SonarWiz Version 5.03 software. Imagery were reviewed and interpreted to detect individual targets with the intent of identifying any man-made objects. This served two purposes: it provided information on potential obstructions to the planned sand dredging operation and data to support the marine archaeological assessment of the area. Each target is interpreted and measured individually. A spreadsheet summarizes specific information for each target such as ID number, position, size, relief, brief description, and magnetic associations. The target positions were also imported in AutoCAD and plotted in plan view.

Chirp Subbottom Profile Data

Subbottom profile data were processed (filtered and gain applied) to generate jpeg images of the data utilizing EdgeTech's Discover-Sub-Bottom, Version 3.36, software package. Images representative of each survey line investigated (both SB216 and SB512) were constructed and imported into an ACAD drawing file to review along with the results of historic cores performed in the area. Based on this review a sand thickness isopach was generated. In addition to generating a sand thickness isopach, subsurface data were analyzed to map potential relict landforms/channels and pipelines in the project area. This interpretation is presented as an overlay to the sonar mosaic presented on Drawing 4.

APPENDIX 4

SUMMARY TABLES OF MAGNETIC ANOMALIES AND SIDE SCAN SONAR TARGETS

MAGNETIC ANOMALIES

Magnetic Anomaly	Easting[1]	Northing[1]	Type[2]	Amplitude[3]	Duration[4]	Sensor Altitude[4]	Sonar Target
M1	3506823	152665	+M	11.2	67.2	21.6	
M2	3507640	152952	D	82.4	333.9	16.8	
M3	3508070	153189	D	33.8	113.4	18.8	
M4	3506471	152262	D	18.2	124.5	22.9	
M5	3507012	152215	D	15.7	106.8	18.5	SS69
M6	3508491	152850	+M	4.3	49.2	20.6	
M7	3507276	152121	-M	2.6	34.8	16.8	
M8	3508113	152438	D	10.6	119.7	18.5	
M9	3508664	152272	+M	5.5	42.8	21.7	
M10	3510211	153062	D	8.6	86.3	22.3	
M11	3505900	150758	+M	4.2	77.0	18.0	
M12	3510450	153075	+M	7.6	61.7	17.2	
M13	3509535	152498	+M	10.0	81.0	20.1	
M14	3504746	149733	D	8.5	69.3	20.8	
M15	3511246	153048	D	18.2	80.5	19.0	
M16	3512524	153585	-M	87.2	105.0	21.0	
M17	3509179	151769	+M	18.3	141.9	18.0	SS48
M18	3510942	152670	D	11.6	116.3	17.9	
M19	3507477	150800	-M	5.1	59.4	17.8	
M20	3510267	152212	-M	45.7	115.1	18.4	
M21	3510167	152046	D	42.0	164.2	19.6	
M22	3510872	152412	-M	8.4	65.3	19.5	
M23	3511392	152558	D	11.5	99.0	21.5	
M24	3508930	151194	D	22.4	141.9	19.5	
M25	3509199	151342	+M	14.0	82.0	19.3	
M26	3509523	151512	D	8.1	94.4	19.0	SS44
M27	3509972	151614	D	6.6	120.8	18.7	SS43
M28	3511248	152260	-M	15.8	109.9	18.4	
M29	3509807	151312	D	30.8	142.3	21.7	
M30	3514010	153348	-M	5.6	72.8	19.4	
M31	3513468	152843	D	5.5	73.2	18.0	
M32	3513551	152884	+M	4.6	78.1	19.0	
M33	3506706	149193	D	6.8	86.6	21.6	
M34	3510123	150812	-M	14.1	104.7	20.7	
M35	3510163	150714	D	11.7	102.2	19.2	

Magnetic Anomaly	Easting[1]	Northing[1]	Type[2]	Amplitude[3]	Duration[4]	Sensor Altitude[4]	Sonar Target
M36	3508990	150006	+M	7.3	88.2	22.3	
M37	3504998	147875	-M	11.5	79.7	22.7	
M38	3506802	148807	D	28.8	201.3	21.7	
M39	3510644	150744	D	24.8	212.2	20.3	
M40	3511188	150917	+M	10.7	73.1	20.6	
M41	3513590	152151	D	24.8	143.7	20.0	SS26
M42	3514215	152461	D	22.0	128.8	20.3	
M43	3514127	152295	-M	8.2	76.9	20.2	
M44	3507656	148906	-M	32.3	97.5	22.3	
M45	3509872	150028	-M	40.1	161.2	20.8	
M46	3505324	147473	D	52.4	150.8	25.0	SS24
M47	3508221	148928	-M	8.4	67.5	22.4	
M48	3510088	149908	+M	10.9	172.5	21.8	
M49	3511146	150454	D	27.5	162.8	22.0	SS25
M50	3509865	149680	-M	15.7	164.2	21.5	
M51	3510147	149826	+M	23.8	179.3	20.5	
M52	3509886	149585	+M	61.4	174.4	21.7	
M53	3506917	147974	D	18.5	146.3	21.5	
M54	3508484	148764	D	43.4	289.1	21.4	
M55	3509207	149121	+M	10.5	125.6	20.7	
M56	3510241	149667	-M	19.5	102.9	20.2	
M57	3508100	148454	+M	13.2	211.7	22.3	
M58	3509882	149363	-M	25.9	104.6	21.8	
M59	3510115	149474	D	7.1	81.7	21.4	
M60	3512208	150441	-M	11.9	127.9	21.6	
M61	3506332	147118	-M	7.2	90.0	30.0	
M62	3509216	148591	D	13.1	97.9	26.4	
M63	3507633	147657	D	5.8	111.4	25.0	
M64	3508761	148241	-M	5.3	224.3	23.9	SS20
M65	3511913	149842	D	8.3	116.1	22.5	
M66	3512766	150279	+M	5.7	80.1	22.1	SS19
M67	3508819	148162	+M	103.3	223.3	24.2	SS20
M68	3513895	150733	-M	11.2	77.2	19.8	
M69	3514071	150833	+M	9.8	94.5	20.2	
M70	3509043	148162	-M	82.2	136.4	21.0	
M71	3511755	149553	D	2.9	35.3	22.4	
M72	3507300	147184	-M	12.4	125.2	25.0	

Magnetic Anomaly	Easting[1]	Northing[1]	Type[2]	Amplitude[3]	Duration[4]	Sensor Altitude[4]	Sonar Target
M73	3509089	148093	-M	53.3	84.9	23.2	
M74	3512917	150025	D	6.0	48.3	21.3	
M75	3512734	149831	D	15.1	123.4	22.3	
M76	3511331	148994	D	9.7	135.7	23.5	
M77	3507164	146769	+M	5.2	84.4	26.3	
M78	3512021	149015	-M	49.2	170.1	23.3	SS12
M79	3512833	149426	D	14.8	339.2	23.6	
M80	3509154	147450	D	4.0	69.0	25.6	
M81	3507483	146593	+M	4.9	46.4	26.5	
M82	3506754	146120	D	5.3	88.1	26.4	
M83	3510774	148159	D	40.5	154.9	24.2	
M84	3514490	150055	D	16.0	92.5	22.5	
M85	3507499	146392	D	7.4	105.0	28.4	
M86	3509475	147157	+M	10.5	109.5	26.3	SS6
M87	3514247	149597	D	116.8	290.0	22.6	
M88	3515346	150042	+M	50.4	133.1	20.8	
M89	3507563	146088	D	19.9	121.9	26.8	
M90	3507035	145819	D	56.3	156.9	27.6	SS5
M91	3510172	147300	D	8.4	76.9	26.2	SS3
M92	3515354	149947	D	819.0	262.4	23.0	
M93	3516180	150364	D	10.2	125.4	22.8	
M94	3516498	150521	D	8.4	96.0	22.2	
M95	3507837	146011	D	5.2	90.1	27.0	
M96	3506855	152107	-M	7.0	51.8	19.5	SS68
M97	3509271	149987	-M	6.7	42.3	21.0	
M98	3512412	150560	-M	4.3	47.5	21.2	

[1] Coordinates are in feet in the LA State Plane Coordinate System, South Zone (1702), NAD 83.

[2] +M - positive monopole, -M - negative monopole, D - dipole.

[3] Amplitude is measured in Gammas.

[4] Duration and Sensor Altitude are measured in feet.

▨ Archaeologist recommends avoidance

SIDE SCAN SONAR TARGETS

Sonar Target	Easting[1]	Northing[1]	Length[2]	Width[2]	Height[2]	Description	Magnetic Anomaly[3]
SS1	3517976	151068	9.8	4.2	0.8	Oblong target	
SS2	3510621	147318	4.2	2.5	4.1	Oblong target	
SS3	3510186	147296	8	1.7	0.9	Oblong target	M91
SS4	3509243	146778	4.1	3.3	4.5	Possible oblong target	
SS5	3507017	145872	12.6	2.9	0.7	Possible oblong target	M90
SS6	3509499	147112	14.3	5.2	0	Possible target	M86
SS7	3517820	151336	4.5	2.3	0.1	Oblong target	
SS8	3506640	145735	11.2	3.2	1.1	Oblong target	
SS9	3506341	145565	9.7	2.9	0.6	Oblong target	
SS10	3509392	147342	7	4	0.7	Oblong target	
SS11	3509317	147583	32.5	1.6	0	Possible linear target	
SS12	3511920	149051	3.7	2.9	2.4	Oblong target	M78
SS13	3506993	146662	9.3	2.2	1.6	Oblong target	
SS14	3512362	149567	15.3	1.4	0	Oblong target	
SS15	3512116	149494	31.4	3.2	0	Linear target	
SS16	3505979	146527	2.5	0.9	0	3 small targets	
SS17	3506619	147059	7.7	1.1	0.3	Linear target	
SS18	3512548	150059	9.2	1.7	0	Oblong target	
SS19	3512755	150293	4.9	3.8	0	Oblong target	M66
SS20	3508792	148184	13.1	2.7	4.7	Oblong target	M64, M67
SS21	3514969	152041	10.1	4.3	0	Oblong target	
SS22	3507665	148489	7	2	5.4	Linear target	
SS23	3515031	152423	5.8	2.4	0	Oblong target	
SS24	3505218	147534	4.5	2	1.1	Oblong target	M46
SS25	3511191	150534	8.9	4.1	0	Oblong target	M49
SS26	3513641	152103	16.5	3.3	0	Oblong target	M41
SS27	3506068	148417	97.2	6.3	0.8	Bottom disturbance	
SS28	3509734	150221	7.1	3.5	0.6	Oblong target	
SS29	3509302	150142	6.4	1.4	0.6	2 oblong targets	
SS30	3509476	150331	4.8	2.3	0.8	Oblong target	
SS31	3504715	147926	116.2	1	1.2	Linear target	
SS32	3513286	152505	4.5	2.6	0.6	Oblong target	
SS33	3510709	151248	7.2	2.7	0	Oblong target	
SS34	3505162	148361	6.6	2.2	1.2	Oblong target	
SS35	3513349	152730	8.2	1.8	0.9	Oblong target	

Sonar Target	Easting[1]	Northing[1]	Length[2]	Width[2]	Height[2]	Description	Magnetic Anomaly[3]
SS36	3512806	152536	10.1	3.6	0	Oblong target	
SS37	3509420	150800	27.1	2.5	0.3	Linear target	
SS38	3509427	150750	4.3	2.2	0	Oblong target	
SS39	3506019	149047	11.6	1	0	Linear target	
SS40	3512161	152582	6.6	4	0	Oblong target	
SS41	3511034	151965	6.6	4.2	0	Oblong target	
SS42	3511785	152579	7.9	2.4	0	Oblong target	
SS43	3509896	151677	4.3	2	0.3	2 oblong targets	M27
SS44	3509611	151504	6.5	2.9	0	Oblong target	M26
SS45	3509115	151437	5.6	1.9	0.3	Oblong target	
SS46	3511210	152658	6.9	1.1	0.3	Oblong target	
SS47	3510819	152725	8.8	3.3	0.4	Oblong target	
SS48	3509127	151790	6	2.5	0.7	Oblong target	M17
SS49	3505938	150290	4.7	3.1	0	Oblong target	
SS50	3503949	149225	8.7	6.3	0.7	2 oblong targets	
SS51	3503936	149247	13.2	7	1	Oblong target	
SS52	3512154	153532	5	3	0.6	Oblong target	
SS53	3504339	149748	7	4.2	0.5	Oblong target	
SS54	3508263	151706	11.7	2.9	0.8	Oblong target	
SS55	3509002	152167	7.3	1.7	0.7	2 oblong targets	
SS56	3508370	151872	7.6	3.8	0	Oblong target	
SS57	3507518	151647	4.1	2.6	1.1	Oblong target	
SS58	3505532	150769	8.4	7	0.4	Oblong target	
SS59	3507119	151591	8.4	3.4	0	Oblong target	
SS60	3507644	151831	7.7	3.8	0	Oblong target	
SS61	3508801	152545	9.1	3.8	0	Oblong target	
SS62	3504202	150354	2.7	2.6	0.4	Round target	
SS63	3507419	151907	7.8	2.1	0.8	Oblong target	
SS64	3507867	152199	15	6.6	0.8	Oblong target	
SS65	3505506	151240	7.5	2.9	0	Oblong target	
SS66	3505377	151196	7.8	2.8	0	Oblong target	
SS67	3504436	150714	9.2	5.6	0	Oblong target	
SS68	3506890	152130	17.6	1.8	0	Linear target	M96
SS69	3506947	152207	4.9	3.1	1	2 oblong targets	M5
SS70	3505447	152084	4.3	1.2	0.7	Oblong target	
SS71	3505898	152500	5.5	4	0.7	Oblong target	
SS72	3506167	152713	6	3	0.4	Oblong target	
SS73	3506982	153231	5.9	2.7	0	Oblong target	

Sonar Target	Easting[1]	Northing[1]	Length[2]	Width[2]	Height[2]	Description	Magnetic Anomaly[3]
SS74	3506794	153138	4.9	2.4	0	Oblong target	
SS75	3506469	153098	3.9	1.8	0	Oblong target	
SS76	3506634	153269	6.3	3.1	0	Oblong target	
SS77	3507008	153454	6.2	3	0	Oblong target	
SS78	3505983	153160	4.4	1.8	0	Oblong target	
SS79	3506703	153515	5.4	2.1	0	Oblong target	

[1] Coordinates are in feet in the LA State Plane Coordinate System, South Zone (1702), NAD 83.

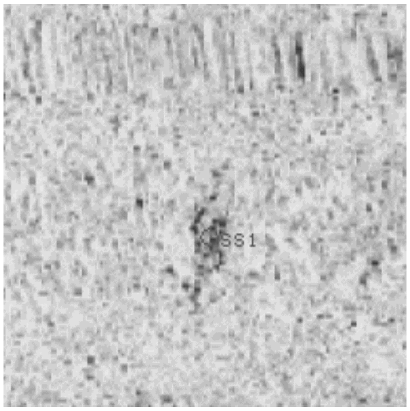
[2] All target dimensions are in feet.

[3] Associated magnetic anomalies.

▨ Archaeologist recommends avoidance

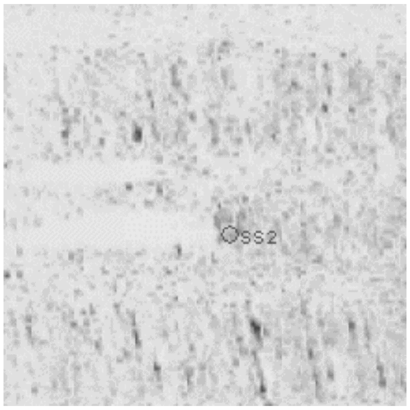
Side Scan Sonar Target Report

Contact Image **Contact Info**



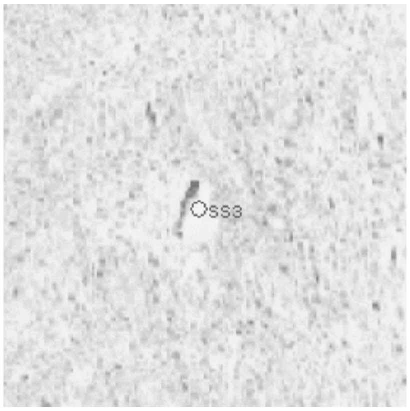
SS1
(X) 3517976.25 (Y) 151068.25

Dimensions
Target Height: = 1 US Feet
Target Length: 10 US Feet
Target Width: 4 US Feet
Description: Oblong target



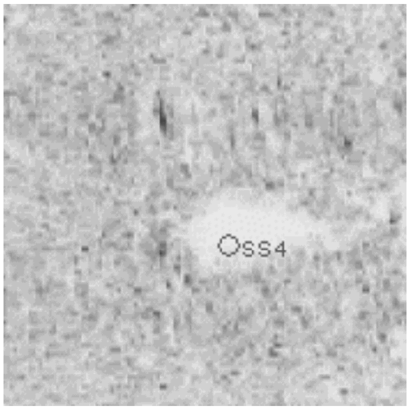
SS2
(X) 3510621.50 (Y) 147317.89

Dimensions
Target Height: = 4 US Feet
Target Length: 4 US Feet
Target Width: 2 US Feet
Description: Oblong target?



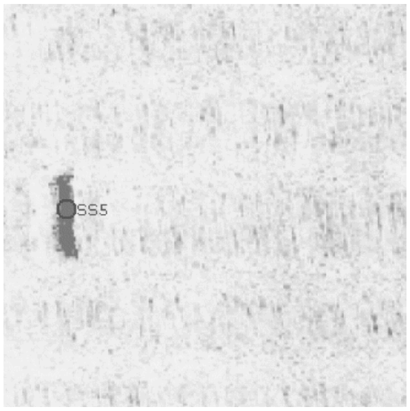
SS3
(X) 3510186.25 (Y) 147296.30

Dimensions
Target Height: = 1 US Feet
Target Length: 8 US Feet
Target Width: 2 US Feet
Description: Oblong target



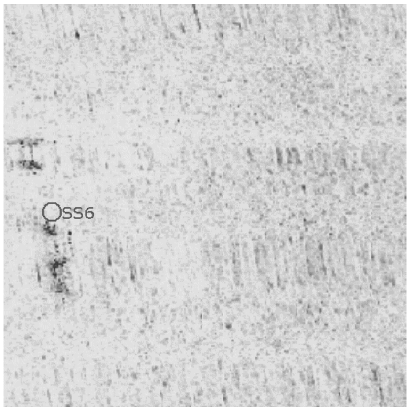
SS4
(X) 3509242.75 (Y) 146778.00

Dimensions
Target Height: = 4 US Feet
Target Length: 4 US Feet
Target Width: 3 US Feet
Description: Possible target?



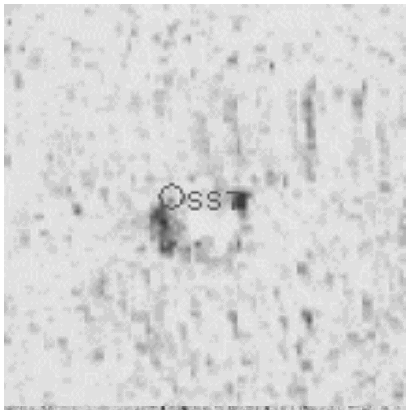
SS5
(X) 3507017.25 (Y) 145871.91

Dimensions
Target Height: = 1 US Feet
Target Length: 13 US Feet
Target Width: 3 US Feet
Description: Possible oblong target



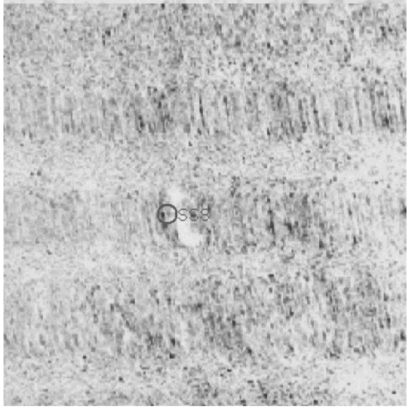
SS6
(X) 3509499.00 (Y) 147112.48

Dimensions
Target Height: = 0 US Feet
Target Length: 14 US Feet
Target Width: 5 US Feet
Description: Possible target



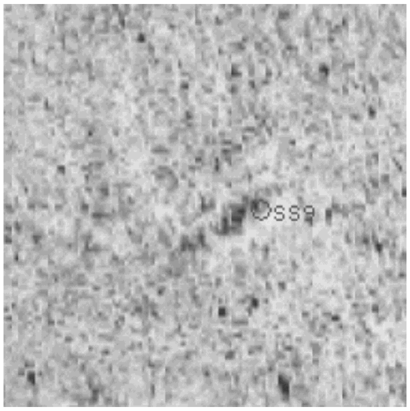
SS7
(X) 3517820.25 (Y) 151336.23

Dimensions
Target Height: = 0 US Feet
Target Length: 4 US Feet
Target Width: 2 US Feet
Description: Oblong target



SS8
(X) 3506639.75 (Y) 145734.56

Dimensions
Target Height: = 1 US Feet
Target Length: 11 US Feet
Target Width: 3 US Feet
Description: Oblong target

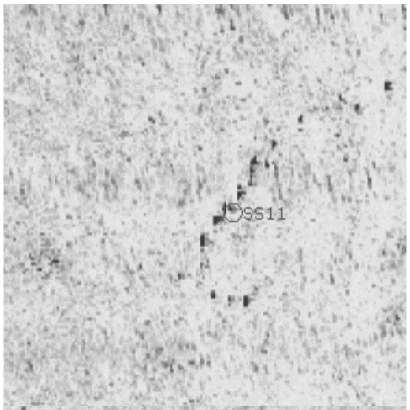


SS9
(X) 3506340.75 (Y) 145564.95

Dimensions
Target Height: = 1 US Feet
Target Length: 10 US Feet
Target Width: 3 US Feet
Description: Oblong target

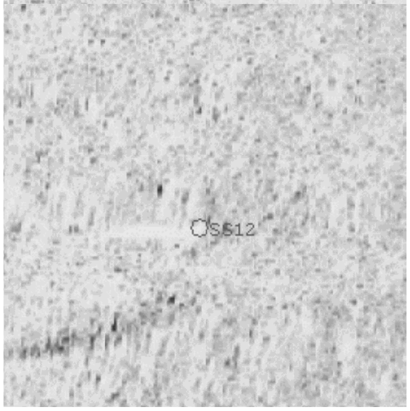
SS10
(X) 3509391.75 (Y) 147342.14

Dimensions
Target Height: = 1 US Feet
Target Length: 7 US Feet
Target Width: 4 US Feet
Description: Oblong target



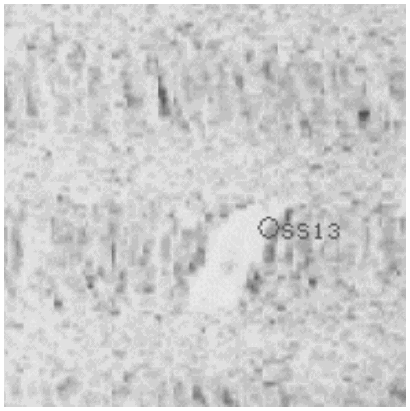
SS11
(X) 3509317.25 (Y) 147582.91

Dimensions
Target Height: = 0 US Feet
Target Length: 33 US Feet
Target Width: 2 US Feet
Description: Possible linear target



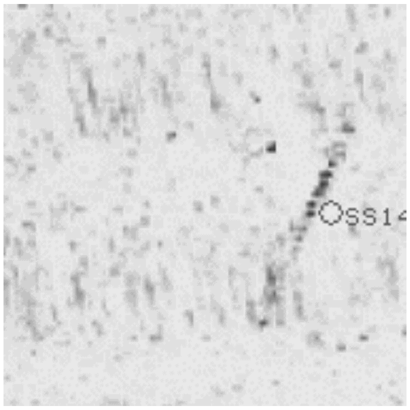
SS12
(X) 3511920.00 (Y) 149051.28

Dimensions
Target Height: = 2 US Feet
Target Length: 4 US Feet
Target Width: 3 US Feet
Description: Oblong target?



SS13
(X) 3506993.50 (Y) 146662.02

Dimensions
Target Height: = 2 US Feet
Target Length: 9 US Feet
Target Width: 2 US Feet
Description: Oblong target

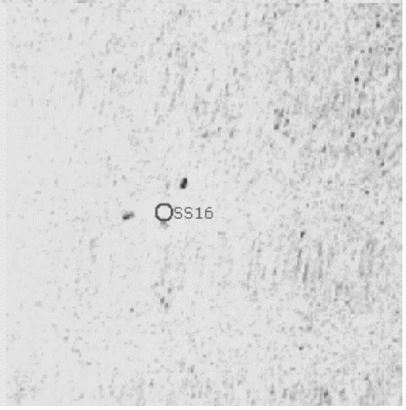


SS14
(X) 3512362.25 (Y) 149566.55

Dimensions
Target Height: = 0 US Feet
Target Length: 15 US Feet
Target Width: 1 US Feet
Description: Oblong target

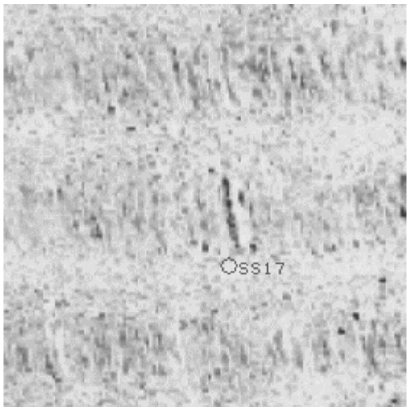
SS15
(X) 3512116.00 (Y) 149493.97

Dimensions
Target Height: = 0 US Feet
Target Length: 31 US Feet
Target Width: 3 US Feet
Description: Linear target



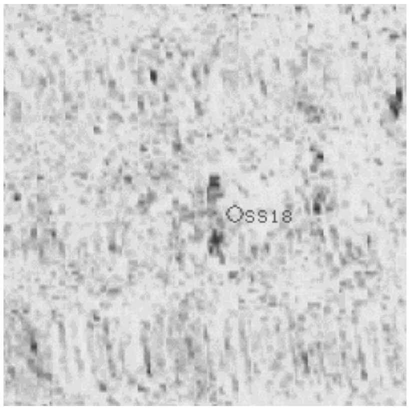
SS16
(X) 3505978.50 (Y) 146527.20

Dimensions
Target Height: = 0 US Feet
Target Length: 3 US Feet
Target Width: 1 US Feet
Description: 3 small targets



SS17
(X) 3506619.25 (Y) 147058.97

Dimensions
Target Height: = 0 US Feet
Target Length: 8 US Feet
Target Width: 1 US Feet
Description: Linear target

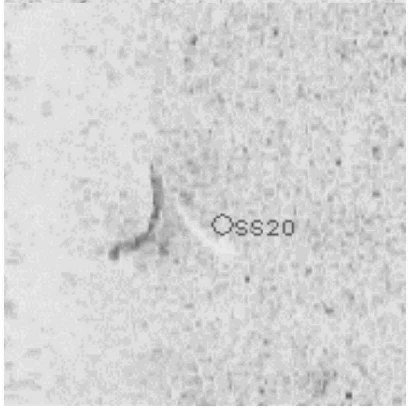


SS18
(X) 3512548.50 (Y) 150058.66

Dimensions
Target Height: = 0 US Feet
Target Length: 9 US Feet
Target Width: 2 US Feet
Description: Oblong target

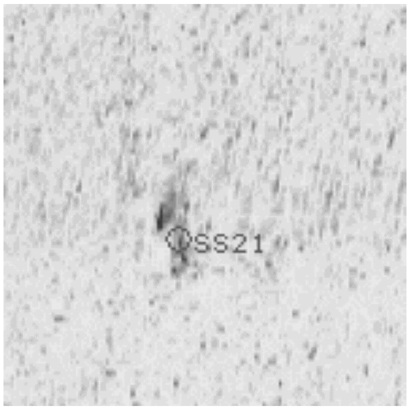
SS19
(X) 3512755.00 (Y) 150292.64

Dimensions
Target Height: = 0 US Feet
Target Length: 5 US Feet
Target Width: 4 US Feet
Description: Oblong target



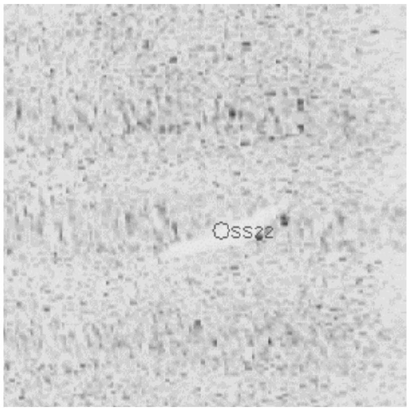
SS20
(X) 3508792.25 (Y) 148184.09

Dimensions
Target Height: = 5 US Feet
Target Length: 13 US Feet
Target Width: 3 US Feet
Description: Oblong target



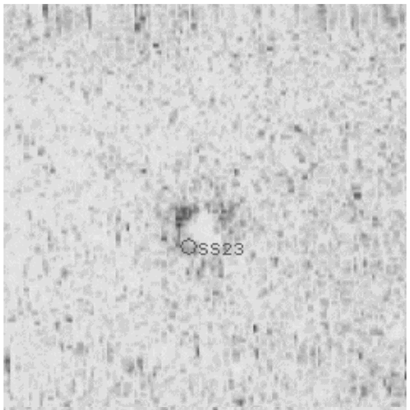
SS21
(X) 3514968.75 (Y) 152041.50

Dimensions
Target Height: = 0 US Feet
Target Length: 10 US Feet
Target Width: 4 US Feet
Description: Oblong target



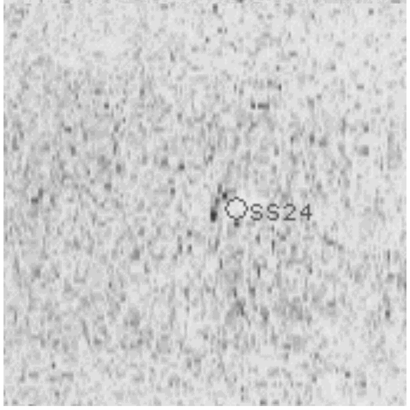
SS22
(X) 3507665.25 (Y) 148488.78

Dimensions
Target Height: = 5 US Feet
Target Length: 7 US Feet
Target Width: 2 US Feet
Description: Linear target



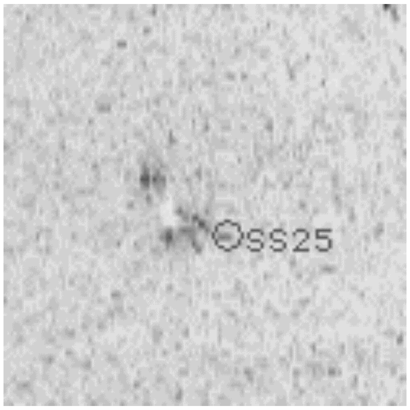
SS23
(X) 3515030.50 (Y) 152423.14

Dimensions
Target Height: = 0 US Feet
Target Length: 6 US Feet
Target Width: 2 US Feet
Description: Oblong target



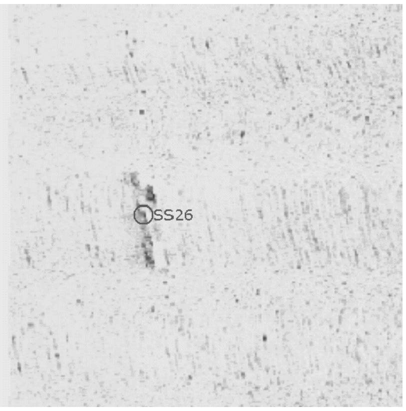
SS24
(X) 3505217.75 (Y) 147533.61

Dimensions
Target Height: = 1 US Feet
Target Length: 5 US Feet
Target Width: 2 US Feet
Description: Oblong target



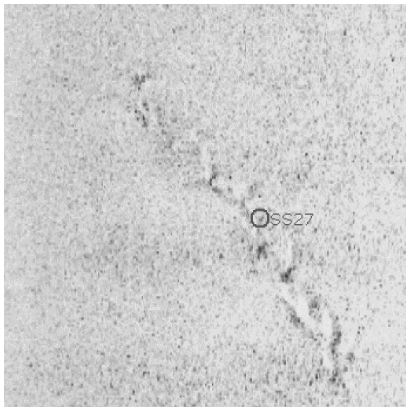
SS25
(X) 3511190.75 (Y) 150534.05

Dimensions
Target Height: = 0 US Feet
Target Length: 9 US Feet
Target Width: 4 US Feet
Description: Oblong target



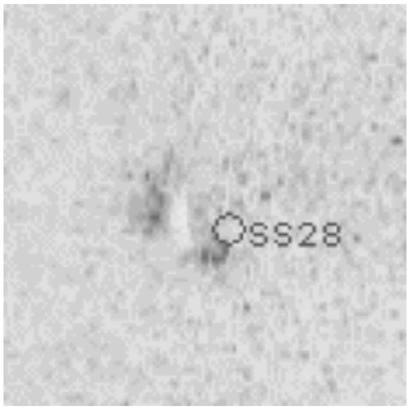
SS26
(X) 3513640.50 (Y) 152103.28

Dimensions
Target Height: = 0 US Feet
Target Length: 16 US Feet
Target Width: 3 US Feet
Description: Oblong target



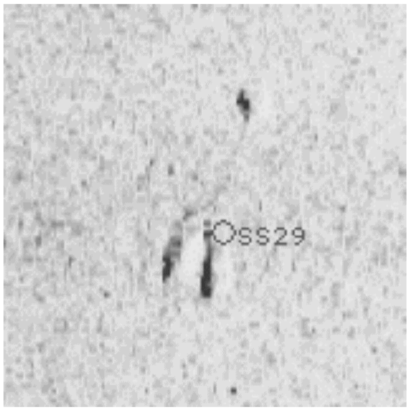
SS27
(X) 3506068.25 (Y) 148416.55

Dimensions
Target Height: = 1 US Feet
Target Length: 97 US Feet
Target Width: 6 US Feet
Description: Bottom disturbance



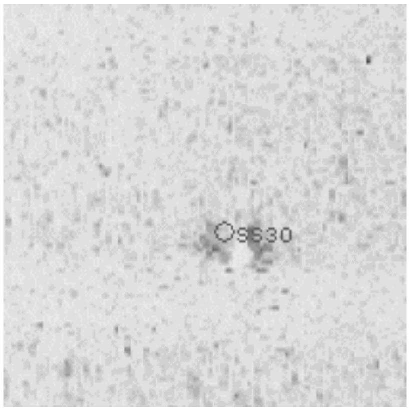
SS28
(X) 3509734.25 (Y) 150221.28

Dimensions
Target Height: = 1 US Feet
Target Length: 7 US Feet
Target Width: 4 US Feet
Description: Oblong target



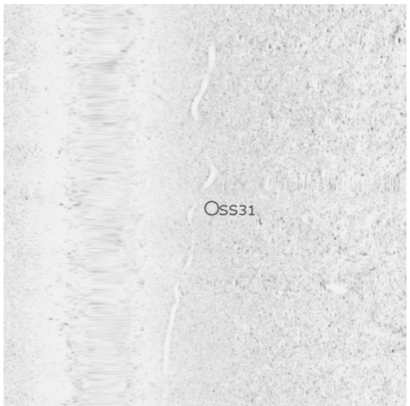
SS29
(X) 3509302.25 (Y) 150141.69

Dimensions
Target Height: = 1 US Feet
Target Length: 6 US Feet
Target Width: 1 US Feet
Description: 2 oblong targets - most likely fish



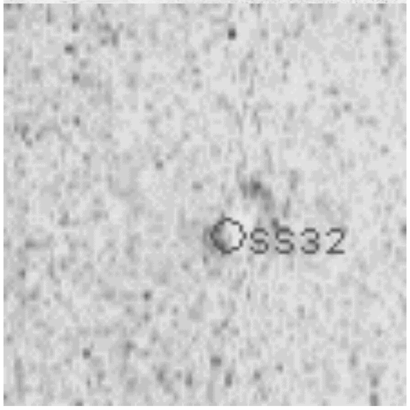
SS30
(X) 3509476.00 (Y) 150330.92

Dimensions
Target Height: = 1 US Feet
Target Length: 5 US Feet
Target Width: 2 US Feet
Description: Oblong target



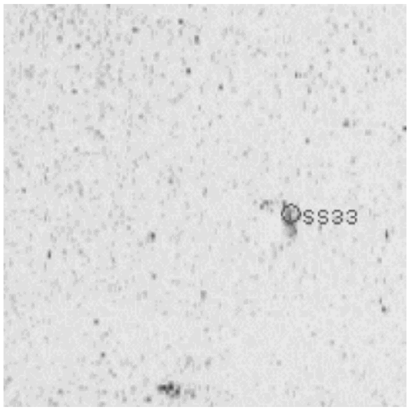
SS31
(X) 3504715.50 (Y) 147925.92

Dimensions
Target Height: = 1 US Feet
Target Length: 116 US Feet
Target Width: 1 US Feet
Description: Linear target



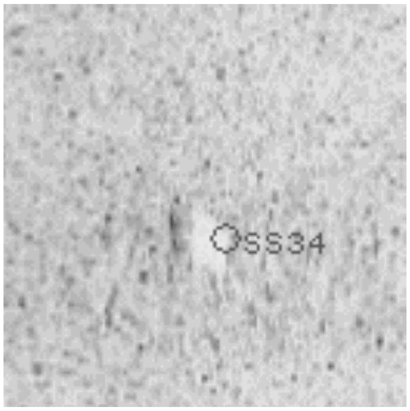
SS32
(X) 3513286.25 (Y) 152505.25

Dimensions
Target Height: = 1 US Feet
Target Length: 4 US Feet
Target Width: 3 US Feet
Description: Oblong target



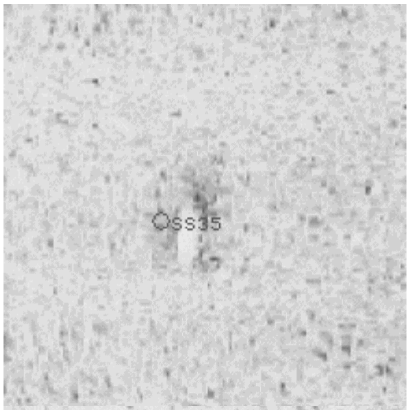
SS33
(X) 3510708.75 (Y) 151247.84

Dimensions
Target Height: = 0 US Feet
Target Length: 7 US Feet
Target Width: 3 US Feet
Description: Oblong target



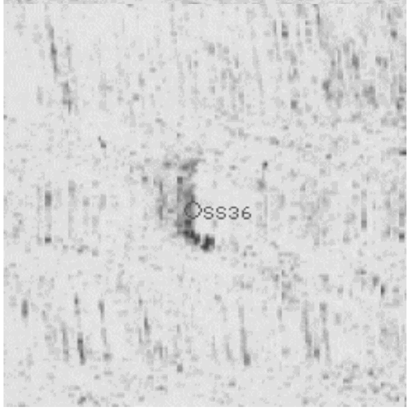
SS34
(X) 3505162.25 (Y) 148360.80

Dimensions
Target Height: = 1 US Feet
Target Length: 7 US Feet
Target Width: 2 US Feet
Description: Oblong target



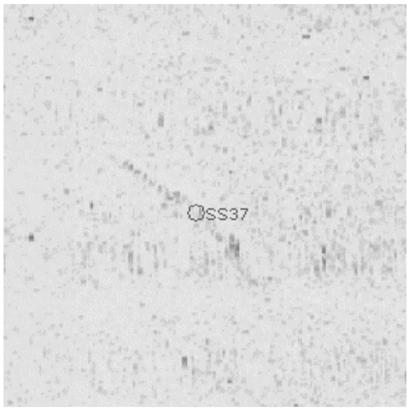
SS35
(X) 3513349.00 (Y) 152729.56

Dimensions
Target Height: = 1 US Feet
Target Length: 8 US Feet
Target Width: 2 US Feet
Description: Oblong target



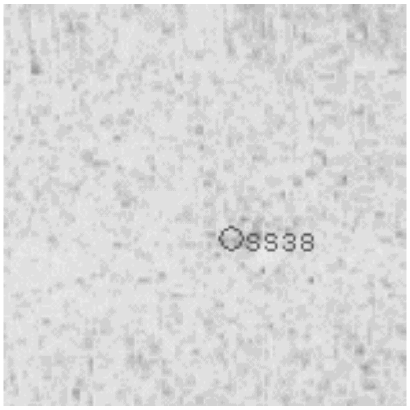
SS36
(X) 3512806.00 (Y) 152536.48

Dimensions
Target Height: = 0 US Feet
Target Length: 10 US Feet
Target Width: 4 US Feet
Description: Oblong target



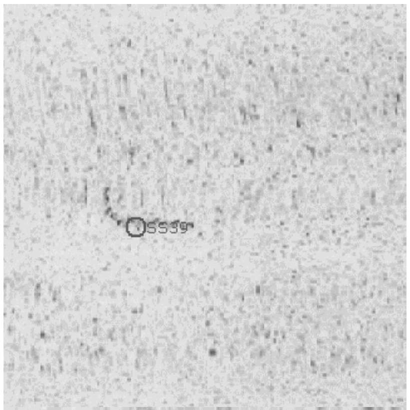
SS37
(X) 3509419.50 (Y) 150800.45

Dimensions
Target Height: = 0 US Feet
Target Length: 27 US Feet
Target Width: 2 US Feet
Description: Linear target?



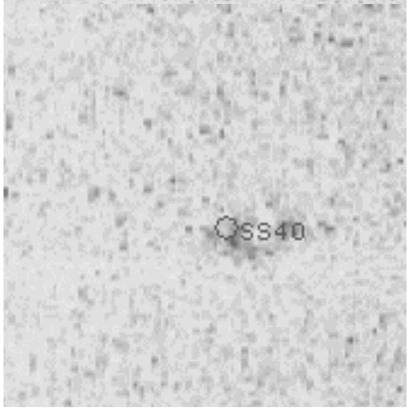
SS38
(X) 3509426.50 (Y) 150750.03

Dimensions
Target Height: = 0 US Feet
Target Length: 4 US Feet
Target Width: 2 US Feet
Description: Oblong target



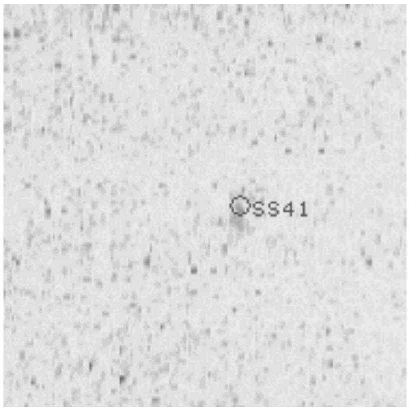
SS39
(X) 3506019.25 (Y) 149047.50

Dimensions
Target Height: = 0 US Feet
Target Length: 12 US Feet
Target Width: 1 US Feet
Description: Linear target?



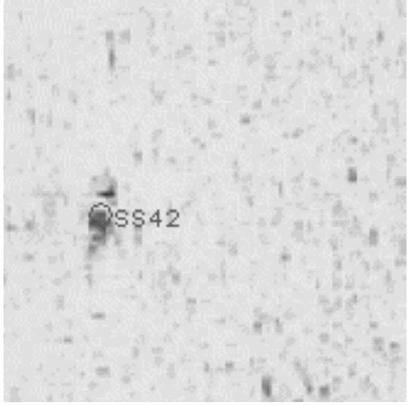
SS40
(X) 3512160.50 (Y) 152582.45

Dimensions
Target Height: = 0 US Feet
Target Length: 7 US Feet
Target Width: 4 US Feet
Description: Oblong target



SS41
(X) 3511034.25 (Y) 151964.80

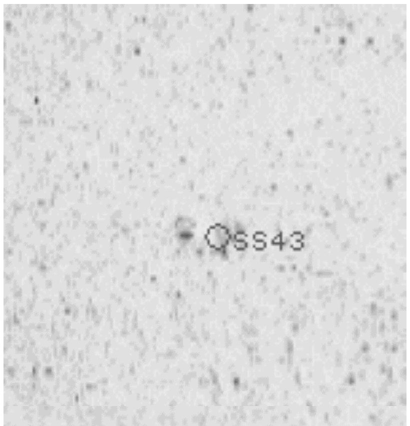
Dimensions
Target Height: = 0 US Feet
Target Length: 7 US Feet
Target Width: 4 US Feet
Description: Oblong target



SS42

(X) 3511784.75 (Y) 152578.73

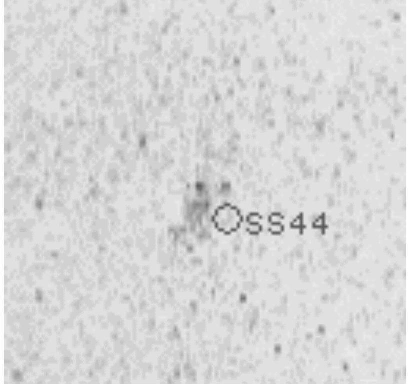
Dimensions
Target Height: = 0 US Feet
Target Length: 8 US Feet
Target Width: 2 US Feet
Description: Oblong target



SS43

(X) 3509896.00 (Y) 151677.22

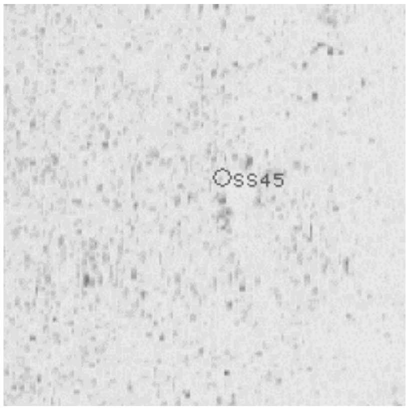
Dimensions
Target Height: = 0 US Feet
Target Length: 4 US Feet
Target Width: 2 US Feet
Description: 2 oblong targets



SS44

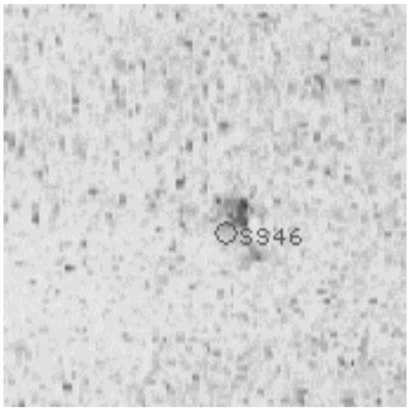
(X) 3509611.25 (Y) 151503.61

Dimensions
Target Height: = 0 US Feet
Target Length: 6 US Feet
Target Width: 3 US Feet
Description: Oblong target



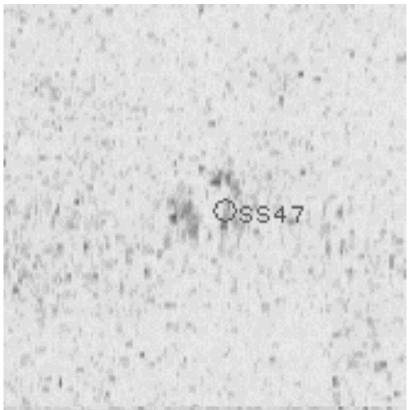
SS45
(X) 3509115.25 (Y) 151436.64

Dimensions
Target Height: = 0 US Feet
Target Length: 6 US Feet
Target Width: 2 US Feet
Description: Oblong target



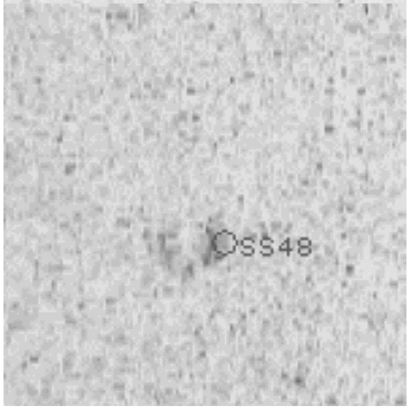
SS46
(X) 3511209.75 (Y) 152658.42

Dimensions
Target Height: = 0 US Feet
Target Length: 7 US Feet
Target Width: 1 US Feet
Description: Oblong target



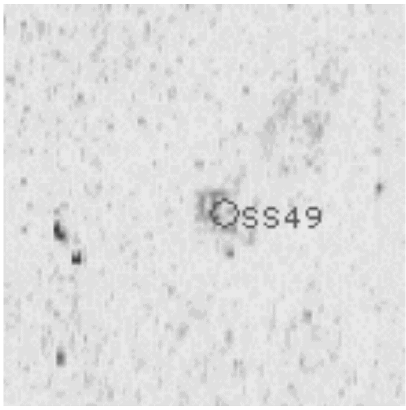
SS47
(X) 3510819.25 (Y) 152724.59

Dimensions
Target Height: = 0 US Feet
Target Length: 9 US Feet
Target Width: 3 US Feet
Description: Oblong target



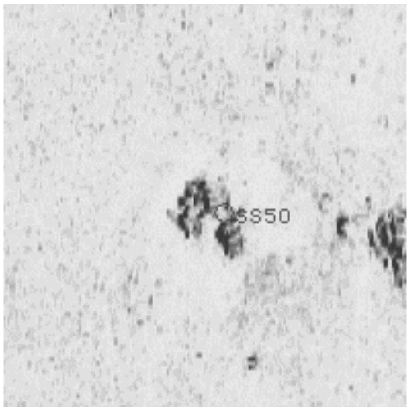
SS48
(X) 3509127.00 (Y) 151790.45

Dimensions
Target Height: = 1 US Feet
Target Length: 6 US Feet
Target Width: 3 US Feet
Description: Oblong target



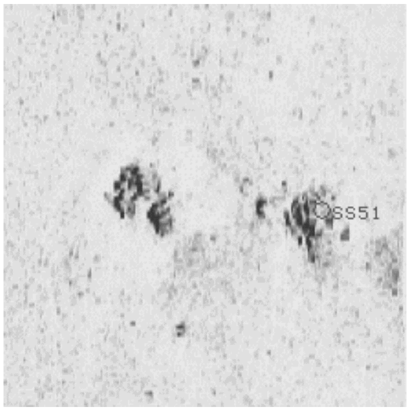
SS49
(X) 3505938.50 (Y) 150290.50

Dimensions
Target Height: = 0 US Feet
Target Length: 5 US Feet
Target Width: 3 US Feet
Description: Oblong target



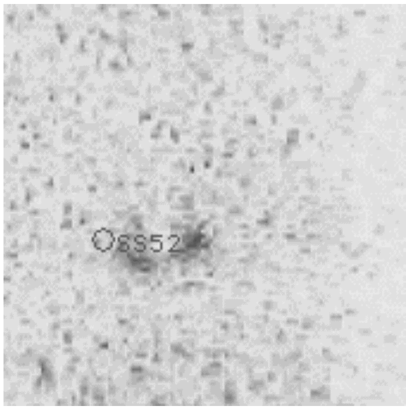
SS50
(X) 3503949.25 (Y) 149225.23

Dimensions
Target Height: = 1 US Feet
Target Length: 9 US Feet
Target Width: 6 US Feet
Description: 2 oblong targets



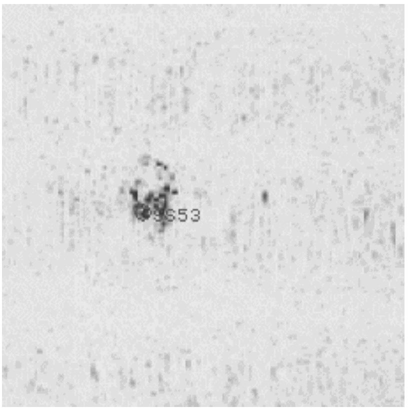
SS51
(X) 3503936.25 (Y) 149247.36

Dimensions
Target Height: = 1 US Feet
Target Length: 13 US Feet
Target Width: 7 US Feet
Description: Oblong target



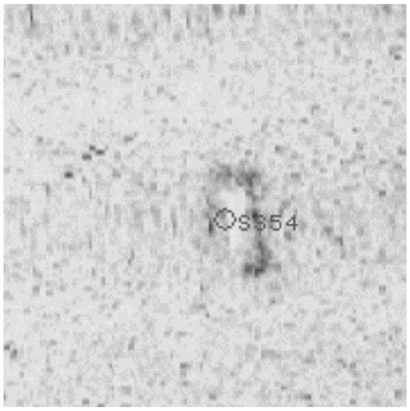
SS52
(X) 3512154.00 (Y) 153531.94

Dimensions
Target Height: = 1 US Feet
Target Length: 5 US Feet
Target Width: 3 US Feet
Description: Oblong target



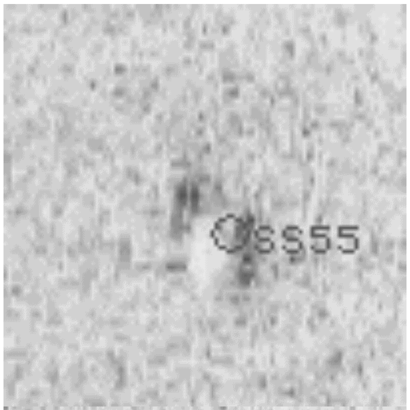
SS53
(X) 3504339.25 (Y) 149747.53

Dimensions
Target Height: = 0 US Feet
Target Length: 7 US Feet
Target Width: 4 US Feet
Description: Oblong target



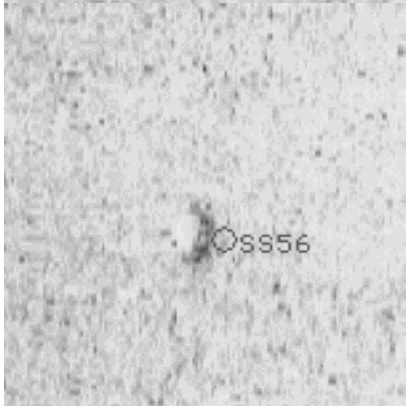
SS54
(X) 3508263.50 (Y) 151706.16

Dimensions
Target Height: = 1 US Feet
Target Length: 12 US Feet
Target Width: 3 US Feet
Description: Oblong target



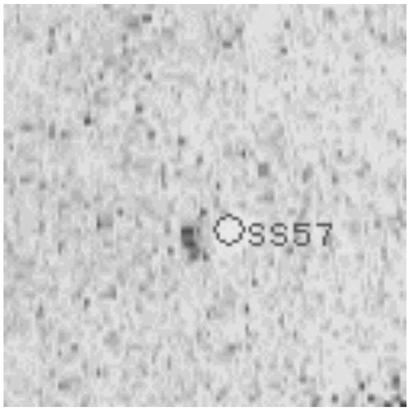
SS55
(X) 3509001.75 (Y) 152166.91

Dimensions
Target Height: = 1 US Feet
Target Length: 7 US Feet
Target Width: 2 US Feet
Description: 2 oblong targets



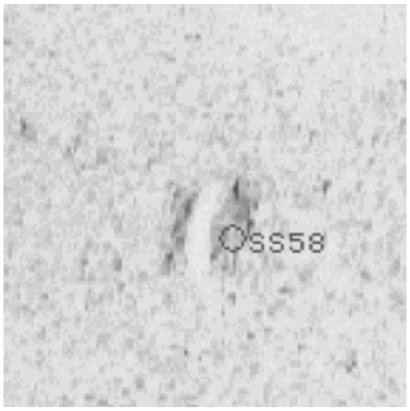
SS56
(X) 3508370.25 (Y) 151871.91

Dimensions
Target Height: = 0 US Feet
Target Length: 8 US Feet
Target Width: 4 US Feet
Description: Oblong target



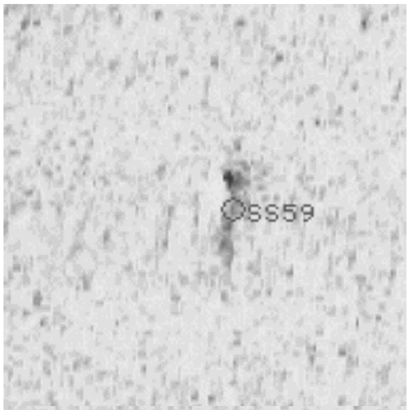
SS57
(X) 3507518.50 (Y) 151646.50

Dimensions
Target Height: = 1 US Feet
Target Length: 4 US Feet
Target Width: 3 US Feet
Description: Oblong target



SS58
(X) 3505532.50 (Y) 150769.08

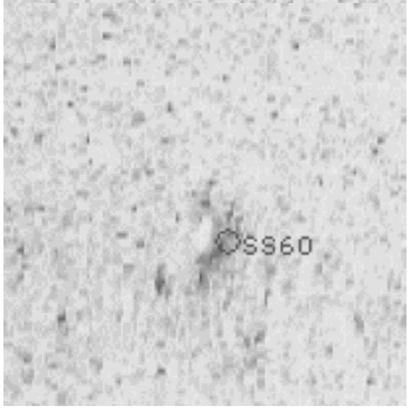
Dimensions
Target Height: = 0 US Feet
Target Length: 8 US Feet
Target Width: 7 US Feet
Description: Oblong target



SS59

(X) 3507119.50 (Y) 151590.84

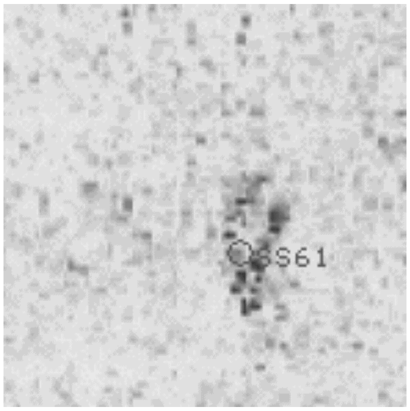
Dimensions
Target Height: = 0 US Feet
Target Length: 8 US Feet
Target Width: 3 US Feet
Description: Oblong target



SS60

(X) 3507644.00 (Y) 151831.25

Dimensions
Target Height: = 0 US Feet
Target Length: 8 US Feet
Target Width: 4 US Feet
Description: Oblong target



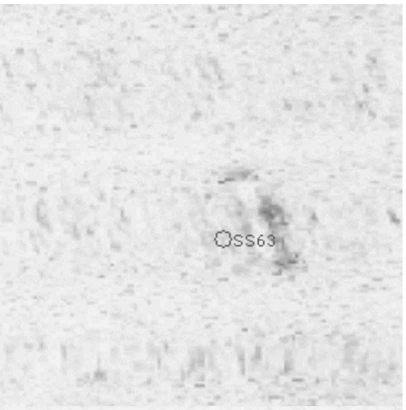
SS61

(X) 3508800.75 (Y) 152544.67

Dimensions
Target Height: = 0 US Feet
Target Length: 9 US Feet
Target Width: 4 US Feet
Description: Oblong target

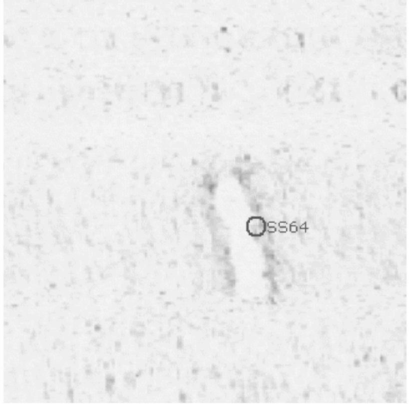
SS62
(X) 3504202.50 (Y) 150353.64

Dimensions
Target Height: = 0 US Feet
Target Length: 3 US Feet
Target Width: 3 US Feet
Description: Round target



SS63
(X) 3507418.75 (Y) 151907.02

Dimensions
Target Height: = 1 US Feet
Target Length: 8 US Feet
Target Width: 2 US Feet
Description: Oblong target



SS64
(X) 3507867.50 (Y) 152198.59

Dimensions
Target Height: = 1 US Feet
Target Length: 15 US Feet
Target Width: 7 US Feet
Description: Oblong target

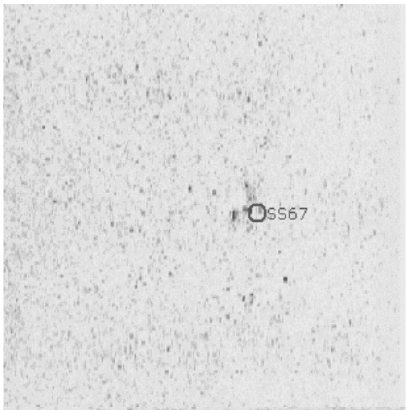
SS65
(X) 3505505.75 (Y) 151240.25

Dimensions
Target Height: = 0 US Feet
Target Length: 7 US Feet
Target Width: 3 US Feet
Description: Oblong target

SS66

(X) 3505376.50 (Y) 151195.89

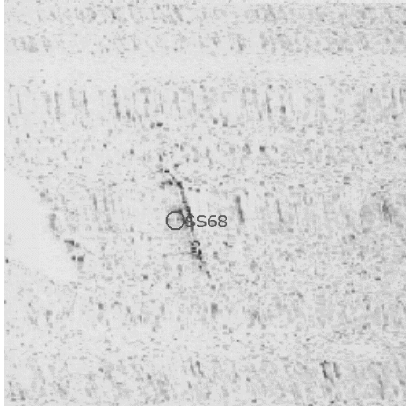
Dimensions
Target Height: = 0 US Feet
Target Length: 8 US Feet
Target Width: 3 US Feet
Description: Oblong target



SS67

(X) 3504436.00 (Y) 150713.56

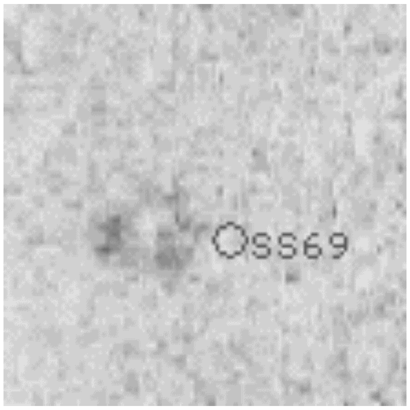
Dimensions
Target Height: = 0 US Feet
Target Length: 9 US Feet
Target Width: 6 US Feet
Description: Oblong target



SS68

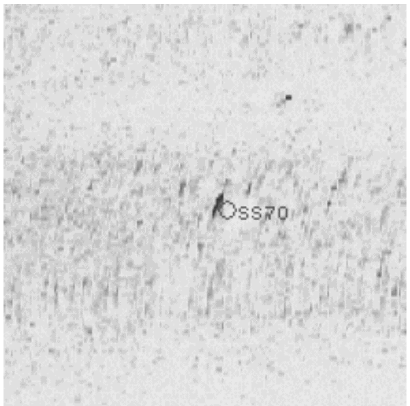
(X) 3506890.25 (Y) 152130.19

Dimensions
Target Height: = 0 US Feet
Target Length: 18 US Feet
Target Width: 2 US Feet
Description: Linear target



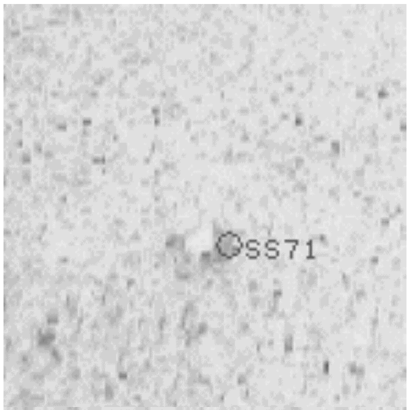
SS69
(X) 3506946.75 (Y) 152207.11

Dimensions
Target Height: = 1 US Feet
Target Length: 5 US Feet
Target Width: 3 US Feet
Description: 2 oblong targets



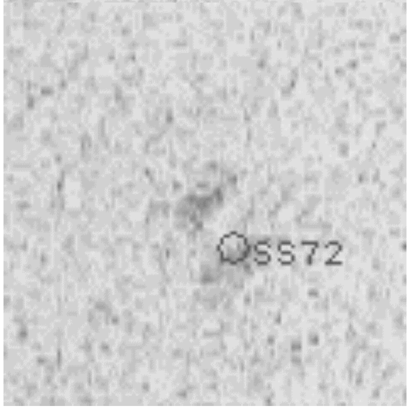
SS70
(X) 3505446.75 (Y) 152084.31

Dimensions
Target Height: = 1 US Feet
Target Length: 4 US Feet
Target Width: 1 US Feet
Description: Oblong target



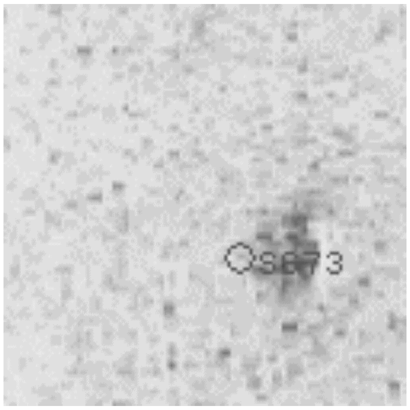
SS71
(X) 3505897.75 (Y) 152499.94

Dimensions
Target Height: = 1 US Feet
Target Length: 6 US Feet
Target Width: 4 US Feet
Description: Oblong target



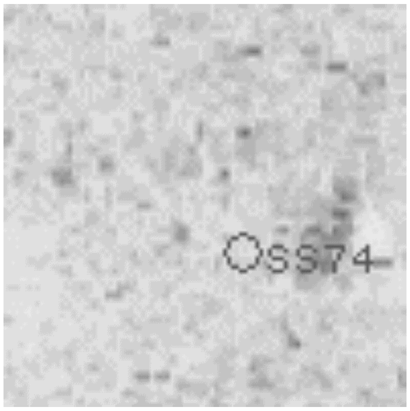
SS72
(X) 3506167.00 (Y) 152712.80

Dimensions
Target Height: = 0 US Feet
Target Length: 6 US Feet
Target Width: 3 US Feet
Description: Oblong target



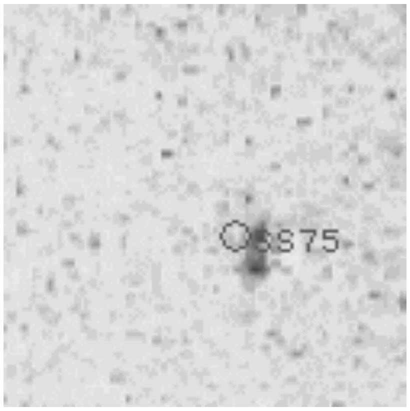
SS73
(X) 3506982.00 (Y) 153231.11

Dimensions
Target Height: = 0 US Feet
Target Length: 6 US Feet
Target Width: 3 US Feet
Description: Oblong target



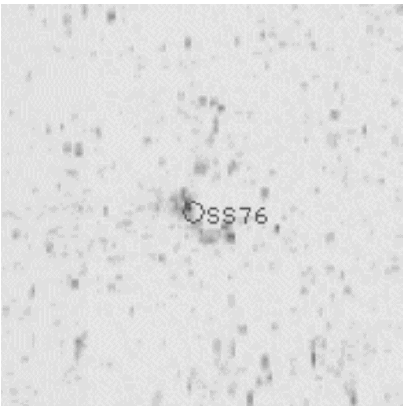
SS74
(X) 3506794.50 (Y) 153138.27

Dimensions
Target Height: = 0 US Feet
Target Length: 5 US Feet
Target Width: 2 US Feet
Description: Oblong target



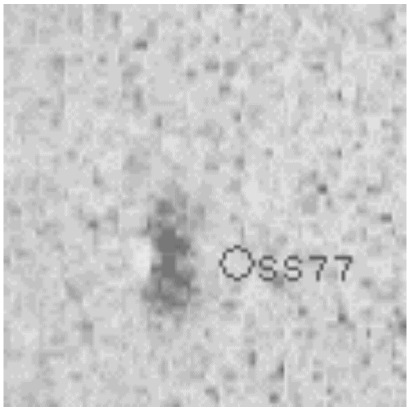
SS75
(X) 3506468.50 (Y) 153098.13

Dimensions
Target Height: = 0 US Feet
Target Length: 4 US Feet
Target Width: 2 US Feet
Description: Oblong target



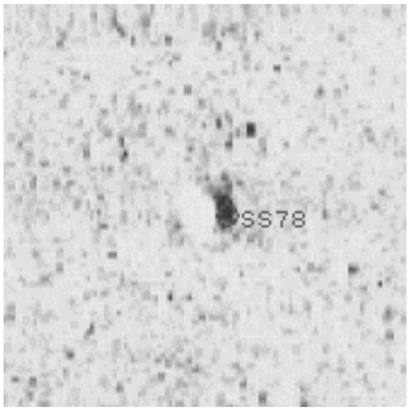
SS76
(X) 3506633.75 (Y) 153269.08

Dimensions
Target Height: = 0 US Feet
Target Length: 6 US Feet
Target Width: 3 US Feet
Description: Oblong target



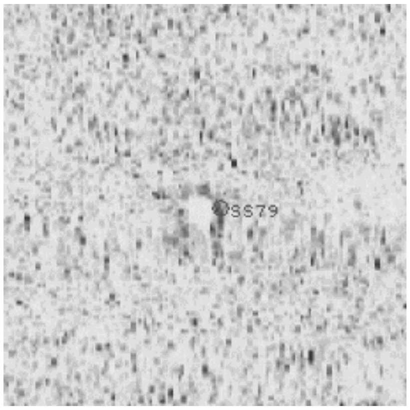
SS77
(X) 3507008.50 (Y) 153454.03

Dimensions
Target Height: = 0 US Feet
Target Length: 6 US Feet
Target Width: 3 US Feet
Description: Oblong target



SS78
(X) 3505983.25 (Y) 153159.59

Dimensions
Target Height: = 0 US Feet
Target Length: 4 US Feet
Target Width: 2 US Feet
Description: Oblong target



SS79

(X) 3506703.25 (Y) 153515.41

Dimensions
Target Height: = 0 US Feet
Target Length: 5 US Feet
Target Width: 2 US Feet
Description: Oblong target

APPENDIX 5

VIBRATORY CORE LOGS

Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

CORE LOG

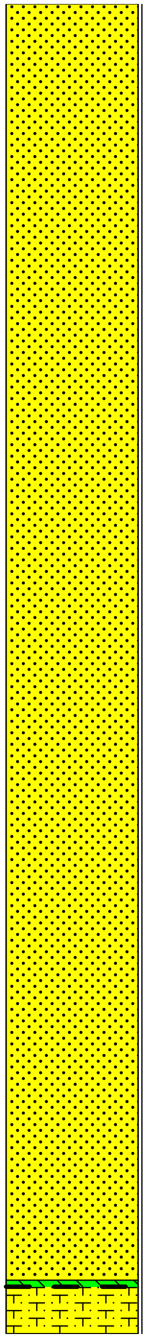
CORE NO. **CEC-11-VC-1**

COLLECTION DATE **10/11/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
STATION NO.	CEC-11-VC-1
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	151993
EASTING	3509676
CORE INSPECTOR	Jeff Motti
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	18.0'
TOTAL RECOVERY	19.9'

Water depth (at time of collection) 28.6'

PROJECT DATUM NAVD88

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
0	-28		0.0-19.1' - Fine sand, medium gray, compact. Shell fragments throughout core. Oyster shells at: 0.9', 2.8', 10.2', and 10.5'. Clam shell at 12.7'. Bottom contact gradational.	VC-1 (0.0-0.4')	0.0-0.4	0
1	-29					1
2	-30			VC-1 (1.8-2.2')	1.8-2.2	2
3	-31					3
4	-32			VC-1 (3.8-4.2')	3.8-4.2	4
5	-33					5
6	-34			VC-1 (5.8-6.2')	5.8-6.2	6
7	-35					7
8	-36			VC-1 (7.8-8.2')	7.8-8.2	8
9	-37					9
10	-38			VC-1 (9.8-10.2')	9.8-10.2	10
11	-39					11
12	-40			VC-1 (11.8-12.2')	11.8-12.2	12
13	-41					13
14	-42			VC-1 (13.8-14.2')	13.8-14.2	14
15	-43					15
16	-44			VC-1 (15.8-16.2')	15.8-16.2	16
17	-45					17
18	-46			VC-1 (17.8-18.2')	17.8-18.2	18
19	-47		19.1-19.9' - Silty fine sand, medium gray, firm. Clay stringer at 19.1'.	VC-1 (19.5-19.9')	19.5-19.9	19

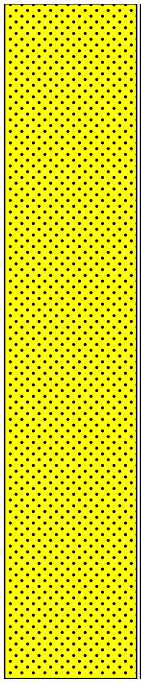
Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

CORE LOG

CORE NO. **CEC-11-VC-2**

COLLECTION DATE **10/11/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	13.0'
TOTAL RECOVERY	10.1'
Water depth (at time of collection)	29.4'
PROJECT DATUM	NAVD88
STATION NO.	CEC-11-VC-2
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	152777
EASTING	3511118
CORE INSPECTOR	Jeff Motti

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
0 1 2 3 4 5 6 7 8 9 10	-28 -29 -30 -31 -32 -33 -34 -35 -36 -37		0.0-10.1' - Fine sand, medium gray, compact. Massive bedding, shell fragments throughout core. Oyster shell at 6.1'. Shell lag at 1.2-1.8' and 10.0'.	VC-2 (0.4-0.8') VC-2 (1.8-2.2') VC-2 (3.8-4.2') VC-2 (5.8-6.2') VC-2 (7.8-8.2') VC-2 (9.7-10.1')	0.4-0.8 1.8-2.2 3.8-4.2 5.8-6.2 7.8-8.2 9.7-10.1	0 1 2 3 4 5 6 7 8 9 10

Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

CORE LOG

CORE NO. **CEC-11-VC-2A**

COLLECTION DATE **10/11/2011**

PROJECT 11ES008 Vibratory Core Sediment Sampling
LOCATION Ship Shoal, Louisiana
CLIENT Coastal Engineering Consultants

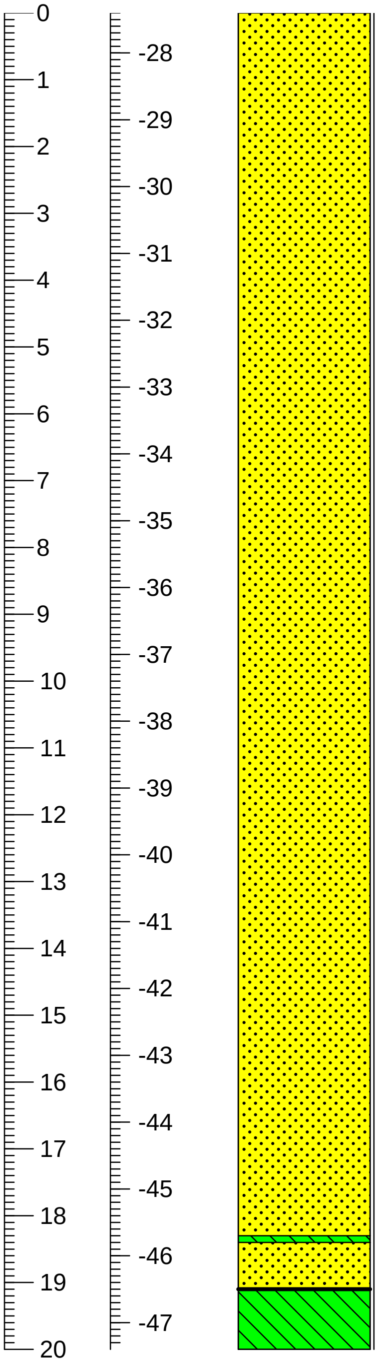
CORE OPERATOR Kevin Murphy
MODEL OF CORER 1500
CORE DIAMETER 3.5"
TOTAL PENETRATION 18.5'
TOTAL RECOVERY 20.0'

Water depth (at time of collection) 29.4'

PROJECT DATUM NAVD88

STATION NO. CEC-11-VC-2A
COORDINATES State Plane NAD 83, LA-South
UNITS US Survey Feet
NORTHING 152784
EASTING 3511119
CORE INSPECTOR Jeff Motti

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-19.1' - Fine sand, medium gray, compact. Massive bedding, shell fragments throughout core. Oyster shell at 0.5', 3.4', 6.5', 9.0', and 15.1'. Clay nodule at 11.2'. Clay stringer at 18.3'. Conus shell at 18.4'. Bottom contact sharp.

19.1-20.0 - Clay, medium gray, firm. Heavily bioturbated.

SAMPLE ID	SAMPLE INTERVAL
VC-2A (0.0-0.4')	0.0-0.4
VC-2A (1.8-2.2')	1.8-2.2
VC-2A (3.8-4.2')	3.8-4.2
VC-2A (5.8-6.2')	5.8-6.2
VC-2A (7.8-8.2')	7.8-8.2
VC-2A (9.8-10.2')	9.8-10.2
VC-2A (11.8-12.2')	11.8-12.2
VC-2A (13.8-14.2')	13.8-14.2
VC-2A (15.8-16.2')	15.8-16.2
VC-2A (17.8-18.2')	17.8-18.2
VC-2A (19.6-20.0')	19.6-20.0

Ocean Surveys, Inc.
129 Mill Rock Road East
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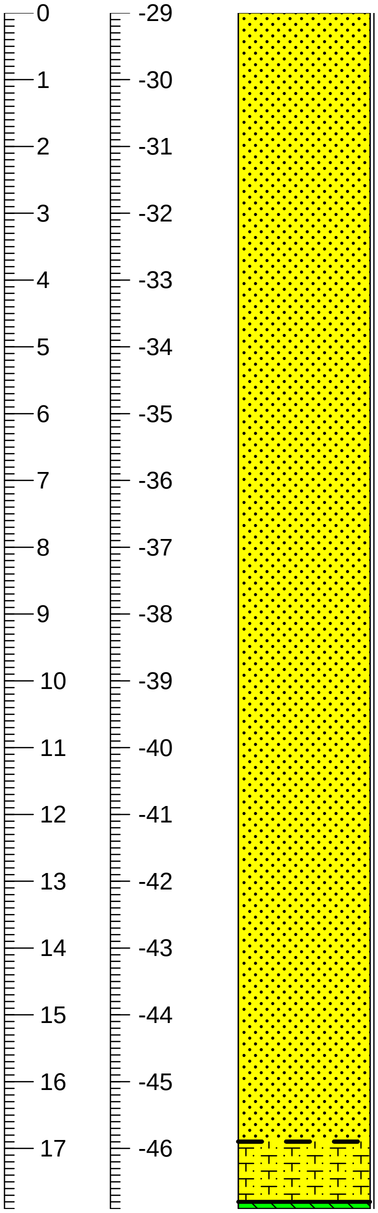
CORE LOG

CORE NO. **CEC-11-VC-3**

COLLECTION DATE **10/12/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
STATION NO.	CEC-11-VC-3
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	151097
EASTING	3509763
CORE INSPECTOR	Jeff Motti
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	18.0'
TOTAL RECOVERY	17.9'
Water depth (at time of collection)	29.6'
PROJECT DATUM	NAVD88



DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
			0.0-16.9' - Fine sand, med gray, compact. Shell fragments throughout core. Oyster shells at 0.5-1.8', 6.0', 10.2', 15.9', and 17.2'. Clay stringers at 14.6' and 14.8'. Bottom contact gradational.	VC-3 (0.0-0.4')	0.0-0.4	
				VC-3 (1.8-2.2')	1.8-2.2	
				VC-3 (3.8-4.2')	3.8-4.2	
				VC-3 (5.8-6.2')	5.8-6.2	
				VC-3 (7.8-8.2')	7.8-8.2	
				VC-3 (9.8-10.2')	9.8-10.2	
				VC-3 (11.8-12.2')	11.8-12.2	
				VC-3 (13.8-14.2')	13.8-14.2	
			16.9-17.8' - Silty fine sand, med gray,compact. Few shell fragments. Bottom contact sharp.	VC-3 (15.8-16.2')	15.8-16.2	
			17.8-17.9' - Clay, med gray, firm.	VC-3 (17.5-17.9')	17.5-17.9	

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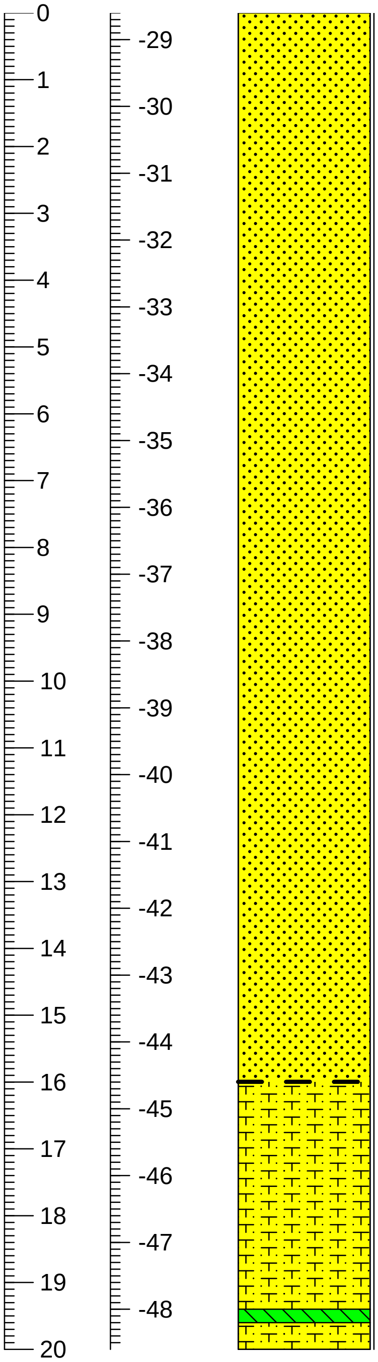
CORE LOG

CORE NO. **CEC-11-VC-4**

COLLECTION DATE **10/12/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	18.5'
TOTAL RECOVERY	20.0'
Water depth (at time of collection)	28.5'
PROJECT DATUM	NAVD88
STATION NO.	CEC-11-VC-4
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	151610
EASTING	3510615
CORE INSPECTOR	Jeff Motti

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-16.0' - Fine sand, med gray, compact. Shell fragments throughout sub section. Shell fragments ~0.1' diameter at 2.2', 3.3', 4.8', 5.9', 6.4', 12.7', 13.6', 13.9', and 16.0'. Bottom contact gradational.

16.0-20.0' - Silty fine sand, medium gray, compact. Shell fragment ~0.1' diameter at 17.0'. 19.4-19.6' Clay layer. Oyster shell at 19.6'.

SAMPLE ID	SAMPLE INTERVAL
VC-4 (0.0-0.4')	0.0-0.4
VC-4 (1.8-2.2')	1.8-2.2
VC-4 (3.8-4.2')	3.8-4.2
VC-4 (5.8-6.2')	5.8-6.2
VC-4 (7.8-8.2')	7.8-8.2
VC-4 (9.8-10.2')	9.8-10.2
VC-4 (11.8-12.2')	11.8-12.2
VC-4 (13.8-14.2')	13.8-14.2
VC-4 (15.8-16.2')	15.8-16.2
VC-4 (17.8-18.2')	17.8-18.2
VC-4 (19.6-20.0')	19.6-20.0

DEPTH BELOW SEABED: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

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CORE LOG

CORE NO. **CEC-11-VC-5**

COLLECTION DATE **10/12/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants

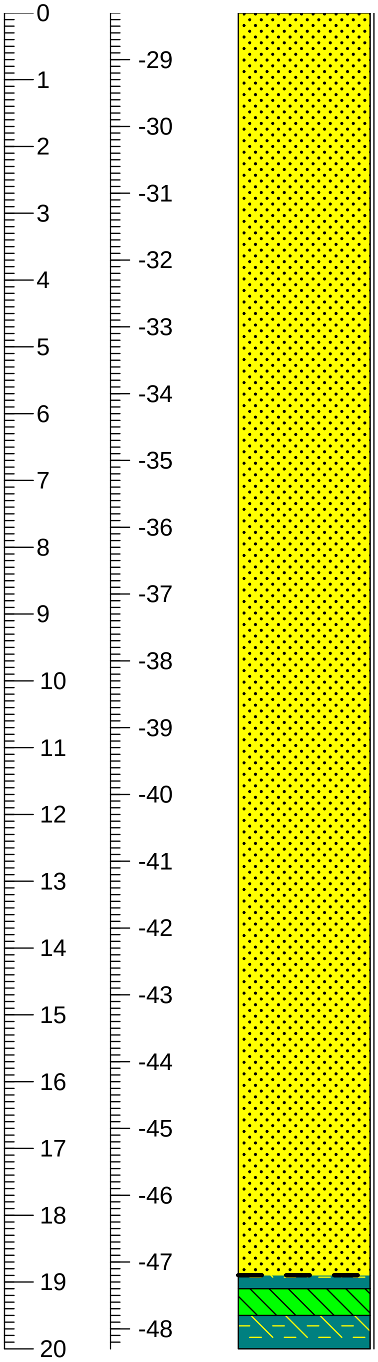
STATION NO.	CEC-11-VC-5
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	152462
EASTING	3512445
CORE INSPECTOR	Jeff Motti

CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	17.3'
TOTAL RECOVERY	20.0'

Water depth (at time of collection) 29.4'

PROJECT DATUM NAVD88

DEPTH BELOW SEABED | ELEVATION (NAVD88) | SEDIMENT TYPE | VISUAL DESCRIPTION AND REMARKS | SAMPLE ID | SAMPLE INTERVAL | DEPTH BELOW SEABED



0.0-18.9' - Fine sand, med gray, compact. Massive bedding. Shell hash from 0.0-2.8'. Shell fragments ~0.1' diameter at 5.2', 7.2', 11.3', and 15.9'. Bottom contact gradational.

18.9-20.0' - Sandy clay, dark gray, firm. Clay layer from 19.1-19.7', shell hash and oyster shells from 19.5-19.7'.

SAMPLE ID	SAMPLE INTERVAL
VC-5 (0.0-0.4')	0.0-0.4
VC-5 (1.8-2.2')	1.8-2.2
VC-5 (3.8-4.2')	3.8-4.2
VC-5 (5.8-6.2')	5.8-6.2
VC-5 (7.8-8.2')	7.8-8.2
VC-5 (9.8-10.2')	9.8-10.2
VC-5 (11.8-12.2')	11.8-12.2
VC-5 (13.8-14.2')	13.8-14.2
VC-5 (15.8-16.2')	15.8-16.2
VC-5 (17.8-18.2')	17.8-18.2
VC-5 (19.6-20.0')	19.6-20.0

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CORE LOG

CORE NO. **CEC-11-VC-6**

COLLECTION DATE **10/12/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants

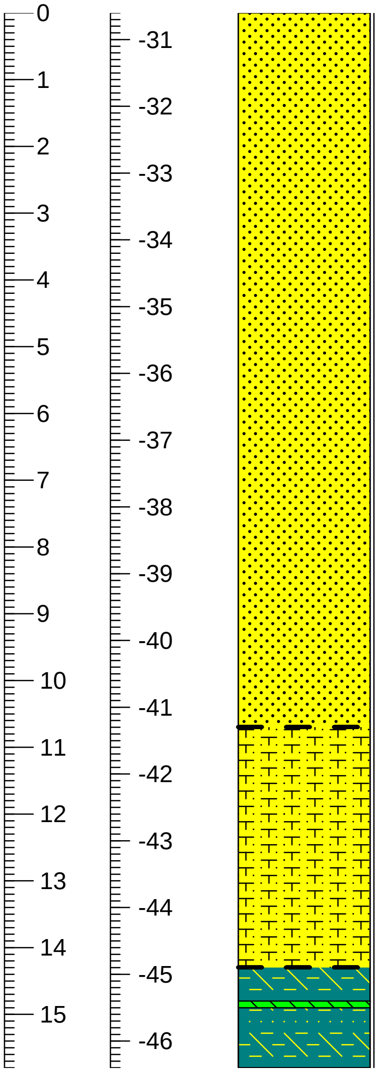
STATION NO.	CEC-11-VC-6
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	149815
EASTING	3510560
CORE INSPECTOR	Jeff Motti

CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	17.5'
TOTAL RECOVERY	15.8'

Water depth (at time of collection) 32.2'

PROJECT DATUM NAVD88

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-10.7' - Fine sand, med gray, compact. Massive bedding. Shell fragments throughout sub section. Shell lags from 0.5-0.7', 5.3-5.4', and 9.1-9.3'. Oyster shell at 10.5'. Clay clast at 2.5'. Burrow at 4.1-4.2'. Clay lamination from 4.8-4.9'. Bottom contact gradational.

10.7-15.8' - Clayey sand-silty sand, dark gray, firm. No bedding. Clay clasts at 12.2' and 14.0'. Oyster shell at 14.3'. Bioturbation from 14.5-14.7'.

SAMPLE ID	SAMPLE INTERVAL
VC-6 (0.0-0.4')	0.0-0.4
VC-6 (1.8-2.2')	1.8-2.2
VC-6 (3.8-4.2')	3.8-4.2
VC-6 (5.8-6.2')	5.8-6.2
VC-6 (7.8-8.2')	7.8-8.2
VC-6 (9.8-10.2')	9.8-10.2
VC-6 (11.8-12.2')	11.8-12.2
VC-6 (13.8-14.2')	13.8-14.2

DEPTH BELOW SEABED: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

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CORE LOG

CORE NO. **CEC-11-VC-7**

COLLECTION DATE **10/12/2011**

PROJECT 11ES008 Vibratory Core Sediment Sampling
LOCATION Ship Shoal, Louisiana
CLIENT Coastal Engineering Consultants

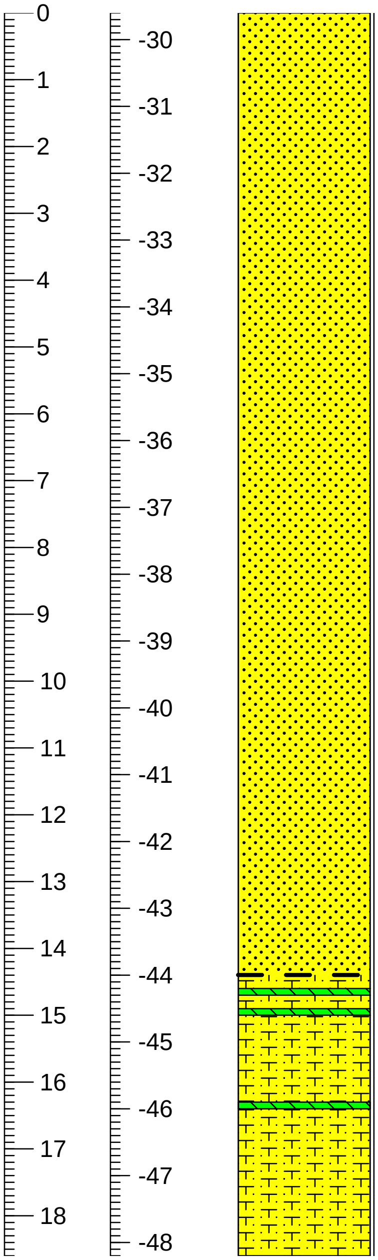
STATION NO. CEC-11-VC-7
COORDINATES State Plane NAD 83, LA-South
UNITS US Survey Feet
NORTHING 150778
EASTING 3511144
CORE INSPECTOR Jeff Motti

CORE OPERATOR Kevin Murphy
MODEL OF CORER 1500
CORE DIAMETER 3.5"
TOTAL PENETRATION 16.5'
TOTAL RECOVERY 18.6'

Water depth (at time of collection) 30.1'

PROJECT DATUM NAVD88

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-14.4' - Fine sand, med gray, compact. Massive bedding. Shell fragments throughout sub section. Oyster shells from 1.1-1.5', 1.9', 2.5, and 2.8'. Clam shell ~0.1' diameter at 10.6'. Bottom contact gradational.

14.4-18.6' - Silty fine sand, med gray, compact. Shell fragments throughout sub section. Clay stringer at 14.6', 14.9', and 16.3'. Shell hash at 15.0'. Aqueous sediment from 17.0-18.6'.

SAMPLE ID	SAMPLE INTERVAL
VC-7 (0.0-0.4')	0.0-0.4
VC-7 (1.8-2.2')	1.8-2.2
VC-7 (3.8-4.2')	3.8-4.2
VC-7 (5.8-6.2')	5.8-6.2
VC-7 (7.8-8.2')	7.8-8.2
VC-7 (9.8-10.2')	9.8-10.2
VC-7 (11.8-12.2')	11.8-12.2
VC-7 (13.8-14.2')	13.8-14.2
VC-7 (15.8-16.2')	15.8-16.2
VC-7 (17.8-18.2')	17.8-18.2

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CORE LOG

CORE NO. **CEC-11-VC-8**

COLLECTION DATE **10/12/2011**

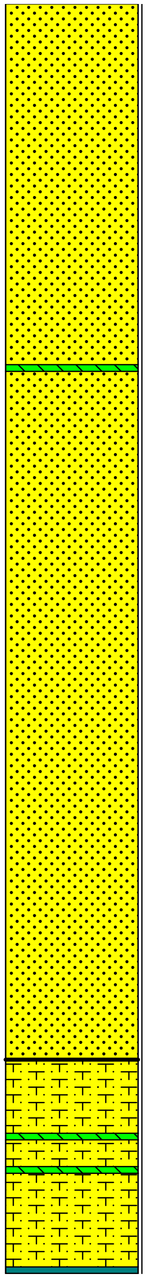
PROJECT 11ES008 Vibratory Core Sediment Sampling
LOCATION Ship Shoal, Louisiana
CLIENT Coastal Engineering Consultants

STATION NO. CEC-11-VC-8
COORDINATES State Plane NAD 83, LA-South
UNITS US Survey Feet
NORTHING 150805
EASTING 3512292
CORE INSPECTOR Jeff Motti

CORE OPERATOR Kevin Murphy
MODEL OF CORER 1500
CORE DIAMETER 3.5"
TOTAL PENETRATION 17.5'
TOTAL RECOVERY 19.0'

Water depth (at time of collection) 30.1'

PROJECT DATUM NAVD88

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
0	-30		0.0-15.8' - Fine sand, med gray, compact. Massive bedding. Shell fragments throughout sub section. Rafted root at 1.7'. Clam shells at 2.1', 4.9', 12.9', and 15.0'. Deformed clay laminae at 5.4'. Clay clast 0.1' diameter at 13.1'. Shell lag at 15.0-15.3' capped by oyster shell. Bottom contact sharp.	VC-8 (0.0-0.4')	0.0-0.4	0
1	-31					1
2	-32			VC-8 (1.8-2.2')	1.8-2.2	2
3	-33					3
4	-34			VC-8 (3.8-4.2')	3.8-4.2	4
5	-35					5
6	-36			VC-8 (5.8-6.2')	5.8-6.2	6
7	-37					7
8	-38			VC-8 (7.8-8.2')	7.8-8.2	8
9	-39					9
10	-40			VC-8 (9.8-10.2')	9.8-10.2	10
11	-41					11
12	-42			VC-8 (11.8-12.2')	11.8-12.2	12
13	-43					13
14	-44			VC-8 (13.8-14.2')	13.8-14.2	14
15	-45					15
16	-46		15.8-18.9' - Silty fine sand, med gray, compact. Massive bedding. Shell fragments throughout sub section. Bioturbated mud drapes from 16.9-17.0'. Sandy clay from 18.9-19.0', bioturbated.	VC-8 (15.8-16.2')	15.8-16.2	16
17	-47					17
18	-48			VC-8 (17.8-18.2')	17.8-18.2	18
19						19

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CORE LOG

CORE NO. **CEC-11-VC-9**

COLLECTION DATE **10/12/2011**

PROJECT 11ES008 Vibratory Core Sediment Sampling
LOCATION Ship Shoal, Louisiana
CLIENT Coastal Engineering Consultants

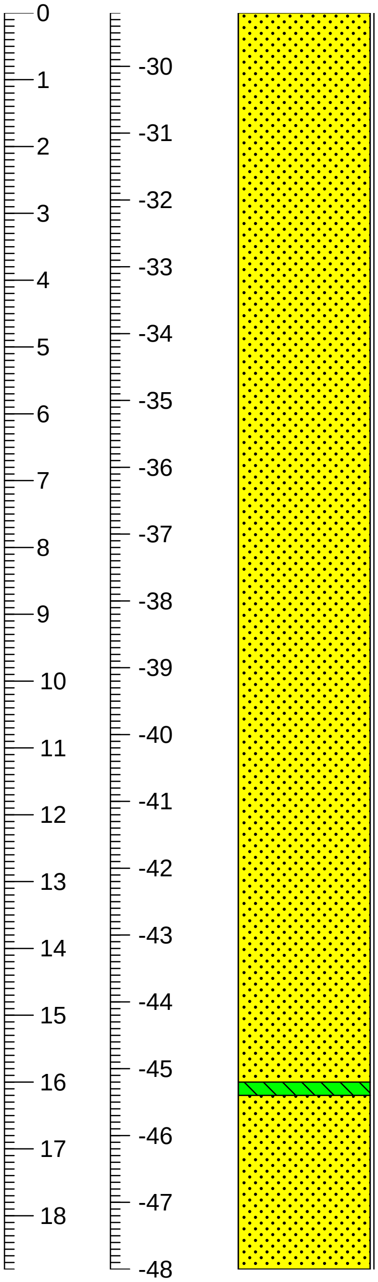
STATION NO. CEC-11-VC-9
COORDINATES State Plane NAD 83, LA-South
UNITS US Survey Feet
NORTHING 151686
EASTING 3512893
CORE INSPECTOR Jeff Motti

CORE OPERATOR Kevin Murphy
MODEL OF CORER 1500
CORE DIAMETER 3.5"
TOTAL PENETRATION 16.5'
TOTAL RECOVERY 18.8'

Water depth (at time of collection) 30.1'

PROJECT DATUM NAVD88

DEPTH BELOW SEABED | ELEVATION (NAVD88) | SEDIMENT TYPE | VISUAL DESCRIPTION AND REMARKS | SAMPLE ID | SAMPLE INTERVAL | DEPTH BELOW SEABED



0.0-18.8' - Fine sand, med gray, compact. Massive bedding. Shell fragments throughout sample. Clay nodule at 1.3'. Oyster shells at 3.6', 4.8', 5.5-5.7', 6.8', and 9.9'. Beach rock 0.1' diameter at 10.5'. Clay laminae from 16.0-16.2'. Shell hash from 16.2-16.5'.

SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
VC-9 (0.0-0.4')	0.0-0.4	0
VC-9 (1.8-2.2')	1.8-2.2	2
VC-9 (3.8-4.2')	3.8-4.2	4
VC-9 (5.8-6.2')	5.8-6.2	6
VC-9 (7.8-8.2')	7.8-8.2	8
VC-9 (9.8-10.2')	9.8-10.2	10
VC-9 (11.8-12.2')	11.8-12.2	12
VC-9 (13.8-14.2')	13.8-14.2	14
VC-9 (15.8-16.2')	15.8-16.2	16
VC-9 (17.8-18.2')	17.8-18.2	18

Ocean Surveys, Inc.
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CORE LOG

CORE NO. **CEC-11-VC-10**

COLLECTION DATE **10/12/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants

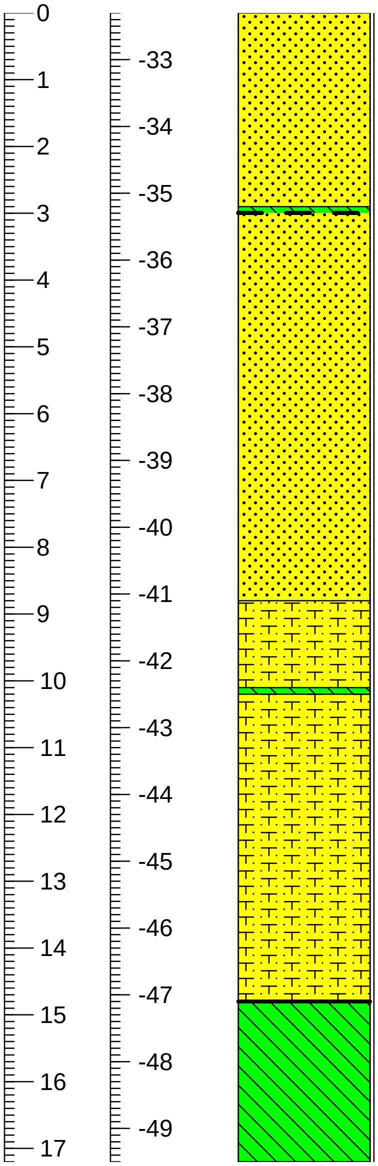
STATION NO.	CEC-11-VC-10
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	148978
EASTING	3511071
CORE INSPECTOR	Jeff Motti

CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	17.5'
TOTAL RECOVERY	17.2'

Water depth (at time of collection) 33.7'

PROJECT DATUM NAVD88

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-8.8' - Fine sand, med gray, compact. Massive bedding. Shell fragments throughout sub section. Oyster shells at 0.7' and 1.3'. Clay stringer at 2.9'. Bottom contact gradational.

8.8-14.8' - Silty fine sand, medium gray, compact. Massive bedding. Shell fragments throughout sub section. Oyster shell at 9.5'. Clay stringer at 10.1'. Clay draper at 11.6'. Bottom contact sharp.

14.8-17.2' - Clay, pale brown from 14.8-16.0', med dark gray from 16.0-17.2', firm. Bioturbation throughout sub section.

SAMPLE ID	SAMPLE INTERVAL
VC-10 (0.0-0.4')	0.0-0.4
VC-10 (1.8-2.2')	1.8-2.2
VC-10 (3.8-4.2')	3.8-4.2
VC-10 (5.8-6.2')	5.8-6.2
VC-10 (7.8-8.2')	7.8-8.2
VC-10 (9.8-10.2')	9.8-10.2
VC-10 (11.8-12.2')	11.8-12.2
VC-10 (13.8-14.2')	13.8-14.2
VC-10 (15.8-16.2')	15.8-16.2

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CORE LOG

CORE NO. **CEC-11-VC-11**

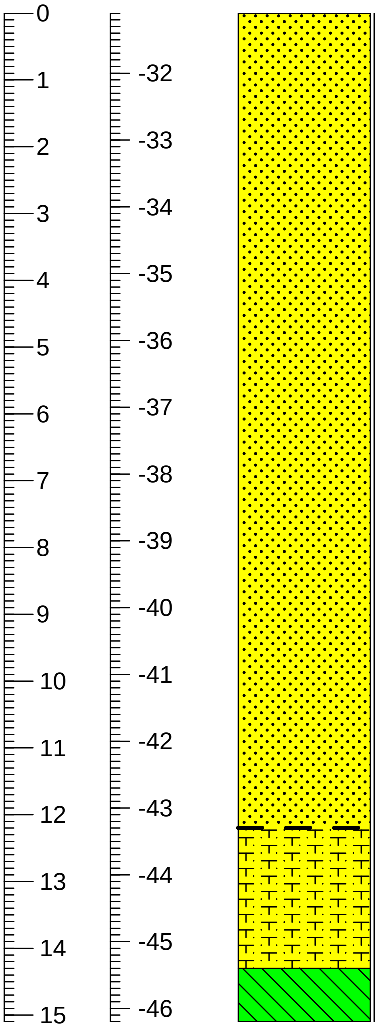
COLLECTION DATE **10/13/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
STATION NO.	CEC-11-VC-11
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	150054
EASTING	3512749
CORE INSPECTOR	Jeff Motti
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	18.0'
TOTAL RECOVERY	15.1'

Water depth (at time of collection) 31.6'

PROJECT DATUM NAVD88

DEPTH BELOW SEABED	ELEVATION (NAVD88)	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-12.2' - Fine sand, med gray, compact. Massive bedding. Shell fragments throughout sub section. Shell hash from 1.2-1.7'. Clay nodules at 2.6' and 3.5'. Clam shell at 6.7'. Oyster and clam shells at 7.8'. Oyster shell at 11.7'. Bottom contact gradational.

12.2-14.3' - Silty fine sand, medium gray, firm. Shell fragments at 12.3' and 13.7'. Beach rock at 13.7'. Bottom contact sharp.

14.3-15.1' - Clay, med dark gray, firm. Sub section bioturbated.

SAMPLE ID	SAMPLE INTERVAL
VC-11 (0.0-0.4')	0.0-0.4
VC-11 (1.8-2.2')	1.8-2.2
VC-11 (3.8-4.2')	3.8-4.2
VC-11 (5.8-6.2')	5.8-6.2
VC-11 (7.8-8.2')	7.8-8.2
VC-11 (9.8-10.2')	9.8-10.2
VC-11 (11.8-12.2')	11.8-12.2
VC-11 (12.8-13.2')	12.8-13.2
VC-11 (14.2-14.6')	14.2-14.6

DEPTH BELOW SEABED: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

Ocean Surveys, Inc.
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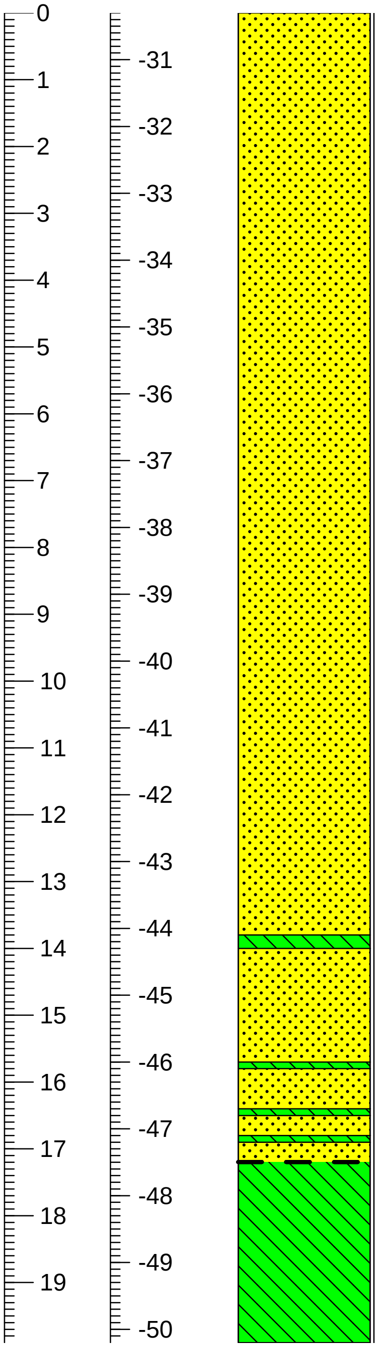
CORE LOG

CORE NO. **CEC-11-VC-12**

COLLECTION DATE **10/13/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	19.0'
TOTAL RECOVERY	19.9'
Water depth (at time of collection)	31.9'
PROJECT DATUM	NAVD88
STATION NO.	CEC-11-VC-12
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	150837
EASTING	3513405
CORE INSPECTOR	Jeff Motti

DEPTH BELOW SEABED | ELEVATION (NAVD88) | SEDIMENT TYPE



VISUAL DESCRIPTION AND REMARKS

0.0-17.2' - Fine sand, med gray, compact. Massive bedding. Shell fragments throughout sub section. Shell lags from 0.9-1.2', 2.0-2.1', 3.7-3.8', 5.1-5.3', 6.4-6.6', 7.1-7.2', and 8.2-8.5'. Clay laminations from 13.8-14.0'. Shell lag from 14.9-15.0'. Clay laminae from 15.7-17.2' heavily deformed due to bioturbation. Bottom contact gradational.

17.2-19.9' - Clay, dark gray, stiff. Deformed sand lenses 0.03' thick.

SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
VC-12 (0.0-0.4')	0.0-0.4	0
VC-12 (1.8-2.2')	1.8-2.2	2
VC-12 (3.8-4.2')	3.8-4.2	4
VC-12 (5.8-6.2')	5.8-6.2	6
VC-12 (7.8-8.2')	7.8-8.2	8
VC-12 (9.8-10.2')	9.8-10.2	10
VC-12 (11.8-12.2')	11.8-12.2	12
VC-12 (13.8-14.2')	13.8-14.2	14
VC-12 (15.8-16.2')	15.8-16.2	16
VC-12 (17.8-18.2')	17.8-18.2	18

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129 Mill Rock Road East
Old Saybrook, CT 06475

CORE LOG

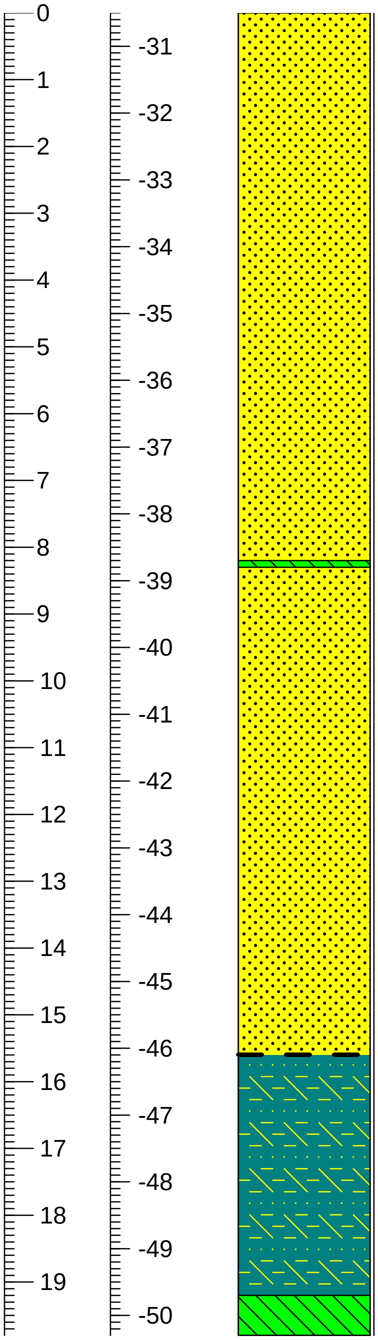
CORE NO. **CEC-11-VC-13**

COLLECTION DATE **10/13/2011**

PROJECT	11ES008 Vibratory Core Sediment Sampling
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
STATION NO.	CEC-11-VC-13
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	150989
EASTING	3514548
CORE INSPECTOR	Jeff Motti
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	18.0'
TOTAL RECOVERY	19.8'

Water depth (at time of collection) 31.0'

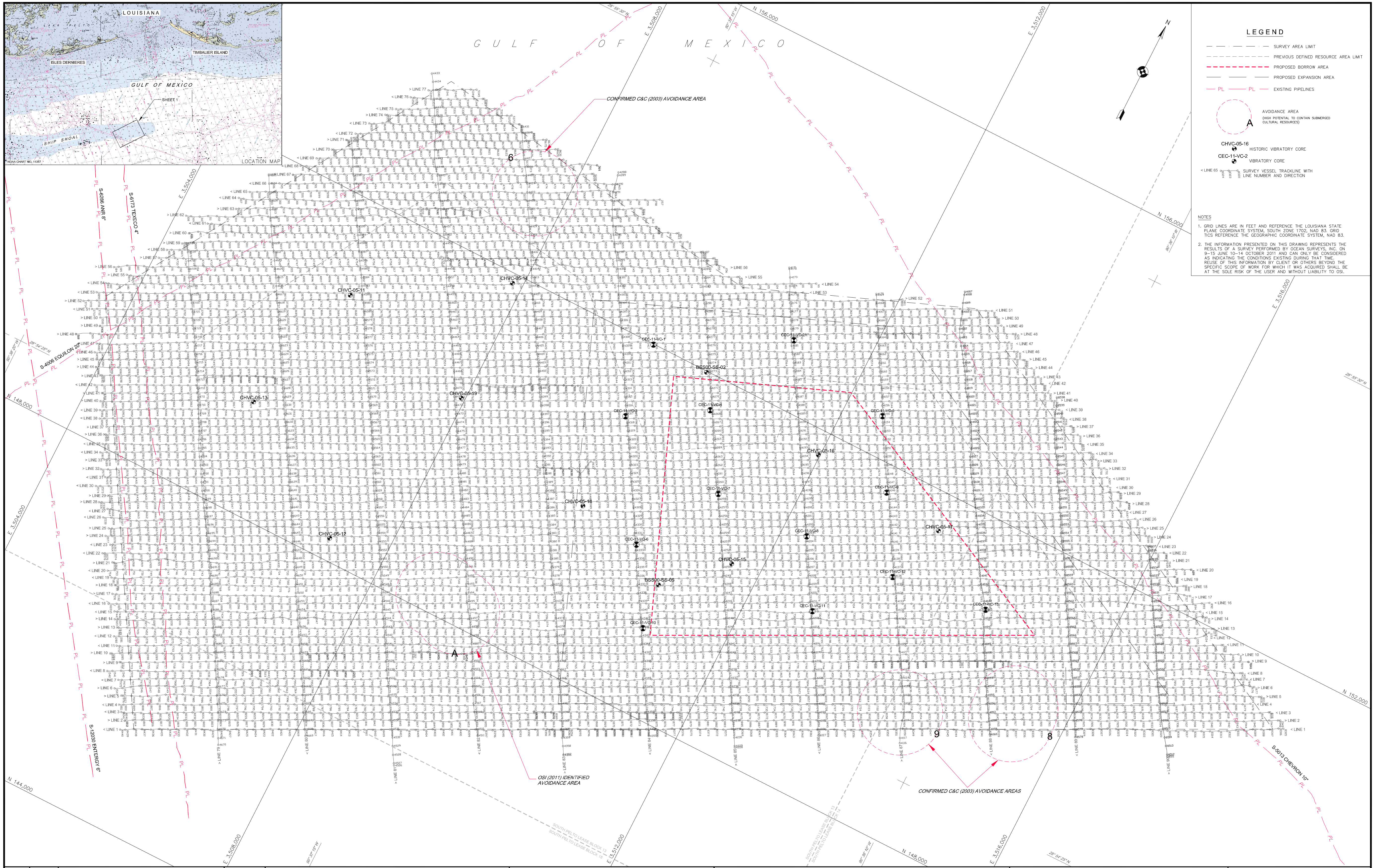
PROJECT DATUM NAVD88



VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL
0.0-15.6' - Fine sand, med gray, compact. Massive bedding. Shell fragments throughout sub section. Shell lags from 0.4-1.2', 2.0, 5.3', 6.2-6.3', 10.2-10.3', and 14.4-14.6'. Deformed clay lamination at 8.2'. Clay nodule at 15.0'. Bottom contact gradational.	VC-13 (0.0-0.4')	0.0-0.4
	VC-13 (1.8-2.2')	1.8-2.2
	VC-13 (3.8-4.2')	3.8-4.2
	VC-13 (5.8-6.2')	5.8-6.2
	VC-13 (7.8-8.2')	7.8-8.2
	VC-13 (9.8-10.2')	9.8-10.2
	VC-13 (11.8-12.2')	11.8-12.2
	VC-13 (13.8-14.2')	13.8-14.2
15.6-19.8' - Clayey sand , dark gray, stiff. 19.2-19.8' clay layer. Contact heavily bioturbated.	VC-13 (15.8-16.2')	15.8-16.2
	VC-13 (17.8-18.2')	17.8-18.2

APPENDIX 6

REDUCED SCALE PROJECT DRAWINGS



NOTES

1. GRID LINES ARE IN FEET AND REFERENCE THE LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE 1702, NAD 83. GRID TICS REFERENCE THE GEOGRAPHIC COORDINATE SYSTEM, NAD 83.

2. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 9–15 JUNE 10–14 OCTOBER 2011 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING DURING THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

REV.	DATE	DESCRIPTION	BY

SCALE IN FEET

400 0 400 800 1200

CHECK GRAPHIC SCALE BEFORE USING

SURVEY VESSEL: R/V ARCADIANA	ECHOSOUNDER: ODOM ECHOTRAC DEPTH SOUNDER
NAVIGATION SYSTEM: TRIMBLE 212 DGPS	SIDE SCAN SONAR: KLEIN 3000 100/500 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK	MAGNETOMETER: GEOMETRICS G882
SURVEY PROCESSING SOFTWARE: HYPACK, SONARWIZ, MAGPICK, DISCOVER	SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHZ XSTAR CHIRP 5–12 kHz

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388–4631
www.oceansurveys.com

PREPARED FOR: COASTAL ENGINEERING CONSULTANTS, INC.

CAMINADA HEADLAND BEACH AND DUNE RESTORATION PROJECT (CPRA BA-45)

PROJECT MANAGER: J.D. SULLIVAN	SURVEY DATES: 9–15 JUNE & 10–14 OCTOBER 2011	
DRAFTED BY: P.J. LACKEY	DATE: 27 JANUARY 2012	PROJECT NUMBERS: 11ES007 & 11ES008

OFFICE OF COASTAL PROTECTION & RESTORATION
ENGINEERING BRANCH
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

BEACH AND DUNE RESTORATION

TRACKLINES

STATE PROJECT NUMBER:

FEDERAL PROJECT NUMBER:

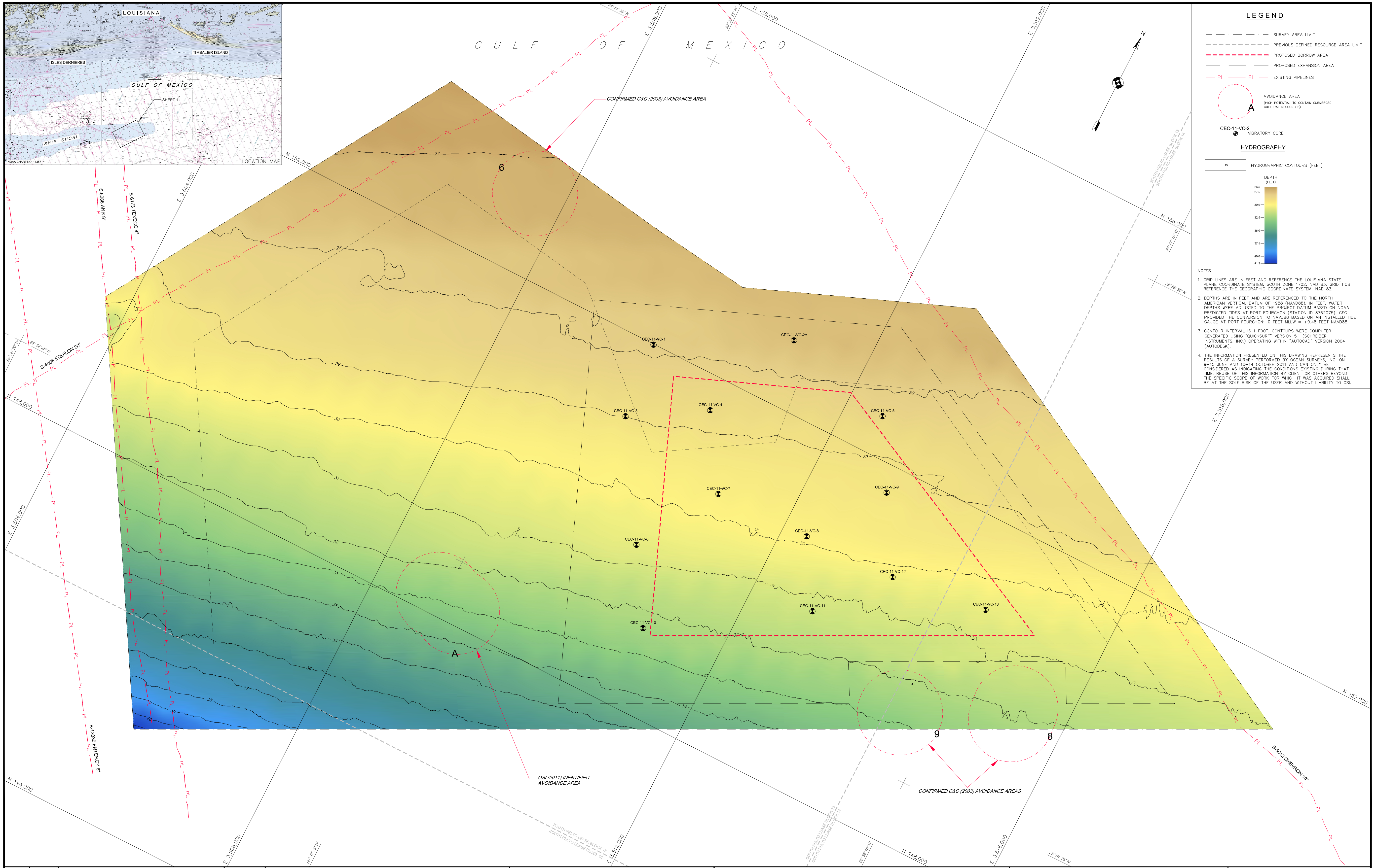
DATE:

DRAWN BY:

DESIGNED BY:

APPROVED BY:

DRAWING 1 - SHEET 1 OF 1



LEGEND

SURVEY AREA LIMIT
PREVIOUS DEFINED RESOURCE AREA LIMIT
PROPOSED BORROW AREA
PROPOSED EXPANSION AREA
PL — PL EXISTING PIPELINES
AVOIDANCE AREA (HIGH POTENTIAL TO CONTAIN SUBMERGED CULTURAL RESOURCES)
CEC-11-VC-2 VIBRATORY CORE

HYDROGRAPHY

30 HYDROGRAPHIC CONTOURS (FEET)

DEPTH (FEET)
26.5
27.5
30.0
32.5
35.0
37.5
40.0
41.3

NOTES

1. GRID LINES ARE IN FEET AND REFERENCE THE LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE 1702, NAD 83. GRID TICS REFERENCE THE GEOGRAPHIC COORDINATE SYSTEM, NAD 83.

2. DEPTHS ARE IN FEET AND ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88), IN FEET. WATER DEPTHS WERE ADJUSTED TO THE PROJECT DATUM BASED ON NOAA PREDICTED TIDES AT PORT FOURCHON (STATION ID 8762075). CEC PROVIDED THE CONVERSION TO NAVD88 BASED ON AN INSTALLED TIDE GAUGE AT PORT FOURCHON: 0 FEET MLLW = +0.48 FEET NAVD88.

3. CONTOUR INTERVAL IS 1 FOOT. CONTOURS WERE COMPUTER GENERATED USING "QUICKSURF" VERSION 5.1 (SCHREIBER INSTRUMENTS, INC.) OPERATING WITHIN "AUTOCAD" VERSION 2004 (AUTODESK).

4. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 9–15 JUNE AND 10–14 OCTOBER 2011 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING DURING THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

REV.	DATE	DESCRIPTION	BY

SCALE IN FEET
400 0 400 800 1200
CHECK GRAPHIC SCALE BEFORE USING

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NAVIGATION SYSTEM: TRIMBLE 212 DGPS	SIDE SCAN SONAR: KLEIN 3000 100/500 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK	MAGNETOMETER: GEOMETRICS G882
SURVEY PROCESSING SOFTWARE: HYPACK, SONARWIZ, MAGPICK, DISCOVER	SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHZ XSTAR CHIRP 5–12 kHz

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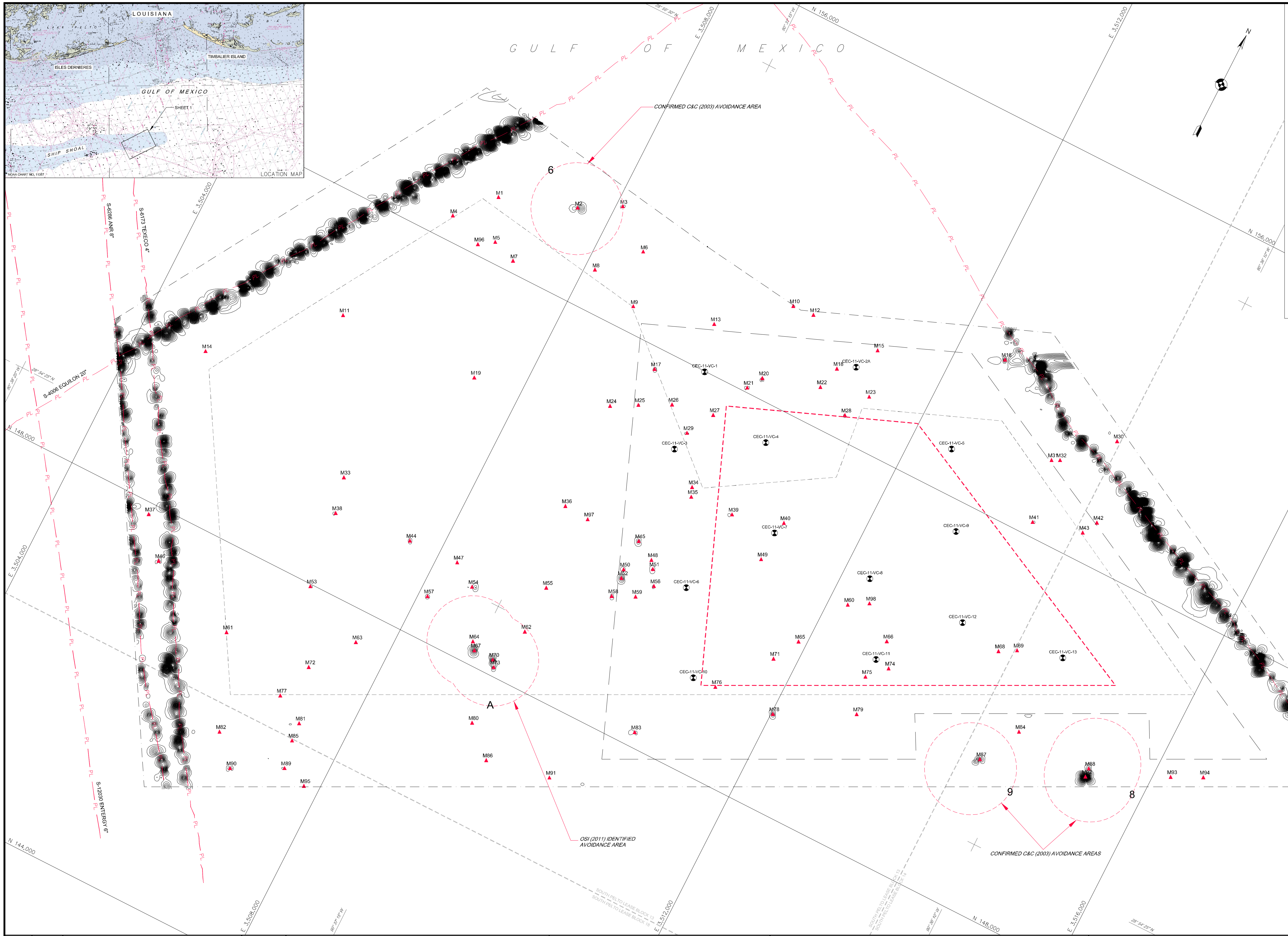
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY:
DESIGNED BY:

BEACH AND DUNE RESTORATION
STATE PROJECT NUMBER:
FEDERAL PROJECT NUMBER:
APPROVED BY:

HYDROGRAPHY
DATE:
DRAWING 2 - SHEET 1 OF 1



LEGEND

— — · — — · —	SURVEY AREA LIMIT
— — — — — — —	PREVIOUS DEFINED RESOURCE AREA LIMIT
- - - - - - - -	PROPOSED BORROW AREA
——— ——— ———	PROPOSED EXPANSION AREA
— PL — PL —	EXISTING PIPELINES
A	AVOIDANCE AREA (HIGH POTENTIAL TO CONTAIN SUBMERGED CULTURAL RESOURCES)
CEC-11-VC-2 ⊕	VIBRATORY CORE
◎	MAGNETIC FIELD CONTOURS (GAMMAS)
M45 ▲	MAGNETIC ANOMALY

NOTES

1. GRID LINES ARE IN FEET AND REFERENCE THE LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE 1702, NAD 83. GRID TICS REFERENCE THE GEOGRAPHIC COORDINATE SYSTEM, NAD 83.
2. CONTOUR INTERVAL IS 10 GAMMAS. MAGNETIC FIELD CONTOURS WERE COMPUTER GENERATED USING MAGPICK VERSION 3.2 GEOMETRICS.
3. SEABED FEATURES AND GEOLOGICAL INTERPRETATIONS ARE BASED ON THE ANALYSIS OF HYDROGRAPHIC, SIDE SCAN SONAR AND MAGNETOMETER DATA. ADDITIONAL INFORMATION REGARDING THE INTERPRETATION PRESENTED CAN BE FOUND IN OSI REPORT NO. 11ES008.
4. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 9–15 JUNE AND 10–14 OCTOBER 2011 AND CAN ONLY BE CONSIDERED THE AS INDICATING CONDITIONS EXISTING DURING THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

REV.	DATE	DESCRIPTION	BY

SCALE IN FEET
400 0 400 800 1200
CHECK GRAPHIC SCALE BEFORE USING

SURVEY VESSEL: R/V ARCADIANA	ECHOSOUNDER: ODOM ECHOTRAC DEPTH SOUNDER
NAVIGATION SYSTEM: TRIMBLE 212 DGPS	SIDE SCAN SONAR: KLEIN 3000 100/500 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK	MAGNETOMETER: GEOMETRICS G882
SURVEY PROCESSING SOFTWARE: HYPACK, SONARWIZ, MAGPICK, DISCOVER	SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHZ XSTAR CHIRP 5–12 kHz

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DRAFTED BY: P.J. LACKEY	DATE: 27 JANUARY 2012	PROJECT NUMBERS: 11ES007 & 11ES008

OFFICE OF COASTAL PROTECTION & RESTORATION
ENGINEERING BRANCH
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY:

DESIGNED BY:

BEACH AND DUNE RESTORATION

STATE PROJECT NUMBER:

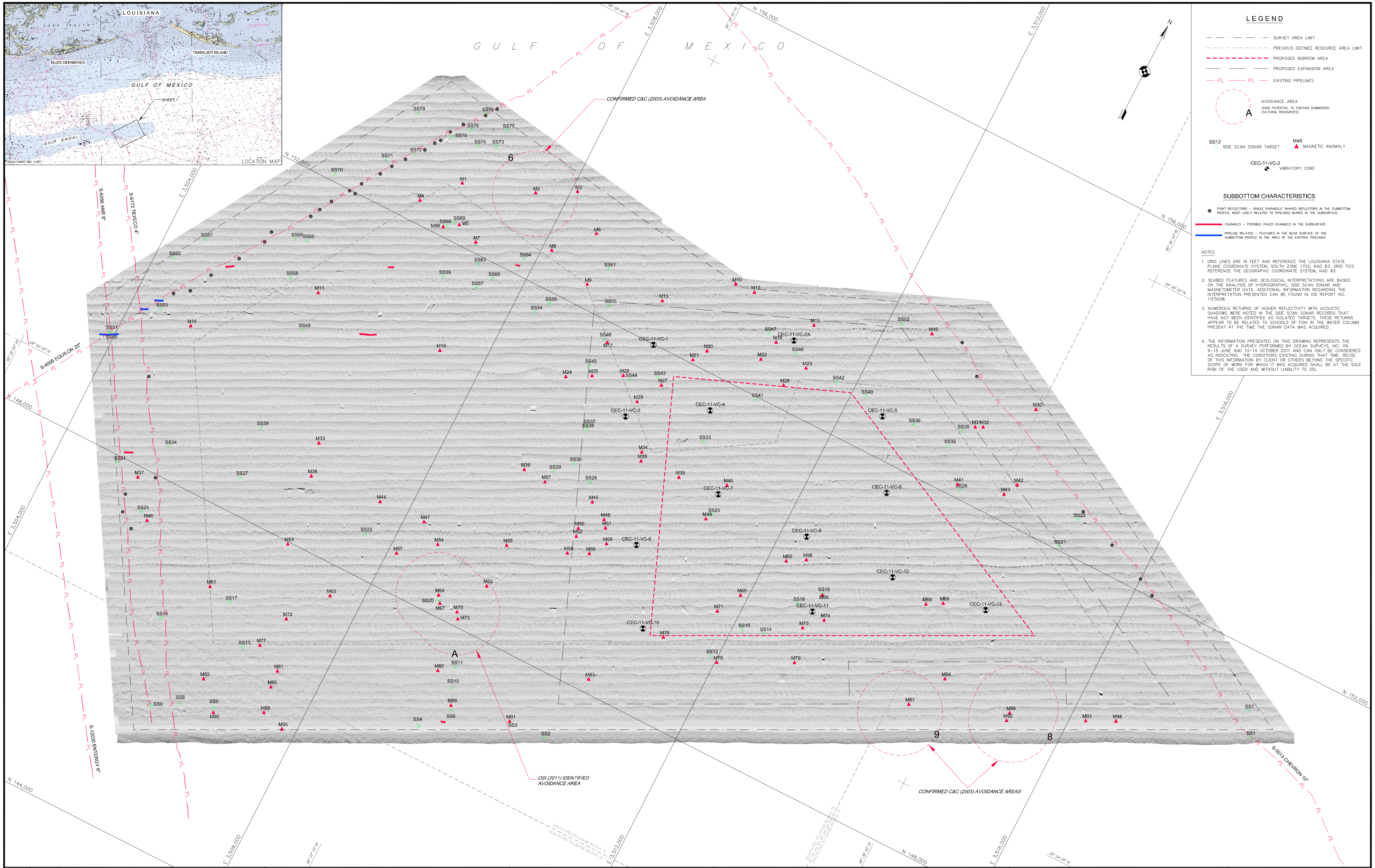
FEDERAL PROJECT NUMBER:

APPROVED BY:

RESIDUAL MAGNETIC FIELD CONTOURS

DATE:

DRAWING 3 - SHEET 1 OF 1



LEGEND

— — · — — · —	SURVEY AREA LIMIT
— — — — — —	PREVIOUS DEFINED RESOURCE AREA LIMIT
- - - - - -	PROPOSED BORROW AREA
——— ——— ———	PROPOSED EXPANSION AREA
— PL — PL —	EXISTING PIPELINES
◯ A	AVOIDANCE AREA (HIGH POTENTIAL TO CONTAIN SUBMERGED CULTURAL RESOURCES)
SS12 ☐	SIDE SCAN SONAR TARGET
M45 ▲	MAGNETIC ANOMALY
CEC-11-VC-2 ◐	VIBRATORY CORE

SUBBOTTOM CHARACTERISTICS

⊙	POINT REFLECTORS – SINGLE PARABOLIC SHAPED REFLECTORS IN THE SUBBOTTOM PROFILE, MOST LIKELY RELATED TO PIPELINES BURIED IN THE SUBSURFACE.
🟥	CHANNELS – POSSIBLE PALEO CHANNELS IN THE SUBSURFACE.
🟦	PIPELINE RELATED – FEATURES IN THE NEAR SURFACE OF THE SUBBOTTOM PROFILE IN THE AREA OF THE EXISTING PIPELINES.

NOTES

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3. NUMEROUS RETURNS OF HIGHER REFLECTIVITY WITH ACOUSTIC SHADOWS WERE NOTED IN THE SIDE SCAN SONAR RECORDS THAT HAVE NOT BEEN IDENTIFIED AS ISOLATED TARGETS. THESE RETURNS APPEAR TO BE RELATED TO SCHOOLS OF FISH IN THE WATER COLUMN PRESENT AT THE TIME THE SONAR DATA WAS ACQUIRED.
4. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 9–15 JUNE AND 10–14 OCTOBER 2011 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING DURING THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

REV.	DATE	DESCRIPTION	BY

SCALE IN FEET
400 0 400 800 1200
CHECK GRAPHIC SCALE BEFORE USING

SURVEY VESSEL: R/V ARCADIANA	ECHOSOUNDER: ODOM ECHOTRAC DEPTH SOUNDER
NAVIGATION SYSTEM: TRIMBLE 212 DGPS	SIDE SCAN SONAR: KLEIN 3000 100/500 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK	MAGNETOMETER: GEOMETRICS G882
SURVEY PROCESSING SOFTWARE: HYPACK, SONARWIZ, MAGPICK, DISCOVER	SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHz XSTAR CHIRP 5–12 kHz

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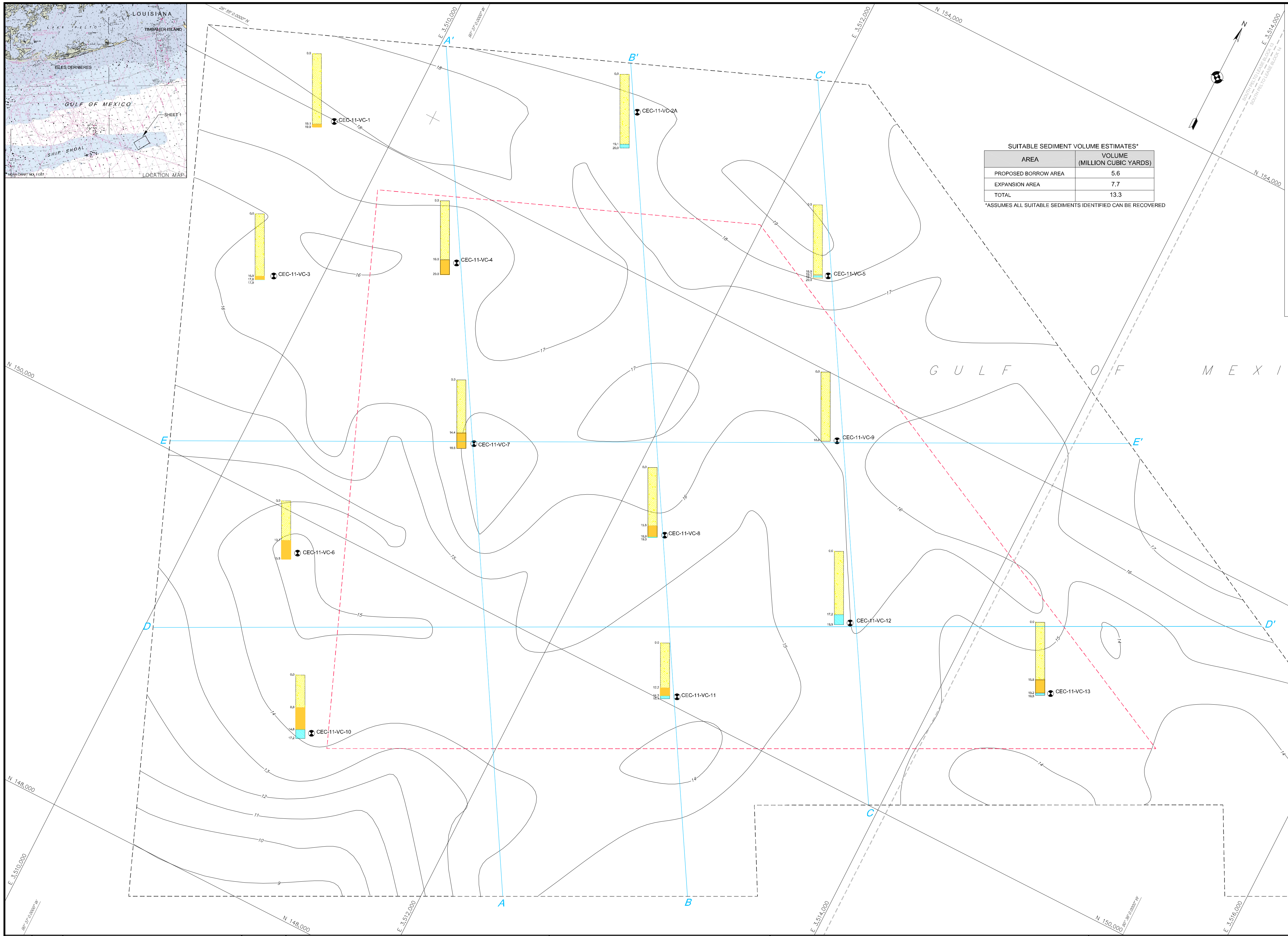
DRAFTED BY: P.J. LACKEY	DATE: 27 JANUARY 2012	PROJECT NUMBERS: 11ES007 & 11ES008

OFFICE OF COASTAL PROTECTION & RESTORATION
ENGINEERING BRANCH
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY:	DESIGNED BY:

BEACH AND DUNE RESTORATION	SIDE SCAN SONAR MOSAIC
STATE PROJECT NUMBER:	
FEDERAL PROJECT NUMBER:	DATE:
APPROVED BY:	DRAWING 4 - SHEET 1 OF 1



SUITABLE SEDIMENT VOLUME ESTIMATES*

AREA	VOLUME (MILLION CUBIC YARDS)
PROPOSED BORROW AREA	5.6
EXPANSION AREA	7.7
TOTAL	13.3

*ASSUMES ALL SUITABLE SEDIMENTS IDENTIFIED CAN BE RECOVERED

LEGEND

🟥 – – –	PROPOSED BORROW AREA
– – –	PROPOSED EXPANSION AREA
—16—	INTERPRETED SAND THICKNESS CONTOUR (FEET)
A —— A'	REPRESENTATIVE SUBBOTTOM PROFILES (REFER TO DRAWING 6 SHEETS 1–3)
CEC-11-VC-11 ◕	VIBRATORY CORE

CORE LOG SUMMARY*

0.0–12.2	SAND
12.2–14.3	SILTY/CLAYEY SAND
14.3–15.1	CLAY

*Based on the evaluation of core logs. For additional information refer to OSI Report No. 11ES008.

NOTES

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2. SAND THICKNESS CONTOURS BASED ON THE INTERPRETATION OF SUBBOTTOM PROFILE AND VIBRATORY CORE DATA. CONTOUR INTERVAL IS 1 FOOT. FOR ADDTIONAL INFORMATION REFER TO OSI REPORT NO. 11ES008.
3. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 9–15 JUNE AND 10–14 OCTOBER 2011 AND CAN ONLY BE CONSIDERED INDICATING THE CONDITIONS EXISTING DURING THAT TIME. REUSE OF THIS AS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

REV.	DATE	DESCRIPTION	BY

SCALE IN FEET
200 0 200 400 600
CHECK GRAPHIC SCALE BEFORE USING

SURVEY VESSEL: A.C. BROWN ELEVATOR	VIBRACORE: MODEL 1500
NAVIGATION SYSTEM: TRIMBLE 212 DGPS	SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHz, XSTAR CHIRP 5–12 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK	SURVEY PROCESSING SOFTWARE: HYPACK

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DRAFTED BY: P.J. LACKEY	DATE: 27 JANUARY 2012	PROJECT NUMBERS: 11ES007 & 11ES008

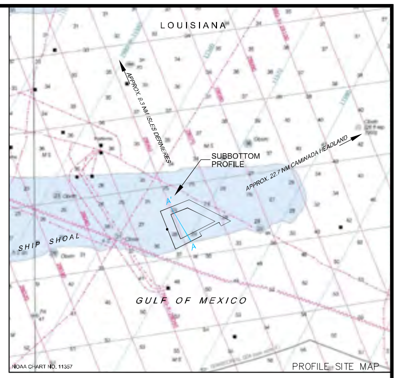
OFFICE OF COASTAL PROTECTION & RESTORATION
ENGINEERING BRANCH
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY:
DESIGNED BY:

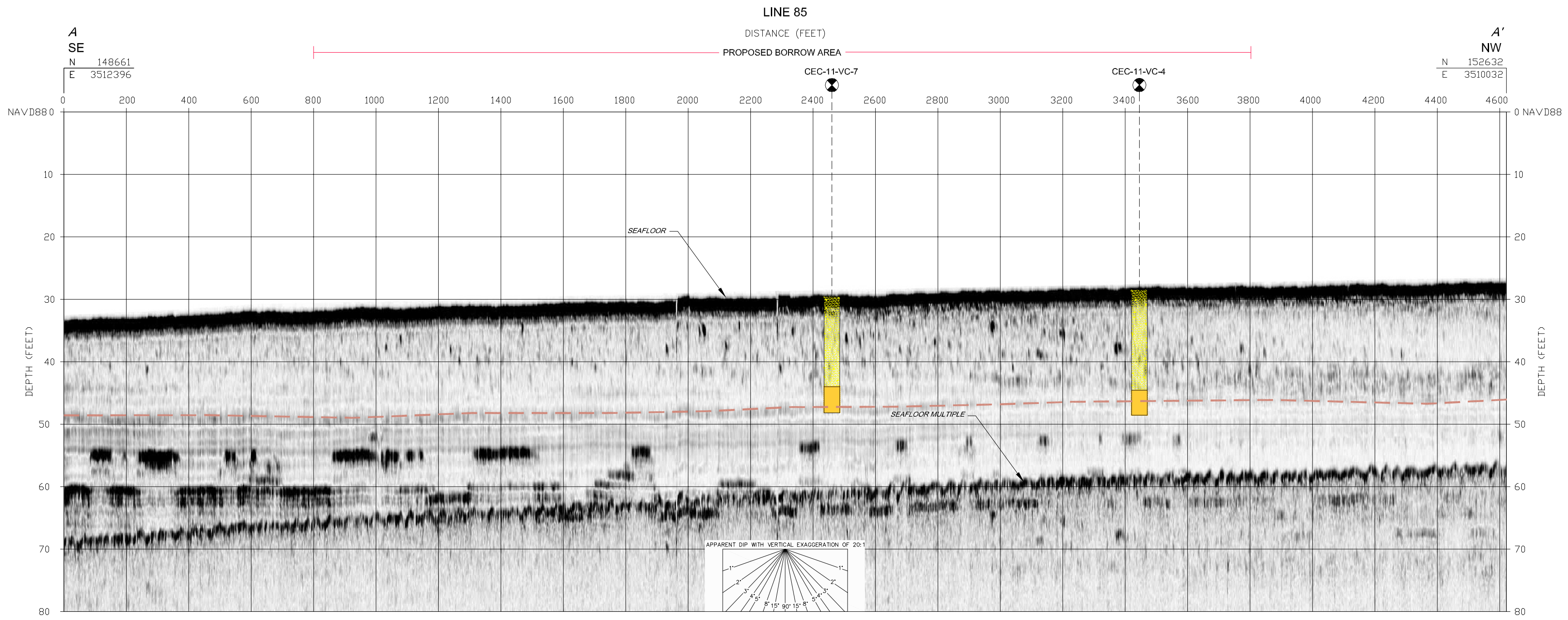
BEACH AND DUNE RESTORATION
STATE PROJECT NUMBER:
FEDERAL PROJECT NUMBER:
APPROVED BY:

SUITABLE SEDIMENT
ISOPACH

DATE:
DRAWING 5 - SHEET 1 OF 1



PROFILE SITE MAP

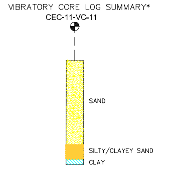


LEGEND

A —— A' REPRESENTATIVE SUBBOTTOM PROFILES (REFER TO DRAWING 5 SHEET 1)

— — — SUBBOTTOM REFLECTOR

VIBRATORY CORE LOG SUMMARY*



*Based on the evaluation of core logs. For additional information refer to OSI Report No. 11ES008.

NOTES

1. DEPTHS ARE IN FEET AND ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88), IN FEET. WATER DEPTHS WERE ADJUSTED TO THE PROJECT DATUM BASED ON NOAA PREDICTED TIDES AT PORT FOURCHON (STATION ID 8762075). CEC PROVIDED THE CONVERSION TO NAVD88 BASED ON AN INSTALLED TIDE GAUGE AT PORT FOURCHON: 0 FEET MLLW = +0.48 FEET NAVD88.
2. REPRESENTATIVE SUBBOTTOM PROFILE AND VIBRATORY CORE DATA WERE REFERENCED TO THE PROJECT DATUM NAVD88 BASED ON HYDROGRAPHIC DATA. ADDITIONAL INFORMATION REGARDING THE GEOPHYSICAL INTERPRETATIONS PRESENTED CAN BE FOUND IN OSI REPORT NO. 11ES008.
3. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 9–15 JUNE AND 10–14 OCTOBER 2011 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING DURING THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

REV.	DATE	DESCRIPTION	BY

SCALE IN FEET
200 0 200 400 600
CHECK GRAPHIC SCALE BEFORE USING

SURVEY VESSEL: A.C. BROWN ELEVATOR	VIBRACORE: MODEL 1500
NAVIGATION SYSTEM: TRIMBLE 212 DGPS	SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHZ, XSTAR CHIRP 5–12 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK	SURVEY PROCESSING SOFTWARE: HYPACK

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ENGINEERING BRANCH
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY:

DESIGNED BY:

BEACH AND DUNE RESTORATION

STATE PROJECT NUMBER:

FEDERAL PROJECT NUMBER:

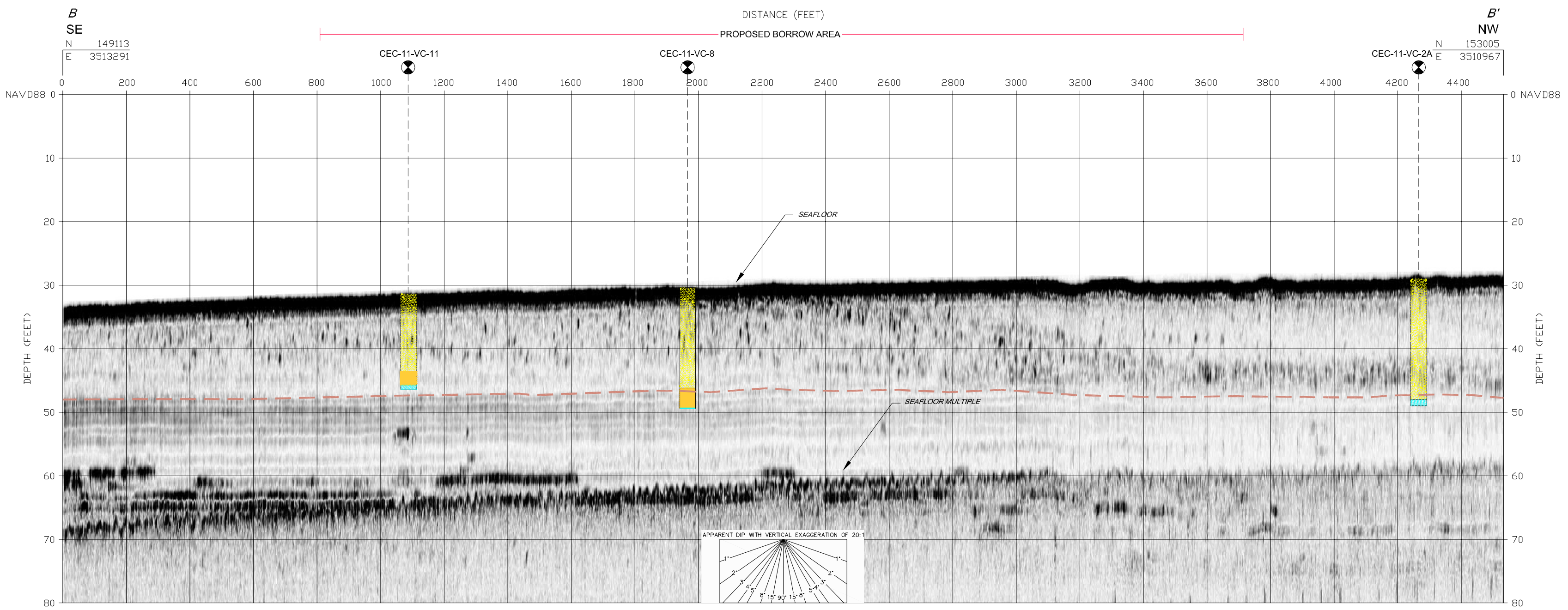
APPROVED BY:

SUBBOTTOM PROFILES

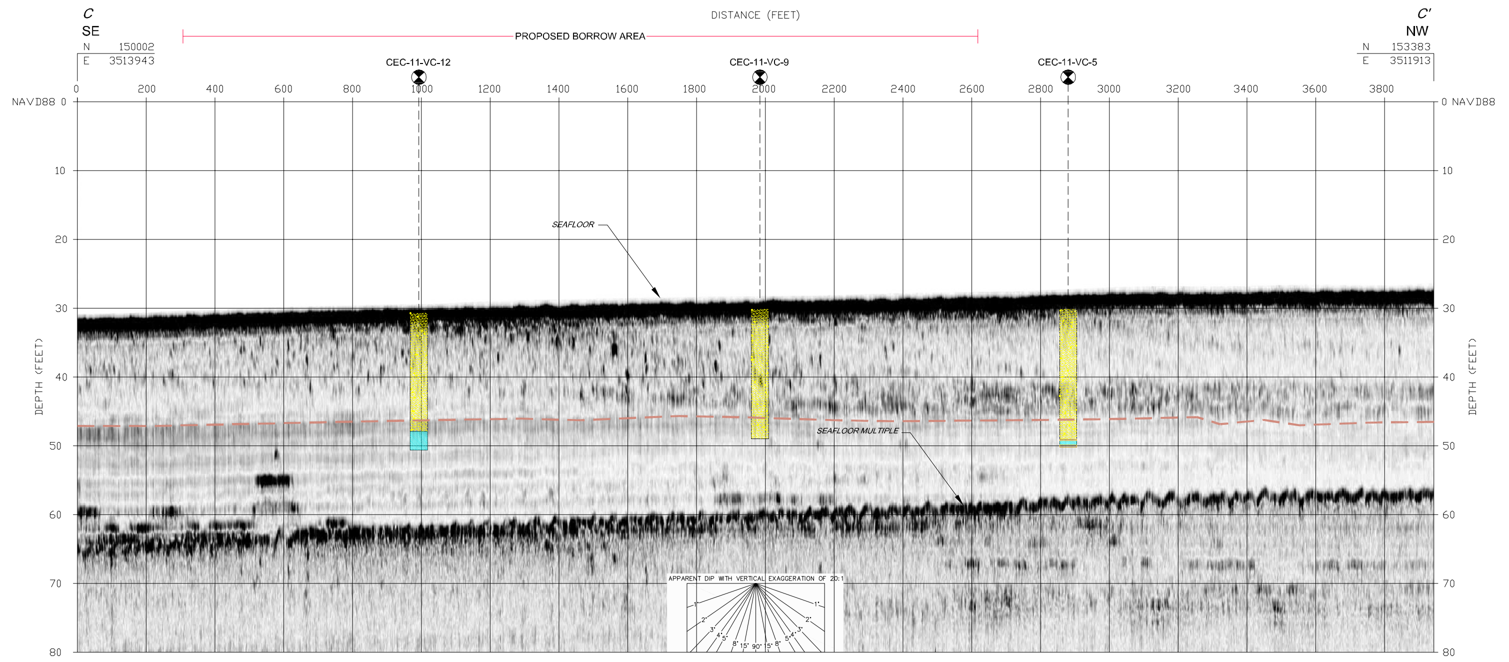
DATE:

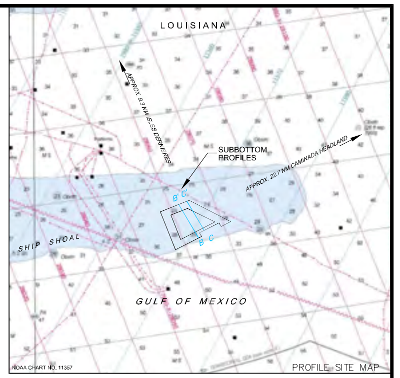
DRAWING 6 - SHEET 1 OF 3

LINE 86



LINE 87





PROFILE SITE MAP

LEGEND

A ——— A' REPRESENTATIVE SUBBOTTOM PROFILES (REFER TO DRAWING 5 SHEET 1)

— — — — SUBBOTTOM REFLECTOR

VIBRATORY CORE LOG SUMMARY*
CEC-11-VC-11

🟨 SAND

🟧 SILTY/CLAYEY SAND

▨ CLAY

*Based on the evaluation of core logs. For additional information refer to OSI Report No. 11ES008.

NOTES

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2. REPRESENTATIVE SUBBOTTOM PROFILE AND VIBRATORY CORE DATA WERE REFERENCED TO THE PROJECT DATUM NAVD88 BASED ON HYDROGRAPHIC DATA. ADDITIONAL INFORMATION REGARDING THE GEOPHYSICAL INTERPRETATIONS PRESENTED CAN BE FOUND IN OSI REPORT NO. 11ES008.
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REV.	DATE	DESCRIPTION	BY

SCALE IN FEET
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CHECK GRAPHIC SCALE BEFORE USING

SURVEY VESSEL: A.C. BROWN ELEVATOR
VIBRACORE: MODEL 1500
NAVIGATION SYSTEM: TRIMBLE 212 DGPS
SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHZ, XSTAR CHIRP 5–12 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK
SURVEY PROCESSING SOFTWARE: HYPACK

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PREPARED FOR: COASTAL ENGINEERING CONSULTANTS, INC.
CAMINADA HEADLAND BEACH AND DUNE RESTORATION PROJECT (CPRA BA-45)

PROJECT MANAGER: J.D. SULLIVAN
SURVEY DATES: 9–15 JUNE & 10–14 OCTOBER 2011
DRAFTED BY: P.J. LACKEY
DATE: 27 JANUARY 2012
PROJECT NUMBERS: 11ES007 & 11ES008

OFFICE OF COASTAL PROTECTION & RESTORATION
ENGINEERING BRANCH
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

BEACH AND DUNE RESTORATION

STATE PROJECT NUMBER:

FEDERAL PROJECT NUMBER:

SUBBOTTOM PROFILES

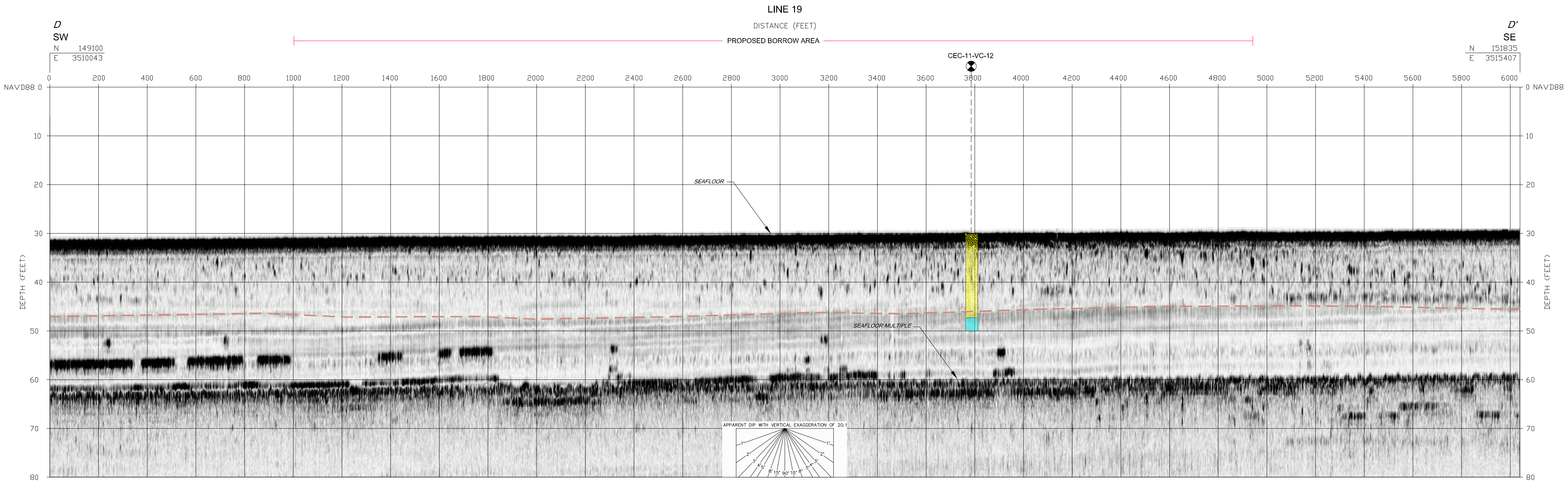
DATE:

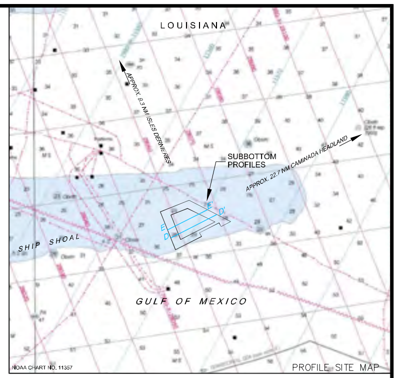
DRAWN BY:

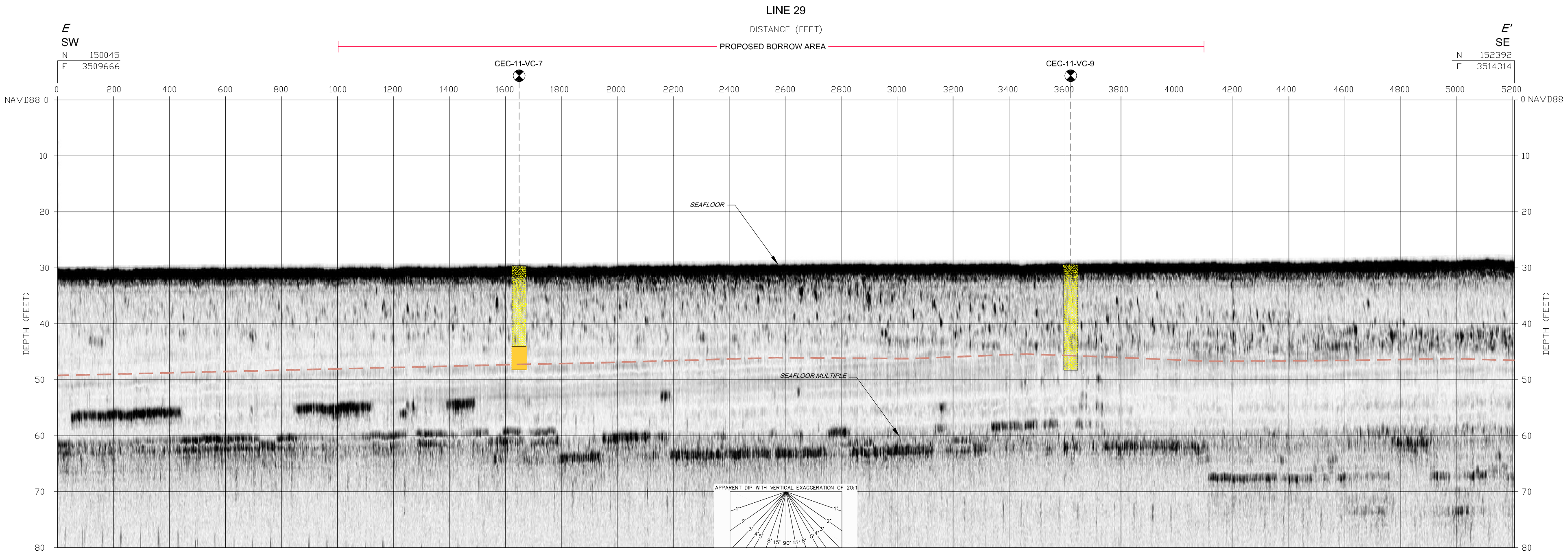
DESIGNED BY:

APPROVED BY:

DRAWING 6 - SHEET 2 OF 3







LEGEND

A —— A' REPRESENTATIVE SUBBOTTOM PROFILES (REFER TO DRAWING 5 SHEET 1)

— — — — — SUBBOTTOM REFLECTOR

VIBRATORY CORE LOG SUMMARY*
CEC-11-VC-11

SAND
SILTY/CLAYEY SAND
CLAY

*Based on the evaluation of core logs. For additional information refer to OSI Report No. 11ES008.

NOTES

1. DEPTHS ARE IN FEET AND ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88), IN FEET. WATER DEPTHS WERE ADJUSTED TO THE PROJECT DATUM BASED ON NOAA PREDICTED TIDES AT PORT FOURCHON (STATION ID 8762075). CEC PROVIDED THE CONVERSION TO NAVD88 BASED ON AN INSTALLED TIDE GAUGE AT PORT FOURCHON: 0 FEET MLLW = +0.48 FEET NAVD88.
2. REPRESENTATIVE SUBBOTTOM PROFILE AND VIBRATORY CORE DATA WERE REFERENCED TO THE PROJECT DATUM NAVD88 BASED ON HYDROGRAPHIC DATA. ADDITIONAL INFORMATION REGARDING THE GEOPHYSICAL INTERPRETATIONS PRESENTED CAN BE FOUND IN OSI REPORT NO. 11ES008.
3. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 9–15 JUNE AND 10–14 OCTOBER 2011 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING DURING THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

REV.	DATE	DESCRIPTION	BY

SCALE IN FEET
200 0 200 400 600
CHECK GRAPHIC SCALE BEFORE USING

SURVEY VESSEL: A.C. BROWN ELEVATOR	VIBRACORE: MODEL 1500
NAVIGATION SYSTEM: TRIMBLE 212 DGPS	SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHZ, XSTAR CHIRP 5–12 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK	SURVEY PROCESSING SOFTWARE: HYPACK

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388–4631
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STATE PROJECT NUMBER:

FEDERAL PROJECT NUMBER:

SUBBOTTOM PROFILES

DATE:

DRAWN BY:

DESIGNED BY:

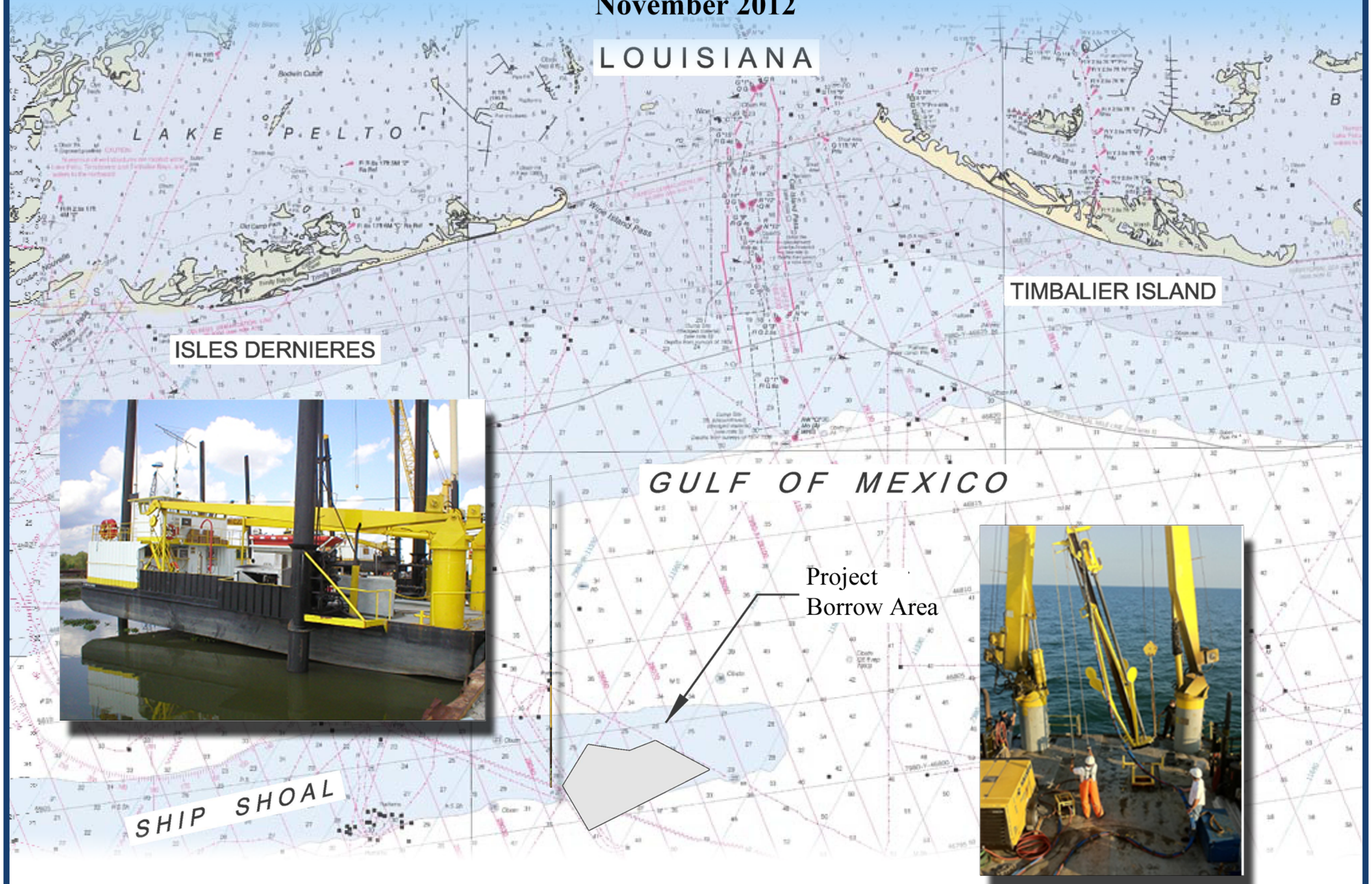
APPROVED BY:

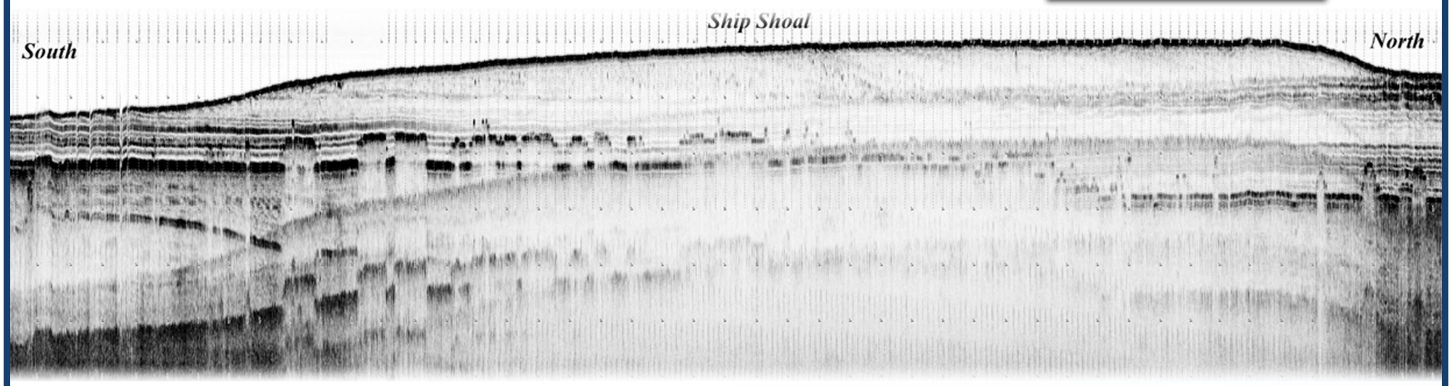
DRAWING 6 - SHEET 3 OF 3

Addendum Report

Ship Shoal Revised Borrow Area
Sediment Sampling Survey
Caminada Headland Beach and Dune Restoration Project
Increment II (CAM-II)

OSI Report #12ES018
November 2012





Prepared For:
Coastal Engineering Consultants, Inc.
3106 S. Horseshoe Drive
Naples, FL 34104

Prepared By:
Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

ADDENDUM REPORT

SHIP SHOAL REVISED BORROW AREA
SEDIMENT SAMPLING SURVEY
CAMINADA HEADLAND BEACH AND DUNE RESTORATION PROJECT
INCREMENT II (CAM-II)
GULF OF MEXICO, LOUISIANA

OSI REPORT NO. 12ES018

Prepared For: Coastal Engineering Consultants, Inc.
3106 S. Horseshoe Drive
Naples, FL 34104

Prepared By: Ocean Surveys, Inc.
129 Mill Rock Road E.
Old Saybrook, CT 06475

1 November 2012

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APPENDICES

John D. Sullivan
Principal Investigator
Manager Geophysical Surveys
OCEAN SURVEYS, INC.

ADDENDUM REPORT

SHIP SHOAL REVISED BORROW AREA
SEDIMENT SAMPLING SURVEY
CAMINADA HEADLAND BEACH AND DUNE RESTORATION PROJECT
INCREMENT II (CAM-II)
GULF OF MEXICO, LOUISIANA

1.0 INTRODUCTION

During the period 19-20 June 2012, an Ocean Surveys Inc. (OSI) field team conducted a vibratory coring program on Ship Shoal in the Gulf of Mexico, Louisiana (Figure 1). This investigation was performed under subcontract to Coastal Engineering Consulting, Inc. (CEC) for the Louisiana Coastal Protection and Restoration Authority (CPRA) Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II). The project includes restoring the eastern end of the Caminada Headland through beach and dune fill placement utilizing offshore sand resources from Ship Shoal within two Bureau of Ocean Energy Management (BOEM) lease areas: "South Pelto Lease Blocks 13 and 14" (Figure 1). The objective of this investigation was to refine estimates of sand resources within the proposed borrow area based on revisions made to avoid potential archaeological resources on Ship Shoal as requested by BOEM.

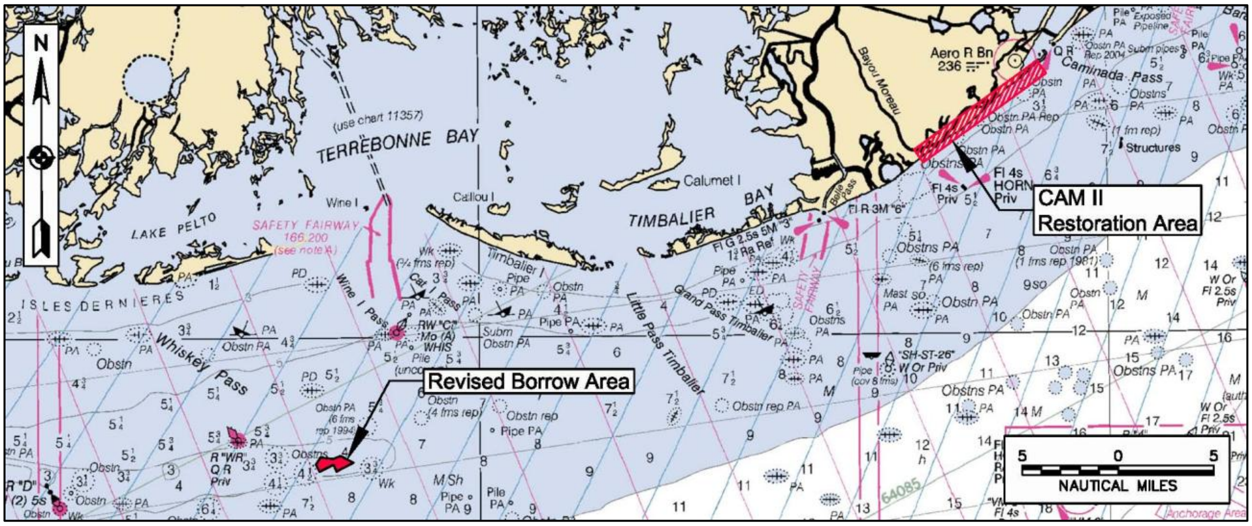


Figure 1. Location of Revised Borrow Area on Ship Shoal and CAM II Restoration Area along Caminada Headland in Lafourche Parish, Louisiana, (NOAA Nautical Chart 11340 in background).

2.0 SUMMARY OF SEDIMENT SAMPLING INVESTIGATION

Prior to sampling, an application for authorization to conduct geological prospecting for mineral resources in the outer continental shelf (OCS) was applied for and authorized by the Bureau of Ocean Management (BOEM) as OCS Permit L12-011. Subsequent to BOEM approval, two of the proposed ten core locations were modified due to a change in the design of the borrow area. These modified locations were submitted to BOEM and approved prior to the sampling investigation being performed. Figure 2 provides an overview of the final proposed core locations approved by BOEM.

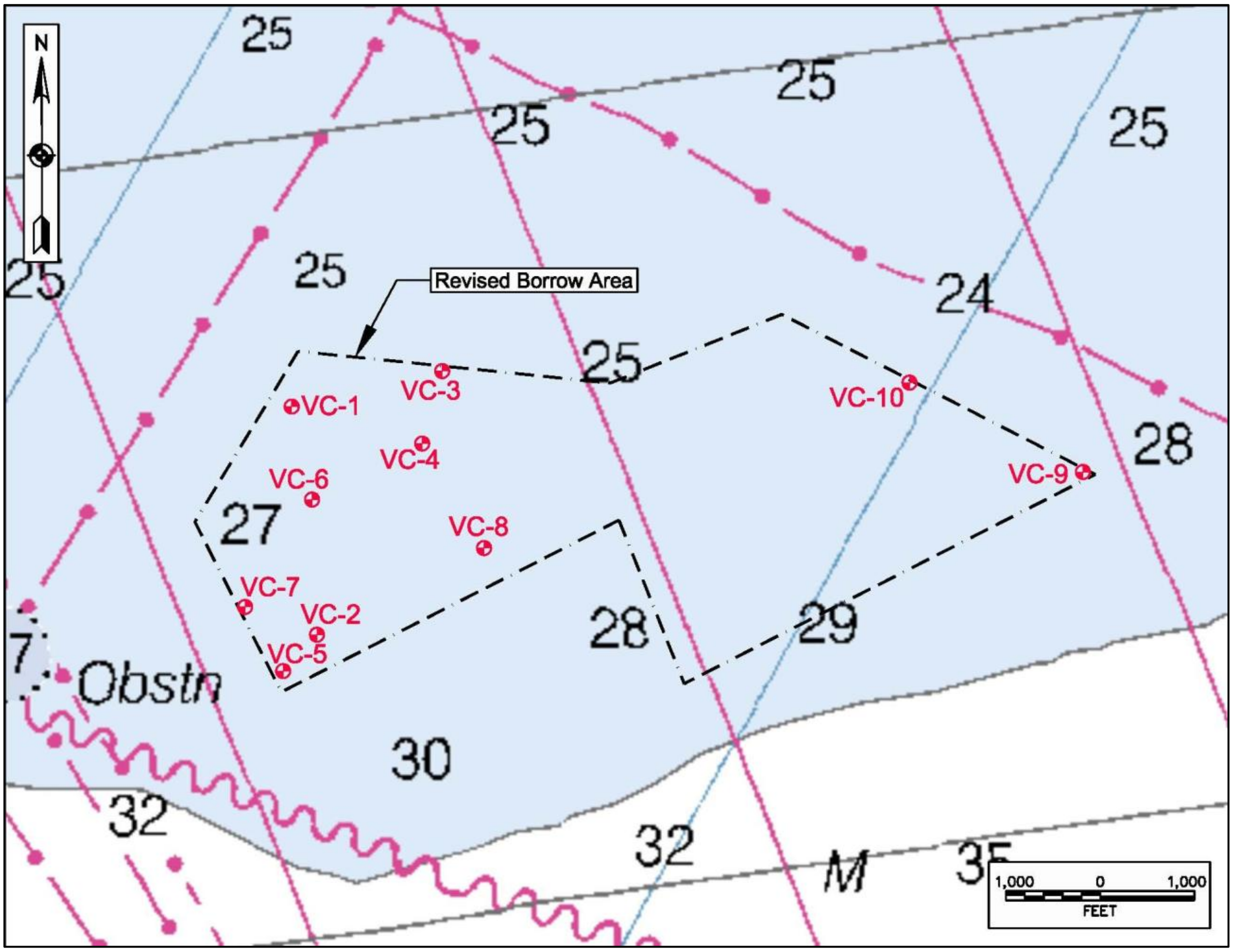


Figure 2. Location of final proposed 2012 core locations (abbreviated names) approved by BOEM (NOAA Nautical Chart 11357 in background).

Similar to the previous sampling investigation supporting the project (October 2011), the coring operation was conducted from *AC Brown Elevator*, a self-propelled liftboat from Elevating Boats, LLC (EBI) in Houma, LA. Figure 3 provides two photographs of the liftboat and shows the vibratory corer used and Table 1 provides a summary of the chronology of field operations, including vessel mobilization/demobilization.

Figure 3 - Photographs of EBI® liftboat. Right photo shows OSI crew recovering a core utilizing one of the stern-mounted cranes permanently installed on the vessel.

Table 1

Task	2012 Dates	Description
Vessel mobilization	18 June	OSI crew arrive in Houma, LA, mobilize *AC Brown Elevator* liftboat.
Transit to site and begin coring operations	19 June	Transit to Ship Shoal, perform testing/calibration of equipment, begin coring operations.
Complete coring operations and transit inland due to weather	20 June	Conduct coring operations, transit inland due to foul weather.
Transit to Houma and begin demobilization of vessel	21 June	Weather continues to worsen. Remaining core locations abandoned per CPRA. Transit to EBI in Houma, LA and begin demobilization.
Complete demobilization	22 June	Complete demobilization of *AC Brown Elevator* and transit of cores to processing facility in New Orleans.
OSI sampling crew and equipment depart site, begin transit to home office	26 June	OSI crew transit to Old Saybrook, CT.
Process vibratory cores	23 June – 3 August	Photograph, subsample, and describe cores at processing lab. Perform grain size analysis of subsamples.

Coring was accomplished by an experienced OSI scientific and technical crew consisting of a geologist/project manager, senior vibratory core operator and coring assistant. The OSI crew was supported by a two-man EBI liftboat crew (captain and mate). The following instruments were installed onboard the vessel to complete the investigation:

- *Trimble Global Positioning System interfaced with a U.S. Coast Guard Differential Beacon Receiver*
- *HYPACK Navigation and Data Logging Software*
- *OSI Model 1500 Pneumatic Vibratory Corer equipped with a 20' long 4" ID core barrel*

The project horizontal reference is the LA State Plane Coordinate System, South Zone (1702), NAD 83 in US Survey Feet. Project vertical reference is NAVD88 in feet. Depth measurements at each coring station were converted to the project datum using adjusted water depths acquired during the prior geophysical survey.

Before departure to Ship Shoal, a project safety meeting was held onboard the liftboat. Discussions included potential hazards that exist from the vessel and equipment configuration, as well as the planned operations. The liftboat remained on Ship Shoal throughout the course of the investigation.

During coring operations, precision DGPS positioning and OSI navigation systems were used to guide the vessel to the coring locations. Navigation checks were performed at the beginning and end of the field program to ensure the positioning system was functioning properly and delivering the horizontal position accuracy required for the project. Once on station the vessel was jacked-up into position to begin coring operations. Core samples were acquired with an OSI Model 1500 pneumatic vibratory corer equipped with a 20' long 4" ID core barrel. The core barrel was fitted with a 3.5" Lexan liner in which a continuous sediment core was recovered. A crane was used to lower the coring apparatus to the bottom. Once the apparatus was safely on the bottom, a 20-foot core sample was attempted.

Vibratory cores were acquired at eight of the ten proposed locations as shown in Figure 2. A summary of as-cored vibratory core locations is provided in Table 2. Due to an approaching tropical storm and adverse sea conditions experienced on site, two proposed core locations (CEC-12-VC-9 & CEC-12-VC-10) could not be completed. Very dense sands present on the shoal lead to refusal above the desired penetration depth of 20 feet at all of the attempted locations. Two cores were acquired at locations CEC-12-VC-1 and CEC-12-VC-8. At CEC-12-VC-1, the initial attempt reached refusal at 11.5 feet below the seafloor. A second core (CEC-12-VC-1A) was collected to attempt greater penetration; however, refusal was encountered at 10.8 feet. At CEC-12-VC-8, the initial attempt encountered refusal at 11.0 feet. To reach the target depth of 20 feet, a second core was collected (CEC-12-VC-8J) by jetting to 9.0 feet and then coring to 20.0 feet.

Table 2
Summary Table of As-Cored Vibratory Core Locations on Ship Shoal

Vibratory Core	Easting[1]	Northing[1]	Longitude[2]	Latitude[2]	Recovery (feet)
CEC-12-VC-1	3507051	151827	28.91555133	90.62633999	14.7
CEC-12-VC-2	3507298	149398	28.90886807	90.62561495	15.0
CEC-12-VC-3	3508616	152178	28.91648983	90.62144224	11.8
CEC-12-VC-4	3508418	151397	28.91434569	90.62207619	17.0
CEC-12-VC-5	3506933	148990	28.90775237	90.62676031	17.1
CEC-12-VC-6	3507253	150814	28.91276243	90.62572825	13.8
CEC-12-VC-7	3506519	149659	28.90959896	90.62804430	14.8
CEC-12-VC-8	3509050	150295	28.91130470	90.62012252	19.2
CEC-12-VC-9	Not completed				
CEC-12-VC-10	Not completed				

1 - Coordinates are in Louisiana State Plane South Zone (1702), NAD 83, Feet.

2 - Longitudes and Latitudes are referenced to WGS84.

At several core locations, expansion of sediment inside the core barrel was observed upon recovery. This expansion is not an uncommon phenomenon in vibratory coring in fine-grained sands and is noted on the core logs by recovery measurements that exceed penetration depths. Once on deck, cores were cut into manageable sections for storage and transportation to the laboratory.

3.0 DATA PROCESSING AND DATA PRODUCTS

Following the conclusion of this investigation, BOEM was notified of the completion of the vibratory coring program approved in OCS Permit L12-011 (letter to Mr. Dominic Smith dated 24 July 2012). In addition, all core sections were transferred to a core processing laboratory at the University of New Orleans (UNO) where they were analyzed by OSI and UNO geologists. This analysis included splitting, visually describing, photographing, and subsampling. Subsamples were collected at 2-foot intervals within each core. Grain size analysis was performed on subsamples visually identified as containing mostly sand. Subsamples were then dried, mechanically sieved, and weighed following ASTM guidelines. Grain size data were analyzed with a custom MATLAB Version R2011b sieve analysis routine, specifically designed to generate grain size distribution cumulative probability curves and perform statistical analyses. These results are presented both in tabular and graphical formats in the digital appendix. Final core logs were prepared using the logging software suite *LogPlot* distributed by RockWare, Inc. Vibratory core logs are presented in Appendix 1. Vibratory core photos and grain size analysis tables are included in the digital appendix on the accompanying disc. Once the project is complete, the core sections will be archived at a CPRA facility in New Orleans.

The results of the sediment sampling program were reviewed along with vibratory cores collected on Ship Shoal previously by OSI (2011) and Coastal Planning and Engineering (2005) to groundtruth subsurface geophysical data within the revised borrow area. An isopach map of surficial suitable sediments was then created for the revised borrow area. The isopach contours and core locations are presented on Drawing 1 at a scale of 1"=300'. This drawing is presented separately in full scale and is included in Appendix 2 in reduced format (11"x17"). Table 3 lists all of the appendices included in this report.

Table 3

Appendix #	Data Presented
1	Core Logs
2	Project Drawings in Reduced Format (11" by 17")
Digital Appendix	Final report file (PDF format), Project drawing files (AutoCAD 2004 and PDF formats), core photographs taken at 1-foot intervals (jpg format), complete set of detailed grain size analysis tables

4.0 DATA DISCUSSION

Results of this coring investigation within the western portion of the revised borrow area are consistent with findings from the 2011 and 2005 geotechnical investigations on Ship Shoal. Clean fine sands (average grain size 0.213mm/2.23phi) were found to overly clayey/silty fine sands (<13% fines) and ultimately firm clays.

Subbottom profile data were reviewed in conjunction with core logs, core photos and grain size results from this and previous investigations in order to create an isopach of suitable sediment resources within the revised borrow area. Because silty/clayey sands generally contained less than 13% fines and were generally less than 5 feet thick (except CEC-11-VC-11, 6 ft), both surficial clean sands and underlying silty/clayey sands were deemed suitable sediment resources for the project (personal communication James Cohlmeyer, P.G., 12/8/11).

Figure 4 shows chirp subbottom profile records along an east-west oriented line (A-A’) and a north-south oriented line (B-B’) within the western portion of the revised borrow area. These records have been overlain with results from the 2011 and 2012 coring programs and show the interpreted lower limit of suitable sediments mapped by OSI. As noted in OSI’s previous investigation, two distinct sequences of seismic reflections were identified including an upper sequence of semi-transparent reflections and a lower sequence of less transparent, horizontal, sub-parallel reflections. Acoustic reflections within the upper sequence are lower amplitude in appearance, characteristic of predominantly sandy sediments, and show faint evidence of northward dipping bedding. This sequence thins to the south and east within the borrow

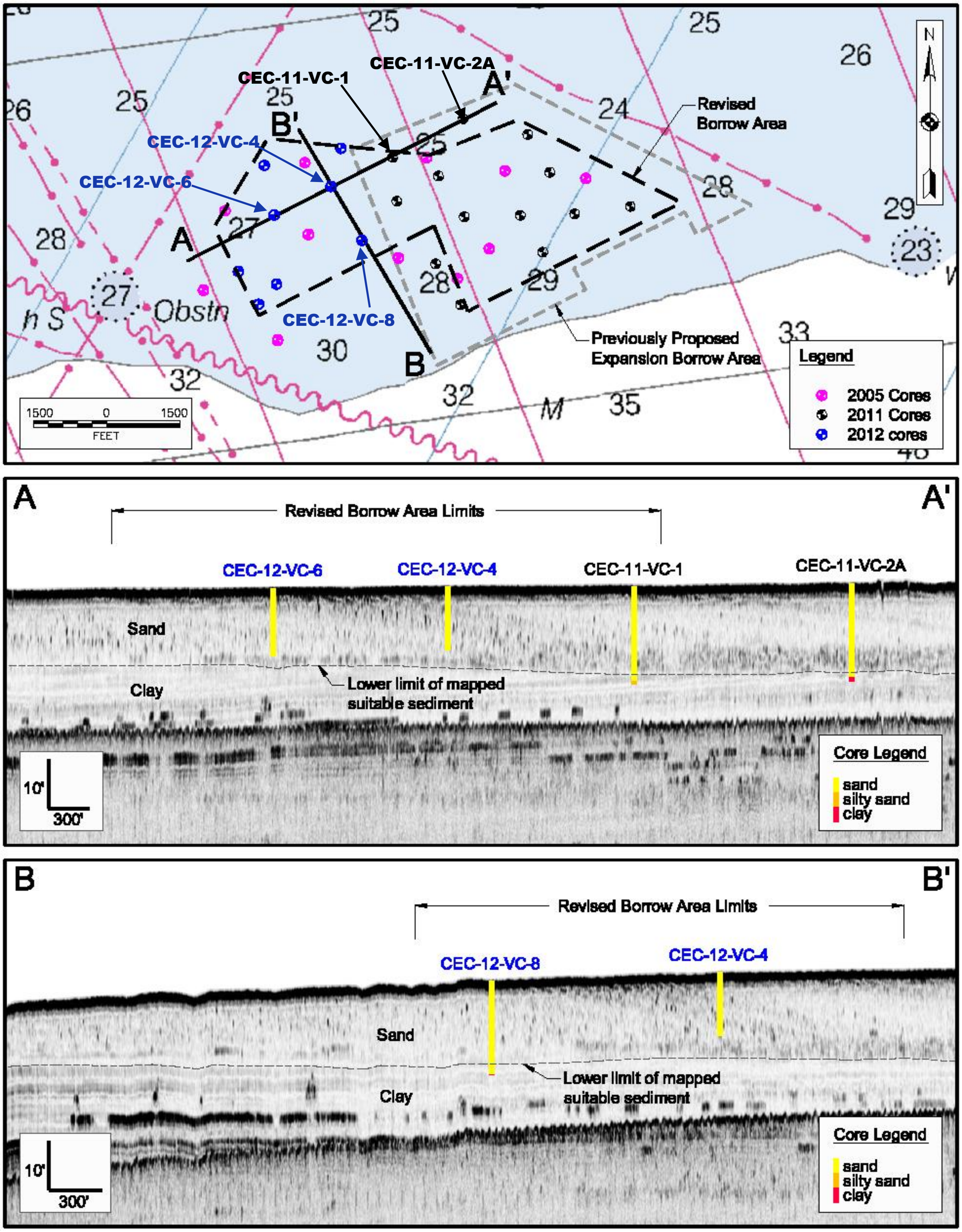


Figure 4. Chirp subbottom profiles through the expanded portion of the revised borrow area showing results from sediment sampling investigations as well as the lower limit of mapped suitable sediments.

area. Higher amplitude, sub-parallel reflections identified in the lower sequence are characteristic of finer-grained silts and clays.

In several locations, depth-to-clay measurements based on the cores correlated to within a foot of the interpreted contact in the subbottom data (see for example CEC-11-VC-2A in Figure 4). In other locations the geophysical interpretations were observed to be within several feet (above and below) of measurements made in the cores (i.e. CEC-12-VC-8). In all cases the variance between core data and geophysical data was well within the expected levels for correlation between the two data sets given that many of the cores showed significant expansion upon recovery (as discussed earlier). At location CEC-12-VC-8, a thin layer of clay was recovered at 19.9 feet below the seabed during the second jetted attempt. This clay contact is approximately two feet below the apparent clay contact interpreted in the subbottom profile data as shown in Figure 4. This difference may be attributed to fluidization and expansion of sediment during the jetting process. In order to produce a conservative sediment isopach of surficial suitable sediments, the shallower of the two estimates of the sand/clay contact were used where the geophysical and geotechnical data sets differed. The resulting isopach of suitable surficial sediments is presented in Drawing 1.

In general, suitable sediments within the revised borrow area are characterized by a northward thickening surficial layer of clean sands and silty sands ranging from 13 feet in the south to 19 feet in the northeast corner. The average thickness of suitable material throughout the borrow area is 16.2 feet. Volume estimates have been calculated for the revised borrow area using a surface modeling package (Quicksurf v5.1). Volume estimates presented in Table 4 assume all suitable sediments identified in the areas are recoverable and do not include graded cuts from the perimeter of the borrow area inward.

Table 4

Area	Surface Area (Million Square Feet)	Volume (Million Cubic Yards)
Revised Borrow Area	21.6	12.9

5.0 SUMMARY

Current Louisiana Coastal Protection and Restoration Authority (CPRA) plans are to restore the beach and dune features along the Caminada Headland using sediment resources identified on Ship Shoal. The investigations described herein included sediment sampling tasks focused on refinement of suitable sediment resources within the revised borrow area on Ship Shoal. The acquired data sets provide a framework for defining the shallow stratigraphy and evaluating the suitability of sand resources within the revised borrow area.

Chirp subbottom profile data showed good correlation with core logs and grain size data and documented a surficial sand body underlain by clay. The subbottom data were analyzed with the geotechnical data to estimate thickness of suitable sediments based on suitability criteria set forth by CEC. The resulting isopach map illustrates the presence of a relatively thick sequence of sandy sediments (13-19 feet thick) throughout the revised borrow area generally thickening northward. A rough estimated volume of suitable sediments within the revised borrow area is 12.9 million cubic yards assuming all material mapped can be recovered. This estimate does not account for graded cuts from the edge of the borrow area inward and will thus have to be revised by CEC based on borrow area design.

APPENDIX 1

VIBRATORY CORE LOGS

Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

CORE LOG

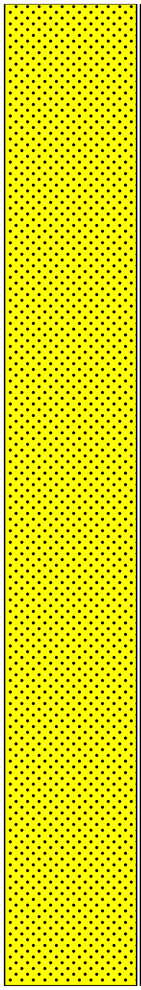
CORE NO. **CEC-12-VC-1**
COLLECTION DATE **6/19/2012**

PROJECT LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION Ship Shoal, Louisiana
CLIENT Coastal Engineering Consultants

STATION NO. CEC-12-VC-1
COORDINATES State Plane NAD 83, LA-South
UNITS US Survey Feet
NORTHING 151827
EASTING 3507051
CORE INSPECTOR Jeff Motti

CORE OPERATOR Kevin Murphy
MODEL OF CORER 1500
CORE DIAMETER 3.5"
TOTAL PENETRATION 11.5'
TOTAL RECOVERY 14.7'

PROJECT DATUM NAVD88
WATER DEPTH AT CORE LOCATION 27.8'

DEPTH BELOW SEABED	ELEVATION	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
0	-28		0.0-14.7' - Fine sand, light gray, compact, massive bedding. Shell fragments throughout core. Oyster shells at 9.0-9.3'. Oyster shell and clay nodule at 9.6'. Oyster shells at 13.5'.	VC-1 (0.0-0.4')	0.0-0.4	0
1	-29					1
2	-30			VC-1 (1.8-2.2')	1.8-2.2	2
3	-31					3
4	-32			VC-1 (3.8-4.2')	3.8-4.2	4
5	-33					5
6	-34			VC-1 (5.8-6.2')	5.8-6.2	6
7	-35					7
8	-36			VC-1 (7.8-8.2')	7.8-8.2	8
9	-37					9
10	-38			VC-1 (9.8-10.2')	9.8-10.2	10
11	-39					11
12	-40			VC-1 (11.8-12.2')	11.8-12.2	12
13	-41					13
14	-42			VC-1 (13.8-14.2')	13.8-14.2	14

Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

CORE LOG

CORE NO. **CEC-12-VC-2**

COLLECTION DATE **6/20/2012**

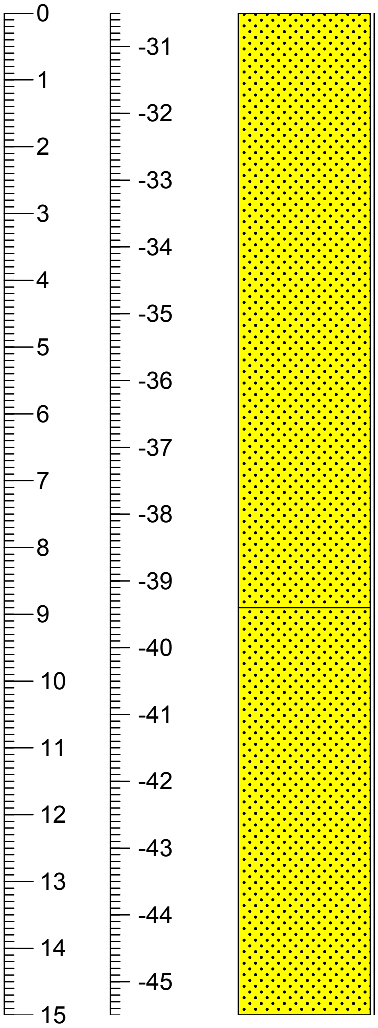
PROJECT	LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants

STATION NO.	CEC-12-VC-2
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	149398
EASTING	3507298
CORE INSPECTOR	Jeff Motti

CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	18.5'
TOTAL RECOVERY	15.0'

PROJECT DATUM	NAVD88
WATER DEPTH AT CORE LOCATION	30.5'

DEPTH BELOW SEABED	ELEVATION	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-8.9' - Fine to medium sand, gray, compact, massive bedding. Clay nodule at 4.5'. Root at 4.6'. Deformed clay layer at 7.6-7.9' and 8.9'.

8.9-15.0' - Fine sand, gray, compact, massive bedding. Shell fragments throughout. Deformed clay layer at 9.1'. Shell hash from 9.7-9.9'. Clay stringers from 12.9-13.1'.

SAMPLE ID	SAMPLE INTERVAL
VC-2 (0.0-0.4')	0.0-0.4
VC-2 (1.8-2.2')	1.8-2.2
VC-2 (3.8-4.2')	3.8-4.2
VC-2 (5.8-6.2')	5.8-6.2
VC-2 (7.8-8.2')	7.8-8.2
VC-2 (9.8-10.2')	9.8-10.2
VC-2 (11.8-12.2')	11.8-12.2
VC-2 (13.8-14.2')	13.8-14.2
VC-2 (14.6-15.0')	14.6-15.0

Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

CORE LOG

CORE NO. **CEC-12-VC-3**

COLLECTION DATE **6/19/2012**

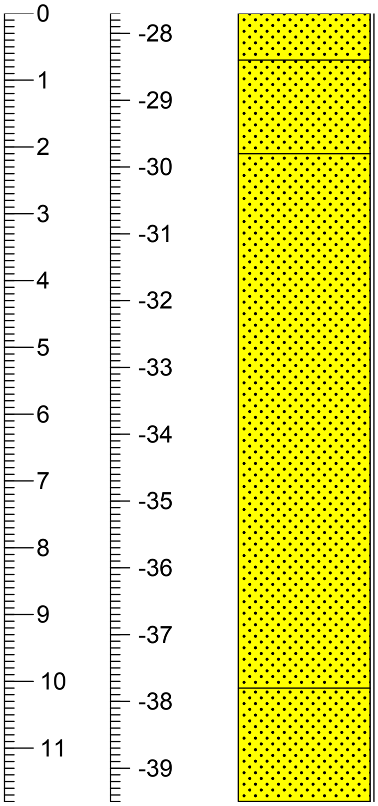
PROJECT LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION Ship Shoal, Louisiana
CLIENT Coastal Engineering Consultants

STATION NO. CEC-12-VC-3
COORDINATES State Plane NAD 83, LA-South
UNITS US Survey Feet
NORTHING 152178
EASTING 3508616
CORE INSPECTOR Jeff Motti

CORE OPERATOR Kevin Murphy
MODEL OF CORER 1500
CORE DIAMETER 3.5"
TOTAL PENETRATION 10.8'
TOTAL RECOVERY 11.8'

PROJECT DATUM NAVD88
WATER DEPTH AT CORE LOCATION 27.7'

DEPTH BELOW SEABED	ELEVATION	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-0.7' - Fine sand, medium gray, compact, massive bedding. Few clay clasts.

0.7-2.1' - Fine sand, medium dark gray, compact, massive bedding. Abundant oyster shells.

2.1-10.1' - Fine sand, medium gray, compact, massive bedding. Shell clasts throughout. Large oyster shells at 6.8' and 9.8-10.1',

10.1-11.8' - Fine sand, medium gray, compact, massive bedding.

SAMPLE ID	SAMPLE INTERVAL
VC-3 (0.0-0.4')	0.0-0.4
VC-3 (1.8-2.2')	1.8-2.2
VC-3 (3.8-4.2')	3.8-4.2
VC-3 (5.8-6.2')	5.8-6.2
VC-3 (7.8-8.2')	7.8-8.2
VC-3 (9.8-10.2')	9.8-10.2
VC-3 (11.3-11.7')	11.3-11.7

Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

CORE LOG

CORE NO. **CEC-12-VC-4**

COLLECTION DATE **6/20/2012**

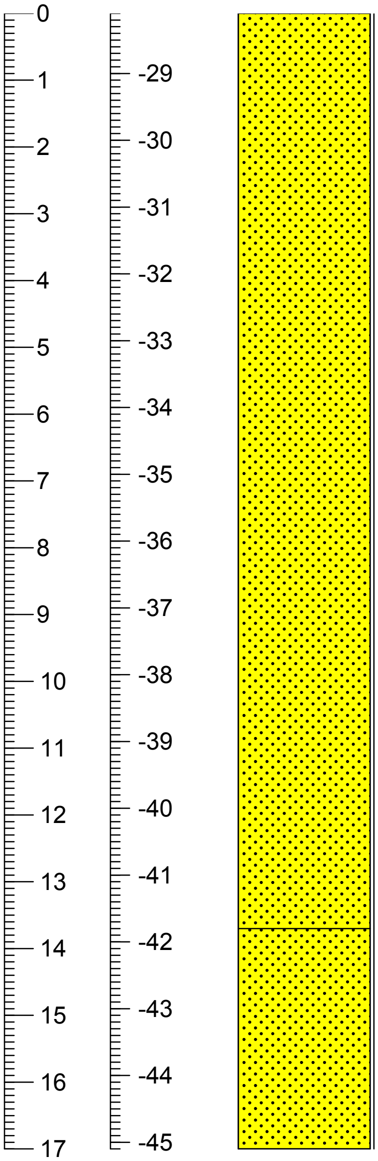
PROJECT	LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants

STATION NO.	CEC-12-VC-4
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	151397
EASTING	3508418
CORE INSPECTOR	Jeff Motti

CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	13.0'
TOTAL RECOVERY	17.0'

PROJECT DATUM	NAVD88
WATER DEPTH AT CORE LOCATION	28.1'

DEPTH BELOW SEABED	ELEVATION	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED



0.0-13.7' - Fine sand, dark gray, compact, massive bedding. Shell fragments and large oyster shells throughout. Clay lamination (0.05' thick) present at 8.2'.

13.7-17.2' - Fine sand, dark gray, highly compacted, massive bedding. Shell fragments throughout.

SAMPLE ID	SAMPLE INTERVAL
VC-4 (0.0-0.4')	0.0-0.4
VC-4 (1.8-2.2')	1.8-2.2
VC-4 (3.8-4.2')	3.8-4.2
VC-4 (5.8-6.2')	5.8-6.2
VC-4 (7.8-8.2')	7.8-8.2
VC-4 (9.8-10.2')	9.8-10.2
VC-4 (11.8-12.2')	11.8-12.2
VC-4 (13.8-14.2')	13.8-14.2
VC-4 (15.8-16.2')	15.8-16.2

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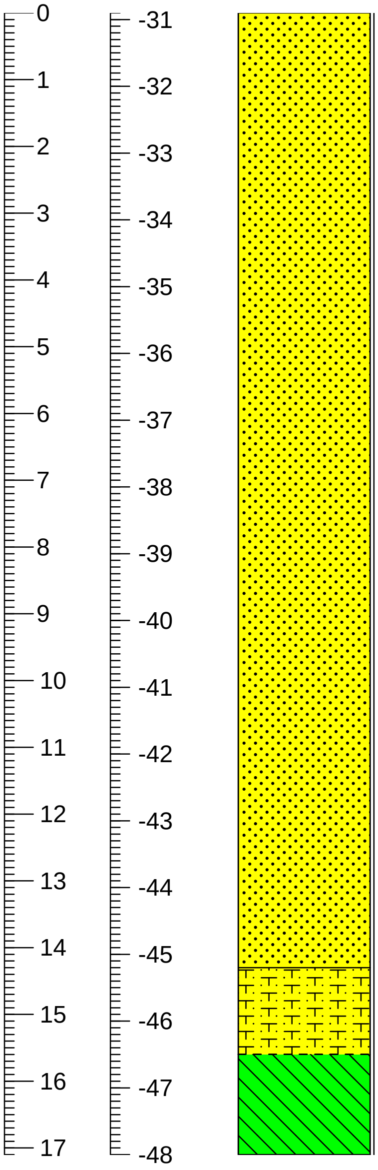
CORE LOG

CORE NO. **CEC-12-VC-5**

COLLECTION DATE **6/20/2012**

PROJECT	LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
STATION NO.	CEC-12-VC-5
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	148990
EASTING	3506933
CORE INSPECTOR	Jeff Motti
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	18.5'
TOTAL RECOVERY	17.1'
PROJECT DATUM	NAVD88
WATER DEPTH AT CORE LOCATION	30.9'

DEPTH BELOW SEABED | ELEVATION | SEDIMENT TYPE | VISUAL DESCRIPTION AND REMARKS | SAMPLE ID | SAMPLE INTERVAL | DEPTH BELOW SEABED



0.0-14.3' - Fine sand, light gray, compact, massive bedding. Shell fragments throughout. Shells at 7.5', 9.2', and 10.7'.

14.3-15.6' - Silty fine sand, light gray, compact. Shell fragments throughout.

15.6-17.1' - Clay, dark gray, firm. Shell fragmentsat 15.6'.

SAMPLE ID	SAMPLE INTERVAL
VC-5 (0.0-0.4')	0.0-0.4
VC-5 (1.8-2.2')	1.8-2.2
VC-5 (3.8-4.2')	3.8-4.2
VC-5 (5.8-6.2')	5.8-6.2
VC-5 (7.8-8.2')	7.8-8.2
VC-5 (9.8-10.2')	9.8-10.2
VC-5 (11.8-12.2')	11.8-12.2
VC-5 (13.8-14.2')	13.8-14.2

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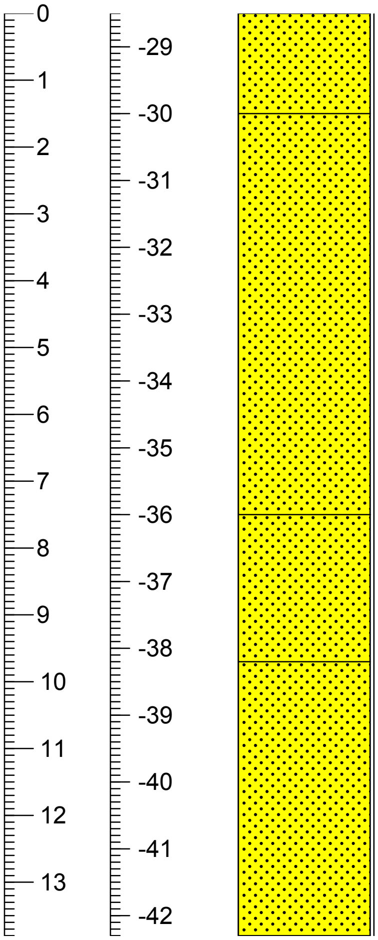
CORE LOG

CORE NO. **CEC-12-VC-6**

COLLECTION DATE **6/20/2012**

PROJECT	LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
STATION NO.	CEC-12-VC-6
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	150814
EASTING	3507253
CORE INSPECTOR	Jeff Motti
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	12.5'
TOTAL RECOVERY	13.8'
PROJECT DATUM	NAVD88
WATER DEPTH AT CORE LOCATION	28.5'



VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL
0.0-1.5' - Fine sand, medium gray, compact, massive bedding. Shell fragments throughout.	VC-6 (0.0-0.4')	0.0-0.4
1.5-7.5' - Fine sand, dark gray, compact, massive bedding. Shell fragments and large oyster shells throughout.	VC-6 (1.8-2.2')	1.8-2.2
	VC-6 (3.8-4.2')	3.8-4.2
	VC-6 (5.8-6.2')	5.8-6.2
7.5-9.7' - Fine sand, medium gray, compact, massive bedding. Shell fragments throughout. Mud drape (0.05' thick) present at 8.0'.	VC-6 (7.8-8.2')	7.8-8.2
9.7-13.8' - Fine sand, dark gray, compact, massive bedding. Large oyster shells throughout.	VC-6 (9.8-10.2')	9.8-10.2
	VC-6 (11.8-12.2')	11.8-12.2
	VC-6 (13.1-13.5')	13.1-13.5

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CORE LOG

CORE NO. **CEC-12-VC-7**

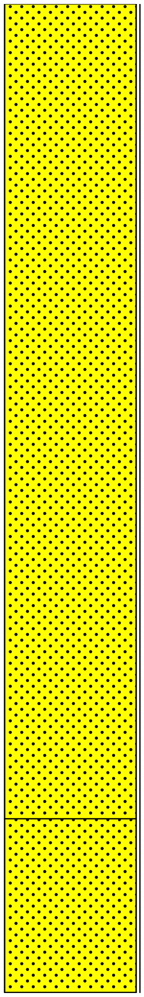
COLLECTION DATE **6/20/2012**

PROJECT LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION Ship Shoal, Louisiana
CLIENT Coastal Engineering Consultants

STATION NO. CEC-12-VC-7
COORDINATES State Plane NAD 83, LA-South
UNITS US Survey Feet
NORTHING 149659
EASTING 3506519
CORE INSPECTOR Jeff Motti

CORE OPERATOR Kevin Murphy
MODEL OF CORER 1500
CORE DIAMETER 3.5"
TOTAL PENETRATION 16.0'
TOTAL RECOVERY 14.8'

PROJECT DATUM NAVD88
WATER DEPTH AT CORE LOCATION 29.8'



DEPTH BELOW SEABED	ELEVATION	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
0	-30		0.0-12.2' - Fine sand, dark gray, compact, massive bedding. Top 0.7' less compact than rest of section. Shell fragments and large oyster shells throughout. Clay clast at 5.8'.	VC-7 (0.0-0.4')	0.0-0.4	0
1	-31					1
2	-32			VC-7 (1.8-2.2')	1.8-2.2	2
3	-33					3
4	-34			VC-7 (3.8-4.2')	3.8-4.2	4
5	-35					5
6	-36			VC-7 (5.8-6.2')	5.8-6.2	6
7	-37					7
8	-38			VC-7 (7.8-8.2')	7.8-8.2	8
9	-39					9
10	-40			VC-7 (9.8-10.2')	9.8-10.2	10
11	-41					11
12	-42		12.2-14.8' - Fine sand, dark gray, compact, massive bedding. Thin clay lamination at 12.6'.	VC-7 (11.8-12.2')	11.8-12.2	12
13	-43					13
14	-44			VC-7 (13.8-14.2')	13.8-14.2	14

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CORE LOG

CORE NO. **CEC-12-VC-8**

COLLECTION DATE **6/20/2012**

PROJECT	LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants

STATION NO.	CEC-12-VC-8
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	150295
EASTING	3509050
CORE INSPECTOR	Jeff Motti

CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	11.0'
TOTAL RECOVERY	11.9'

PROJECT DATUM	NAVD88
WATER DEPTH AT CORE LOCATION	29.9'

DEPTH BELOW SEABED	ELEVATION	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
0	-30	🟨	0.0-11.9' - Fine sand, light gray, compact, massive bedding. Shell fragments throughout. Shells at 2.3', 3.0', 5.8', and 6.1'. Clay nodule at 5.5'. Clay stringer at 6.6' and 9.5'.	VC-8 (0.0-0.4')	0.0-0.4	0
1	-31					1
2	-32			VC-8 (1.8-2.2')	1.8-2.2	2
3	-33					3
4	-34			VC-8 (3.8-4.2')	3.8-4.2	4
5	-35					5
6	-36			VC-8 (5.8-6.2')	5.8-6.2	6
7	-37					7
8	-38			VC-8 (7.8-8.2')	7.8-8.2	8
9	-39					9
10	-40			VC-8 (9.8-10.2')	9.8-10.2	10
11	-41					11

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CORE LOG

CORE NO. **CEC-12-VC-8J**

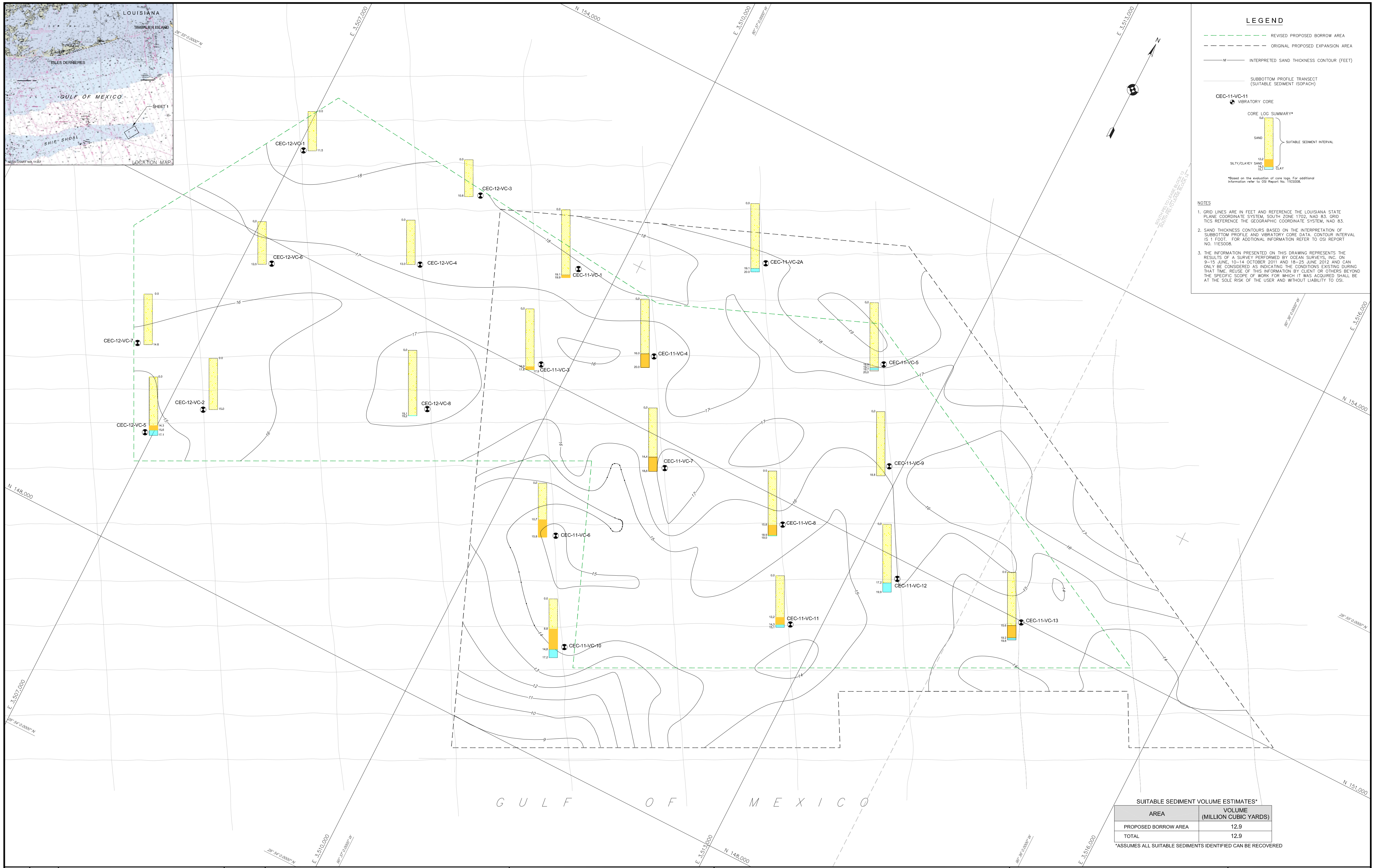
COLLECTION DATE **6/20/2012**

PROJECT	LCPRA Caminada Headland Beach and Dune Restoration Project (BA-45, Increment II)
LOCATION	Ship Shoal, Louisiana
CLIENT	Coastal Engineering Consultants
STATION NO.	CEC-12-VC-8J
COORDINATES	State Plane NAD 83, LA-South
UNITS	US Survey Feet
NORTHING	150295
EASTING	3509050
CORE INSPECTOR	Jeff Motti
CORE OPERATOR	Kevin Murphy
MODEL OF CORER	1500
CORE DIAMETER	3.5"
TOTAL PENETRATION	11.0'
TOTAL RECOVERY	10.2'
PROJECT DATUM	NAVD88
WATER DEPTH AT CORE LOCATION	29.9'

DEPTH BELOW SEABED	ELEVATION	SEDIMENT TYPE	VISUAL DESCRIPTION AND REMARKS	SAMPLE ID	SAMPLE INTERVAL	DEPTH BELOW SEABED
0	-30		0.0-9.0' - Jet			0
1	-31					1
2	-32					2
3	-33					3
4	-34					4
5	-35					5
6	-36					6
7	-37					7
8	-38					8
9	-39	▨	9.0-19.2' - Silty fine to fine sand, light gray, compact, massive bedding. Shell fragments throughout. Shells at 9.5', 13.5', 16.1'and 17.7'.			9
10	-40			VC-8J (9.8-10.2')	9.8-10.2	10
11	-41					11
12	-42			VC-8J (11.8-12.2')	11.8-12.2	12
13	-43					13
14	-44			VC-8J (13.8-14.2')	13.8-14.2	14
15	-45					15
16	-46			VC-8J (15.8-16.2')	15.8-16.2	16
17	-47					17
18	-48		Thin clay layer from 19.1-19.2'. Note - Interval too small to graphically represent in Sediment Type column.	VC-8J (17.8-18.2')	17.8-18.2	18
19	-49			VC-8J (18.8-19.1')	18.8-19.1	19

APPENDIX 2

REDUCED SCALE PROJECT DRAWING



LEGEND

REVISED PROPOSED BORROW AREA

ORIGINAL PROPOSED EXPANSION AREA

16 INTERPRETED SAND THICKNESS CONTOUR (FEET)

SUBBOTTOM PROFILE TRANSECT (SUITABLE SEDIMENT ISOPACH)

CEC-11-VC-11
VIBRATORY CORE

CORE LOG SUMMARY*

0.0
SAND
12.2
SILTY/CLAYEY SAND
14.3
15.1
CLAY
SUITABLE SEDIMENT INTERVAL

*Based on the evaluation of core logs. For additional information refer to OSI Report No. 11ES008.

NOTES

1. GRID LINES ARE IN FEET AND REFERENCE THE LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE 1702, NAD 83. GRID TICS REFERENCE THE GEOGRAPHIC COORDINATE SYSTEM, NAD 83.
2. SAND THICKNESS CONTOURS BASED ON THE INTERPRETATION OF SUBBOTTOM PROFILE AND VIBRATORY CORE DATA. CONTOUR INTERVAL IS 1 FOOT. FOR ADDTIONAL INFORMATION REFER TO OSI REPORT NO. 11ES008.
3. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 9–15 JUNE, 10–14 OCTOBER 2011 AND 18–25 JUNE 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING DURING THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

SUITABLE SEDIMENT VOLUME ESTIMATES*

AREA	VOLUME (MILLION CUBIC YARDS)
PROPOSED BORROW AREA	12.9
TOTAL	12.9

*ASSUMES ALL SUITABLE SEDIMENTS IDENTIFIED CAN BE RECOVERED

REV.	DATE	DESCRIPTION	BY

SCALE IN FEET
300 0 300 600 900
CHECK GRAPHIC SCALE BEFORE USING

SURVEY VESSEL: A.C. BROWN ELEVATOR
VIBRACORE: MODEL 1500
NAVIGATION SYSTEM: TRIMBLE 212 DGPS
SUBBOTTOM PROFILERS: GEOSTAR CHIRP 2–16 kHZ, XSTAR CHIRP 5–12 kHz
SURVEY ACQUISITION SOFTWARE: HYPACK
SURVEY PROCESSING SOFTWARE: HYPACK

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388–4631
www.oceansurveys.com

PREPARED FOR: COASTAL ENGINEERING CONSULTANTS, INC.
CAMINADA HEADLAND BEACH AND DUNE RESTORATION PROJECT (CPRA BA-45)
PROJECT MANAGER: J.D. SULLIVAN
SURVEY DATES: 9–15 JUNE & 10–14 OCTOBER 2011 & 18–25 JUNE 2012
DRAFTED BY: P.J. LACKEY
DATE: 17 AUGUST 2012
PROJECT NUMBERS: 12ES018

OFFICE OF COASTAL PROTECTION & RESTORATION
ENGINEERING BRANCH
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY:
DESIGNED BY:

BEACH AND DUNE RESTORATION
STATE PROJECT NUMBER:
FEDERAL PROJECT NUMBER:
APPROVED BY:

SUITABLE SEDIMENT ISOPACH

DATE:
DRAWING 5 - SHEET 1 OF 1