FINAL REPORT
MARINE GEOPHYSICAL INVESTIGATION FOR THE EVALUATION OF SAND RESOURCE AREAS
OFFSHORE TOPSAIL ISLAND NORTH CAROLINA
CONTRACT DACW54-02-D-0006 DELIVERY ORDER 0002

US Army Corps of Engineers
Wilmington District

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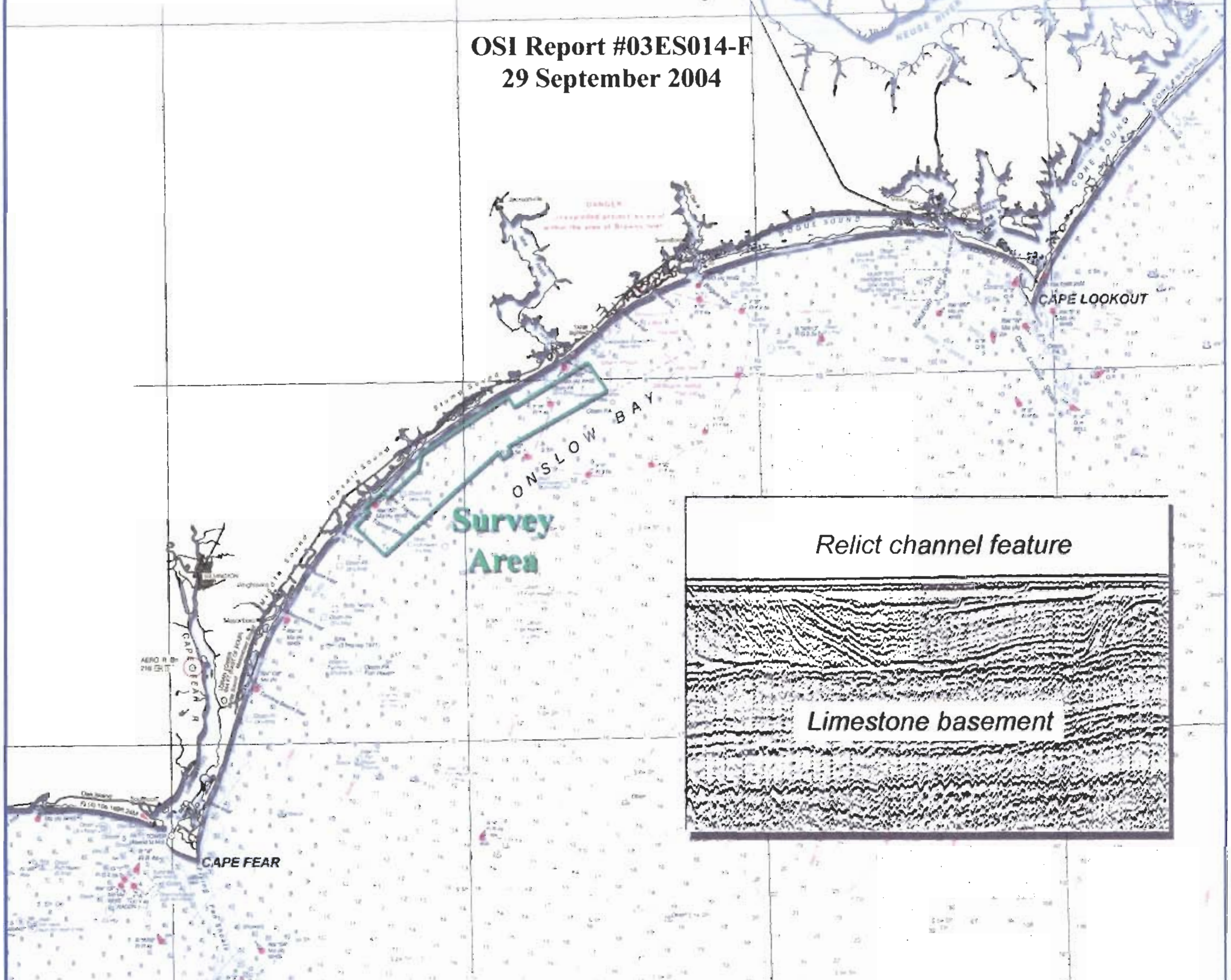
September 29, 2004

Final Report

Marine Geophysical Investigation For The Evaluation of Sand Resource Areas

Offshore Topsail Island, North Carolina
New Topsail Inlet to New River Inlet
In Oslow Bay

OSI Report #03ES014-F
29 September 2004



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1.0 INTRODUCTION

During the period 27 March to 17 April 2003, Ocean Surveys, Inc. (OSI) conducted a marine geophysical investigation to search for and evaluate potential sand resource (borrow) areas offshore Topsail Island, North Carolina (Figure 1). The area designated for investigation covers the inner continental shelf from approximately Rich Inlet to just northeast of New River Inlet, and lies seaward of the 30 foot depth contour extending 5 nautical miles (nm) offshore. Topsail Island is a barrier island that forms the coastline in the central portion of Onslow Bay and contains numerous public beaches including Topsail, Onslow, Sea Haven, and North Topsail Beaches among others. Several small towns and developments dot the island which stretches from New Topsail Inlet at the southwest end to New River Inlet at the northeast tip and occupies territory in both Pender and Onslow Counties, respectively. This work is part of the continuing effort to replenish the oceanfront of Topsail Island with sand for shoreline stabilization and the protection of property and man made structures from storms. This investigation was performed under contract with Greenhorne & O'Mara, Inc. (G&O) for the Wilmington District (WD) of the U.S. Army Corps of Engineers (USACE).

1.1 Project Background

As a barrier island is a transitory and essentially ephemeral geologic feature, man's existence in such areas frequently necessitates protection of the shoreline to allow continued habitation. Natural coastal processes cause migration of barrier islands and erosion of the shoreface, especially during extreme events. Hurricanes and winter storms (nor'easters) are responsible

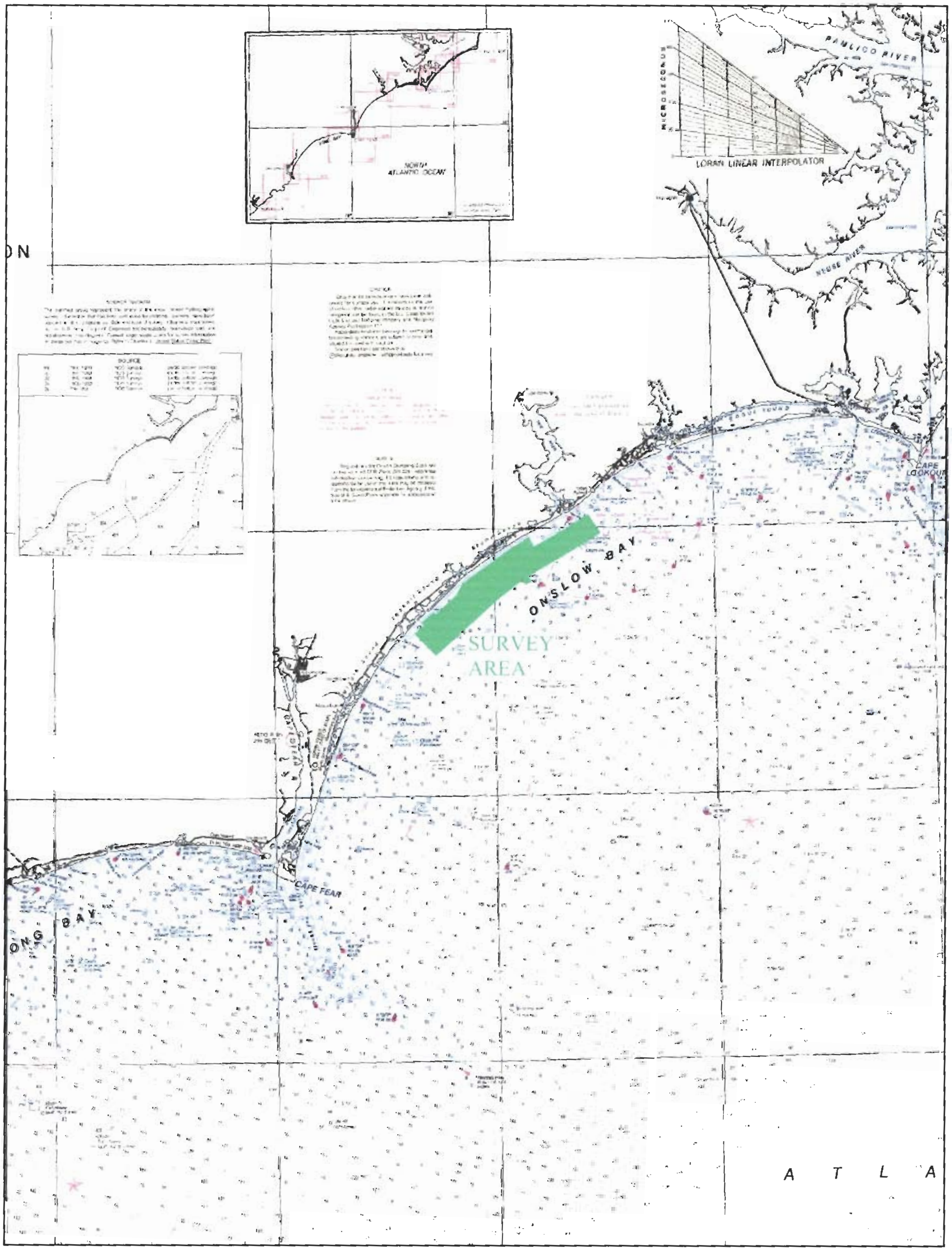

Figure 1. Location map of the Topsail Island offshore survey area.

for most storm-related damage along the North Carolina shore (Pilkey et al., 1998), which experiences a higher frequency of hurricanes than other regions of the East Coast. Six major hurricanes have impacted this stretch of coast since 1996; Bertha (July 1996), Fran (September 1996), Bonnie (August 1998), Dennis (September 1999), Floyd (September 1999), and Isabel (September 2003). Some sources suggest many of the beaches throughout Onslow Bay have never fully recovered from this onslaught of storms. The increased risk associated with living in an occasionally volatile and rapidly changing environment equates to more time and money required to preserve these coastal areas for man's habitation and recreational use. Additionally, stabilization of the shoreline, inlets, and navigable waterways is necessary to allow unrestricted marine transportation in support of commerce and trade.

The USACE is tasked with providing protection for these coastal areas. Each region of the coast has different physical parameters shaping the shoreline, as well as economic factors, that are carefully examined to determine the most suitable methods by which effective shoreline protection and stabilization can be achieved. Dredging of sand from the lower shoreface and inner continental shelf with subsequent placement on the beach is a very common practice along the eastern seaboard. It is not typically recognized as a permanent fix to the problem, rather it is a method of shoreline protection maintenance requiring periodic beach supplements, the frequency of which depends on the amount of erosion in each area.

In the case of Topsail Island, back bay sand resources in Topsail Sound were identified and evaluated during early studies (USACE, 1989). However, the environmental implications involved in the dredging and use of these areas were believed to be a severe limitation to their potential as primary sand sources (USACE, 1989; HDR Engineering, 2002). The project thus shifted offshore in search of suitable sand resources. Studies were conducted in August 2002 and March 2003 by HDR Engineering, Inc. (HDR) off Topsail Beach and North Topsail Beach, respectively, to map and classify seafloor composition within the same area covered by this investigation. These surveys collected physical samples of the bottom and visual records of distinctive habitats to provide glimpses of the lower shoreface geology in this portion of

Onslow Bay. A general picture of the surficial and nearsurface geology (upper 20 ft) in the Bay emerged to suggest areas where thicker sediments could be further explored.

The recent studies performed by HDR (2002 and 2003) consisted primarily of geotechnical investigations (diver probes, cores, samples, video), fathometer/depth profiles, and side scan sonar imagery (acoustic photographs of the seafloor). Limited seismic reflection profiling of the subsurface had been completed in the Bay prior to this investigation (Meisburger, 1977; Meisburger, 1979; McQuarrie, 1998), and those data were generally used to obtain an overview of the geological framework in Onslow Bay. As a result, emphasis for this study was placed on detailed subsurface exploration to delineate sand thickness as well as areal extent. Under suitable geologic site conditions, ones which allow the penetration of acoustic signals, a geophysical survey is the most cost effective and efficient method to map subbottom stratigraphy, particularly over expansive areas of the ocean floor. When combined with sediment cores to ground truth the seismic reflection data, stratigraphic units may be characterized and mapped.

1.2 Project Objectives

The primary objectives of this investigation were (1) to determine water depths and general bottom morphology, (2) map the areal extent and thickness of unconsolidated sediments (primarily sand suitable for beach nourishment), and (3) delineate the extent of bedrock units on and below the seafloor. The project depth of interest was defined as –70 ft MLLW. Maps of potential sand resource areas generated from interpretation of these data will be used by the WD to estimate the quantity and quality of suitable materials available for beach nourishment. The data will also be used during environmental evaluations of the site in regard to a potential sand borrow area's proximity to possibly sensitive benthic communities on rock outcrops, locally referred to as "hardbottom" areas. Results from this investigation will further refine the potential offshore resource areas and allow the design of the next, more detailed mapping phase of sand resource areas exhibiting the highest potential for economic mining.

1.3 Project Tasks

In order to accomplish the objectives outlined above, the following survey tasks were completed by OSI:

- **Hydrographic survey** to determine water depths and general seafloor morphology; high frequency (200 kHz) survey grade depth sounder used to measure depths that were subsequently adjusted for tidal variations, to Mean Lower Low Water datum.
- **Subbottom profiling** to map the areal extent and thickness of unconsolidated sediments and location of hardbottoms; two different seismic reflection systems were utilized (both 0.5-12 kHz) to provide unique, high resolution subsurface profiles of the marine stratigraphy.

Following completion of the marine geophysical investigation, a geotechnical program involving the acquisition of vibratory core samples throughout the Topsail Island offshore area was conducted by the WD during the summer of 2003. Sediment samples were obtained at each core station, most of which were positioned on survey tracklines and at key locations to maximize their ground truthing contribution to the geophysical interpretation. Results from this coring program were correlated with the seismic reflection profiles to develop the potential suitable sand resource maps delivered with this report.

2.0 REGIONAL GEOLOGY

Onslow Bay is a modern coastal embayment bordered by Cape Lookout to the north and by Cape Fear to the south. This embayment is underlain by sedimentary rock units that range in age from Upper Cretaceous through the Holocene and are associated with the Carolina Platform, a major tectonic component of the trailing-edge continental margin of North America. Regional subsidence of this major structural ramp of pre-Jurassic crust controlled lateral progradation of the coastal margin. Seaward progradation of the continental shelf occurred primarily during the Tertiary via a succession of onlap and downlap accretional sequences at the shelf edge (Snyder et al., 1982). The present day shelf geomorphology was produced by subsequent beveling and shoreface truncation during Neogene and Quaternary erosional trangressions (Snyder et al., 1982; Popenoe, 1985).

The continental shelf in Onslow Bay consists of relatively complex sequences of Tertiary strata which crop out on the seafloor and dip gently seaward. These units are dissected by relict fluvial channels and partially covered by a patchy veneer of Quaternary sands and gravels (Snyder et al., 1988). Late Neogene to Quaternary erosional remnants of indurated carbonates and calcareous sandstones and siltstones ("hardbottoms") occur locally in the Onslow embayment (Riggs et al., 1985).

The oldest Tertiary rocks cropping out in Onslow Bay are of Oligocene age (Figure 2). They are composed of two basic limestone units, the Belgrade and the Trent Formations, which consist of moldic, biomicrorudite limestones with interbedded calcarenite sands and grayish-green calcareous quartz sands (Riggs et al., 1985). Another stratigraphic unit of similar age, the River Bend Formation, primarily an olive green quartz-based fine sand and silt deposit (often dolomitic), also underlies areas offshore Topsail Island. Beyond the northeast end of the survey area off Bogue Inlet, a major unconformity separates these rocks from the overlying Miocene Pungo River Formation which consists of interbedded phosphate sands, variably phosphatic silts and clays, diatomaceous clays, limestones, and dolomite (Snyder et al., 1988). The Pungo River Formation is then unconformably overlain by patches of Pliocene and Quaternary sediments. The only Pliocene depositional record preserved on the inner-to-middle continental shelf of North Carolina is limited to a few calcarenite caprocks which have become the seed for modern hardbottom environments.

Due to the severity of the Quaternary erosional trangressions, the shelf stratigraphic record of multiple glacioeustatic sea-level fluctuations is almost totally restricted to paleofluvial channel-fill sequences. These channels can be traced many miles with subsurface depths of up to 80 ft and widths up to 6 miles reported (Hine and Snyder, 1985). The channels located

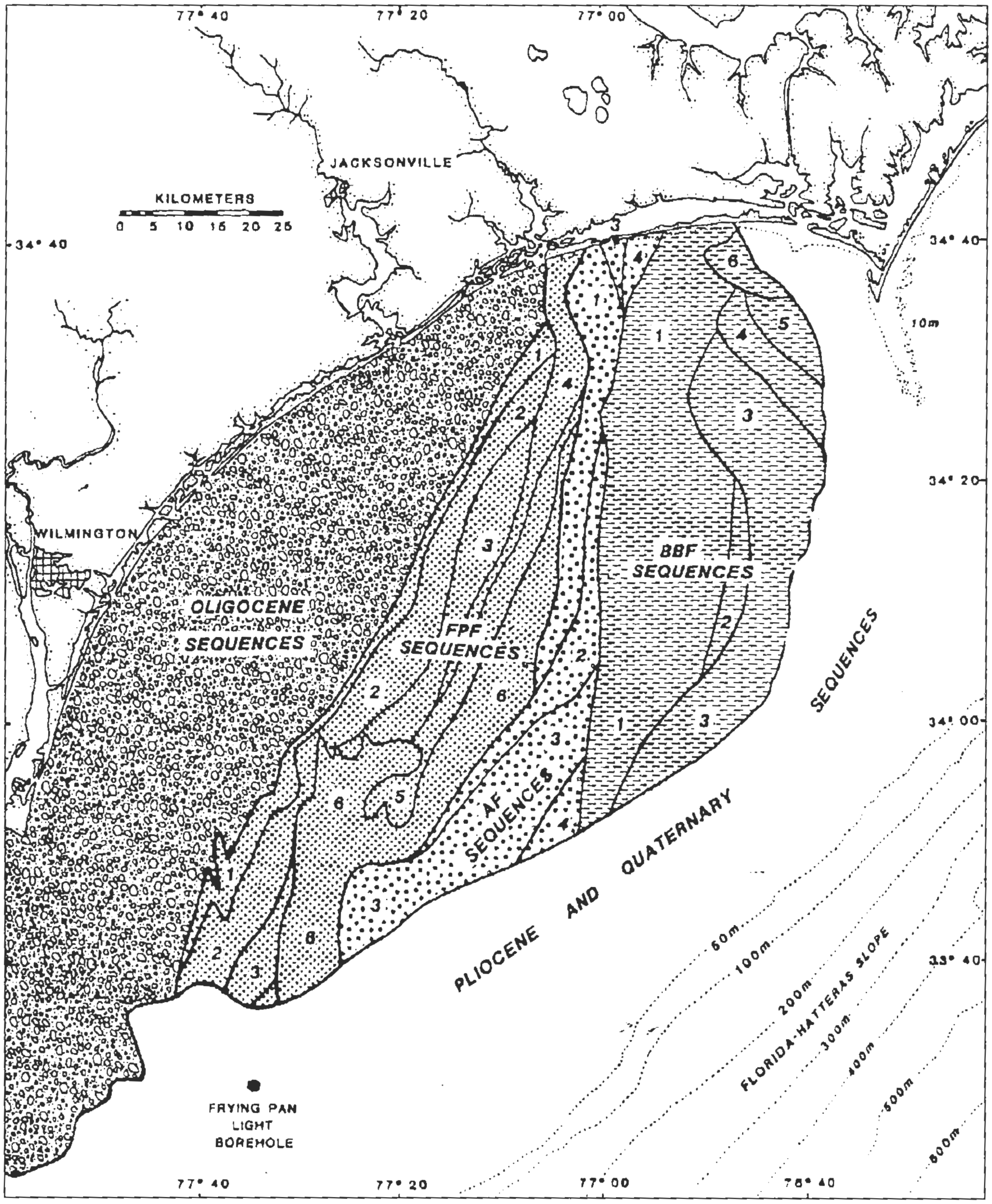

Figure 2. Geologic map of Onslow Bay showing the complex outcrop distribution of the Oligocene and Miocene rocks. Depositional sequences FPF (Frying Pan Fm.), AF (Aurora Fm.), and BBF (Bogue Banks Fm.) belong to the Miocene Pungo River Formation (modified from Riggs et al., 1985).

on the inner shelf of Onslow Bay are mainly lower coastal plain streams that were infilled with estuarine and shelf fossiliferous muds and fluvial sands. Dates obtained from analyzing vibracore samples taken from these channels suggest that most of the infilling was completed during the mid-Pleistocene transgressive flooding event (Belknap, 1982; Hine and Snyder, 1985).

Surficial Holocene sedimentary deposits in Onslow Bay are scarce. No significant sediment input via river discharge exists in the Onslow embayment north of Cape Fear. Consequently, the embayment is generally viewed as sediment-starved, with most Quaternary surficial sediments eroded and reworked from the upper layers of existing submarine lithologies by bio-erosion, diagenesis, and open ocean wave and current forces. The result is a thin, patchy veneer of modern sands covering the low relief Oligocene limestone and siltstone hardbottoms and numerous Quaternary channel-fill sequences (HDR, 2002, HDR, 2003, Meisburger, 1979, McQuarrie, 1998).

3.0 SURVEY AREA AND CONTROL INFORMATION

3.1 Survey Area and Tracklines

The area of interest covers approximately 85 square nm offshore of Topsail Island from as close as 0.5 nm to over 5 nm from the coastline (see Figure 1). The site stretches nearly 23 nm generally from Rich Inlet northeast past New River Inlet, varying in width from 2.5-4.5 nm. Survey limits were designed to encompass prospective sand resource areas identified within the two areas previously investigated (HDR, 2002; HDR, 2003) and extend farther offshore where it was believed rock may be deeper below the seafloor. The 30 foot depth contour was intended as the nearshore survey limit.

A total of approximately 315 nautical trackline miles were surveyed along 60 lines in the area offshore Topsail Island (Figure 3). Line spacing varied from 1500-6000 ft, offering a reconnaissance level view of the site. Approximately 22 lines were oriented parallel to shore while 38 were laid out generally perpendicular to the coast. Data acquisition along some tracklines was extended to obtain additional information on subsurface conditions in promising areas. All equipment systems were operated simultaneously along each trackline.

3.2 Horizontal and Vertical Control

Horizontal control for the project was established by using a survey grade Trimble 4000 global positioning system (GPS) interfaced with a Leica MX52R Coast Guard differential beacon receiver to deliver geodetic position data at 1 second intervals to a stated accuracy of better than 3 ft. The geodetic positions output by the DGPS were converted in real time to the local state plane coordinate system by the data logging computer running HYPACK navigation software. The horizontal datum used for the project is the North Carolina State Plane Coordinate System, Zone 3200, referenced to NAD 83 in feet.

To verify DGPS accuracy, a navigation check was performed on a known control point prior to commencement of the survey. Coordinates for red marker No. 24 in Motts Channel along the Intracoastal Waterway (ICWW) in Wrightsville Beach were provided by the WD for use on the project. Subsequent navigation checks were conducted at the beginning and end of each day at the Motts Channel Seafood dock where the survey vessel was tied up (see coordinates for horizontal points below). Position accuracies of less than 3 ft were observed over the course of the field work using the New Bern, North Carolina Coast Guard beacon (294 kHz transmission frequency @ 100 bps) which provided good reliability and signal strength for the duration of the project.

Control Point	Easting (ft)	Northing (ft)	Description
Red Marker No. 24	2358605	171219	Center of pile supporting red marker no. 24 on the east side of Motts Channel off the ICWW in Wrightsville Beach

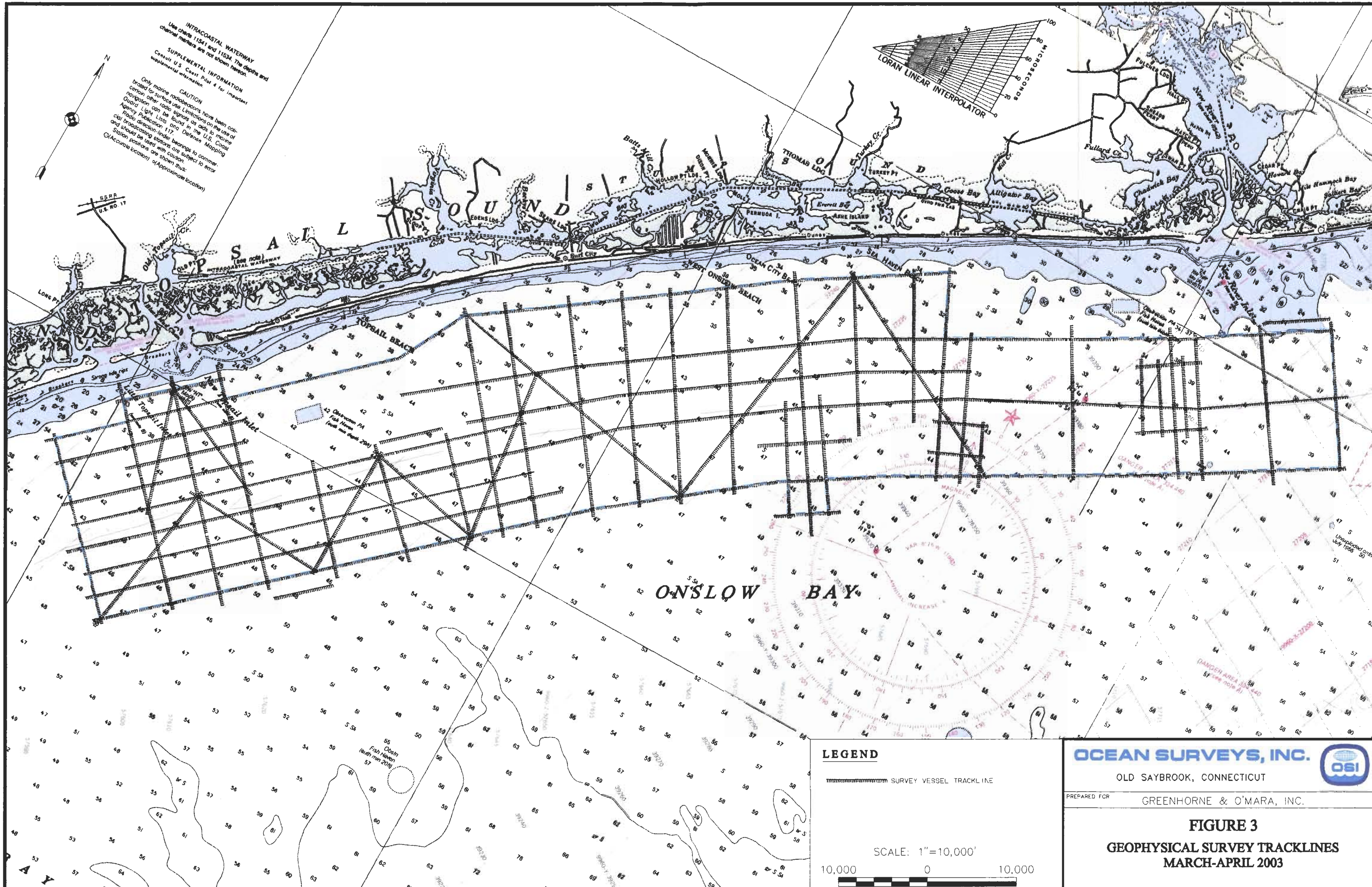

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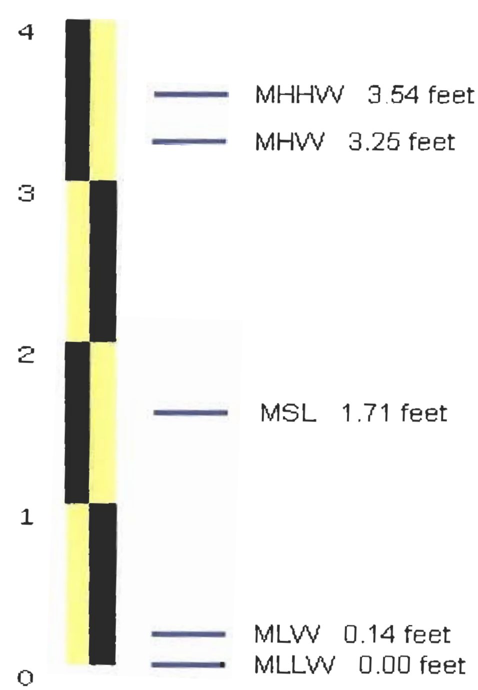
FIGURE 3
GEOPHYSICAL SURVEY TRACKLINES
MARCH-APRIL 2003

OSI FILE NO. 03ES014
23 SEPTEMBER 2004

Control Point	Easting (ft)	Northing (ft)	Description
Seafood dock	2359150	171439	Coordinates of GPS antenna with survey vessel tied up at dock; adjacent to center pile on south side of the boat lift

Vertical reference for the project is in feet and is the mean lower low water (MLLW) datum. Predicted tide data for the New River and New Topsail Inlets, bracketing the survey area, were adjusted for local meteorological events using in situ water level data from the NOAA station in Beaufort, North Carolina. Significant wind events did occur during the survey period which caused coastal setup (water pushed up against the shore). Comparisons of the Beaufort tide station data with predicted tidal curves for New Topsail and New River Inlets (based on Hampton Roads, VA) were performed to verify the accuracy of the vertical reference prior to the adjustment. The adjusted tide data closest to each depth sounding point (New Topsail versus New River Inlet) were then used to reference the water depth measurements to the MLLW datum.



The diagram above shows the relationship of vertical datums for the project site, obtained both regionally from the NOAA web site (www.co-ops.nos.noaa.gov /benchmarks) and for specific Beaufort benchmarks at the NGS web site (www.ngs.noaa.gov/cgi-bins/ngs_opsd.prl).

4.0 FIELD OPERATIONS SUMMARY

4.1 Survey Equipment and Crew

Survey operations were conducted from the R/V West Cove, a 42 foot Duffy with 14 foot beam featuring twin Caterpillar 350 HP diesel engines, hydraulic winches and an A frame for handling towed sensors, and a large cabin for housing the survey electronics (Figure 4). A full suite of standard navigation equipment (radars, VHF radios, GPS plotters, etc.) mounted on this sturdy frame provides a safe, reliable working platform even under difficult sea conditions. The West Cove is especially suited for nearshore day excursions with ample range (two 250 gallon fuel tanks) and a cruising speed of 20 knots.

A summary of the primary equipment used to complete the investigation and its function is presented in the following table. Figure 4 illustrates the equipment configuration aboard the R/V West Cove. Refer to Appendix C for additional information regarding equipment operations and procedures for data acquisition. Equipment specification sheets are included in Appendix D.

Equipment	Equipment Function
Trimble 4000 Global Positioning System (GPS) and Leica MX52R USCG Differential Beacon Receiver interfaced with HYPACK software	Satellite positioning system which tracks up to eight satellites at a time, and applies position correction factors relayed to it via radio link from the nearest DGPS Coast Guard Beacon to provide reliable, precision (+/- 3 feet) positioning. The system outputs position fixes at a rate of 1 per second to an onboard navigation and data-logging computer which allows the survey vessel helmsman to accurately navigate the vessel along pre-selected survey tracklines.

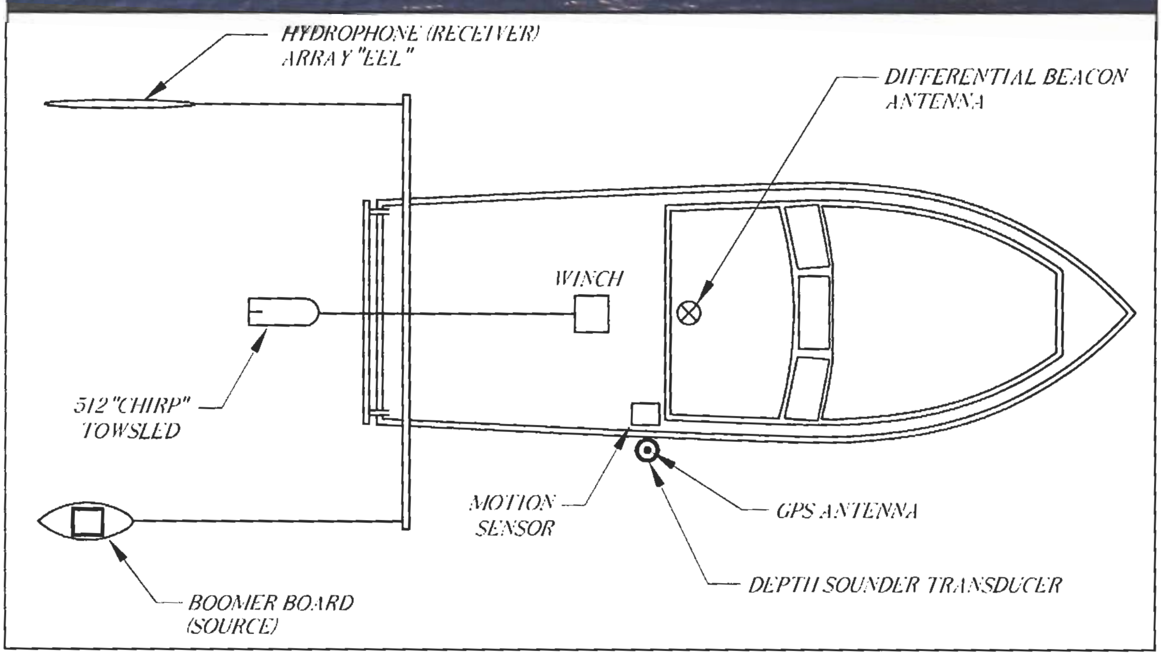


Figure 4. Survey vessel photograph and geophysical equipment configuration.

Equipment	Equipment Function
Innerspace Model 448 Digital Depth Sounder	Microprocessor controlled, high resolution, survey-grade depth sounder that operates at a frequency of 200 kHz, providing precise water depth measurements.
TSS DMS-05 Motion Sensor	Sensor measures heave, pitch, and roll of survey vessel for removal of boat motion from the depth sounding data. Particularly integral component for open ocean surveys where sea swell and waves are present. Measurements can be used to remove boat motion from sounding and subbottom data.
KVH AutoComp 1000 Flux Gate Compass	Magnetic compass interfaced to the motion sensor and vessel navigation which provides accurate heading information to all systems at a rate of 10 times per second. Increased position accuracy of remote sensors is achieved by recording frequent boat heading changes.
EdgeTech X-Star "Chirp" Subbottom Profiling System	Seismic reflection profiler that generates an intense, short duration acoustic pulse in the water column in the range of 0.5-12 kHz. The combination of low and moderate acoustic frequencies used by this system are intended to achieve both deep penetration below the seafloor and increased resolution of layers in the nearsurface, respectively. Advanced signal processing incorporated in the "chirp" system increases the signal to noise ratio of the acoustic pulse.
Applied Acoustics Engineering, Inc. "Boomer" Seismic Reflection System	Seismic reflection profiler that uses an intense, low frequency acoustic pulse in the water column in the range of 0.5-10 kHz. The low to moderate acoustic frequencies are designed primarily for deeper penetration, with reasonable resolution, to investigate stratigraphic units at greater depths below the bottom.

Hydrographic and subbottom profiling systems were run simultaneously along each survey trackline, with the depth transducer rigidly mounted and "chirp" sled towed off the stern of the vessel. The "boomer" sound source and hydrophone array (receiver) were surface towed off the stern using a boom to separate the devices and maintain their position outside the propeller wash and boat wake to minimize background noise. Both subbottom systems were operated at frequencies ranging from 0.5-12 kHz. Since the "boomer" system was the limiting factor that controlled survey speed and direction, survey start position each day was determined by the existing wave field to provide the best overall data quality. When necessary, equipment sensors were pulled in and placed on deck so the survey vessel could transit at high speed to the next line in order to run in the preferred direction.

A geophysical survey crew with over 25 years of combined field experience was assembled to perform this investigation (listed below). This field knowledge, in addition to spare survey equipment mobilized to the job site, allowed for continuous, highly efficient survey operations.

Geophysical Survey Crew:

Jeffrey D. Gardner	Geophysical & Oceanographic Project Manager
G. Mathew Slusher	Geophysical Technician
G. Tige Main, Jr.	Vessel Captain, Survey Technician

4.2 Chronology of Field Operations

Difficult weather conditions persisted from the start of the field work until 10 April 2003, when sea conditions were consistently over 3 ft. Most surveying was accomplished in the morning since by 1100-1200 hrs the wind and seas had increased to a point where the data quality was severely reduced. The bad weather pattern broke on the evening of 10 April and calm conditions settled over the area for the remainder of the field work. This allowed for a better production rate each day and an overall improvement in data quality.

The following table lists the general chronology of events during the field program:

Task	Dates	Description
Vessel mobilization	18-21 March	Load navigation and geophysical survey equipment in Connecticut and test all systems
Transit to NC	22-26 March	Survey vessel and crew transit via sea and land to Wrightsville Beach, North Carolina
On site operations	27 March to 17 April	Geophysical survey of site offshore Topsail Island; collected ~315 line miles of seismic profiles
On site demobilization	18 April	Offload some equipment
Transit to CT	19-22 April	Survey vessel and crew return to OSI headquarters

4.3 Geotechnical Program

A total of 369 vibratory core stations were occupied by the WD during the summer of 2003, most throughout the Topsail Island offshore survey area (Figure 5). Additional cores were collected in nearshore areas of interest beyond the limits of this seismic investigation. At some stations (ie. VV-11, VV-83, etc.), more than one core attempt was made due to limited penetration and/or recovery on initial efforts, which resulted in a total of 412 vibratory core logs. The core barrel and liner were vibrated into the seabed until refusal was reached (generally defined as limited or no penetration over a certain time period), extending 1-20 feet below the bottom. Grain size analysis (sieving) was then performed on subsamples taken from selected layers to obtain specific information on sediment classification. For further information refer to the WD's analysis and final report. Core samples were obtained from potential sand resource areas identified from the preliminary data review, as well as outlying regions of the site to document nearsurface geologic conditions. Geotechnical data gathered from these cores were used to ground truth the seismic reflection profiles and identify sediment types.

After results of the grain size analyses were received by the WD, detailed spreadsheets were developed to examine critical components of the samples, including sand, silt, and shell content. Sand suitability guidelines developed by the WD in conjunction with other local agencies allowed the sand layers in each core to be appropriately designated. Core logs were provided to OSI in April 2004 and a summary of the suitable sand present (or absent) in each core was delivered to OSI in June 2004 for correlation with the seismic profile data. Comparison of all the geotechnical data provided by the WD (core logs, coordinates, grain size analysis results, suitable sand thickness values) took place over June and July 2004. A final tabulation of suitable sand thickness values was completed in August 2004 (table in Appendix B) with 360 undisputed core sample results. A number of discrepancies remained with 52 cores, however, some assumptions were made by OSI to include 23 of these, while

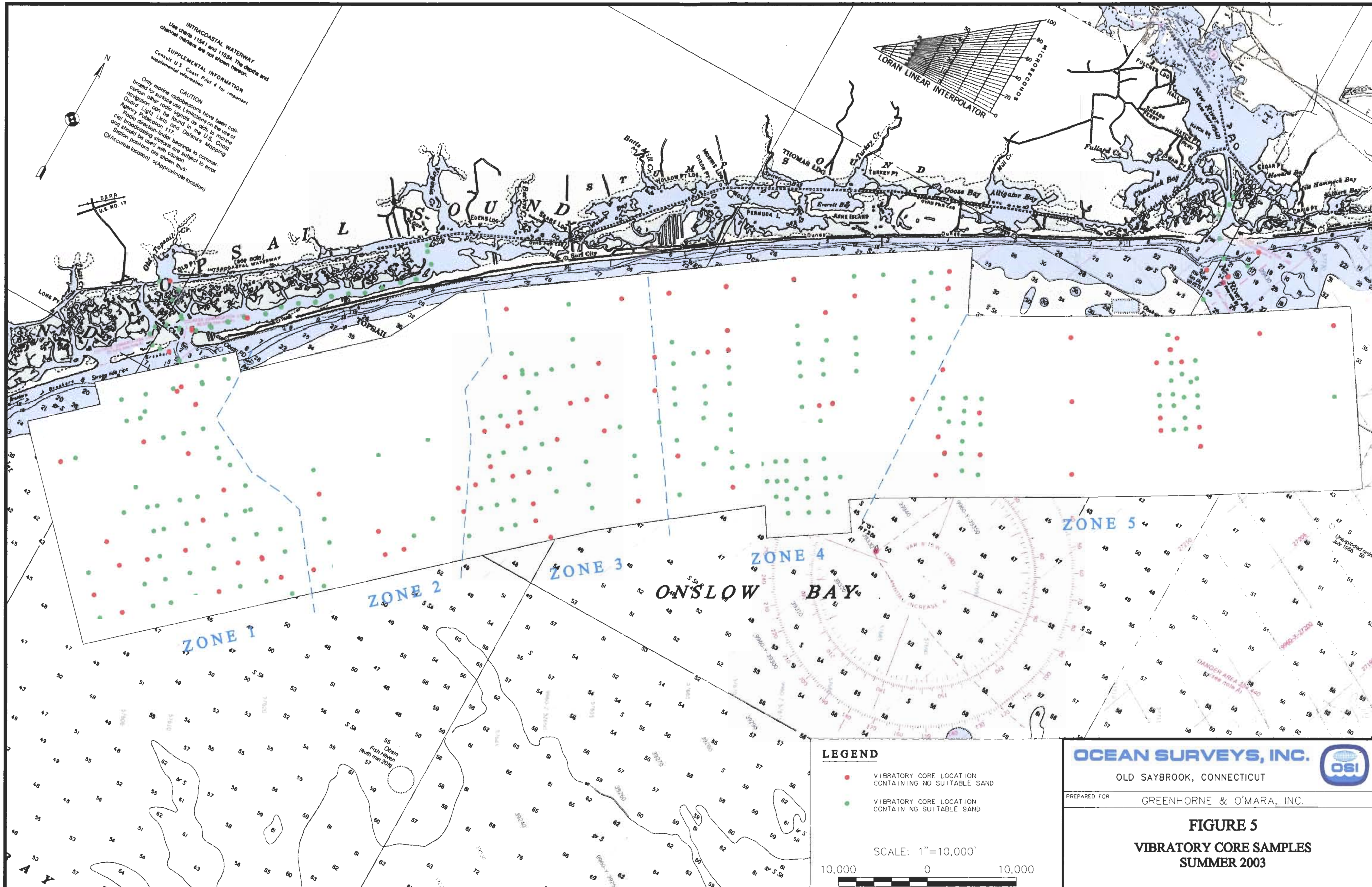


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FIGURE 5
VIBRATORY CORE SAMPLES
SUMMER 2003

OSI FILE NO. 03ES014
23 SEPTEMBER 2004

the balance of 29 unresolved core samples were not used to generate the suitability contour map.

5.0 DATA PROCESSING AND DELIVERABLES

Prior to completion of the field investigation, raw vessel navigation data were plotted for review of survey coverage in the field. There were no lengthy periods of bad GPS position data, however, there were some line sections where seismic data quality was reduced due to deteriorating sea conditions. Most of these areas were resurveyed during calmer weather conditions to obtain better subbottom records. A swell filter was used on the seismic data when possible to eliminate the effects of the waves without compromising data quality, and the motion sensor recorded vessel movement that was later removed from the hydrographic data.

Upon return to OSI headquarters in Connecticut, navigation and hydrographic data were processed using HYPACK software and subsequently exported to AutoCad for plotting. Depth data were checked for erroneous points (depth lock ups on water column noise, fish, etc.), adjusted for boat motion using the heave sensor data, and finally referenced to the MLLW datum using predicted tide data corrected for local meteorological events. Water depth contours were then generated from this data set using a 2 foot contour interval (see Drawing #2, Sheets 1-2). It is important to remember the wide trackline spacing when considering depths between lines. Contours were computer generated using QuickSurf Version 5.2 digital terrain modeling software, applying a tin-grid method.

Additional processing was necessary to filter the "chirp" subbottom data, as the "boomer" system operated within the same frequency spectrum during data acquisition, causing significant "cross talk" between the two systems (both systems generally operate over the frequency range of 0.5-12 kHz). Once the influence of the "boomer" signals was removed from the "chirp" data, the "chirp" profiles were interpreted and correlated to geotechnical information to relate acoustic reflectors and the seismic stratigraphy to contacts between different lithologic units. Details of the processing performed on the "chirp" subbottom profiles is included in Appendix C. The raw "boomer" profiles (hard copy) were of sufficient quality to allow interpretation and provided valuable input for this mapping, even though the scope of work did not require analysis of these reflection data.

Since it is not possible to map the "suitable sand" unit using the seismic reflection data alone (minor changes in the percentages of silt and shell do not produce enough impedance variation to be detected by the subbottom profiler), the "chirp" profiles were used primarily to define the boundaries of the surficial sand unit and its thickness, where possible. Thus the core samples and results from the grain size analyses became the primary mapping tools with the seismic profiles available for modifying area limits. Suitable sand thickness values were intentionally contoured by hand to incorporate all the surficial geologic information available to the project, as discussed in the Section 6.1 below.

The seismic reflection data were also used to map the location and depth of prominent paleochannels (P1-P12) transecting the survey area and, in conjunction with the WD vibracore results as well as core stations and diver bottom inspections from previous studies, were used to delineate the limits of hardbottom areas on the seafloor. Large areas of shallow bedrock have been outlined (see Drawing #2 and #3). However, due to the wide survey line spacing and noticeably patchy distribution of sediments and rock on the seafloor throughout much of the site, small isolated exposures of hardbottom could not be reasonably defined. A veneer of surficial sediment covers the rock in most places (less than 3-6 ft thick), interspersed with hardbottom outcrops.

The historical geology of the region offshore Topsail Island has been fairly well documented in previous studies (see references), thus discussions below focus on specific sediment classification of importance to this project. Refer to the drawings presented in Appendix A, as summarized in the table below, while reviewing these sections. The discussion has been organized into portions of the survey area exhibiting different bottom and subbottom characteristics identified previously and shown in Figure 6 (Zones 1-5). The zones cover the survey area from southwest to northeast and refer to prominent features or places along the coastline. All water depths are referenced to MLLW and sediment thickness values are measured below the seafloor, unless otherwise noted.

Drawings Delivered (in Appendix A):

Drawing No.	# Sheets	Scale	Title / Description
1	1	10,000 ft per inch	Site map with tracklines, notes, and legends
2	2	5,000 ft per inch	Hydrographic contours and general geologic features
3	2	5,000 ft per inch	Suitable sand thickness contours with core sample locations

6.0 SURVEY RESULTS

6.1 Hydrographic Data

Depth data collected in the survey area have been contoured to show the general seafloor topography offshore Topsail Island. Water depths ranging from 28-52 ft were recorded in the survey area over a relatively gentle offshore slope. Throughout a majority of the site, the depth sounding records indicate a rough bottom surface typical of coarse material (cobbles, boulders), rock, and/or bedforms.

Individual profiles reveal some detail on bottom characteristics along the tracklines, but due to the reconnaissance nature of this survey these small scale features cannot be accurately mapped between lines. Many scarp features were observed throughout the site exhibiting depth differences typically of 2-5 ft. These scarps approach vertical and mark locations where

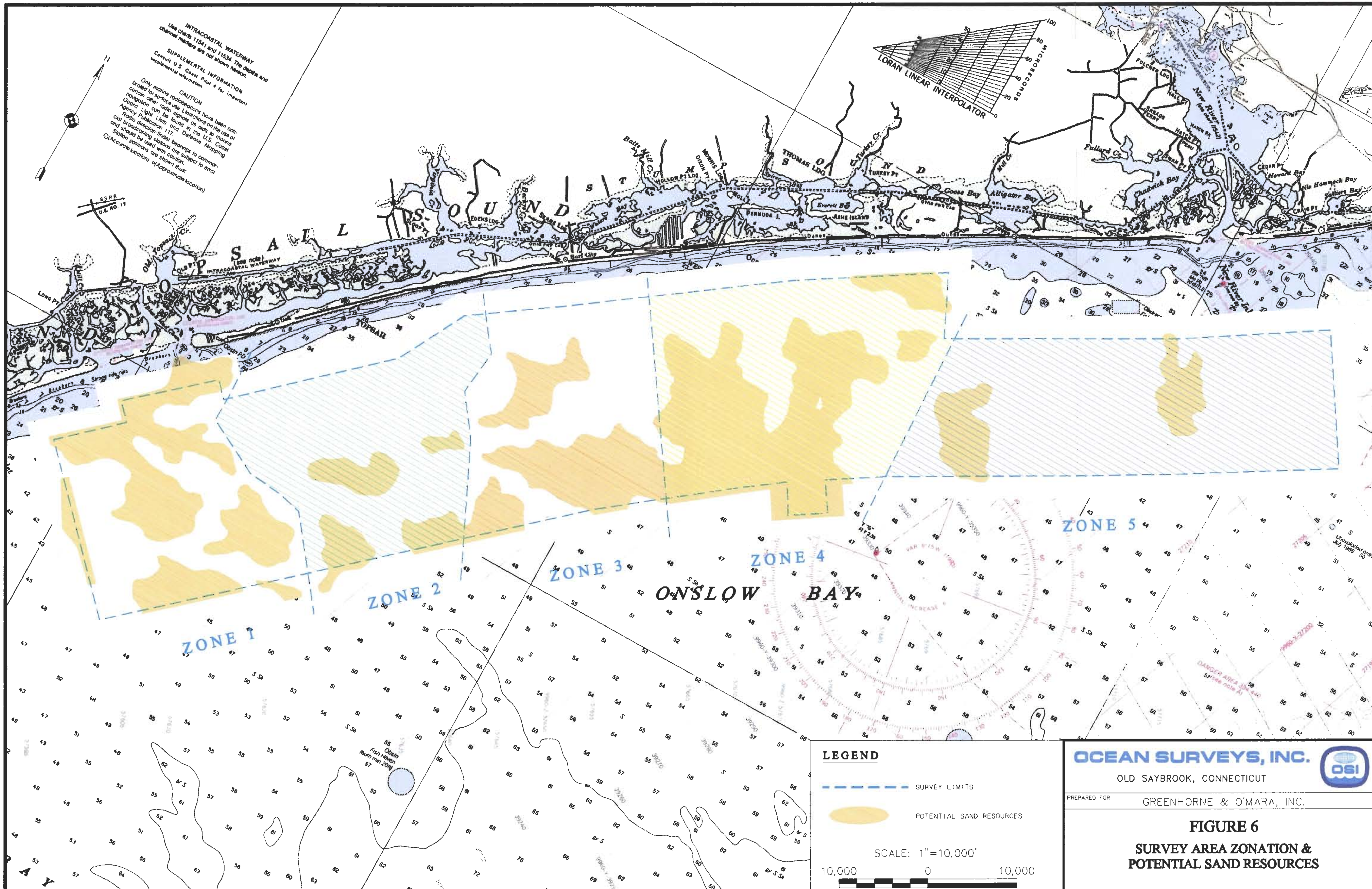

FIGURE 6

SURVEY AREA ZONATION & POTENTIAL SAND RESOURCES

OSI FILE NO. 03ES014
23 SEPTEMBER 2004

the underlying limestone rock unit protrudes above the seafloor at a very low angle of dip. These features are most common in the east end of the survey area in Zone 5 and around the bedrock high present in Zone 2. Larger scarps with relief of 6-12 ft were identified in Zone 5 offshore of New River Inlet.

6.2 Sand Suitability Designation

The sand suitability maps generated for this project were developed from the WD's criteria for suitable sand and the resulting thickness established in each core sample. The final values were established in August 2004 and then correlated with the seismic profiles to (1) determine if any correlation existed between suitable or surficial sand and acoustic reflectors and (2) to modify surficial sand boundaries based on underlying reflectors representative of different lithologies (ie. silt-clay sequences or bedrock). A detailed listing of the cores and suitable sand values used for this mapping are included in the geotechnical table in Appendix B.

The WD's criteria used for this mapping include:

- surficial sand only (generally SP or SP-SM classification on core logs)
- no overlying unsuitable material of any thickness allowed
- no internal layers of unsuitable material of any thickness allowed
- suitable sand defined by grain size analyses as 90% of material >#200 sieve (location designated unsuitable if >10% silt present, based on grain size spreadsheet)
- no restrictions on the percentages of coarse material or shell
- no minimum thickness restriction (cores with any thickness of suitable sand were included in the summary sheet provided)

OSI's criteria and assumptions for mapping include:

- suitable sand contours only generated within the limits of the seismic investigation (there are not enough core points to contour sand deposits in the inlet and back bay channels)
- at stations where multiple core attempts were made, the sample with the thickest suitable sand layer was used; attempts listed as "no recovery" were designated as non-data points (assumed sediment fell out of core liner during retrieval, rather than the vibracore encountering hard refusal)

- isolated core samples which showed less than 2 ft of suitable sand were not included within the suitable sand boundaries, if seismic data indicated shallow rock or did not show the presence of a surficial sand unit
- for sand suitability thickness discrepancies in 23 cores, values from the WD summary table (AtoG%20Silt%20Remove%20%2010%25%20Rev%201.csv, sent 24 June) were used instead of those included in the grain size analysis spreadsheet (Topsail%20Island%20OSI%203.xls, sent 22 June); see Appendix B
- 20 cores were not included in the mapping due to discrepancies with location, missing core logs, or missing data in the grain size analysis spreadsheets (see geotechnical data table in Appendix B)
- 9 cores were excluded from the mapping by the WD based on additional review of grain size data (Appendix B); information provided on 29 July (Topsail Island CR.xls)

The mapping completed for this investigation focused on contouring the suitable sand unit thickness as defined by the WD. All available site information collected by and provided to OSI was used to delineate the limits of suitable sand as shown in Figure 6 and contoured in detail on Drawing #3, Sheets 1 and 2. These include the seismic reflection "chirp" and "boomer" profiles, the WD core sample results, bottom topography from the depth sounder, and survey results from previous studies, HDR 2002 and HDR 2003. Figure 7 shows the surface sample and core locations as well as the basement rock units mapped from these two prior investigations off Topsail Island.

Specific sand borrow areas have intentionally not been defined, as it is expected that the WD will designate these at a later date following complete examination of the project results and any future redefinition of suitable sand that may occur. For similar reasons, volume estimates for the sand resource areas have not been calculated.

The following sections discuss the interpretation of seismic reflection data and correlation with the core sample results, and summarize the geomorphology of the defined suitable sand unit and other geologic features within the investigated area.

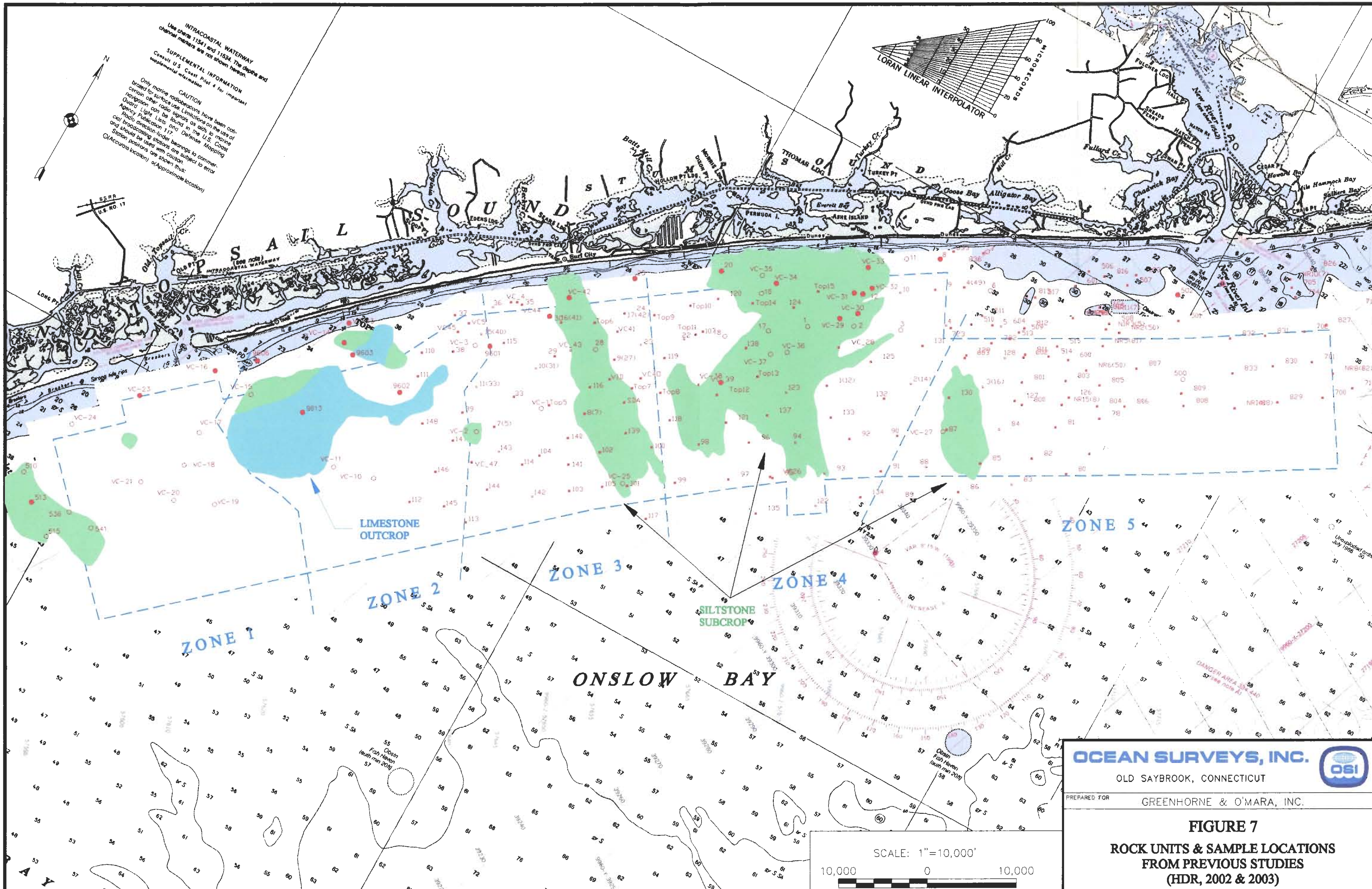

FIGURE 7
ROCK UNITS & SAMPLE LOCATIONS FROM PREVIOUS STUDIES (HDR, 2002 & 2003)

OSI FILE NO. 03ES014
23 SEPTEMBER 2004

6.3 Zone 1; Rich Inlet to New Topsail Inlet

This zone covers the southwest end of the survey area and includes the second most extensive deposits of suitable sand available within the five zones offshore Topsail Island. Zone 1 occupies somewhat of a depression between subcrops (subsurface rock high) of the River Bend Formation (unconsolidated siltstone) generally southwest of the survey area (HDR, 2002) and the structural limestone rock high of the Trent Formation which outcrops in Zone 2 off Topsail Beach.

Overall sediment thickness in this zone is much greater than Zone 2 to the northeast, with many cores reaching 15-20 ft below the bottom. This is particularly true in the vicinity of the ancestral New Topsail river channel (fluvial paleochannel, P1) which cuts as deep as 60 ft into underlying lithologies (Figure 8) and transects through Zone 1. This is the primary paleochannel in this zone and exhibits the highest relief of all identified over the 23 miles of coastline. While thin, horizontal reflectors representative of finer, laminated estuarine silts and clays are evident at depth within this structure, cross bedded or acoustically transparent returns indicative of sandy sediments are also present on the seismic profiles at the surface and at depth. Many of the cores retrieved from this paleochannel reveal surficial sands of varying thicknesses suitable for beach replenishment (VV-185, VV-197, VV-132, and possibly VV-11A). Significant quantities of sand may be available deeper within this structure, but these deeper deposits may not be economical to dredge.

There are three other relict channel features evident in this zone (P2, P3, P4) which appear to contain less surficial sand and more fine grained sediments, especially paleochannel P2 along the southwest boundary of Zone 1 (Figure 9). Despite the fact that some of these channels are primarily mud filled, a suitable sand layer typically 1-4 ft thick was identified on the surface at nearly every core location. However, it is evident from comparison of the seismic profiles and core sample results that there is no definitive correlation between the location of

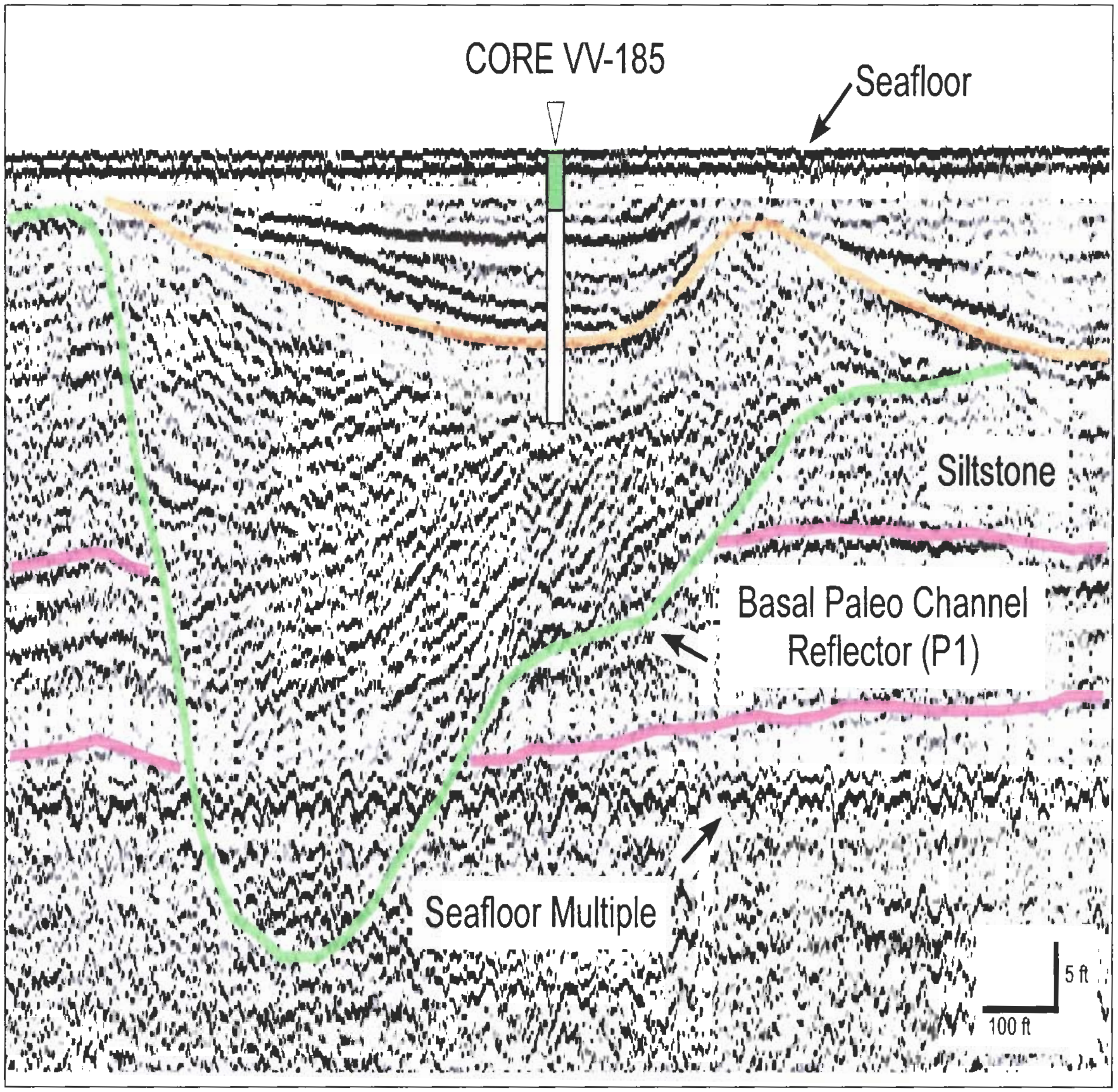

Figure 8. Seismic reflection "boomer" profile of paleochannel P1 in Zone 1, revealing the depth of this relict channel feature. Green shading in the core represents suitable sand identified by the WD (4.5 ft in core VV-185). Note younger basal channel reflector (orange) truncates the top of the older channel sequence of paleochannel P1.
[Seismic data from Line 56]

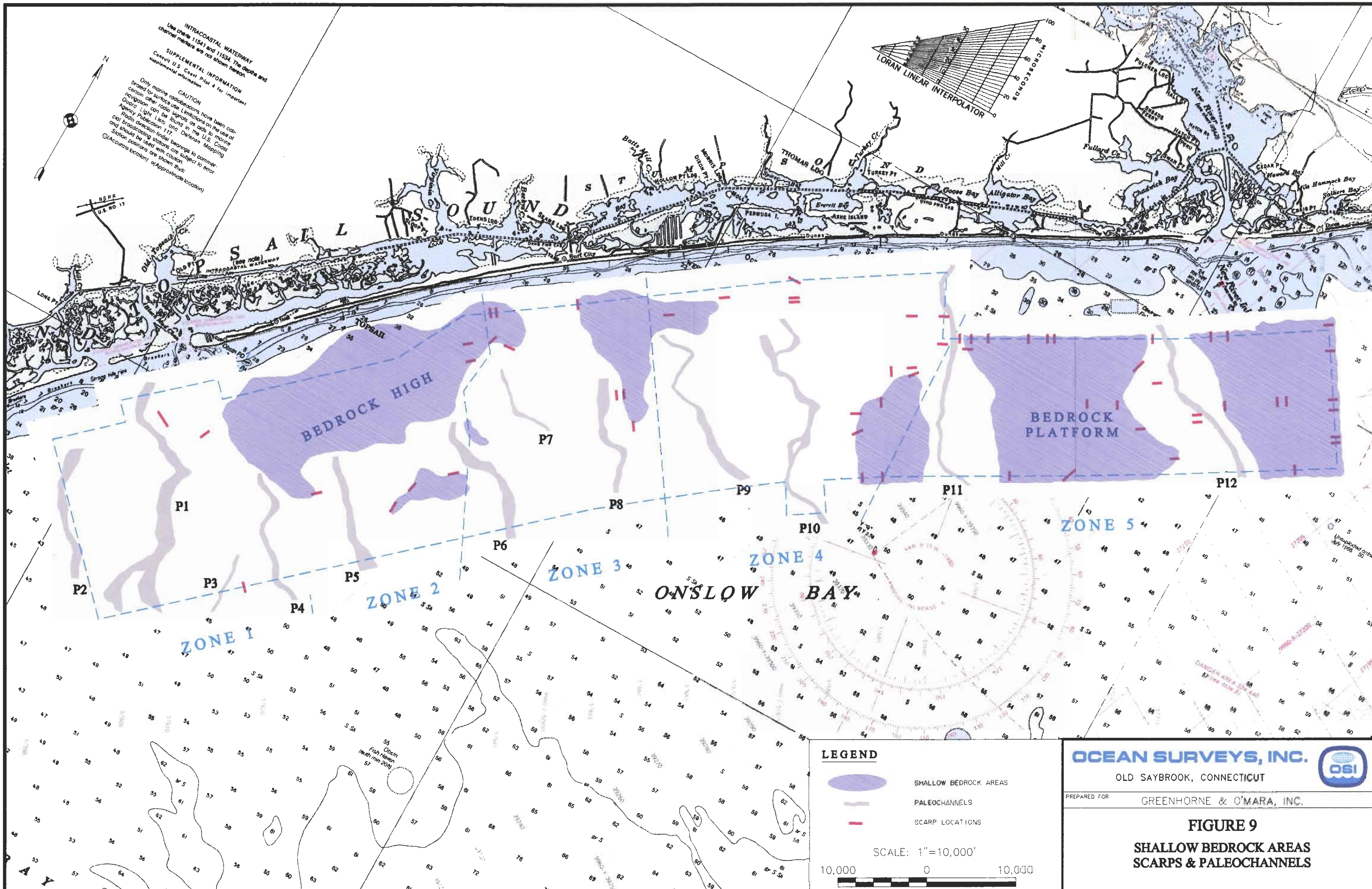

FIGURE 9
SHALLOW BEDROCK AREAS SCARPS & PALEOCHANNELS

OSI FILE NO. 03ES014
23 SEPTEMBER 2004

suitable sand and paleochannels. The surficial sediment layer is simply a discontinuous veneer, mainly comprised of sand and lithic gravel, which partially covers all other lithologic units and structures on this region of the inner continental shelf.

Adjacent and west of the primary paleochannel P1, and centered in the northwest corner of this zone, a significant suitable sand area encompassing cores VV-127, VV126, VV-130, VV-187, VV-188, VV189, and VV-182 exists. A reasonably sized suitable sand lense was also identified along the southern limits of the zone in and adjacent to the P1 channel (cores VV-185, VV-186, VV-198).

Core analyses also suggest significant quantities of suitable sand (6-8 ft thick) are available along the nearshore boundary of this zone at the north end of the primary paleochannel P1 (cores VV-11A, VV-116, VV-135). This suitable sand area continues landward of the survey limits around New Topsail Inlet, where a 3-11 ft thick layer of usable material was located (cores VV-139 to VV-144 and VV-364).

Seismic profiles suggest the surficial sediment layer generally thins toward the northeast and the bedrock high located in Zone 2. Except for a couple core samples, all the cores collected east of the primary paleochannel P1 penetrated less than 10 ft below the seafloor. Despite the reduced penetration, based on grain size results, there is usable material here for beach replenishment. The southeast corner of this zone between cores VV-222 and VV-225B appears to be a promising area that may warrant further study.

6.4 Zone 2; Offshore Topsail Beach

This region offshore Topsail Beach is dominated by a broad, shallow limestone rock outcrop (Trent Formation) which forms a structural high in this portion of the survey area. Only a thin veneer of sediment is scattered over the rock in most places. This is the most expansive hardbottom area in all of the five zones investigated, and covers well over half of Zone 2

(Figure 9). This rock unit is characterized as a moldic, sandy limestone (HDR, 2002), harder and more resistant to weathering than the finer grained, generally unconsolidated siltstone of the River Bend Formation.

The limestone rock surface slopes offshore where many core samples penetrated up to 10 ft into the bottom (cores VV-240, VV-241, VV-367 to VV369, and VV-252). Several patches of suitable sand were identified within this surficial sediment layer, but due to the reduced areal extent of sediment overburden, Zone 2 appears to hold the lowest quantity of usable beach fill material of the five zones. Paleochannel P5 bisects the offshore portion of this zone and the north end of buried channel P6 extends into the area. Both of these paleochannels are relatively shallow, less than 25 ft deep, compared to the major P1 channel in Zone 1. Cores suggest suitable sand is available over relict channel P5 (cores VV-240 and VV-241) and in the immediate vicinity, but no core stations were positioned within the northern portion of channel P6 within Zone 2 to verify surficial materials overlying this feature.

If sand resources are pursued within this zone, further studies should be focused around core stations VV-241 and VV-369 where 4 ft and 5 ft of suitable sand, respectively, was identified.

6.5 Zone 3; Offshore Surf City

The limestone rock outcrop offshore Topsail Beach slopes gradually down toward the south and east through this zone forming several broad, low-lying depressions filled with slightly thicker sequences of unconsolidated sediments. Intermittent limestone rock outcrops of the Trent Formation (scarps) persist mainly in the nearshore half of this region while calcareous siltstone subcrops of the River Bend Formation are reportedly wide spread under portions of this zone (HDR, 2003). Overall, Zone 3 is estimated to have the third most extensive suitable sand deposits of the five zones in the survey area, but projected to be less than half that contained in Zone 1.

Rock remains shallow in the nearshore half of the zone, leaving room for only a thin veneer of sand and gravel. Several patches of suitable sand were mapped around cores VV-294, VV-296, and VV-297, however, less than 3 ft of suitable material was found at these core stations. Overall, sediment thickness starts to increase offshore of these cores as do the potential sand resources. Cores VV-271 (~7 ft suitable) and VV-273 (11 ft suitable) mark an area of high potential between paleochannels P6 and P7. Just east of core VV-273, results from cores VV-282 and VV-284, spaced approximately 30 ft apart, highlight the extreme variability of the surficial deposits in the survey area. About 10 ft of unsuitable silty sand and 2.3 ft of suitable sand were identified, respectively, at these two locations.

Along the offshore boundary of this zone, particularly east of paleochannel P6, all core samples except for one station (VV-279) recovered greater than 10 ft of sediments, with many locations achieving 15-20 ft of penetration. Suitable sands varying from 1-11 ft thick were identified in this area. Further study is recommended in this area and along the border of Zones 3 and 4 where greater than 20 ft of unconsolidated materials, which hold a significant quantity of suitable sand, exist. This potential resource area starts east of relict channel P8 where core VV-99 recovered approximately 8 ft of suitable sand, and may connect with a thick layer of suitable material located around core VV-93 in the southwest corner of Zone 4.

Cores obtained within the three paleochannels in this zone revealed primarily silty sands (P6; core VV-259 and P7;cores VV-265, VV-269) and cohesive silt layers (P8; cores VV-289, VV-291). However, cores VV-275 and VV-256 that appear to be positioned closer to the edge of relict channel P6 (based on the seismic data) recovered surficial suitable sand 5.5 ft and 2 ft thick, respectively. In some cases, the position of the cores within the relict channel (channel edge or mid section) may dictate the amount of sand identified, particularly at depths below the surficial sand sheet. However, suitable material is not restricted within the boundaries of these paleochannels, as nearby core VV-257 is located outside the seismic limits of the relict channel and recovered 3 ft of suitable sand. Figure 10 illustrates the position of cores VV-275 and VV-257 with respect to paleochannel P6.

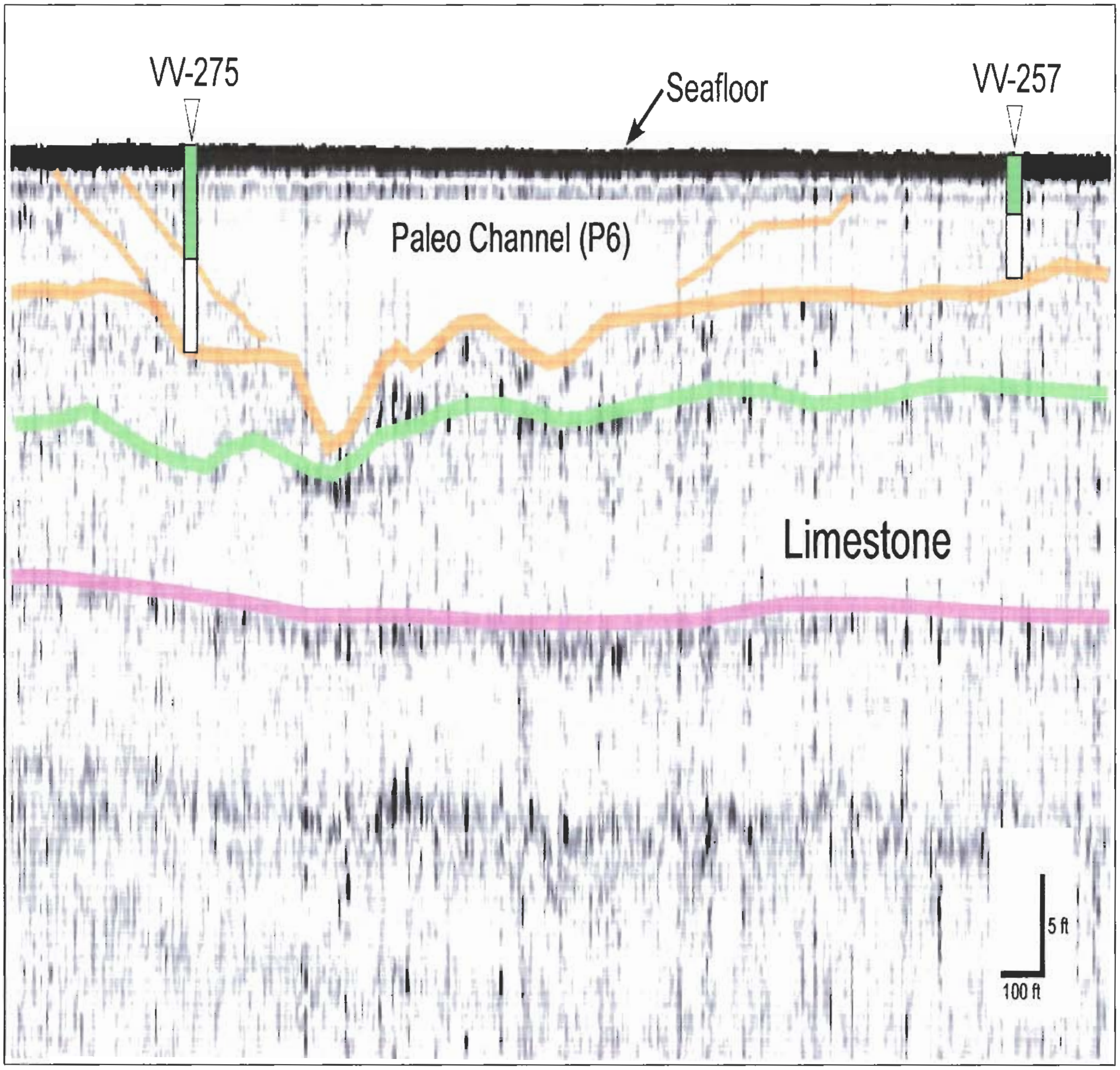

Figure 10. "Chirp" profile of shallow paleochannel P6 identified in Zone 3. Green shading in the cores represents suitable sand defined by the WD (5.5 ft in core VV-275 and 3 ft in core VV-257). Note results from core VV-275 suggest thick suitable sand deposit near the edge of the paleochannel.
[Seismic data from Line 56]

6.6 Zone 4; Ocean City to Sea Haven Beach

The limestone rock unit remains at depth throughout much of this zone with a continuation of relatively thicker sediment sequences present in the upper 20 ft of the stratigraphic column. Shallow siltstone and limestone hardbottoms do exist locally, between depressions in the rock surface, as evidenced by numerous scarps on the depth sounding records mainly closer to shore and along the border with Zone 5 (refer to Figure 9). Thickest sediments occupy a broad topographic low in the rock surface oriented nearly north-south which runs through the central portion of this zone.

Geophysical and geotechnical data suggest this zone certainly has the largest potential sand resources which are projected to be approximately double the volume of Zone 1. Zone 4 is the only region within the 23 mile survey area where core samples (nine) containing greater than 10 ft of suitable sand were identified (cores VV-320, VV-323, VV-326, VV-85, VV-75, VV-86, VV-93, VV-157, and VV-311), with the exception of one core just outside the survey area of Zone 1 nearshore (core VV-364) and one core in the southwest corner of Zone 3 (core VV-273). Most of the deep cores in Zone 4 are located in the area surrounding buried channel P10 (see Drawing #3).

In addition, a thick sediment wedge exists along the offshore limits of this zone west of paleochannel P9 which continues southwest into Zone 3 (as discussed in Section 6.5). Seismic profiles show offshore dipping reflectors, possibly representative of the remnants of an earlier lower shoreface sequence, with unconsolidated sediments greater than 30-35 ft thick in this offshore area. The increased sediment thickness was verified by the deep penetration of many vibracores (cores VV-342, VV-93 to VV-100, VV-103, and VV-104). Based on the above information, this portion of the survey area appears to have high potential for additional surficial sand resources. Also, if very thin layers of unsuitable material were allowed, it would increase the vertical extent of the suitable sand layer by providing access to deeper, possibly suitable sand units (ie. cores VV-96 to VV-99). The addition of unsuitable sediment layers of minimal thickness would barely alter the overall median grain size of the source material.

There are two paleochannels which traverse nearly the entire width of this area, P9 and P10, while the northern end of channel P11 runs through the northeast corner of this area from Zone 5. All the cores collected within the seismic limits of channel P9 recovered suitable sand at the surface, from 3.5 ft at station VV-91 offshore to 7.5 ft at station VV-302 nearshore. Similarly, most cores conducted over buried channel P10 (ie. cores VV-78 and VV-326) also recovered sandy surficial sediments deemed suitable for beach fill. Figure 11 shows a "chirp" profile into channel P10 with the positions of cores VV-325 and VV-326 noted. The approximate alignment of cores VV-313, VV-314, VV-315, VV-318, and VV-319 may closely follow another relict channel feature in the northernmost corner of Zone 4 as a cohesive silt layer of varying thickness was encountered at each of those locations, indicative of a mud-filled estuarine channel feature (not clearly evident on the "chirp" profiles).

Further study along the nearshore limits on this zone, particularly in the northeast corner and beyond the limits toward shore, might uncover additional deposits of suitable sand.

6.7 Zone 5; Alligator Bay to Mile Hammock Bay, Offshore New River Inlet

The Belgrade limestone rock unit slopes up into Zone 5 forming a very shallow, hardbottom platform which covers nearly 80% of this area offshore from New River Inlet. The rock surface is so shallow that it is difficult to interpet on the seismic profiles. Sediment cover is extremely thin in most places and is comprised of sand and gravel in the troughs between exposed rock escarpments. The scarps exhibit higher relief in this portion of the coastline, as heights of up to 12 ft were observed along the eastern offshore limits of the survey area. Two areas of interest were designated for surveying in this zone where prior investigations suggested at least some surficial sediment was present; the first near the border of Zone 4 in the offshore half of the site and the second directly offshore from New River Inlet.

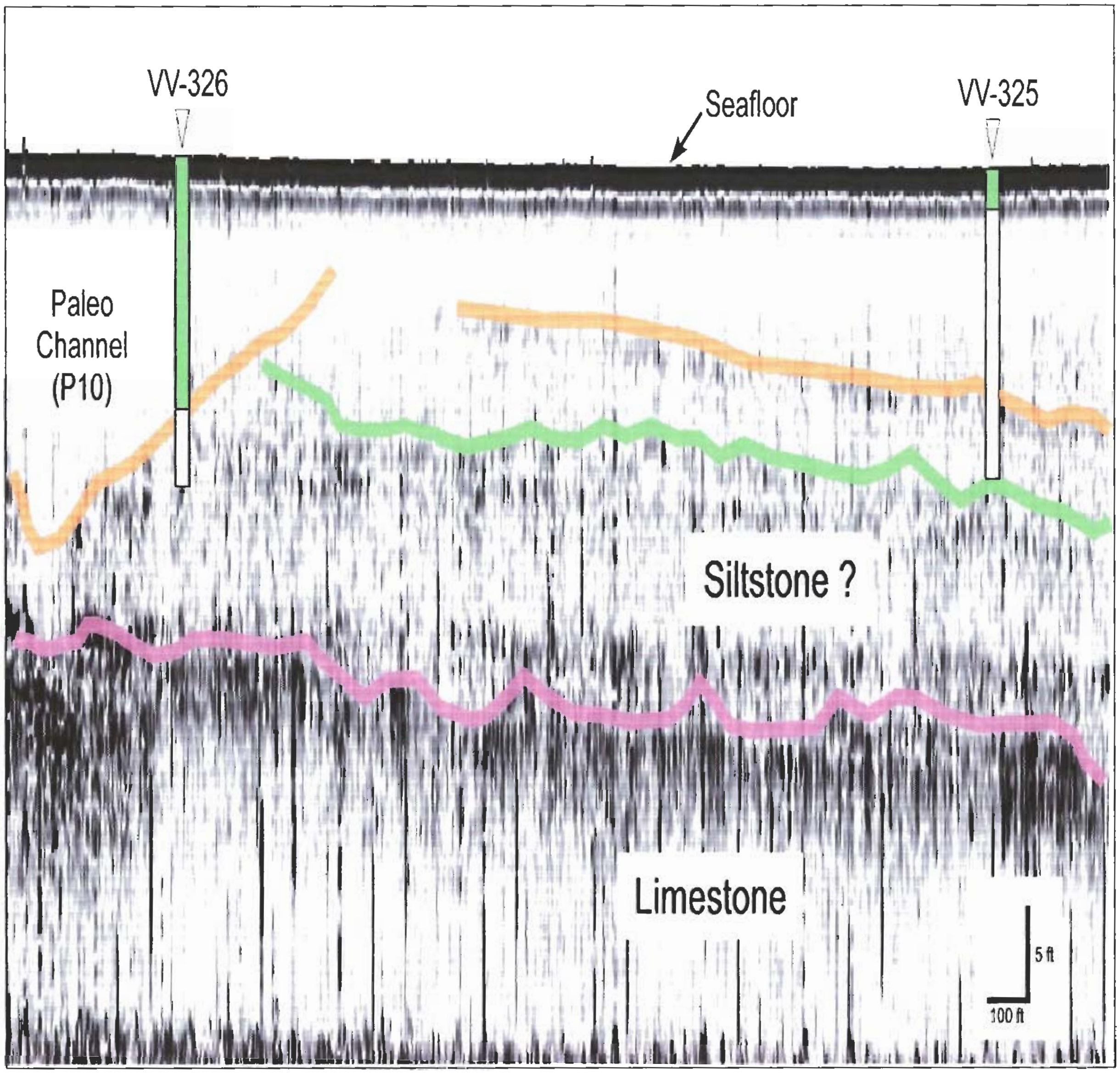

Figure 11. Subbottom "chirp" profile illustrating the apparent correlation of geophysical and geotechnical data at core VV-326 compared to the more typical result of no clear correlation between the seismic profile and the surficial sand layer recovered in core VV-325. Green shading in the cores represents suitable sand defined by the WD (12.7 ft in core VV-326 and 2 ft in core VV-325).
[Seismic data from Line 27]

The westernmost potential sand resource area in this zone appears to contain a limited volume, since core samples recovered less than 3 ft of suitable material. A number of cores penetrated up to 13-15 ft (cores VV-47, VV-48, VV-49, and VV-51) but did not hold significant quantities of surficial suitable sand. Either increased amounts of fine grained sediments (silt fraction) or coarse gravel and weathered limestone were recovered at depth. Only one core (VV-45) was positioned within the limits of paleochannel P11, revealing organic silt with wood fibers below 2.2 ft of usable sand. Similarly, cores VV-164A and VV-165 at the north end of relict channel P11 in Zone 4, also recovered organics and silty sand from inside the channel limits mapped from the seismic data. The data thus suggest this is a predominantly mud-filled paleochannel probably not conducive to further investigation.

Based on the geophysical and geotechnical data collected for this phase of work, a sand resource area with slightly higher potential exists off New River Inlet. This suitable sand body covers approximately the same areal extent as the one to the west, however, a couple core samples reveal thicker suitable deposits (5-9 ft in cores VV-17, VV-23, VV-25). Cores collected within paleochannel P12, which runs through this sand resource area (VV-14, VV-17, VV-27, VV-29), suggest coarser grained, sandy sediments may be prevalent in this relict channel (Figure 12).

Overall, Zone 5 appears to contain the second lowest quantity of suitable sand behind Zone 2, with a low probability of expanding suitable sand coverage around the two areas identified. Based on results from this investigation, there does not appear to be any other significant surficial sand bodies within this zone.

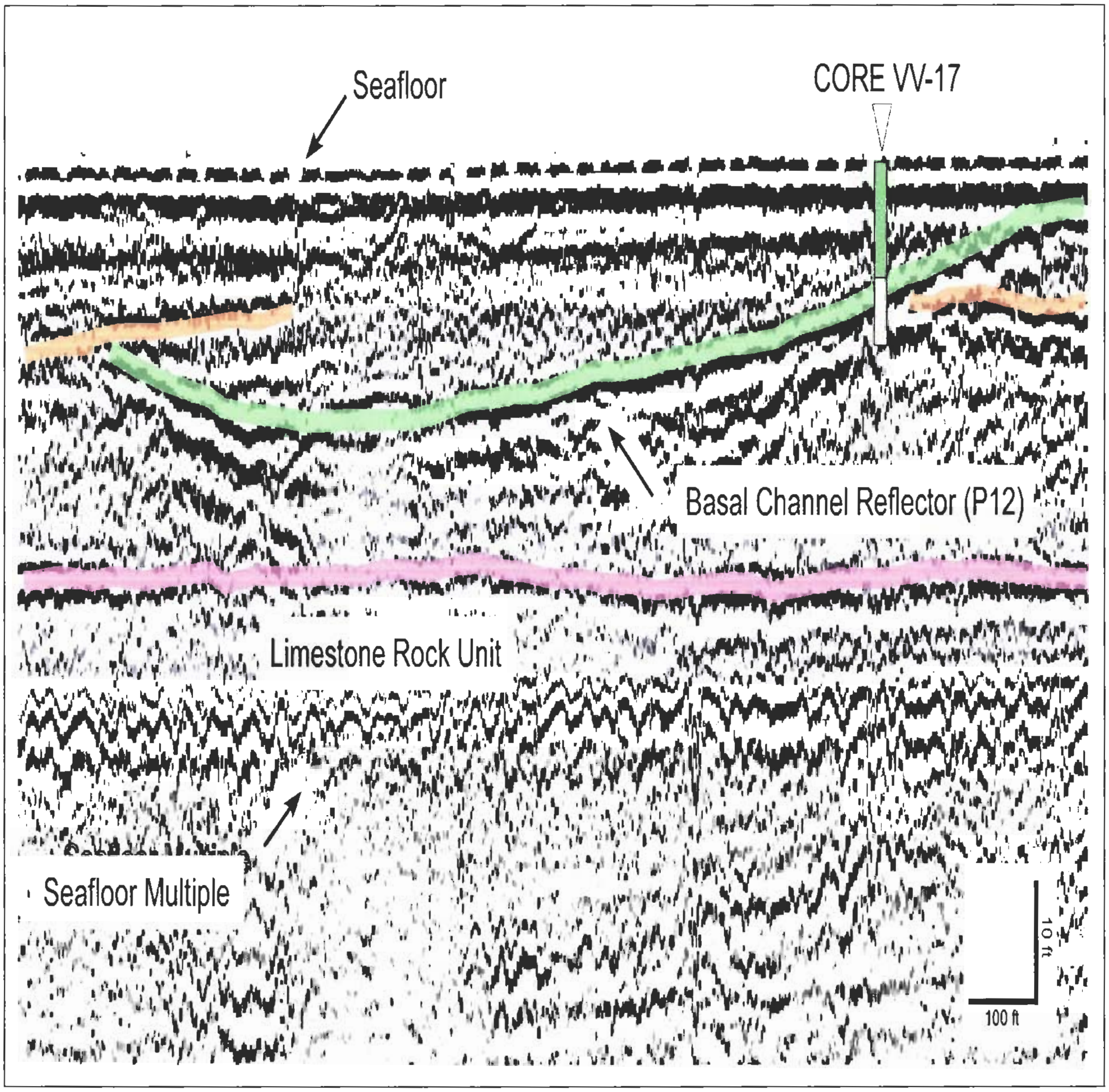

Figure 12. Seismic reflection "boomer" section showing paleochannel P12 off New River Inlet in Zone 5 and core sample VV-17 positioned within its limits. Green shading in the core represents suitable sand identified from grain size analyses by the WD (8.6 ft in core VV-17). The acoustic transparency and small chaotic reflectors within channel P12 may indicate predominantly coarse sediments.
[Seismic data from Line 10]

6.8 Geologic Features of Significance

6.8.1 Hardbottom Areas

Shallow limestone and siltstone rock units in this region of the coast dominate and control the nearsurface geology and submarine landscape offshore Topsail Island. The Oligocene age rock units dip gradually toward the southeast and outcrop intermittently on the seafloor. The indurated, moldic sandy limestone protrudes above the seafloor as scarps exhibiting relief of 2-15 ft with relatively flat-lying hardbottom areas between. The siltstone unit, rarely identified outcropping, is a poorly consolidated calcite cemented quartz silt and able to be sampled with a vibratory corer. Higher relief limestone scarps are more common in the eastern half of the survey area offshore New River Inlet. These scarps and flat hardbottom areas form habitats for local benthic communities of flora and fauna. Unconsolidated sediments accumulate in the localized depressions at the toes of scarps (0.5-10 ft thick). Physical, biological, and chemical erosion of the underlying rock units contributes material to the surficial sediment layer. On a larger scale, thicker sediment sequences (greater than 10 ft thick) have filled in broad depressions in the rock surface which extend in a southerly direction off New Topsail Inlet and Alligator Bay (see Drawing #3).

The beveling of Tertiary lithologies by erosional transgressions, combined with an absence of fluvial input to Onslow Bay, have kept these hardbottom areas exposed or in the shallow subsurface on the inner continental shelf.

6.8.2 Paleochannels

It is evident from the core results that surficial suitable sand resources are available within the limits of many paleochannels identified from this investigation, but are not restricted within the surficial boundaries of these features. Oppositely, the entire length of some cores contain estuarine silts and clays from the seafloor down. Seismic reflection profiles reveal a variety of acoustic signatures within these channels which are representative of different sediment facies deposited within a fluvial-type environment. The upper sections of these facies were beveled off during the Holocene transgressions preserving the deeper fluvial deposits in the stratigraphic record. The deeper portions of many of these channels are bounded by a generally U-shaped basal reflector typical of relict fluvial features. In some cases, multiple channel cuts are evident on the seismic data as more recent, shallower fluvial channels cut through the upper sections of older, deeper riverine deposits (Zone 1, paleochannel P1).

For some of the paleochannels identified from this investigation, the amount of sand recovered at depth in a core may be correlated with its position within the limits of the relict channel, where cross bedded materials evident on the seismic profiles may represent a sand bar or similar structure formed by lateral progradation or channel migration. The amount of sand size sediments available as potential beach fill material within these features is generally dependent upon, but not limited to, the evolutionary stage of the fluvial feature prior to burial, the environment through which the channel flowed (inlet, back bay, shoreface), and the amount of material remaining in the basal channel units after transgressive erosional events. Overall, suitable sand areas are not confined within the limits of these features; they are more controlled by bedrock surface topography and distribution of the surficial Holocene sand sheet.

7.0 SUMMARY AND RECOMMENDATIONS

The marine geophysical investigation performed for the ongoing Topsail Island beach nourishment project has provided significant geologic information for delineating the areal extent and thickness of potential offshore sand resource areas. The seismic reflection profiles, in conjunction with grain size analysis results from cores acquired by the WD, have further defined the nearsurface geology and allowed a more detailed map of the potential suitable sand areas to be developed.

A number of areas have been identified over this 23 mile long stretch of shoreline where sandy material suitable for beach restoration is available. The surficial sand layer which includes any defined suitable sand unit is very discontinuous in nature, subdivided by a complex pattern of Oligocene rock outcrops and subcrops in this portion of Onslow Bay. The result is a montage of unconsolidated materials and rock on the seafloor exhibiting very few expanses of homogeneous sediments either laterally or vertically. Wave and current action in the Bay move the surface material, periodically exposing rock units just below the seafloor. The ensuing erosion and reworking of the shallow limestone and siltstone rock units in this portion of Onslow Bay contributes coarse and fine grained materials, respectively, to the surficial sand sheet essentially reducing its suitability.

Throughout most of the survey area where shallow rock is the dominant lithology, the thickest sequences of unconsolidated sediments generally occur in or adjacent to the paleochannels which cut through all five zones of the investigated area. Aside from these relict fluvial features, results of this investigation identified two main regions offshore where thicker surficial sediments exist; (1) offshore of New Topsail Inlet in Zone 1 where paleochannel (P1) and adjacent sediment facies apparently infill a depression between the limestone hardbottom to the northeast and the siltstone subcrops to the southwest (HDR, 2002), and (2) a broad, shallow depression in the limestone rock surface which extends nearly due south offshore from Alligator Bay through Zone 4 and partially into Zone 3. Many of the core samples achieved penetration over 15 feet in these areas. The interpretation and correlation of seismic reflection and geotechnical data suggest that these two regions contain the largest volume of continuous surficial sand reservoirs in the area investigated.

The table below summarizes the approximate percentages of suitable sand deposits within each of the five zones based on results from this study. Estimated percentages are based on the surface area contained inside the 2 ft suitable sand contour which, in this case, is similar in proportion to total sand volume.

Zone	Area Confined by the 2 ft Suitable Sand Contour	Estimated Percentage of Suitable Sand
1	4.7 million square yards	24%
2	1.1 million square yards	5%
3	2.6 million square yards	13%
4	10.1 million square yards	51%
5	1.5 million square yards	7%
TOTAL	~20 million square yards	100%

The maps generated from the results of this investigation are only valid for suitable sand as defined in this report. Any modification of the criteria for suitability (ie. include greater silt percentage, exclude certain percentage of coarse and shell material, allow internal unsuitable layers of minimal thickness) would require remapping of the suitable materials. There are certainly additional surficial sand resources present in the site that are not represented in this mapping, as a finer data spacing would likely expand many of the suitable sand areas delineated. However, due to the complex geology in the site, the opposite is also likely to occur where additional seismic and cores reveal gravel and Oligocene rock units shallower than indicated in some areas.

Given the shallow nature of the limestone and siltstone underlying the site, and the relatively large geophysical and geotechnical data spacing throughout the area, the distribution of suitable sands may be much more patchy and discontinuous than indicated on the contour map. The west-northwest facing edges of these rock layers protrude above the seafloor at a low angle and form troughs between the hardbottom scarps. The troughs are filled with sand and gravel eroded from the underlying rock units. Thus the distribution and thickness of the surficial sediment layer is largely controlled by the morphology of the rock surface, and more specifically by the spacing and relief of the rock scarps (HDR, 2003). Surveying and sampling on a finer scale is recommended for the next phase of work to more accurately map the potentially significant sand borrow areas and develop more precise estimates of the volume of material available for beach replenishment.

Further investigations will likely reveal some of the suitable sand areas mapped for this phase actually contain many localized depressions filled with sand rather than represent continuous deposits of suitable material. This may result in the removal of some of these suitable sand areas from consideration as potential borrow sites. The physical extraction of suitable sand from localized "pockets" in the seafloor may not be economically feasible, environmentally efficient, or technically viable.

It is also important to note, since the completion of the field investigation in April 2003, one significant storm event, hurricane Isabel, has taken place which may have altered bottom conditions offshore Topsail Island. This hurricane made landfall near Drum Inlet north of Cape Lookout in September of 2003 as a Category 2 storm (wind speeds of ~90 mph and storm surge of 6-10 feet). The waves associated with events such as this are capable of transporting and redistributing even coarse surficial sediments within the survey area. As a majority of suitable sand is contained within the upper 6 ft of the stratigraphic column, this means some reworking of the seafloor has undoubtedly occurred. The next phase of geophysical and geotechnical data collection may show the affects from this and other storms on the surficial sediment sheet and the maps generated for this investigation.

This investigation was not tasked with addressing the potential sand resources in the nearshore zone (landward of the 30 ft depth contour), inlets, or back bay regions. The WD did collect a number of core samples during the summer of 2003 in these areas. If a possibility exists for utilizing these areas as potential sources for beach fill, seismic reflection profiles and additional core samples would enhance the information for these regions of the coast and estuary. The combination of geophysical and geotechnical data acquisition compliment one another, both economically and technically, for the mapping of subsurface sediment layers, particularly when the layers are confined by underlying lithologies with distinctive acoustic signatures.

Since the suitable sand unit within the surficial sand sheet is primarily a thin veneer offshore Topsail Island, high resolution of the nearsurface stratigraphy should be the priority over deeper penetration into the subsurface. For this reason, a "chirp" or other subbottom profiler using a higher frequency transducer would be recommended (2 kHz and above) for future work to achieve better resolution of shallow layering while still obtaining sufficient penetration to record data to the base of the surficial sand sheet or top of rock in most places. If a broader view of the stratigraphic column is desired, a lower frequency, "boomer"-type system (0.5-5 kHz) provides excellent quality profiles and would not interfere with the higher frequency subbottom systems.

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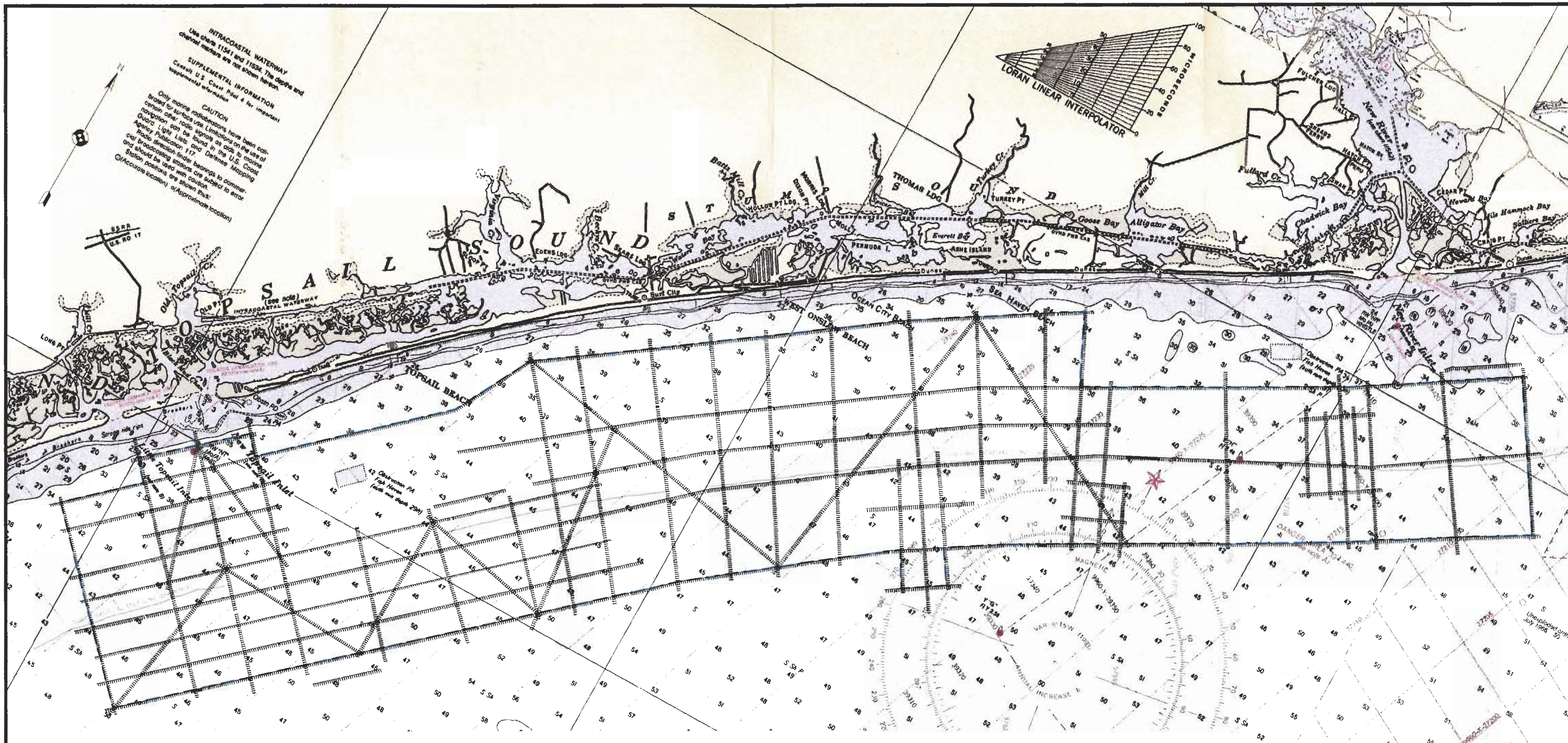
APPENDICES

APPENDIX A

PROJECT DRAWINGS (11x17" size)



NOTES

1. THE HORIZONTAL GRID SYSTEM IS IN FEET AND IS THE NORTH CAROLINA STATE PLANE COORDINATE SYSTEM, ZONE 3200, NORTH AMERICAN DATUM OF 1983.
2. SURVEY VESSEL POSITIONING WAS BY DIFFERENTIAL GPS USING CORRECTORS FROM THE NEW BERN, NORTH CAROLINA COAST GUARD RADIO BEACON (294 kHz FREQUENCY AT 100 BPS TRANSMISSION RATE).
3. DEPTHS ARE IN FEET AND ARE REFERENCED TO MEAN LOWER LOW WATER BASED ON A COMBINATION OF PREDICTED TIDE DATA FROM THE NEW TOPSAIL AND NEW RIVER INLETS AND ACTUAL TIDE DATA RECORDED AT THE DUKE MARINE LAB IN BEAUFORT. REFER TO THE DATA PROCESSING APPENDIX FOR ADDITIONAL INFORMATION.
4. SURFICIAL AND SUBSURFACE GEOLOGIC FEATURES WERE INTERPRETED FROM DEPTH SOUNDING AND SEISMIC REFLECTION DATA. AN AVERAGE ACOUSTIC VELOCITY OF 5000 FEET PER SECOND WAS USED FOR ALL SEISMIC ANALYSIS. THIS IS A STANDARD VELOCITY FOR NEARSURFACE, SATURATED MARINE SEDIMENTS USED FOR CONVERTING SEISMIC TIME SECTIONS TO DEPTH.
5. CORE SAMPLE LOCATIONS AND SEDIMENT SUITABILITY WERE PROVIDED BY THE WILMINGTON DISTRICT CORPS OF ENGINEERS. SUITABLE SAND AREA LIMITS AND CONTOURED THICKNESSES WERE GENERATED BY OSI INCORPORATING ALL THE AVAILABLE GEOLOGIC INFORMATION FOR THE SITE. REFER TO THE BODY OF THE REPORT FOR MORE INFORMATION.
6. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 27 MARCH–17 APRIL 2003 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BY THE 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.

LEGEND

SAND SUITABILITY CONTOURS

- LIMIT OF POTENTIAL SAND RESOURCE AREA
- 2 FEET
- 4 FEET
- 6 FEET
- 8 FEET
- 10 FEET
- 12 FEET
- 14 FEET
- 16 FEET
- 18 FEET

GEOLOGIC FEATURES

- SCARP LOCATION
- P2 — PALEOCHANNEL
- SHALLOW BEDROCK AREAS
- V-150 — VIBRATORY CORE CONTAINING SUITABLE SAND
- V-161 — VIBRATORY CORE CONTAINING NO SUITABLE SAND

SCALE: 1"=10,000'

10,000 0 10,000

OCEAN SURVEYS, INC. OSI

OLD SAYBROOK, CONNECTICUT

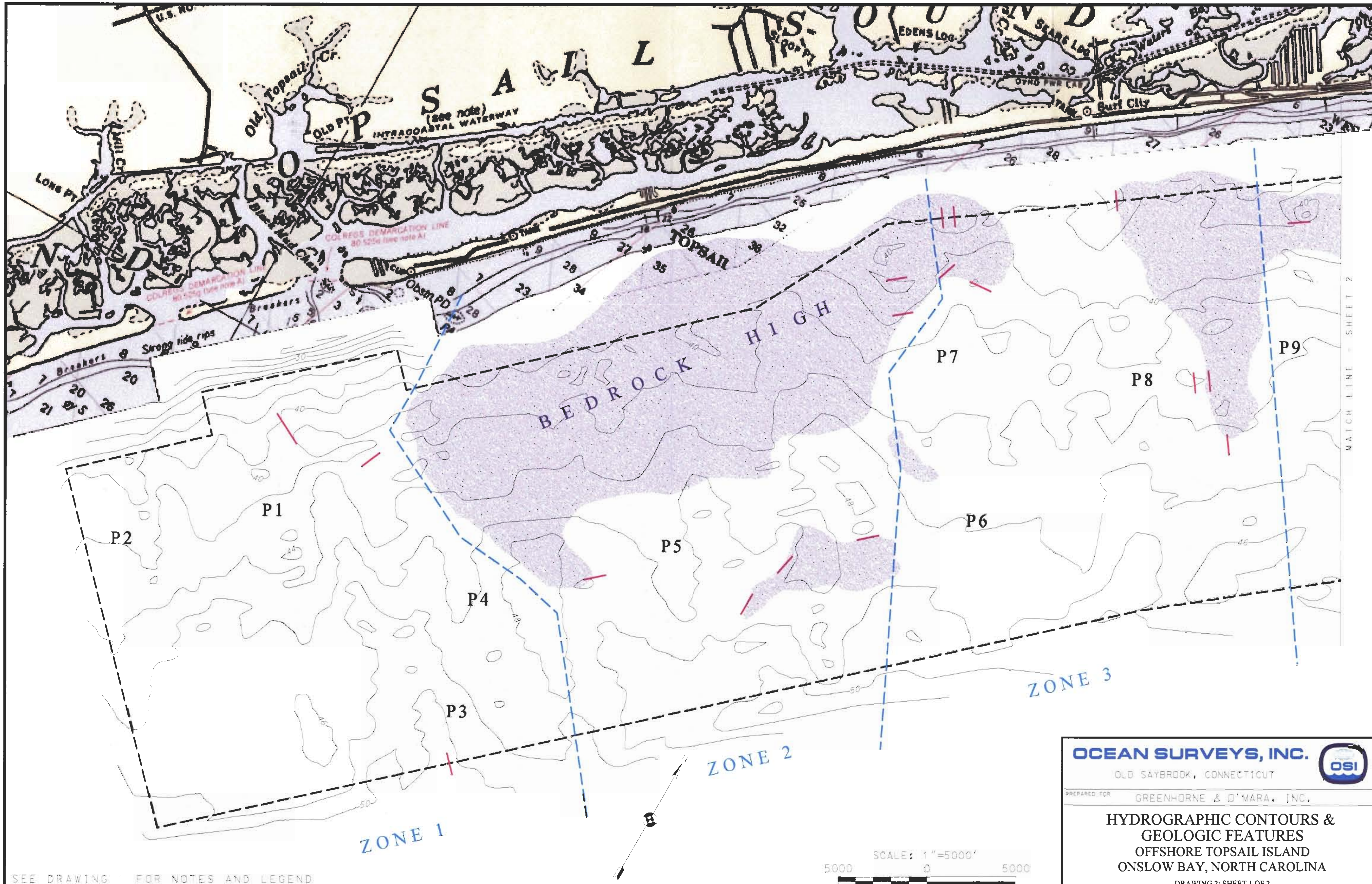
PREPARED FOR GREENHORNE & O'MARA, INC.

SURVEY TRACKLINES & DRAWING NOTES & LEGEND

OFFSHORE TOPSAIL ISLAND ONSLOW BAY, NORTH CAROLINA

DRAWING 1: SHEET 1 OF 1

OSI FILE NO. 03ES014
20 SEPTEMBER 2004



OCEAN SURVEYS, INC.
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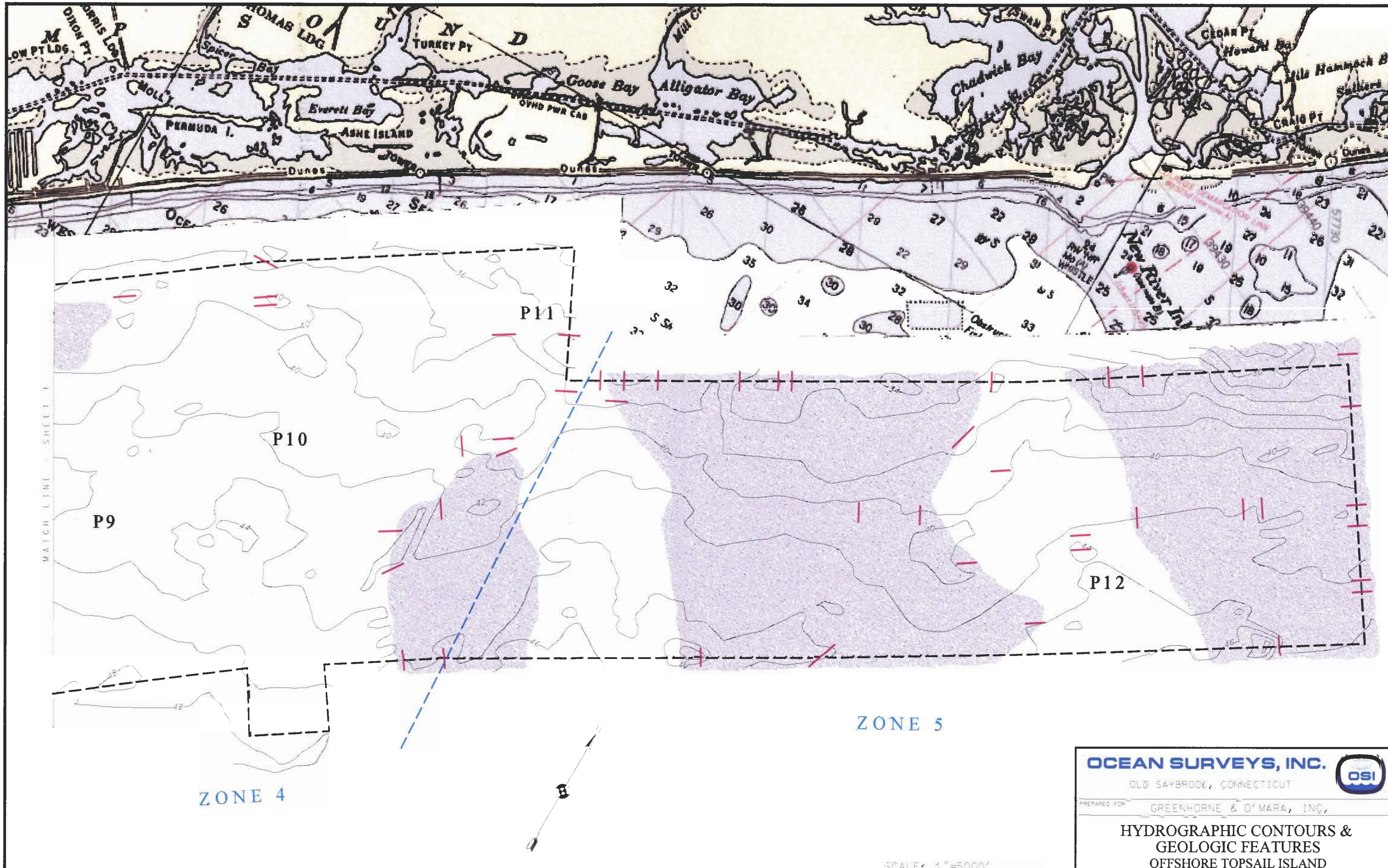
HYDROGRAPHIC CONTOURS & GEOLOGIC FEATURES
OFFSHORE TOPSAIL ISLAND
ONSLOW BAY, NORTH CAROLINA

DRAWING 2: SHEET 1 OF 2

OSI FILE NO. 03ES014
20 SEPTEMBER 2004



SEE DRAWING 1 FOR NOTES AND LEGEND

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HYDROGRAPHIC CONTOURS & GEOLOGIC FEATURES
OFFSHORE TOPSAIL ISLAND
ONSLOW BAY, NORTH CAROLINA

DRAWING 2: SHEET 2 OF 2

OSI FILE NO. 03ES014
20 SEPTEMBER 2004

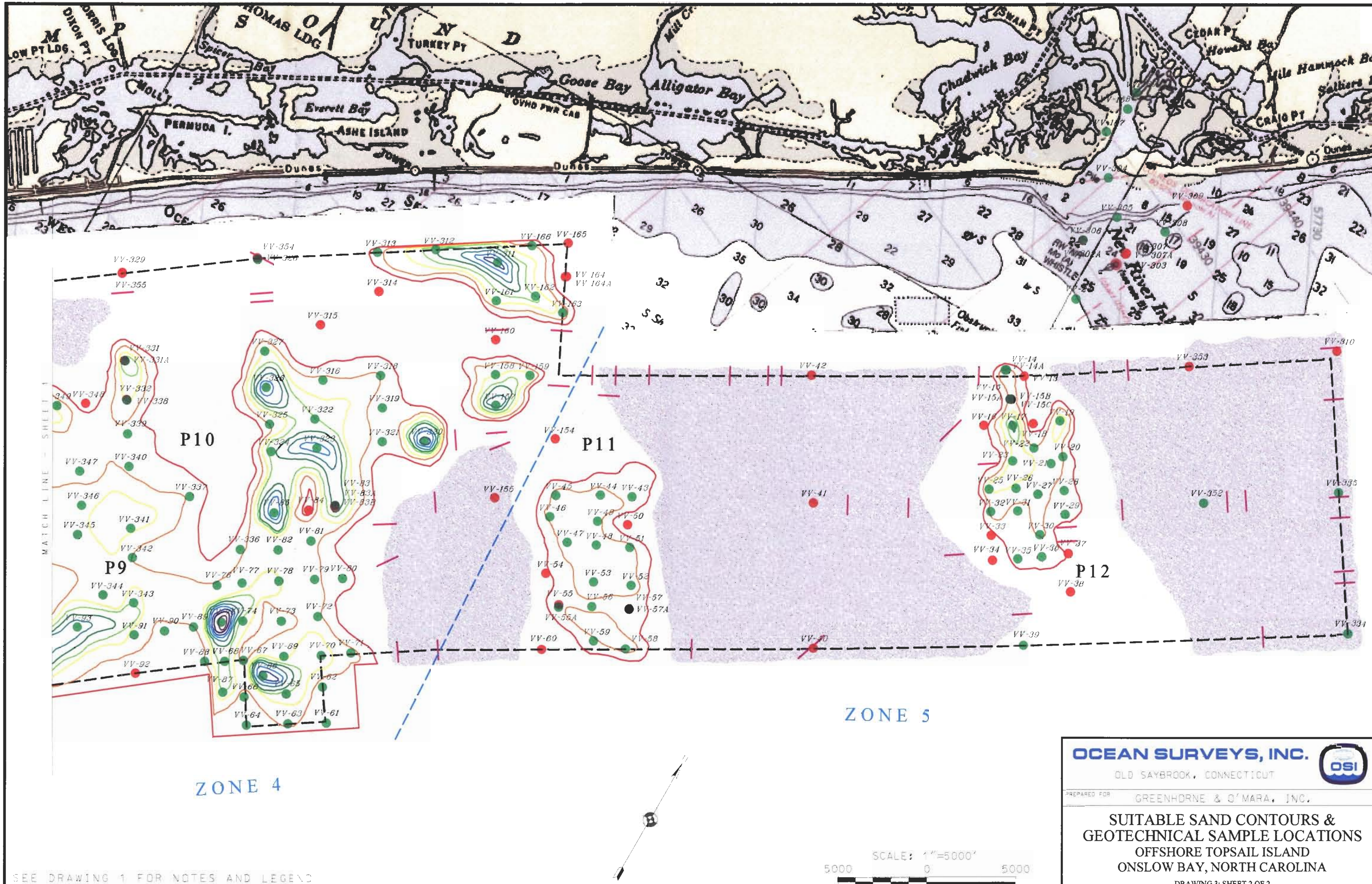
OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT

PREPARED FOR GREENHORNE & O'MARA, INC.

SUITABLE SAND CONTOURS & GEOTECHNICAL SAMPLE LOCATIONS
OFFSHORE TOPSAIL ISLAND
ONSLOW, NORTH CAROLINA

DRAWING 3: SHEET 1 OF 2

OSI FILE NO. 03ES014
20 SEPTEMBER 2004



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PREPARED FOR GREENHORNE & O'MARA, INC.

SUITABLE SAND CONTOURS & GEOTECHNICAL SAMPLE LOCATIONS
OFFSHORE TOPSAIL ISLAND
ONSLOW BAY, NORTH CAROLINA

DRAWING 3: SHEET 2 OF 2

OSI FILE NO. 03ES014
20 SEPTEMBER 2004

APPENDIX B

GEOTECHNICAL DATA TABLES

TOPSAIL ISLAND GEOTECHNICAL DATA

Summarized from Wilmington Corps of Engineers spreadsheets and core logs

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
Cores with no discrepancies in WD data files provided (360)									
VV-01	2399727	224065	3.5	>17.5	14		5.9	17.5	15
VV-02	2400769	224628	0.0	>19.5	4.5		1.8	19.5	14.5
VV-03	2402096	224229	4.0	>14.8	5.2			14.8	13.8
VV-04	2402003	222922	4.3	>8.9	5.6			8.9	4.3
VV-05	2403766	221877	2.5	>4.9	6.6			4.9	2.5
VV-06	2404031	221629	2.5	>8.5	4.7			8.5	2.5
VV-07	2402867	220177	1.7	>5.6	4.8			5.6	2.4
VV-08	2402857	220133	4.5	>7.5	7.2			7.5	4.5
VV-09	2404341	220562	0.5	>4.0	4.6			4	0.5
VV-10	2404405	220450	2.5	>8.0	8.4			8	2.5
VV-11	2405652	221065	0.0	nr	15.3			9.3	0
VV-11A	2405649	210570	7.6	>13.0	15.5			13	7.6
VV-12	2405555	221223	0.0	nr	4.9			3.8	0
VV-12A	2405547	221237	3.5	>4.5	3			4.5	3.5
VV-14	2501063	275506	3.2	>5.8	37.2			5.8	3.2
VV-14A	2501004	275465	2.9	>9.5	36.8			9.5	2.9
VV-15	2502075	274163	0.5	>3.5	38.5			3.5	0.5
VV-15A	2502086	274165	0.0	nr	38.9			2.5	0
VV-15B	2502144	274195	0.0	nr	38.8			2.5	0
VV-15C	2502142	274202	2.7	>8.0	38.8			8	2.7
VV-16	2501539	272154	0.0	>8.0	39.4	1.1		8	6.2
VV-17	2502960	272956	8.6	>8.6	40.6			8.6	8.6
VV-18	2503897	273621	0.0	>12.0	40.3	0		12	11.2
VV-20	2506292	272862	2.0	>8.0	41.6	2		8	6
VV-21	2505900	272189	2.5	>9.0	41.9	2.5		9	6.1
VV-22	2504617	272457	2.2	>14.0	41.6	1.6		14	2.2
VV-23	2503950	271231	4.5	>11.0	41.4	4.5		11	6.8
VV-24	2502488	280899	2.9	>6.1	40.6	2.9		6.1	6.1
VV-26	2504887	269997	3.7	>12.0	41.3	5.2		12	11.2
VV-27	2506115	270325	2.4	>3.0	42			3	2.4
VV-28	2507307	271252	1.6	>3.0	41.8			3	1.6
VV-29	2508027	270112	1.3	>2.0	42			2	1.3
VV-30	2507346	268391	2.2	>3.0	42.1			3	2.2
VV-31	2505605	268945	1.5	>3.5	41.1			3.5	1.5
VV-32	2504305	268149	2.2	>3.0	40.6			3	2.2
VV-33	2505000	266994	0.0	>2.0	40.8	0		2	0.5
VV-34	2505762	265819	0.0	>2.5	42.1	0		2.5	2.1
VV-35	2506954	266603	1.0	>2.0	43	1		2	2
VV-36	2508063	267380	1.8	>3.5	44.2			3.5	3
VV-37	2509273	268282	0.0	>5.5	44	0		5.5	4.5
VV-38	2510458	266491	0.0	>3.8	43.5	0		3.8	3.5
VV-39	2509637	262576	1.7	>7.5	44	1.7		7.5	6
VV-40	2499488	256516	0.0	>2.5	44	0		2.5	1.5
VV-41	2495422	263580	0.0	>6.0	40.6	0		6	4.5
VV-42	2491718	269754	0.0	>4.0	35.2	1.5		4	3
VV-43	2486407	258785	1.0	>6.0	41.4	2.4		6	5

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
VV-45	2482652	256719	2.2	>8.5	42.6		2.7	8.5	4.5
VV-46	2482958	255505	2.3	>8.5	44.7	3.3		8.5	8.3
VV-47	2484532	254749	2.8	>13.5	44.5	2.8		13.5	11.2
VV-48	2486027	255433	2.2	>15.0	44.2	2.2		15	11
VV-49	2485416	256629	2.3	>13.5	43.8	10.3		13.5	11.2
VV-50	2486982	257302	0.0	>6.0	43.5	3		6	5.5
VV-51	2487730	256257	2.6	>14.5	44.1	11.9		14.5	13.5
VV-52	2488860	254451	3.5	>6.0	44.2			6	3.5
VV-53	2486935	253564	2.7	>5.0	44.8			5	2.7
VV-54	2484369	252644	0.0	>2.5	45.8			2.5	1.7
VV-55	2485884	251471	0.0	>2.0	47	0		2	0.8
VV-55A	2485939	251355	1.8	>2.5	47.2			2.5	1.8
VV-56	2487546	252313	1.7	>2.5	45.3			2.5	1.7
VV-57	2489440	253261	0.0	>3.5	44			3.5	0.8
VV-57A	2489444	253270	1.1	>3.0	44			3	1.1
VV-58	2490369	251201	2.8	>4.5	45.2			4.5	2.8
VV-59	2488580	250691	1.9	>9.0	46.5	5.4		9	7
VV-60	2486301	248815	0.0	>4.5	46	0		4.5	1.5
VV-61	2477892	239174	0.8	>3.0	48.1	0.8		3	1.8
VV-62	2476691	240820	1.5	>2.5	46.5			2.5	1.5
VV-63	2476043	238052	3.0	>3.5	45.9			3.5	3
VV-64	2474064	236820	1.5	>2.0	46.3			2	1.5
VV-65	2475125	239464	5.5	>6.0	45.7			6	5.5
VV-66	2473160	238127	1.4	>5.0	46.3	1.4		5	3.3
VV-67	2472095	239882	1.8	>7.5	45.8		3.5	7.5	7.5
VV-69	2473956	241227	3.7	>4.5	43.6			4.5	3.7
VV-70	2475742	242314	5.0	>6.5	44.8			6.5	5
VV-71	2477107	243276	3.0	>6.0	45.5			6	3
VV-72	2474488	244122	2.8	>4.5	43.6			4.5	2.8
VV-73	2472849	242877	1.4	>5.0	45	1.4		5	3.4
VV-74	2470966	241795	5.5	>6.5	46.2			6.5	5.5
VV-75	2469942	241129	19.0	>20.0	47			20	20
VV-76	2468702	242807	2.1	>20.0	46.9			20	20
VV-77	2469856	243625	2.3	>12.5	45.7	2.3		12.5	3.5
VV-78	2471598	244760	4.0	>10.5	44.8			10.5	4
VV-79	2473286	245846	2.3	>5.0	44.1	2.3		5	3.4
VV-80	2474617	246676	1.4	>7.0	44.8			7	5.5
VV-81	2472030	247606	2.3	>6.5	44	2.3		6.5	3
VV-82	2470682	246253	2.5	>7.0	44.3			7	5.5
VV-83	2472223	249946	0.0	nr	42.9			6	0
VV-83A	2472201	249985	0.0	nr	42.9			8	0
VV-83B	2472198	250029	8.5	>20.0	42.9			20	20
VV-84	2471042	249039	0.0	>15.0	43.9			15	13
VV-86	2473488	239676	14.8	>16.0	44.3			16	14.8
VV-88	2470230	238742	2.0	>2.5	46.7			2.5	2
VV-89	2468728	240116	2.0	>3.0	45.7			3	2
VV-90	2467436	239106	1.3	>3.0	46	0.5		3	1.3
VV-91	2466064	238069	3.5	>5.0	46.8			5	3.5
VV-92	2467198	236226	0.0	nr	48.7			4	0
VV-94	2460076	236136	0.0	>20.0	46.1			20	2

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
VV-96	2462418	232475	3.2	>20.0	46.9			20	19
VV-97	2458752	229556	0.0	>20.0	46.4			20	20
VV-98	2457121	231835	2.8	>20.0	45.5			20	19
VV-100	2454475	235648	1.5	>20.0	45.5			20	1.5
VV-103	2451441	230442	2.6	>15.0	47.4			15	12.3
VV-104	2452974	228377	1.0	>15.0	50.1			15	9.6
VV-105	2416114	230784	5.8	>7.8	6.7			7.8	5.8
VV-106	2416128	230715	4.6	>7.1	7			7.1	4.6
VV-107	2414533	229679	3.3	>4.0	3.5			4	3.3
VV-109	2413061	228346	1.2	>3.9	6.1			3.9	1.2
VV-110	2413048	228399	4.6	>9.5	10.6		5.8	9.5	7.5
VV-111	2411892	226783	1.2	>4.5	6.2			4.5	1.2
VV-112	2411944	226781	3.7	>5.1	7.1			5.1	3.7
VV-113	2410369	225368	0.0	nr	4.4			3.4	0
VV-113A	2410366	225365	0.0	nr	4.6			3	0
VV-113B	2410362	225374	0.0	nr	4.6			3.9	0
VV-113C	2409998	225276	1.2	>3.5	3.5			3.5	1.2
VV-113D	2410102	225259	2.8	>4.0	6.7			4	2.8
VV-116	2407109	214363	7.0	>9.9	35.7			9.9	7
VV-118	2410177	214057	0.0	nr	41.2			5	0
VV-118A	2410166	214103	0.0	nr	40.5			5	0
VV-121	2404767	212285	1.7	>9.0	33.3		2.9	9	7.7
VV-122	2405577	209655	1.3	>9.4	38.8		1.3	9.4	7.9
VV-123	2402703	210407	1.5	>9.9	33.5			9.9	4.3
VV-124	2404413	208624	2.0	>17.0	38.5			17	15
VV-125	2402974	207216	2.0	>12.1	38.9			12.1	12.1
VV-126	2401043	205429	4.8	>11.0	38.7			11	11
VV-127	2398297	202867	4.9	>5.9	39.8			5.9	4.9
VV-128	2400223	200904	0.0	>7.3	43.8		3.5	7.3	7.3
VV-129	2401453	202085	2.5	>8.3	40.9		6.7	8.3	8.3
VV-130	2404306	204848	8.3	>8.3	42.6			8.3	8.3
VV-131	2407242	207553	0.0	>6.6	42.2		2.5	6.6	6.6
VV-132	2408912	209079	5.4	>5.4	42.2			5.4	5.4
VV-133	2410632	210637	1.4	>7.5	44.1			7.5	7.1
VV-134	2412256	212152	3.5	>5.0	41.4			5	3.5
VV-135	2409681	216446	6.3	>13.0	36.7			13	12.8
VV-136	2409536	216575	1.5	>5.0	36.8			5	1.5
VV-137	2407185	222496	6.8	>6.8	3.7			6.8	6.8
VV-137A	2407377	222409	3.0	>3.2	7.5			3.2	3.2
VV-138	2408640	223907	4.3	>3.8	5.8			3.8	3.8
VV-138A	2408751	223888	3.0	>3.0	8.1			3	3
VV-139	2406144	217430	5.0	>5.0	6.5			5	5
VV-140	2404650	217699	0.0	nr	11.1			3.6	0
VV-140A	2404641	217702	0.0	>5.0	10.4			5	0
VV-141	2403599	217481	5.0	>5.0	7.8			5	5
VV-142	2402640	217391	4.4	>4.4	11.4			4.4	4.4
VV-143	2401814	218358	3.8	>3.8	13.7			3.8	3.8
VV-144	2401932	219357	1.0	>6.2	13.5		1	6.2	6.2
VV-145	2417324	232237	4.4	>4.4	3.1			4.4	4.4
VV-145A	2417388	232204	4.2	>4.2	6.4			4.2	4.2

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
VV-146A	2418858	233443	3.0	>6.0	7.7			6	3
VV-147A	2420418	234450	3.5	>4.9	8			4.9	3.5
VV-148	2421726	235951	4.6	>7.0	2.8			7	4.6
VV-148A	2421791	235910	3.0	>5.0	5			5	3
VV-149	2423244	237477	4.0	>6.2	7			6.2	4
VV-149A	2423306	237489	2.8	>5.0	6.7			5	2.8
VV-150	2424588	238643	5.0	>7.5	3.1			7.5	5
VV-150A	2424644	238638	1.3	>3.1	3.1			3.1	1.3
VV-151	2425207	240945	6.5	>6.5	2.4			6.5	6.5
VV-151A	2425279	240934	1.5	>5.0	4.5		1.5	5	5
VV-152	2424165	241969	5.2	>10.0	3.9			10	5.2
VV-153	2423797	242578	5.4	>10.0	2.9			10	7
VV-153A	2423803	242560	6.2	>10.2	2.1			10.2	7.5
VV-159	2478024	261825	4.9	>6.8	38.6			6.8	6.8
VV-160	2475354	262615	0.0	>10.0	38			10	10
VV-161	2474280	264524	4.2	>4.2	35.4			4.2	4.2
VV-163	2477844	265816	3.2	>4.0	35			4	3.4
VV-164	2476944	267622	0.0	nr	33.9			0	0
VV-164A	2476999	267674	0.0	>3.6	34.8			3.6	3.6
VV-165	2476131	269345	0.0	>5.3	33			5.3	5.3
VV-166	2474449	268211	2.5	>2.5	34.2			2.5	2.5
VV-167	2499232	289904	4.5	>4.5	3.2			4.5	4.5
VV-168	2499653	291597	1.5	>4.5	9.2			4.5	1.5
VV-169	2499613	292627	2.8	>5.0	1.9			5	2.8
VV-170	2401680	199432	1.0	>20.0	42.4		2.2	20	19.7
VV-171	2403211	197330	1.7	>16.0	42.8		6.9	16	11
VV-172	2404511	195062	1.0	>18.0	44.4		7.5	18	15
VV-173	2407178	193823	1.2	>20.0	44.2		1.2	20	10.8
VV-174	2409207	191693	2.3	>6.0	45.5		2.3	6	5.8
VV-175	2410992	189848	0.0	>14.0	46.4			14	12.6
VV-176	2412837	187952	1.0	>17.0	47.5			17	14.5
VV-177	2414715	189749	0.0	>10.0	46.5			10	8.5
VV-179	2411791	194146	0.0	>10.0	46			10	9.1
VV-180	2409234	195736	0.0	>9.0	44.2			9	7
VV-182	2409287	199517	4.3	>8.0	44.7			8	7.6
VV-184	2414179	196288	0.0	>20.0	47.1		3.2	20	18.7
VV-185	2415302	193753	4.5	>20.0	46.5		6.5	20	18.3
VV-186	2417347	192119	3.3	>20.0	47.7		6.2	20	17.8
VV-187	2407902	204964	4.0	>15.0	42.5			15	13
VV-188	2409013	202653	7.8	>10.0	44.2			10	10
VV-189	2411275	201372	9.3	>15.0	45.5			15	14
VV-190	2413215	199408	1.4	>15.0	47.5			15	14
VV-191	2415210	197315	0.8	>20.0	47.2		4.5	20	19.5
VV-192	2417022	195388	2.0	>4.0	47		2	4	3
VV-196	2412135	202063	1.6	>8.6	44.8			8.6	8
VV-197	2414068	200168	4.0	>14.3	45.5		6.5	14.3	12
VV-198	2418885	193430	3.0	>10.5	46.5			10.5	8
VV-199	2420955	195485	2.2	>7.4	46.6			7.4	5
VV-200	2419104	197378	1.3	>8.5	46.3		1.3	8.5	6.7
VV-201	2417406	199345	0.0	>3.7	46.1			3.7	2.5

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
VV-202	2416026	201998	3.7	>9.3	46.3			9.3	7.6
VV-203	2414052	203893	3.2	>4.0	43.4			4	3.2
VV-204	2412016	205448	1.4	>15.0	43.6		4	15	9.4
VV-205	2410957	207734	2.0	>18.6	43.2		2	18.6	12
VV-206	2412238	208881	0.0	>3.0	44.2			3	1.5
VV-208	2415564	205206	3.2	>3.5	49			3.5	3.2
VV-209	2417402	203240	0.0	nr	44.4			2	0
VV-209A	2417412	203231	0.0	nr	47.8			2	0
VV-210	2419363	201064	1.0	>1.7	47.3			1.7	1
VV-211	2421161	199148	0.8	>1.2	49.1			1.2	0.8
VV-212	2422944	197201	0.0	nr	49.9			9.5	0
VV-212A	2422952	197200	1.5	>9.7	49.7			9.7	8
VV-213	2424730	198909	1.4	>2.6	49.9			2.6	1.4
VV-214	2423188	201056	0.0	>8.7	50.5		0	8.7	6.3
VV-215	2421469	203113	1.2	>3.4	49.4	1.2		3.4	3.4
VV-216	2419338	205038	2.1	>2.9	48.2			2.9	2.1
VV-217	2417713	207313	0.0	nr	45.4			0.4	0
VV-218	2415460	210149	1.8	>1.8	45.3			1.8	1.8
VV-220	2414662	211075	3.7	>3.7	44.2			3.7	3.7
VV-221	2416925	210105	1.8	>5.4	46.7			5.4	3.6
VV-222	2419581	208964	1.6	>6.2	45.4	1.6		6.2	4.3
VV-223	2421422	206932	3.0	>8.6	43.5			8.6	3.7
VV-224	2423382	204873	2.0	>6.2	46.4			6.2	6.2
VV-225	2425197	202896	0.0	nr	46.9			3.3	0
VV-225A	2425316	202799	0.0	nr	47			3.9	0
VV-225B	2425320	202789	1.8	>4.6	46.8			4.6	4.6
VV-226	2426996	200873	1.5	>2.1	47.8			2.1	1.5
VV-228	2425464	206734	6.7	>10.0	46.9			10	6.7
VV-229	2427160	204809	1.2	>7.2	48.5			7.2	6.3
VV-230	2428243	202087	0.0	>12.0	48.3		2.5	12	11.8
VV-231	2430211	201136	2.7	>5.6	48		2.7	5.6	5
VV-232	2432886	203642	1.8	>5.0	48.3	2.8		5	4
VV-233	2430968	204647	0.0	>3.1	48.5			3.1	2.6
VV-234	2420980	206495	0.5	>0.7	48.3			0.7	0.5
VV-235	2425348	214315	1.5	>3.9	45.8			3.9	2.5
VV-236	2427253	212294	0.0	>2.9	46.8			2.9	1.2
VV-237	2429152	210165	1.5	>2.3	49.1			2.3	1.5
VV-238	2430958	208179	1.8	>2.2	48.3			2.2	1.8
VV-239	2432775	206175	1.5	>2.4	48.1	1.5		2.4	2.4
VV-240	2435058	208427	2.8	>9.6	50			9.6	2.8
VV-241	2432931	210063	4.0	>9.4	49		4	9.4	7.1
VV-242	2435123	211995	0.0	nr	49			2	0
VV-242A	2435128	211996	0.0	nr	49.5			2	0
VV-243	2437071	210130	0.0	nr	50.6			3.2	0
VV-244	2438605	211705	0.0	nr	50.5			2	0
VV-246	2439717	216282	1.3	>2.1	48			2.1	1.3
VV-247	2440972	217380	1.3	>3.2	48.2			3.2	2.2
VV-248	2444245	216680	1.4	>2.4	50.1			2.4	2.2
VV-249	2442339	218748	0.0	nr	49			1.1	0
VV-250	2440500	220698	0.0	nr	46.7			0	0

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
VV-251	2436610	224756	2.0	>6.0	45.9		2	6	4.8
VV-252	2434772	223711	2.0	>10.0	47.4			10	2
VV-253	2441995	222006	0.0	>1.6	46.8	0		1.6	1
VV-254	2443841	220035	5.0	>5.0	49			5	5
VV-255	2447034	219186	1.2	>9.0	48.7			9	2
VV-256	2448158	220344	2.0	>4.0	47.3			4	2
VV-257	2445224	221258	3.0	>5.9	47.5			5.9	3
VV-258	2443444	223428	2.8	>4.3	46.5			4.3	2.8
VV-259	2442451	224621	0.0	>9.5	45.3			9.5	3
VV-260	2441715	225561	2.2	>5.3	44.4			5.3	2.2
VV-261	2439854	227722	0.0	>6.4	43.6			6.4	6.4
VV-262	2438888	228904	2.4	>12.0	43			12	12
VV-263	2406107	221247	2.0	>10.0	9.8			10	2
VV-264	2438118	236792	1.5	>2.3	41.9	1.2		2.3	1.5
VV-265	2438837	234153	0.0	>8.5	43.1			8.5	6.3
VV-266	2440351	235416	2.0	>2.7	42.4			2.7	2
VV-267	2441945	233949	1.2	>2.9	44.2			2.9	2.2
VV-268	2443620	232811	1.4	>5.3	44			5.3	2.4
VV-269	2442211	231568	0.0	nr	43.1			1	0
VV-269A	2442210	231560	1.4	>4.5	43			4.5	2.2
VV-270	2442971	230589	0.0	nr	42.4			1.7	0
VV-270A	2442972	230588	2.0	>10.0	46.3			10	8.5
VV-272	2441842	229531	0.0	>17.5	43.8			17.5	14.5
VV-274	2445136	224947	0.0	>20.0	46			20	20
VV-275	2446608	222655	5.5	>10.5	47.7			10.5	8.3
VV-276	2448700	223410	0.0	>11.2	47.6			11.2	11
VV-277	2449877	221893	0.0	>10.6	49.3			10.6	1.5
VV-278	2452269	221147	0.0	>18.2	50			18.2	18.2
VV-279	2454634	226305	1.1	>6.3	47.9	1.1		6.3	6.3
VV-280	2450245	225928	0.9	>12.6	48.1			12.6	12.6
VV-281	2448323	227719	3.4	>11.7	44			11.7	11.7
VV-282	2446463	226239	0.0	>9.6	47			9.6	8.8
VV-283	2448305	227724	3.2	>12.2	42.4			12.2	12.2
VV-284	2446479	226211	2.3	>15.3	44.7	8		15.3	15.3
VV-285	2444775	228340	1.0	>13.3	43.8			13.3	13.3
VV-287	2447379	231004	0.0	>2.8	43.6			2.8	0.5
VV-289	2451480	234471	0.0	>15.8	44.2		0	15.8	15.8
VV-290	2452784	235716	1.3	>7.5	44.5			7.5	7.5
VV-291	2449757	237947	0.0	>18.0	41.8		0	18	18
VV-292	2448026	236527	0.0	>3.4	42.3			3.4	0.5
VV-293	2446637	235278	0.0	>11.9	43.8			11.9	11.9
VV-294	2440106	235749	3.5	>3.5	40.4			3.5	2.8
VV-295	2441696	236170	1.8	>5.1	42.7		1.8	5.1	4.2
VV-296	2442920	237499	2.7	>5.8	40.8			5.8	5.8
VV-297	2444797	239030	2.3	>8.5	41.1			8.5	8.5
VV-298	2443270	241603	1.4	>5.7	39.9			5.7	5.7
VV-299	2447118	240717	0.0	>7.8	40.8			7.8	0.5
VV-300	2452270	244450	0.0	>2.3	42.9	0		2.3	2.3
VV-301	2454452	244900	1.0	>10.6	43.2			10.6	10.6
VV-302	2453106	246897	7.5	>10.0	39.8			10	8

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
VV-302A	2501169	283953	0.0	>5.5	25.8	3.8		5.5	5.3
VV-303	2503639	284535	0.0	>2.0	25	0		2	0.5
VV-304	2500642	287710	8.0	>8.0	3.4			8	6.7
VV-305	2502175	286034	3.5	>5.7	8.8			5.7	3.5
VV-306	2501171	283968	1.3	>4.6	25.7			4.6	3.8
VV-307	2503628	284480	0.0	nr	24.9			3	0
VV-307A	2503614	284526	0.0	>4.0	24.8			4	3.8
VV-308	2504910	286664	2.3	>2.5	22			2.5	2.3
VV-309	2505250	288560	0.0	>2.0	18.3	0		2	0.5
VV-310	2516644	285682	0.0	>3.0	33.2	0		3	2.8
VV-312	2469899	265312	7.7	>8.0	36.1			8	7.7
VV-313	2467127	263530	1.6	>6.7	36.8	3	1.6	6.7	6.3
VV-314	2468301	261669	0.0	>14.5	39.4	10.2	0	14.5	14.5
VV-315	2466410	258404	0.0	>8.0	40.4		0	8	8
VV-316	2468077	255775	2.7	>14.5	41.3			14.5	14.5
VV-318	2470744	257631	2.0	>14.0	40.5		9.3	14	14
VV-319	2471737	256100	1.3	>12.5	40		1.3	12.5	11.8
VV-321	2472685	254452	1.5	>2.5	40.6			2.5	2
VV-322	2468774	253656	6.1	>14.0	41.9			14	13.6
VV-324	2467573	250846	7.0	>7.5	41.6	0		7.5	7
VV-325	2466719	252128	2.0	>15.5	42.7			15.5	13
VV-327	2464437	255546	4.0	>17.0	41	6		17	16.5
VV-328	2461502	259819	1.5	>11.0	37.4			11	10.5
VV-329	2455283	255367	0.0	>12.0	40.4			12	11.4
VV-330	2450050	251475	0.0	>4.5	37.5	0		4.5	3.8
VV-331	2457866	251146	0.0	nr	43			6.8	0
VV-331A	2457914	251153	6.5	>6.5	43.2			6.5	6.2
VV-332	2459067	249312	0.0	>20.0	43.8			20	17
VV-334	2525141	272241	3.0	>5.0	44.1			5	3
VV-335	2520721	278853	0.8	>4.0	42.2	0.8		4	2.8
VV-336	2468822	245201	1.8	>5.5	45.2	1.8		5.5	5.2
VV-337	2464860	246355	1.9	>12.5	44.1			12.5	12
VV-338	2459103	249286	4.0	>7.5	43.5			7.5	7.1
VV-339	2460084	247667	1.5	>4.5	42.7	3		4.5	3.9
VV-340	2461068	246123	1.8	>8.0	42.8	6.4		8	7.8
VV-341	2462896	243159	4.3	>14.5	44.2			14.5	14.2
VV-342	2463803	241778	2.0	>20.0	44.3	18		20	20
VV-343	2465143	239614	5.0	>10.5	46			10.5	10.3
VV-344	2463425	239128	2.3	>3.0	45.7			3	2.3
VV-345	2460486	241349	3.0	>3.5	42.3			3.5	3
VV-346	2459853	242888	3.0	>10.0	42.5			10	9.4
VV-347	2458798	244496	1.3	>5.5	43.2			5.5	4.8
VV-348	2457178	247968	0.0	>16.0	42			16	15.6
VV-349	2455844	247042	3.9	>7.5	42.1			7.5	6.9
VV-350	2455924	242541	1.6	>5.5	43.4			5.5	4.9
VV-351	2456911	241055	2.8	>8.5	44.5			8.5	8.2
VV-352	2514423	274549	1.5	>6.0	41.3	1.5		6	6
VV-353	2509879	280775	0.0	>2.0	35		0	2	2
VV-354	2461444	259878	0.0	>17.0	36			17	17
VV-355	2455291	255326	0.0	>5.5	39.5			5.5	5.5

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
VV-356	2450079	251499	0.0	>4.5	36.8	2.7		4.5	4.5
VV-357	2454152	241218	0.0	>5.5	44.2	3.5		5.5	5.5
VV-358	2456362	238426	1.5	>1.5	44.8			1.5	1.5
VV-359	2459093	237658	1.0	>15.5	46.6			15.5	15.5
VV-360	2445742	248297	0.0	>3.0	39.3			3	1.5
VV-361	2440880	244804	1.0	>4.6	39	2.8		4.6	4.6
VV-362	2435085	240823	0.0	>3.0	37.8			3	2.2
VV-363	2408123	217889	4.0	>8.0	18.9			8	4
VV-364	2410443	220053	11.0	>14.0	23.8			14	11
VV-365	2411909	218452	2.0	>13.0	35.5			13	10.6
VV-366	2430845	219459	1.5	>10.0	45.5			10	7.9
VV-367	2432863	217387	2.0	>10.0	44.8			10	6.4
VV-368	2434912	215500	1.0	>11.0	47.5			11	9.4
VV-369	2438810	213570	5.0	>10.0	48	1		10	5
Cores with discrepancies in WD spreadsheets and data files						(in blue)			
	Assumed summary thickness correct for following cores, used in mapping (23):								
VV-13	2502124	275681	0.0	>12.3	37.5	0		12.3	12.3
VV-19	2505131	274521	6.0	>6.0	39			6	6
VV-25	2503595	269196	4.6	>5.0	40.7			5	4.6
VV-44	2484826	257985	3.7	>8.0	43.3			8	7
VV-68	2471208	239311	6.0	>6.0	46.7			6	6
VV-85	2469443	247945	13.0	>15.0	43.9			15	13
VV-87	2471985	237756	5.8	>12.5	46.7	7.3		12.5	8.5
VV-93	2463079	236840	10.3	>20.0	46.7			20	18.5
VV-99	2455852	233723	8.3	>20.0	46.7			20	20
VV-114	2407801	214985	0.0	>15.3	36.2			15.3	15.3
VV-115	2407647	214318	0.0	>8.6	36.5			8.6	6.3
VV-154	2481031	259452	0.0	>3.8	38.2			3.8	2.5
VV-155	2479764	254889	0.0	>2.8	39.6			2.8	1.2
VV-157	2477209	259417	10.0	>10.0	40			10	10
VV-158	2476330	260902	3.8	>11.0	38.2			11	11
VV-162	2476047	265852	6.0	>6.0	35.2			6	6
VV-271	2440561	230118	6.9	>10.3	43.1			10.3	10.3
VV-273	2442919	226716	11.0	>13.7	45.2			13.7	11
VV-286	2446186	229702	4.0	>13.0	42			13	13
VV-311	2473266	266419	15.1	>18.2	36.4			18.2	15.1
VV-320	2474725	255655	14.0	>14.0	40.5			14	13.6
VV-323	2469693	252300	12.4	>13.5	40.6			13.5	13.1
VV-326	2465522	253829	12.7	>16.5	42.3			16.5	16
	Following cores not used for suitable sand mapping due to discrepancies (20):								
VV-09A	2404346	220561	0.0	mr	4.7			2	0
VV-217A	2417691	207324	0.0	mr	45.3			0.5	0
VV-250A	2440430	220690	0.0	mr	46.7			0	0
VV-117	2408685	212623	5.0						
VV-146	2418813	233514	0.0						
VV-152A	2424231	241955	4.6						
VV-156	2478180	257771	0.0						
VV-193									
VV-219	2413590	210149	1.6						

Core ID	Easting	Northing	Suitable Sand Thickness	Overall Sediment Thickness	Water Depth	Gravel Depth	Silt Depth	Total Penetration	Total Recovery
VV-288	2449726	232913	1.2						
VV-317	2473670	259277	4.5						
VV-92A	2461880	236218	1.8	>5.0	48.7			5	3.7
VV-95	2461216	234462	13.8	>18.5	47			18.5	17.3
VV-100A	2454477	235648	1.5	>12.0	45.7			12	8.5
VV-101	2454345	235633	1.5	>15.0	46.3		1.5	15	12.5
VV-102	2453664	233932	3.0	>18.0	45			18	14.3
VV-108	2416128	229647	3.7	>5	8			5	3.7
VV-147	2420240	234509	4.3	>5.9	4.8			5.9	4.3
VV-245	2441678	214522	2.5	>3.2	47.2			3	2.5
VV-333	2518697	268257	1.8	>4.5	38.4		1.8?	4.5	4.5
	Following cores deleted by WD for excessive fines 7-29-04 (9):								
VV-119	2411530	214616	0.0	>9.0	42.1			9	2.4
VV-120	2406882	210869	0.0	>9.0	39.5			9	2.4
VV-178	2413316	191142	0.0	>20.0	46.3			20	17
VV-181	2407127	197488	0.0	>9.0	44			9	7.7
VV-183	2411241	197600	0.0	>5.0	45.7			5	4.6
VV-194	2409639	206546	0.0	>6.5	42.7			6.5	6.5
VV-195	2410409	204021	0.0	>5.6	43.7			5.6	3.8
VV-207	2413829	207127	0.0	>3.4	46.2			3.4	3.1
VV-227	2423584	208874	0.0	>10.0	47.7			10	6.3

NOTES:

1. Position coordinates referenced to NC State Plane System, Zone 3200 in feet, NAD 83.
2. Suitable sand thickness determined by the Wilmington District Corps of Engineers (WD).
3. Overall sediment thickness estimated to be equivalent to the total core penetration.
4. Sand found below gravel layer at following locations; VV-73, 215, 222, 284, 314, 324, 327.
5. Organic deposits with wood fragments found at locations VV-22 and VV-164A.
6. Silt equivalent to "ML" and "MH" layers logged in the cores.
7. Discrepancies include missing core logs, samples missing from grain size spreadsheet, coordinates that do not match, and suitable sand values that do not agree.

APPENDIX C

SURVEY INSTRUMENTATION AND PROCEDURES

DATA PROCESSING AND ANALYSIS

SURVEY INSTRUMENTATION AND PROCEDURES

Trimble 4000 Differential Global Positioning System using US Coast Guard Beacon

The Trimble 4000 GPS receiver interfaced with a Leica MX52R Coast Guard beacon receiver provides a reliable, high-precision satellite positioning/navigation system for a wide variety of operations and environments. In operation, the beacon receiver continuously receives differential satellite correction factors via radio link from a DGPS Coast Guard Beacon. The 4000 receiver continuously tracks up to 9 satellites, accepts the correction factors via the beacon receiver interface, and applies the corrections to obtain a high-accuracy real-time position fix. This Trimble 4000 system provides corrected position fixes at the rate of one fix per second. A second interface port on the 4000 unit enables the operator to record all position data, raw measurement data, and navigation data onto a personal computer and interface it with the software navigation package.

In this system configuration, the manufacturer's reported positioning accuracy is +/- 3 feet. The Coast Guard beacon located at New Bern, North Carolina (frequency of 294 kHz at 100 bps) was used during the survey with good reliability and signal strength.

Coastal Oceanographic's HYPACK Navigation Software

Survey vessel trackline control and position fixing were obtained by utilizing an OSI computer-based data logging package running Coastal Oceanographic's HYPACK navigation software. Vessel position data from the Trimble 4000 receiver were updated at 1.0 second intervals and input to the navigation system which processes the geodetic position data into state plane coordinates and are 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 preplotted trackline as the survey progresses. Digitized shoreline and the locations of existing structures, buoys, and control points can also be displayed on the monitor in relation to the vessel position. The HYPACK navigation software provides 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.

Prior to commencement of the fieldwork, a trackline file was generated for use with the navigation software, which included the lines to be surveyed with the remote sensing systems.

In addition, the shoreline was digitized from the NOAA charts and incorporated into the on-screen display. Horizontal control points were also displayed for the helmsman to navigate toward for performing daily navigation checks.

Innerspace Model 448 Depth Sounder

Precision water depth measurements were obtained by employing an Innerspace Model 448 depth sounder with a 200 kHz, 8°-beam transducer. The Model 448 recorder provides precise, high-resolution depth records using a solid-state thermal printer as well as digital data output, which allows integration with the navigation software. The Model 448 also incorporates both tide and draft corrections plus a calibration capability for local water mass sound speed.

Sound speed calibrations were accomplished by performing "bar checks". The bar check procedure consists of lowering an acoustic target on a measured sounding line to the specified project depth. The speed of sound control is adjusted such that the target reflection is printed precisely at this known depth on the recorder. The acoustic target is then raised to successively shallower depths and calibration readings at these depths are recorded. Variations, which exist in the indicated depth at these calibration points, are incorporated in the sounding data processing to produce maximum accuracy in the resulting depth measurements. Bar checks were performed at the beginning and end of each field day to check the sound speed calibration.

TSS DMS-05 Motion Sensor

The TSS DMS-05 motion sensor was designed for use with multibeam echosounders and incorporates advanced processing techniques and high grade inertial sensing elements to attain heave, pitch, and roll measurements with high dynamic accuracy and immunity to vessel turns and speed changes. The DMS-05 allows full utilization of all echosounder beams and survey capabilities to IHO standards. The system has a heave range of 10 meters with a 1 centimeter resolution. Roll and pitch parameters can be measured digitally to a 0.05° dynamic resolution over a ±30° range. Standard NMEA output strings provide an easy interface with other equipment. Digital data are logged by the HYPACK navigation computer. The DMS-05 permits survey operations to continue through degrading weather conditions, increasing project productivity and efficiency.

KVH AutoComp 1000 Flux Gate Compass

The KVH AutoComp 1000 fluxgate compass was used to measure magnetic compass headings along survey tracklines. The AutoComp 1000 incorporates next generation electronic fluxgate technology to provide 0.5 degree accuracy and an automatic compensation system that automatically corrects for compass deviation on the vessel, without a compass adjuster. The system automatically calibrates itself after installation by steering the survey vessel in a circle so the microprocessor controlled unit can measure, process, and compensate for the magnetic field. The unit corrects for B, C, D, and E coefficient errors, while standard NMEA 0183 output provides easy interfacing with other equipment. The digital data is logged on the HYPACK navigation computer.

EdgeTech XStar "Chirp" Subbottom Profiling System

High resolution subbottom profiling was accomplished utilizing an EdgeTech XStar Full Spectrum "Chirp" Subbottom Profiler system operating with frequencies of 0.5-12 kHz. The subbottom profiler consists of three components: the deck unit (Pentium III PC processor, amplifier, monitor, keyboard, and trackball), an underwater cable, and a Model 512 towed vehicle housing the transducers. Data is displayed on a VGA monitor and EPC 1086 thermal printer while saved in a SEG Y digital format on the XStar computer.

The XStar 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.

The "chirp" subbottom profiler is designed for acquiring high resolution subsurface data from the upper portions of the stratigraphic column (20-150 feet depending on site conditions). The higher end frequencies allow good resolution of subbottom layering while the lower end acoustic frequencies provide significant penetration. This particular system is capable of providing excellent acoustic imagery of the subsurface in a wide variety of marine environments and is a good balance between resolution and penetration.

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.

Applied Acoustics Engineering "Boomer" Seismic Reflection System

Deeper subsurface exploration was accomplished utilizing an Applied Acoustics 100-300 joule "boomer" system comprised of a boomer plate, power supply, hydrophone array, TSS-model 360 filter and time-varied-gain system, and an EPC 1086 thermal paper recorder. The "boomer" employs a sound source that utilizes electrical energy discharged from a capacitor bank to rapidly move a metal plate in the transducer bed. The short-duration motion of the metal plate creates a broad band (500–8000 Hz) pressure wave capable of penetrating hundreds of feet of marine sediments under suitable site conditions.

For each outgoing pulse, the sequence of reflected return signals from sediment interfaces within the subbottom is received on the multi-element hydrophone array. Received signals are electronically filtered to remove noise and harmonics, amplified, and displayed trace-by-trace iteratively on the graphic recorder to yield a continuous display somewhat analogous to a geologic cross-section.

Operationally, the subbottom profiling system is installed aboard the survey vessel along with other instrumentation, such as precision hydrographic equipment, and operated along the desired survey lines. Both the energy source and the hydrophone array are deployed in an appropriate configuration to minimize the recording of background noise generated by the survey vessel. For this investigation, the seismic source and hydrophone array were deployed astern of the vessel and electronic filter settings were adjusted to an approximate bandwidth of 800-3500 Hz. This towing configuration and filter setting provided a relatively quiet environment even in moderately rough sea conditions.

DATA PROCESSING AND ANALYSIS

Survey Trackline Reconstruction

Initially, vessel position data were reviewed in the field to ensure proper coverage of the survey area prior to onsite demobilization. Upon completion of the field work and return to the OSI office, survey tracklines were reconstructed and computer plotted from the x-y coordinates logged by the HYPACK navigation computer. The trackline plots were then used in the subsequent tasks of data interpretation and positioning of the hydrographic and seismic reflection data.

Hydrographic Data

Digitally recorded depth data were first checked against the graphic records for verification of depth quality. Erroneous digital depth points recorded during the survey were removed from the data set. These may be caused by debris in the water column such as a passing ship's wake (air bubbles), suspended material, fish or mammals, as well as densely populated communities of plants attached to the seafloor (sea grasses), if present. Recorded raw depth data were adjusted for the draft of the transducer and changes in water mass sound speed as determined from the bar check information.

The depth data were then referenced to the Mean Lower Low Water (MLLW) datum by applying tide data based on two predicted tide stations, New Topsail Inlet and New River Inlet, after adjusting predicted readings by the difference between predicted and actual tides recorded at the NOAA tide station at the Duke University Marine Lab in Beaufort, NC the closest actual tide station. This was necessary to account for meteorological conditions during the field investigation which were not reflected in the predicted tides and generally consisted of strong southerly winds. All final water depth data have been referenced to MLLW on the drawings.

Contouring of the data set was accomplished using the computer software package "QuickSurf" V. 5.2 (Schreiber Instruments, Inc. 1996). QuickSurf is a general purpose surface modeling system that operates totally within AutoCAD. QuickSurf imports processed survey data points (x,y,z) into an AutoCAD or MicroStation format drawing and generates surface models from these data. A number of contouring methods are available for different data applications and site specific conditions. A suite of sophisticated tools allows the user to manipulate modeled surfaces into high-quality finished maps and perform a variety of engineering computations.

Seismic Reflection Data

"Chirp" Profiles

The "chirp" profiles collected in the survey area were processed using the seismic analysis software package REFLEXW (Sendmeier Software Version 2.5). The program is a 32 bit software package which runs in the Windows 2000 environment and allows the user full control over signal processing functions such as filtering, stacking, and multiple gain adjustment options. HYPACK navigation files are merged with the seismic data to generate the event marks unique to each survey trackline. Acoustic reflectors of interest to the project can then be picked manually in a cross sectional format on the monitor or automatically by the program.

Since the vertical axis of the seismic records is signal travel time and not material thickness, a conversion from time to thickness or reflector depth was performed. A constant propagation velocity of 5,000 feet per second was used during depth and thickness computations in this investigation as an average representative velocity of the saturated marine sediments overlying the acoustic basement. Multiple layer modeling of the seismic traces allows different velocities to be assumed for each layer, if appropriate. The program performs the time to distance/depth conversions using the input velocities and produces a corrected geologic cross section. Digital files can be exported containing the bottom and subbottom reflector depths in a number of formats for use with other modeling and mapping type programs.

In general, the processing steps performed using the REFLEXW program are as follows:

1) File conversion and geometry input
   SEGY formatted reflection shot point files were imported into ReflexW. All survey geometry parameters contained in the file headers were checked and corrected when necessary.

2) Navigation and Position Fix Input
   Trace coordinates were checked with the raw HYPACK navigation files to ensure proper layback of the data. Event or fix numbers were then integrated with the SEG Y "chirp" files for correlation with tracklines and other data.

3) Band Pass Filtering
   A 1-D bandpass filter (~1500-5000 Hz) was applied to all traces to increase the signal/noise ratio improving the interpretability of reflected arrivals. This helped minimize interference recorded from the "boomer" system.

4) Deconvolution
   A spiking-deconvolution using the recursion-algorithm of Levinson (Wiener-Filter method) was applied to concentrate the signal wavelet in the time domain creating a highly broadband and smooth spectrum.

5) Envelope Calculation
   A complex trace-analysis was carried out using the Hilbert-Transformation to calculate the envelope or instantaneous amplitude. This instantaneous attribute gave an overview of the energy distribution of the traces and facilitated the determination of "chirp" signal arrivals.

6) Swell Filtering
   A lowpass filter in the distance dimension was applied to eliminate fluctuations in x-direction smaller than a chosen wavelength. This step was used for the smoothing of small scale sea swell effects.

7) Muting
   A muting curve above the sea floor was defined to set all data points in the water column to zero amplitude. This was done to clear out all reflections produced in the water column improving visualization and interpretability of the "chirp" profiles.

Reflector characteristics were examined in an attempt to determine the possible material types represented on the profiles. Correlation with the geotechnical data (cores) then allows lithological identities (clay, sand, bedrock, etc.) to be assigned to the acoustic profiles.

"Boomer" Profiles

The scope of work for this project did not require the "boomer" data to be processed or interpreted as part of this phase of work. However, the quality of the raw data printed on the EPC 1986 recorder was sufficient to allow review of any subsurface features that may have a different acoustic signature on the "boomer" system versus the "chirp" profiler. In some locations, the "boomer" data shows deeper structures more clearly, which provides indirect information on the depth of nearsurface geologic features (ie. paleochannels, rock outcrops) relevant to the surficial sand layer mapping.

APPENDIX D

EQUIPMENT SPECIFICATION SHEETS

4000RSi & 4000DSi

DGPS Reference Surveyor and Differential Surveyor

Key features and benefits

- **Sub 0.5 meter accuracy**
- **Real time QA/QC**
- **Everest Multipath Rejection Technology**
- **Super-trak Signal Processing Technology**

Trimble

The 4000RSi™ Reference Surveyor receiver and 4000DSi™ Differential Surveyor receiver incorporate the latest in GPS technology, offering true, real-time positioning accuracy better than 0.5 meter. Based on Trimble's advanced Maxwell processing technology, these DGPS receivers provide the highest level of accuracy even when operating in the most challenging conditions.

The 4000RSi receiver operates as an autonomous reference station, generating DGPS corrections in the RTCM SC-104 standard format for transmission to mobile GPS receivers.

The 4000DSi receiver is designed to use DGPS corrections in the RTCM SC-104 standard format broadcast by the 4000RSi receiver. The 4000DSi's standard NMEA-0183 messages, navigation firmware, data, and 1PPS outputs allow for optimal flexibility for system integration and interfacing with other instruments.

The signal processing of the two receivers incorporates Trimble's Super-trak™ technology. This technology enhances low power satellite signal acquisition, improves signal tracking capabilities under less than ideal conditions and provides increased immunity to signal jamming from radio frequency interference (RFI). These improvements are derived from integrating complex RF circuitry onto a single chip and by using state-of-the-art Surface Acoustic Wave filter technology.

Super-trak technology increases productivity and facilitates continual operations in demanding environments, such as ports, harbors, along river banks and near RFI sources that would normally interfere with satellite signals.

The 4000RSi and 4000DSi receivers also incorporate Trimble's latest advance in multipath rejection through enhanced signal processing: the patented EVEREST™ Multipath Rejection Technology. This technology eliminates multipath error before the receiver calculates GPS measurements. When combined with Trimble's advanced carrier-aided filtering and smoothing techniques applied to exceptionally low noise C/A code measurements, the result is real-time positioning accuracy on the order of a few decimeters.

The two receivers are ideal for hydrographic and navigation systems, vessel tracking, dynamic positioning systems, dredging, and other dynamic positioning and navigation applications. Both receivers feature nine channels of continuous satellite tracking (12 channels optional); a lightweight, rugged, weatherproof housing; and low power consumption for extending the field operation time from batteries.

During operation, both receivers can output binary and ASCII data for archiving or post-mission analysis. In addition, the 4000RSi receiver can operate as a mobile receiver with the same features, functionality and options as the 4000DSi receiver. For optimum DGPS performance, combine the receivers with any of Trimble's data communication systems and QA/QC firmware to ensure the integrity of positioning accuracy.

4000RSi & 4000DSi

DGPS Reference Surveyor and Differential Surveyor

4000 RSI FEATURES

- RTCM Input
- RTCM Output; filtered and carrier-smoothed RTCM differential corrections (version 1.0 and 2.X) (4000RSi)
- EVEREST Multipath Rejection Technology
- Super-trak Signal Processing Technology
- Better than 0.5 meter DGPS accuracy using 4000RSi receiver corrections
- 0.5 second measurement rate
- Weighted-least squares solution
- Autonomous operation - automatic mode restoration after power-cycle
- Data integrity provision
- 2 RS-232 I/O ports with flow control for data recording and data link (4 RS-232/422 on rack mount)
- Triple DC input
- Low power; lightweight; portable; environmentally protected
- 1 PPS output; NMEA-0183 outputs
- L1 geodetic antenna; 30m antenna cable (4000RSi)
- Compact Dome antenna; 30m antenna cable (4000Dsi)
- 1-year warranty
- Firmware upgrades via serial port

OPTIONS AND ACCESSORIES

- Firmware update service - 1 and 4 year
- Extended hardware warranty
- L1 Carrier Phase
- 12 L1 channels
- L1/L2 Carrier Phase (rackmount)
- 12 L1/L2 channels (rackmount)
- Internal Memory for datalogging
- Event Marker input (requires memory option)
- QA/QC feature
- Rackmount Version
- 4 serial I/O ports (standard on rackmount)
- L1 and L1/L2 Geodetic antennas
- 30m antenna cable extension, with in-line amplifier
- Office Support Module: OSM II (CE Marked)
- Receiver transport case
- TRIMTALK™ Series radio links
- ProBeacon™ MSK receiver
- LEMO to dual BNC sockets adapter

PHYSICAL CHARACTERISTICS

Receiver

Size	9.8" W x 11.0" D x 4.0" H (portable) (24.8cm X 28.0cm x 10.2cm) 16.8" W x 16.0" D x 5.25" H (rackmount) (42.7cm x 40.6cm x 13.3cm)
Weight	6 lbs (2.7kg) (portable), 15 lbs. (6.8kg) (rackmount) 0.5 lbs (0.2kg) compact dome antenna 5.7 lbs (2.6kg) L1 geodetic antenna
Power	Nominal 10.5-35 VDC, 7 Watts (portable) 100, 120, 220, 240 VAC, 40 Watts (rack mount) DC: 10-36 Volts, 30 Watts
Operating temperature	-20°C to +55°C (portable), 0°C to +50°C (rack mount)
Storage temperature	-30°C to +75°C (portable) -20°C to +60°C (rack mount)
Humidity	100%, fully sealed, buoyant (portable) 95%, non-condensing (rack mount)

Geodetic Antenna

Size	16" D x 3.5" H
Weight	5.7 lbs.
Operating temperature	-40°C to +65°C
Storage temperature	-55°C to +75°C
Humidity	100%, fully sealed

Interface

Keyboard	Alphanumeric, function and softkey entry
Display	Backlit LCD, four lines of forty alphanumeric characters; Large, easy-to-read– 2.8mm x 4.9mm; Viewing area: 32 cm²; adjustable backlight and viewing angle
Serial Ports	Port 1 and 3: up to 57600 bps, software flow control Port 2 and 4: up to 57600 bps, hardware/software flow control RS-232 / RS-422 user configurable (rack mount)
Data recording	RTCM and GPS data available via serial port
Remote control	Trimble Data Collector Interface
Antenna	External, LEMO socket connector (portable), N-Type Socket connector (rack mount)
RTCM Messages	Types 1, 2, 3, 6, 9, 16; Version 1.0 and 2.X
1 PPS	LEMO 7-pin, adapter to BNC available (portable) BNC socket (rack mount)
Event Marker	LEMO 7-pin, adapter to BNC available (portable) BNC socket (rack mount)
NMEA-0183	ALM, BWC, GGA, GLL, GRS, GSA, GST, GSV, RMB, RMC, VTG, WPL, ZDA

PERFORMANCE CHARACTERISTICS

Signal Processing	Multibit Super-trak technology; Maxwell architecture with EVEREST Multipath Rejection Technology; very low noise C/A code processing
Tracking (Standard)	9 channels L1 C/A code and carrier
(Optional)	12 L1, 12 L1 + 12 L2; C/A, P and/or cross-correlation code and carrier (rack mount)
Startup time	< 2 minutes after cold start
Measurement rate	0.5 second per independent measurement
Accuracy	Typically better than 0.5 m RMS: assumes at least 5 satellites, PDOP less than 4, and using 4000RSi corrections.
RTCM Corrections	4000RSi corrections can be applied to all differential-equipped RTCM compatible GPS receivers.

ORDERING INFORMATION

4000RSi Reference Surveyor	P/N 29443-75
4000RSi Reference Surveyor pair	P/N 29561-00
4000DSi Differential Surveyor	P/N 29443-70
4000RSi Reference Surveyor Rackmount	P/N 26541-80

Trimble
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MX 51R DGPS Beacon Receiver

A Loop Antenna and Proprietary Processing Means the Ultimate in Performance.

Compatible with public DGPS beacon systems including U.S. Coast Guard and IALA.

Superior Signal Reception

The MX 51R employs a high-performance ferrite loop antenna. Unlike whip (E-field) antennas that require excellent grounding to perform properly, the MX 51R loop (H-field) antenna requires no ground. This makes it ideal for small vessels, vehicles, air-craft, or portable applications.

The MX 51R loop antenna significantly reduces the effects of atmospheric noise such as P-static caused by thunder storms. The loop antenna also offers superior performance close to an interfering beacon or in the near field of the tracked beacon, because, unlike a whip antenna, it is not sensitive to the E-field induction component of the signal.

GPS/Beacon Combined Antenna

The optionally available combined GPS/Beacon antenna uses a single antenna cable for both signals, thus simplifying installation and maintenance.

Increased Accuracy

Through the simple addition of a Leica MX 51R Beacon Receiver, any mobile differential GPS navigator can take full advantage of the DGPS corrections broadcast by marine beacons. With such a system, accuracy on the order of 5 meters or better can be achieved economically. The MX 51R is fully compatible with U.S. Coast Guard and IALA DGPS beacons and operates with any DGPS beacon broadcasting in the 283.5 to 325.0 KHz band. The beacon's direction finding signal is modulated with DGPS corrections using MSK (Minimum Shift Keying) modulation. The MX 51R receives and demodulates the signal to recover correction messages.

Automatic Beacon Selection

The almanac message broadcast by DGPS beacons contains the location, frequency, and output power of beacons in the vicinity. This information is maintained in the GPS navigator, so the MX 51R can be automatically tuned to the nearest beacon.

Ease of Operation

A single serial port provides for control of both the MX 51R and output of DGPS corrections. The MX 51R provides MX 50R emulation and can be easily interfaced to any GPS receiver designed to work with the MX 50R. When teamed with a Leica DGPS Navigator such as the MX 4200D, MX 200/300 or MX 9000 series, the MX 51R is automatically controlled by the navigator. The MX 51R signal strength and SNR are continuously displayed by the GPS navigator.

Rugged and Compact

The MX 51R is housed in a rugged, environmentally sealed, aluminum enclosure. Compact size, single connection to the GPS receiver, and ferrite loop antenna simplify installation. The MX 51R is powered by 11-15 VDC and draws less than 3 watts.

Leica

HYPACK™ MAX Components

- Create planned survey lines
  - Single and Multiple Segments
  - 2-D or 3-D with Channel Cross Section Templates
- Create plotting sheets
  - Used for plotting during data collection or for generating smooth sheets
- Create matrix files
  - Real time coverage maps
  - Binning of sounding data
  - Paint the bottom in real time with depth information
- Background in Survey display
  - BSB Raster (from Maptech)
  - Microstation DGN
  - CAD DXF (Drawing Exchange Format)
  - Ortho-photo (Registered TIF)
  - S-57 Version 3 (DX-90) Vector Chart Data
  - C-Map Vector Chart Data
  - NIMA Vector Product Format (VPF)
- Geodesy tools
  - On-line 3 and 7-parameter datum transformations
  - National grids, including U.S. State Plane NAD-27 and NAD-83
  - Corpscon transformation module
  - Datum Transformation, Grid Conversion, and inverse routines
- Survey
  - Single beam, Dual frequency, Multi-beam and Multiple Transducer Support
  - GPS, Range-Azimuth, Range-Range positioning system support
  - RTK GPS real time water level determination
  - Separate helmsman and operator displays (requires special video cards)
  - Real time targeting and navigation data
- Data Processing
  - Water Level / Tides: RTK GPS, telemetry, manual, harmonic
  - Sound velocity corrections with refraction corrections
  - Interactive, graphical editing of single beam data
- Sounding Selection
  - Cartographic sorting
  - Binning (Mapper)
  - Sounding reduction based on surface modeling
- Cross Section and Volumes
  - Average End Area (Pre-Dredge and Pre-Dredge versus Post-Dredge)
  - Standard HYPACK method for complex cross sections
  - USACE Methods (Savannah; Philadelphia)
  - Printing and plotting of sections in true scale
  - Multiple cross sections for historical comparisons
- Smooth Sheets
  - Output for HP/GL compatible plotters
  - Grids, track lines, soundings, planned lines, targets, title blocks
  - Contours (solid line or solid color filled)
- Surface Modeling (TIN Models)
  - Volume by surface comparison
    - Survey vs. Level (reservoir)
    - Survey vs. Channel
    - Survey vs. Previous Survey (Beach Erosion Studies)
  - 2-D and 3-D Presentations
  - Solid surface and color-contoured models with light shading
  - Generation of DXF Contour (Smoothing, Solid Color Fills, 2-D or 3-D)
  - Cutting sections through surface models
- Import/Export to CAD
  - Import DXF and DGN to Design and Survey programs
  - Export DXF, DGN (and coming soon - S-57)
  - Export soundings, track lines, planned lines, targets and projection grids
- Metadata (Generate FGDC compliant metadata files for your data)
- Digitizing of echograms and chart information
- File adjustments to correct mounting and timing errors
- Single beam latency test to determine delays between navigation and echosounder.
- Coastal Oceanographics' famous technical support

HYSWEEP Multi-beam & Multiple Transducer Option

Multiscan: Real time data collection and visualization

- Time tagging to sub-millisecond accuracy
- Accepts input from:
  - Reson multi-beams
  - Odom multi-beams and multiple transducer systems
  - ELAC Hydrostar multi-beam
  - Simrad multi-beams
  - Atlas multi-beam
  - Ross multiple transducer systems
  - Seatex and TSS motion reference units
  - Most industry gyros and fluxgates
  - Navigation data from HYPACK™ MAX and HYPACK™ 8.9
- Real time visualization tools
  - Profile (Sweep, Beam Pattern or Wavefront)
  - 3-D Seafloor (Wireframe, Solid TIN & Color TIN)
  - Multibeam Waterfall (Solid TIN & Color TIN)
  - Sidescan Waterfall & Sidescan Signal Diagram
  - Area Coverage Map (both Multibeam and Sidescan)
  - Q-C Tests
    - Average depth change by beam
    - Estimated standard deviation by beam
    - Nadir beam versus single beam statistics
- Real time targeting from multi-beam and side scan displays

Multibeam Editor: Multibeam and multiple transducer editing

- Review of position, gyro and heave-pitch-roll information
- Entry of water level corrections
- Entry of sound velocity corrections for ray-bending calculations
- Graphical review and editing of survey data
  - 3-D Color coded wire frame
  - 3-D Solid TIN presentation
  - Perspective or profile views
- Automated and manual filtering
- Export to HYPACK™ MAX SWP, NOAA and ASCII XYZ formats

Multibeam Patch Test

- Determines alignment and timing errors of multi-beam system.

HYPACK™ MAX Configurations

HYPACK™ MAX - Our normal package which has everything you need to design your survey, collect your single beam data, process it and generate final products.

HYSWEEP - The optional package which allows you to collect and process multi-beam and multiple transducer data.

SURVEY MAX - For users who already have a HYPACK™ MAX license and want to outfit another survey vessel. It allows access to the programs needed for survey design and data collection.

MAX LITE - The standard HYPACK™ MAX, less the final product programs (Plotting, TIN Modeling, Digitizing and Cross Sections and Volumes). Sold to clients who will be using CAD/GIS for their final products.

MAX OFFICE - For clients who want to set up an additional processing computer, MAX OFFICE allows access to the single beam processing, sounding selection and final product programs.

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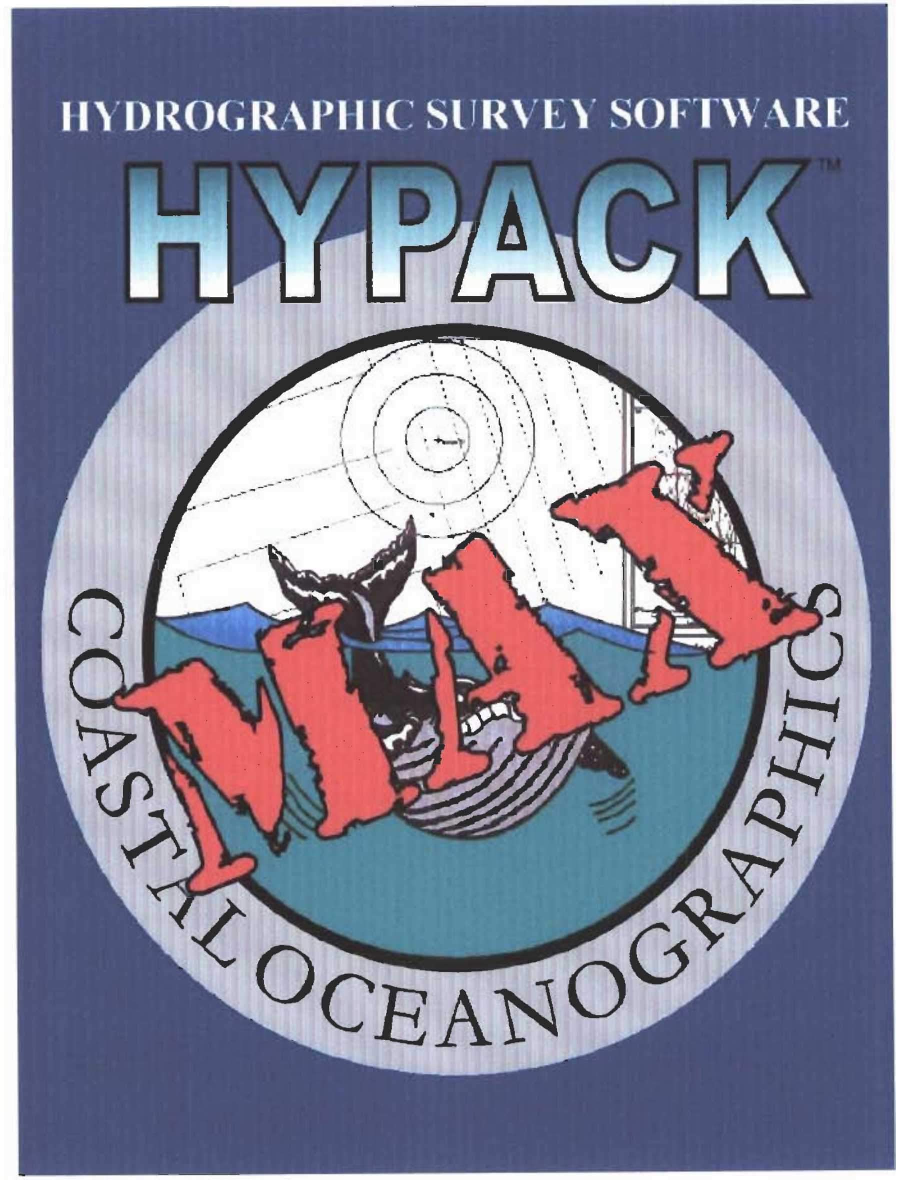
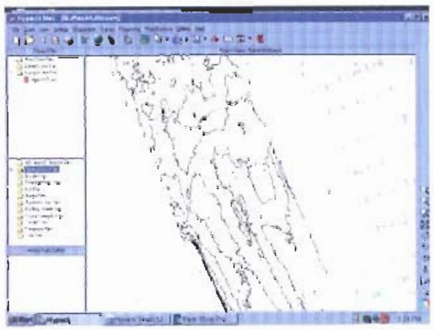


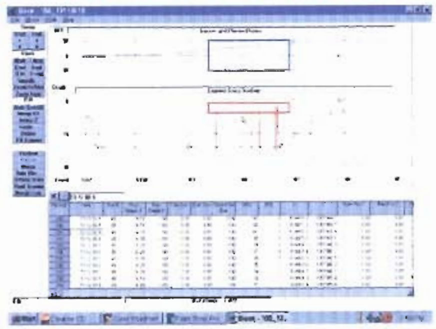
HYPACK® MAX * HYPACK® MAX * HYPACK® MAX

SURVEY DESIGN



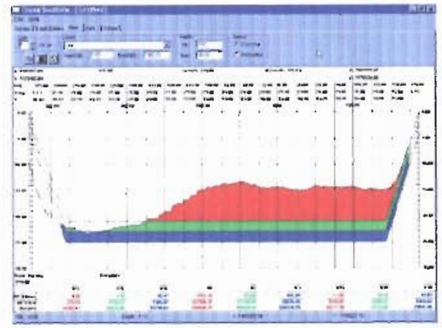
HYPACK™ MAX contains powerful tools that let you quickly design and display your survey information. Its powerful drawing engine can display background files in DXF, DGN, TIF, S-57, BSB raster and C-Map vector, at any rotation. Design tools allow you to quickly create planned lines in a variety of patterns, including multiple segment lines. HYPACK™ MAX automatically stores your data to project directories, allowing you to set up new survey projects and to quickly return and survey existing projects. All of this, in Windows' easy drag-and-drop environment, makes learning HYPACK MAX a breeze.

SINGLE BEAM EDITOR



HYPACK™ MAX's graphical editing routines allow you to quickly edit your single beam survey data. Water level corrections can be automatically applied using RTK GPS water level techniques, telemetry gauges, manual observations or download of NOAA water level data. Sound velocity corrections can also be applied. Users can quickly review and edit individual points or blocks of data. HYPACK™ MAX's new "Field to Finish" process now allows users to automatically edit their data, perform sounding reduction and generate final products, before you reach the dock!

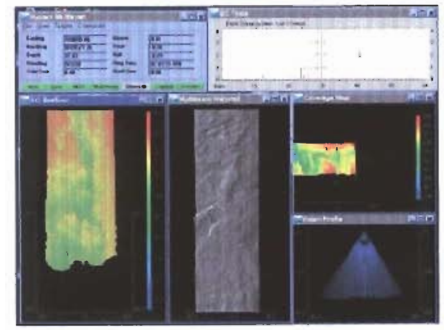
SECTIONS/VOLUMES



HYPACK™ MAX's Cross Section and Volume program is used by the U.S. Army Corps of Engineers to compute precise quantities in support of dredging projects. The program can compute average end area quantities for pre-dredge and pre-dredge versus post-dredge surveys for the entire channel. Quantities can be printed and sections with quantity information can be printed or plotted. The Cross Sections program allows users to present multiple sections on a single graph, allowing for historical comparisons of cross section profiles. Volumes can also be computed using complete surfaces in HYPACK™ MAX's TIN Model program.

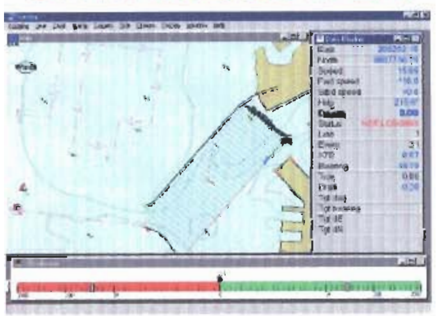
HYSWEEP®

MULTISCAN



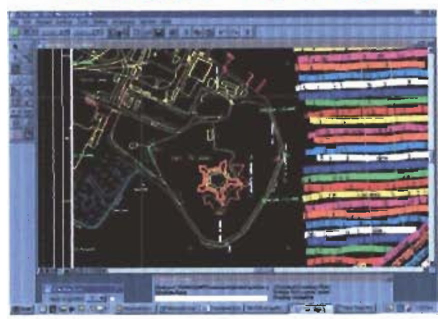
HYSWEEP is an optional package, used for the collection and processing of multi-beam and multiple transducer data. The Multiscan program is used for data collection. It provides visualization tools for multibeam data while providing sub-millisecond time tagging of sensor data. Waterfall displays of multibeam and multiple transducer data, beam patterns, color-coded coverage diagrams, side scan sonar displays and quality control windows allow you to make sure your survey meets your specifications in real time. Multiscan also allows real time targeting of bottom objects. Multiscan runs simultaneously with the HYPACK™ MAX Survey program.

DATA COLLECTION



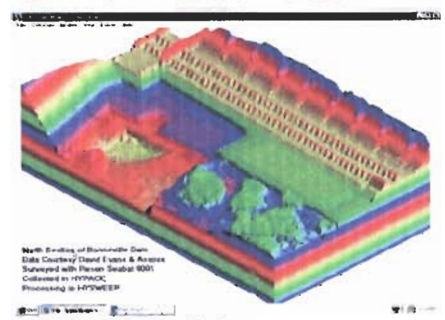
HYPACK™ MAX's Survey program allows the flexibility and power needed to perform your work. It supports GPS, Range-Azimuth and Range-Range systems. It provides full support for almost every echosounder, gyro, motion sensors, magnetometer, tide gauges or other survey devices. It supports single vessels, multiple vessels or ROVs. Users can display background chart data in DXF, DGN, S-57, BSB Raster, C-Map or VPF. Users with dual monitors can configure separate helmsman and operator monitors. Once you survey in HYPACK™ MAX, you'll be hooked.

EXPORT TO CAD



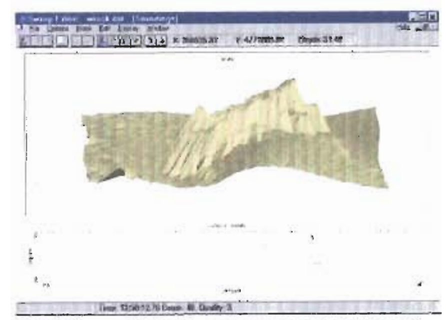
Import and export between HYPACK™ MAX and CAD/GIS systems is simple. HYPACK™ MAX can display DXF and DGN files from CAD/GIS in the Design screen and in real time on the Survey screen. It also allows users to export soundings, track lines, planned survey lines, targets, projection tics and contours to a variety of CAD/GIS formats. Users can also build "composites" of different CAD/GIS information in the Survey program, overlaying construction drawings in DXF or DGN on top of orthometric photos (TIF) or electronic chart (S-57; C-Map; BSB) info.

SURFACE MODELING



HYPACK™ MAX has a powerful surface modeling program which creates TIN models of your single beam, multiple transducer, or multibeam data. The TIN Model program can provide 2-D and 3-D views of your surface with color-contouring and light-shading. It also enables you to compute volumes for your survey data versus either a constant level, a channel surface or a previous survey. Users can cut sections through surfaces and perform standard average end-area volume computations. The TIN Model program also exports contours to DXF format for export to CAD.

MULTIBEAM EDITOR



HYSWEEP's powerful editor allows users to graphical edit multibeam and multiple transducer data. Users can apply water level corrections and sound velocity information. The Multibeam Editor computes refraction corrections and then displays the sounding information in either wireframe or solid TIN view. Users can manually edit the sounding data or use powerful automated filters to remove bad data points. Data is then exported to either HYPACK™ MAX SWP or ASCII XYZ format where users can then access all of HYPACK™ MAX's powerful final product programs.

KVH AutoComp™ 1000 Digital Compass and Heading Sensor

A precision stand-alone heading sensor for sail, power, and OEM applications

The AutoComp 1000 employs KVH's breakthrough digital fluxgate compass technology to provide precision heading data to an array of systems, including autopilots, GPS, video charts, radars, computers, and other electronic instruments. Designed as a remote sensor, the AutoComp 1000 can be mounted in a magnetically "clean" location (e.g., away from speakers, motors, wiring bundles, and other sources of changing magnetic fields), and its continuous automatic compensation feature ensures that the most precise heading data (within ±0.5°) is available at all times. The AutoComp 1000 is fully compatible with the NMEA 0183 output standard and a universal interface card is available for use with other interface standards.

Highlights:

* Remote sensor with continuous autocompensation ensures reliable heading data at all times

* Accurate to within ±0.5°

* Fast 10 Hz NMEA 0183 standard output compatible with other ARPA radars, autopilots, and other electronic systems; optional interface card available for other outputs

* Options include mounting bracket and extension cables

* Variants for use aboard sailboats and power vessels as well as in OEM applications

TSS DYNAMIC MOTION SENSORS

Features:

- **Dynamic roll and pitch accuracy to 0.05°**
- **Depth rated to 3000m (optional 6000m)**
- **Solid state angular rate gyro**
- **Survey to Class 1 IHO standard**
- **High dynamic accuracy during vessel turns**

Benefits:

- **DMSView intuitive control software**
- **User-configurable outputs**
- **Real-time digital and analogue outputs**
- **Compact and lightweight**

The Research Vessel Prince Madog.
Picture courtesy of VT Ocean Sciences.

The DMS range of motion sensors has been designed specifically for the motion measurement needs of the marine industry. Whether it is achieving IHO standard survey from any size of vessel, or providing safety critical monitoring of offshore platforms, large vessels, helicopter landing decks, cranes and positioning systems, the DMS provides accurate motion measurement in all sea conditions.

Incorporating an enhanced external velocity and heading aiding algorithm for improved accuracy during dynamic manoeuvres, the solid state angular rate sensors offer reliability and a complimentary blending algorithm has proven that the DMS is the highest performance vertical reference unit ever produced by VT TSS.

The DMSView software programme is an intuitive Windows -based operating programme that enables installation, set-up and integrity checking, and monitoring of the sensor. The user can select from a series of frequently used data protocols or configure a bespoke output from a selection of variables.

The DMS is rated to 3000m as standard with 6000m available on request. The sensor can be supplied in various configurations for integration with towed vehicles and other bespoke applications. As with all VT TSS systems, the DMS is certified to meet all current and anticipated European legislation for electromagnetic compatibility and electronic emissions.

TSS DYNAMIC MOTION SENSORS

TECHNICAL SPECIFICATIONS

Dynamic accuracy	Heave	Roll & Pitch			
	All (except DMS-RP25)	DMS-05	DMS-10	DMS-25	DMS-RP25
	5cm or 5% whichever is greater (period 0 to 20s)	0.04°	0.07°	0.2°	0.25°
	Amplitude	±30°			
Maximum range	Heave ±10m; Roll & Pitch ±60°				
Bandwidth	Heave 0.05 to >30 Hz; Roll & Pitch 0 to 30Hz				
Data output rate	Digital: up to 200 Hz Analogue: up to 500 Hz (with an external repeater)				
Available output parameters	Adjustable data packet output rate down to 1 Hz Heave; roll; pitch; remote heave; angular rate X, Y, Z – acceleration X, Y, Z (body frame); angular rate east north, up – acceleration east, north, up (geographical frame); IMU temperature; surge; sway; sensor status; external speed; external heading; UTC time				
Dimensions	172mm x 99mm diameter (excluding connector and mounting plate)				
Weight	3000m <2.3 Kg; 6000m <4.0 Kg in air				
Power supply	15-30 Vdc				
Temperature range	0°C to 55°C operating; -20°C to +70°C storage				
Power requirement	10-36V, <6.5W				
Velocity input packet formats	DMS-05, -10, -25 models only: NMEA 0183 (required VTG & GLL or GGA); TSIP; Doppler Speed Log				
Heading input packet formats	NMEA 0183; SGB; Robertson; Sperry LR40/60				
Depth rating	3000m (optional 6000m)				
Shock (survival)	30g peak 40ms half-sine				
Vibration (operating)	30mm/s or 0.2mm, 7-300 Hz				
Available output formats	DMSView for Windows offers standard TSS and other manufacturers' data strings in addition to user-configurable menu				
Software interface	Digital: RS232 or RS422 (software selectable) Analogue: via an optional remote interface for power, communications and aiding				
MTBF (computed)	50,000 hours				
Warranty	15 months from delivery or 12 months from installation - international warranty including parts and labour				

Due to continuous development, specifications may vary from those listed above.

VT TSS

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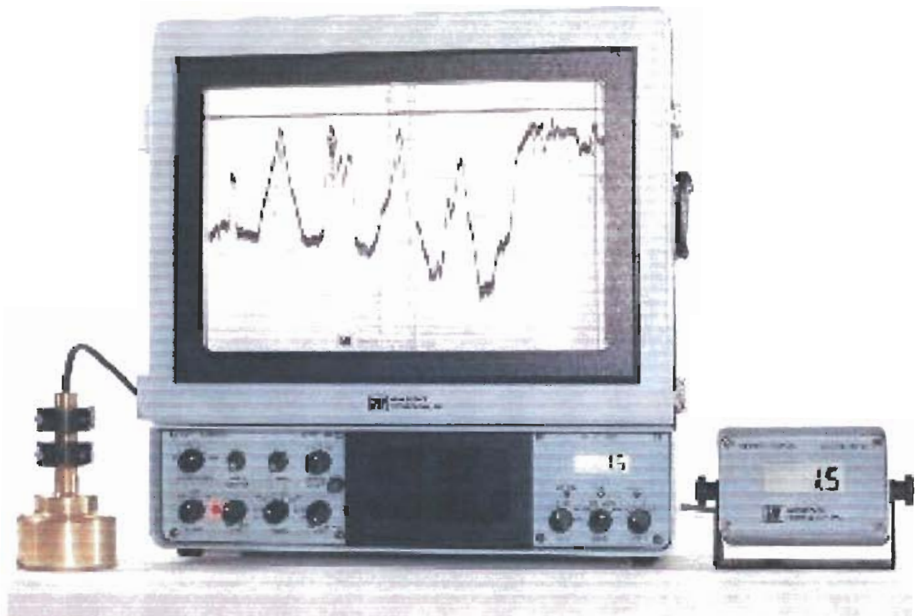
Tel: +1 713 461 3030 Fax: +1 713 461 3099 Email: sales@vttss.com

INNERSPACE TECHNOLOGIES



MODEL 448 THERMAL DEPTH SOUNDER RECORDER

The 448 Thermal Depth Sounder Recorder provides survey precision, high resolution depth recordings using solid state thermal printing. The lightweight, portable unit is designed for use in small boat surveying as required for nautical chart production, engineering surveys, harbor and channel maintenance, pre and post dredge surveys, etc. The Model 448 TDSR uses a thermal printing technique pioneered by Innerspace for depth sounding which provides the high resolution and accuracy required by groups such as the U.S. Army Corps of Engineers, dredging companies, survey companies, port administrations, etc. The design allows easy integration into hydrographic data collection systems.

There are more 448's in service in the USA than any other precision depth sounder. It is widely used by private survey companies, the National Oceanic and Atmospheric Administration and the U.S. Army Corps of Engineers. In the Corps of Engineers alone, there are over fifty 448's in service at 18 district offices and a number of 449's as well.

CSP 300 - PORTABLE Seismic Energy Source

Designed to be the smallest, lightest 350 Joule power source in the world by the manufacturer of the field proven, industry standard CSP range of Energy Sources.

- Cutting edge power supply technology evolved from years of field use.
- All CSP units contain our new, proprietary Variable Input Power Circuitry (AVIP) enabling the new breed of CSPs to operate from the smallest of generators.
- Reliability and security with global after sales service and support from the world's leading seismic power source manufacturer.
- All CSP units contain our proprietary pulse shaping circuitry for optimisation of high resolution data.
- All CSP units meet current EC emissions regulations enabling interference-free field and laboratory use.
- Higher rated charger for better 'overhead' or more energy, compared with CSP1000.
- Virtually silent energy source operation.
- Short circuit proof in all fault conditions.
- All settings externally selectable including voltage output power increments of 100, 200, 300 & 350 Joules.
- Solid state (semiconductor) discharge method.
- All CSP units come complete with Hardigg case and HV cable junction box as standard.
- Unrivalled cost-effectiveness.

Dimensions : 17.78cm high x 48.25 cms wide x 50.8 cms deep (including handles).

Weight : 24 kg (35 kg with 4U Hardigg Case)

Mains Input : 200-240 VAC. 115V Units available to order. 45-65Hz @ 2.0kVA. 3 pin connector. Contains AVIP soft start circuitry to reduce generator requirements.

Voltage Output : 3550 volts DC, 4 pin interlocked connector, Semi-conductor discharge method.

Output Energy : Externally selectable in increments of 100, 200, 300 & 350 Joules.

Charging Rate : 1050J/second for continuous operation at 0 - 50°c ambient or 1500J/second for short duration work.

Capacitance : 48μf , 10^8 shot life.

Trigger : +ve key opto isolated or closure set by front panel switch. BNC connector on front panel and remote.

Repetition Rate : 6 pps maximum. To 3pps @ 350J.

Earth : M8 stainless steel stud on front panel.

Internal Design : A Modular approach allows for easy servicing and capacitor replacement. (However, for safety reasons, only factory trained technicians should attempt a repair)

Safety Features : Main electronic control circuits and secondary layer of safety circuitry. Specially designed HV connector. High speed dump resistors for high voltage components. Capacitor bleed resistors. Open circuit shutdown. Short circuit proof. Cover and connector interlocks. Remote control available for triggering and operation.

CSP UNITS ARE PART OF OUR INTEGRATED RANGE OF BOOMER AND SPARKER SYSTEMS

AAE CAT 200 Catamaran, AA200 Boomer Plate and CSP 300 – Portable Power Source.

Complete CSP 300–PORTABLE Boomer System with OMS 360 processor and Alden 9315 CTP printer.

SUB BOTTOM PROFILING

AA200 BOOMER PLATE AND CAT200 CATAMARAN

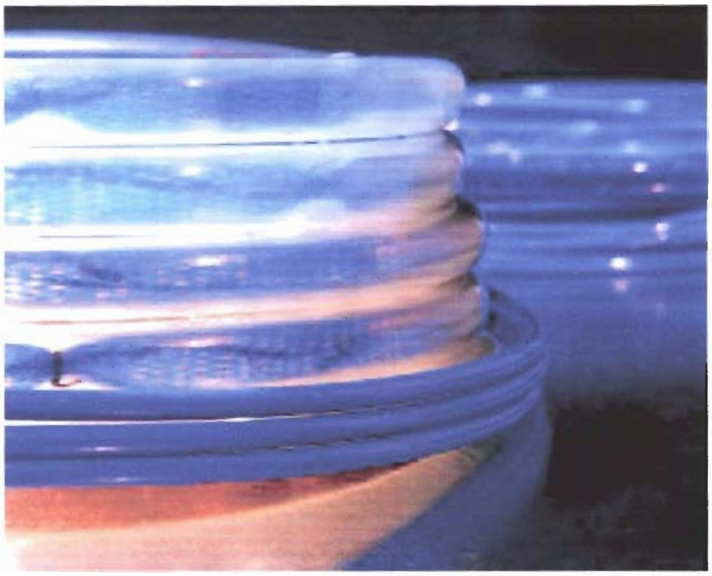
The Model AA200 is a proven design in boomer plates which encompasses precision moulding techniques to give a rugged design with a stable and repeatable signature. Designed specifically for use with our CSP range of energy sources, (although others can be used) the efficiency of the AA200 transducer ensures high output with an excellent pulse shape.

Designed for ease of use in the real world offshore, we have ensured that the flying lead connectors can be replaced in the field in case of damage. Diaphragm replacement is also straightforward. The lightweight design allows easy transportation. The unit is shown fitted to our 'CAT200' small sized catamaran which has been praised for its towing characteristics. Spectral content information is available.

- Small Size and weight
- Repeatable high output pulse
- Rugged mechanical design
- Proven Performance

Sub Bottom Profiling

AAE 8 & 20 Element Hydrophone Streamers



- **High quality, complete 8 & 20 Element Hydrophone Streamers.**
- **Kerosene filled for neutral buoyancy.**
- **Supplied with a robust 50-metre tow-leader as standard.**
- **Comes complete with pre-amp and easily replaceable alkaline battery.**
- **Extensively field proven to offer consistently high quality results.**

TECHNICAL SPECIFICATION

HYDROPHONE LENGTH (8 & 20 EL' VARIANTS)	:4.5 METRES
HYDROPHONE ELEMENT SPACING ON	:8 ELEMENT VARIANT = 365mm 20 ELEMENT = 150mm
FREQUENCY RESPONSE	:20Hz – 10kHz (-3dB)
OVERALL HYDROPHONE SENSITIVITY (8 ELEMENT)	:MINUS 176dB REF 1v PER MICRO PASCAL
OVERALL HYDROPHONE SENSITIVITY (20 ELEMENT)	:MINUS 167dB REF 1v PER MICRO PASCAL

COMES WITH ROBUST TOW LEADER – STANDARD LENGTH (50 METRES) OR LENGTH OF CHOICE

WEIGHT IN AIR	:5KG (8 ELEMENT)
WEIGHT IN AIR	:7.5 KG (20 ELEMENT)

COMES WITH USER REPLACEABLE 9v ALKALINE BATTERY (DURACELL TYPE MN 1604)

APPLIED ACOUSTIC ENGINEERING
Marine House, Marine Park, Gapton Hall Road, Great Yarmouth, NR31 0NL, England
Tel: + 44 (0) 1493 440355 Fax: + 44 (0) 1493 440720
www.appliedacoustics.com email: general@appliedacoustics.com

FULL SPECTRUM™
SUB-BOTTOM PROFILER

X-STAR

Sub-Bottom Profiler Shallow Tow System

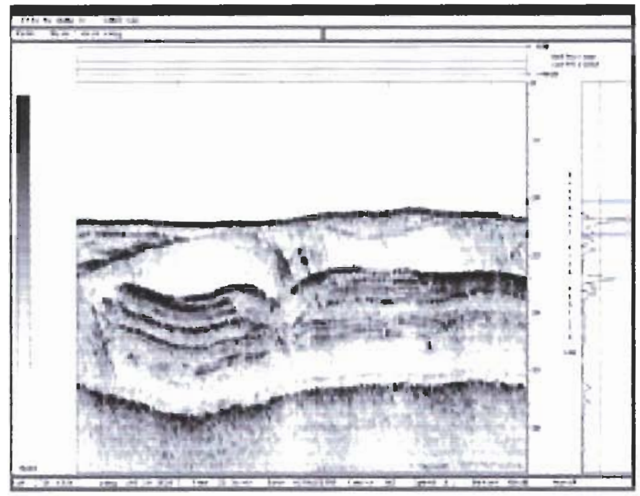
X-STAR is a high resolution wideband Frequency Modulated (FM) sub-bottom profiler utilizing EdgeTech's proprietary FULL SPECTRUM™ CHIRP technology. The system transmits a FM pulse that is linearly swept over a full spectrum frequency range (for example 2-16 kHz for 20 milliseconds.) The acoustic return received at the hydrophones is passed through a pulse compression filter, generating high resolution images of the sub-bottom stratigraphy in oceans, lakes, and rivers.

Because the FM pulse is generated by a digital to analog converter with a wide dynamic range and a transmitter with linear components, the energy, amplitude, and phase characteristics of the acoustic pulse are precisely controlled. This precision results in high repeatability and signal definition required for sediment classification.

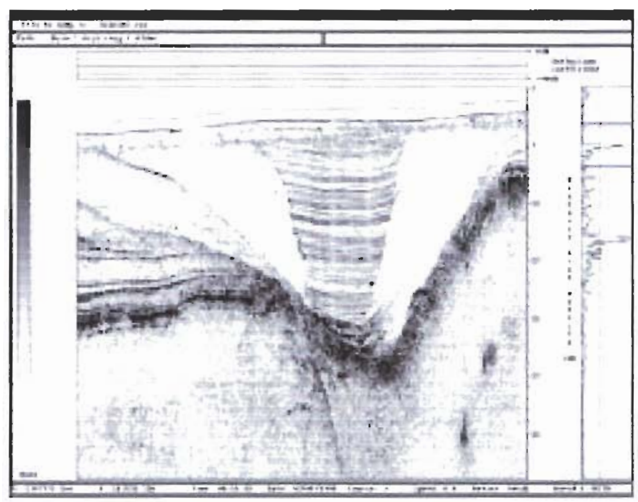
Several stable, low drag tow vehicles are available that contain wide band transmitter arrays and sensitive line array receivers that can operate in water depths up to 300 meters. The selection of tow vehicle depends on the sub-bottom characteristics and resolution required.

Full Spectrum Benefits

FM pulses have been used in radar for over 30 years and are sometimes called chirp or swept frequency pulses. Its application in sonar systems has come with the availability of high speed Digital Signal Processors (DSP).



Unequalled images that combine good penetration and high resolution. 20-30 dB improved SNR over conventional systems by using Full Spectrum (FM) Pulses.



• EEZ resource development • Geo-technical surveys • Hazard surveys • Environmental site investigations • Geological studies • Sediment classification • Buried object location • Search and recovery • Locate and map buried pipelines and cables • Mining and dredging surveys • Bridge and shoreline scour surveys

EdgeTech®
THE SOUND SOLUTION

1141 Holland Drive, Suite 1, Boca Raton, FL 33487
Tel: (561) 995-7767 • Fax: (561) 995-7761
E-mail: sales@edgetech.com • Website: www.edgetech.com

Full Spectrum signal processing technology uses a proprietary matched filter to process wideband signals. This matched filter uses special amplitude and phase weighting functions for the transmitted pulse and a pulse compression filter that maximizes the Signal to Noise Ration (SNR) of the acoustic images over a wide band of operating frequencies. These X-STAR signal processing features provide a significant SNR improvement in the acoustic image generated by other impulse and chirp sonars with band limiting components that are limited in dynamic range.

One of the outstanding aspects of Full Spectrum signal processing is the use of a broad bandwidth transmitting pulse that sweeps out over a range of frequencies. This generates a great deal of acoustic energy in the water. Instead of trying to operate with one very sharp acoustic peak pulse, like conventional CW systems, the Full Spectrum sonar spreads the transmission out over a long time duration. In addition, to the resolution improvement, the process of correlation processing achieves a signal processing gain over the background noise. To equal the typical performance of the Full Spectrum sonar pulse, conventional pulsed sonar would have to operate at a peak pulse power 100 times higher than the Full Spectrum pulse.

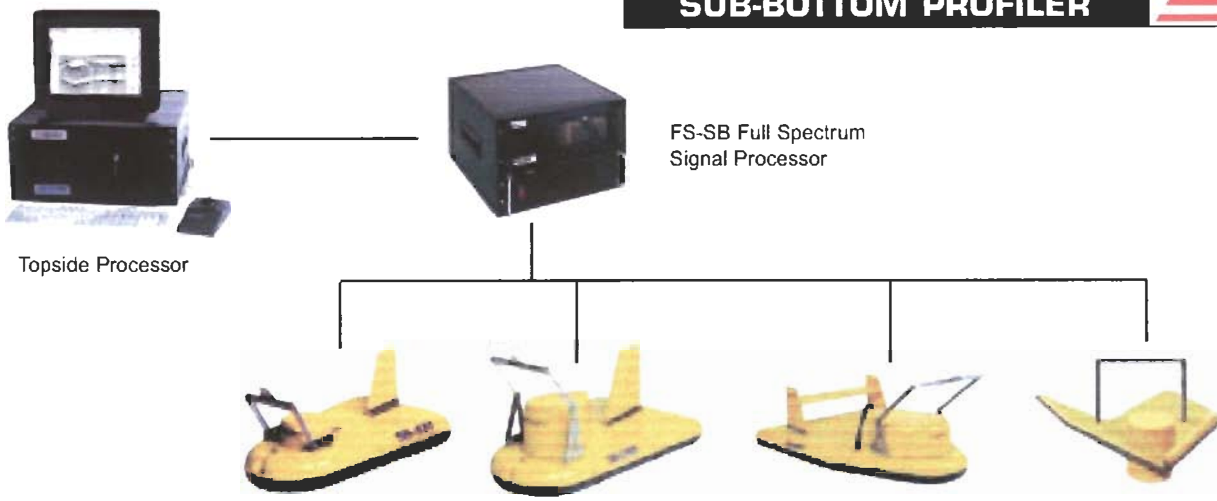
Normally, when using long pulses the resolution of the seabed is lost. Resolution of the seabed is regained after correlation processing the received signal. This is because the output of the correlation is a very sharp wavelet that has duration of the order of the inverse of the sweep bandwidth. Thus, the more bandwidth used, the sharper this pulse will become.

Another important feature, which enhances the ability of the Full Spectrum Sub-bottom Profiler system to classify sediments, is realized by the built-in de-convolution of the system response from the output pulse. The sonar's system impulse response is measured at the factory and is used to design a unique output pulse that will prevent the source from ringing. In addition to this, the Full Spectrum wavelet is weighted in the frequency domain to have a Gaussian like shape. As the Gaussian shaped spectrum is attenuated by the sediment, energy is lost but its bandwidth is preserved. Thus, even after being attenuated by 20 meters of sand, the Full Spectrum pulse has approximately the same resolution as a non-attenuated pulse.

The Full Spectrum Sonar side lobes are greatly reduced in the effective transducer aperture. The wide bandwidth of the sweep frequency smears the side lobes of the transducer and thus achieving a beam pattern with virtually no side lobes. The effective spatial beam width obtained after processing the Full Spectrum sub-bottom pulse is typically 20 degrees measured to the -3db points. This feature is clear when inspecting the Full Spectrum records. Since the transmitted pulse is highly repeatable and its peak amplitude is precisely known, the sediment reflective values can be estimated from the peak pulse amplitude measurements of the bottom returns.

Use different tow vehicles for desired penetration and resolution. The topside portion remains the same. The FM pulse is user selected based on the sub-bottom conditions at the survey site and the type of sub-bottom features that need to be imaged.

FULL SPECTRUM™
SUB-BOTTOM PROFILER



Towfish Model	SB-424	SB-216S	SB-0512	SB-0408
Frequency Range	4-24 kHz	2 - 16 kHz	500 Hz - 12 kHz	400 Hz - 8 kHz
Pulse Type	FM	FM	FM	FM
Standard Pulse Bandwidths / Length (other custom pulses available)	3-24 kHz / 10 ms 4-24 kHz / 10 ms 4-20 kHz / 10 ms 4-16 kHz / 10 ms	2-15 kHz / 20 ms 2-12 kHz / 20 ms 2-10 kHz / 20 ms	2-12 kHz / 20 ms 2-10 kHz / 20 ms 2-8 kHz / 40 ms 1.5-7.5 kHz / 40 ms 1-6 kHz / 40 ms 1-5 kHz / 40 ms 0.5-5 kHz / 40 ms	1.5-10 kHz / 20 ms 1-7 kHz / 40ms 1-6 kHz / 40 ms 0.7-4.5 kHz / 40 ms 0.6-3.0 kHz / 40 ms 0.4-2.4 kHz / 40 ms
Vertical Resolution	4 cm / 4-24 kHz 6 cm / 4-20 kHz 8 cm / 4-16 kHz	6 cm / 2-15 kHz 8 cm / 2-12 kHz 10 cm / 2-10 kHz	8 cm / 2-12 kHz 12 cm / 1.5–7.5 kHz 19 cm / 1- 5 kHz	9 cm / 1.5 kHz-10 kHz 15 cm / 1-6 kHz 37 cm / 0.4-2.4 kHz
Penetration (typical)				
in coarse calcareous sand	2	6	20	40
in clay	40	80	200	300
Beam Width (depends on center frequency)	16° / 4-24 kHz 19° / 4-20 kHz 23° / 4-16 kHz	17° / 2-15 kHz 20° / 2-12 kHz 24° / 2-10 kHz	16° / 2-12 kHz 24° / 1.5–7.5 kHz 32° / 1- 6 kHz	10° / 1.5 kHz-10 kHz 14° / 1-7 kHz 37° / 0.4-2.4 kHz
Transmitters	1	1	4	2
Receive Arrays	2	2	4	8
Size (centimeters)	77L x 50W x 34H	105L x 67W x 46H	210L x 134W x 46H	249 L x 214W x 91
Weight (kilograms)	22	44	186	364
Shipping weight (kg.)	82	122	288	consult factory
dimension (cm.)	L89 x W64 x H54	L115 x W79 x H59	L172 x W137 x H58	
Cable Requirements	3 shielded twisted pairs (5 used)	same	same	3 shielded twisted pairs (all used)
Max Depth (meters)	300	300	300	300
GeoStar Interface	Yes	Yes	No	No

Other System Specifications

Tow Speed	3-5 knots optimal, 7 knots maximum safe operational
MaximumTow Fish Operating Depth	300 meters (1,000 feet)
Optimum tow height	3 to 5 meters above seafloor
Calibration	Each system is acoustic tank tested to calibrate for reflection coefficient measurements

FULL SPECTRUM™
SUB-BOTTOM PROFILER

FS-SB Full Spectrum Processor

Main Processor	Intel CPU with high speed PCI bus
Digital Signal Processor	TMS320
Memory	32 MB RAM
Storage	Hard drive, CD-ROM, floppy disk
Operating System	Windows® 98
I/O to Topside Processor	Ethernet
A/D	Analog Input, 16 bit resolution, 200 kHz max. sampling rate
D/A	Analog Output,16 bit resolution, 200 kHz max. sampling rate
Pulse Type	Full Spectrum (Frequency Modulated with amplitude and phase weighting)
Pulse Trigger	Internal or External
Pulse Repetition	0.5 to 12 Hz
Trigger In	TTL negative edge triggered (Middle BNC)
Trigger Out	TTL negative edge triggered. Minimum 5ms long pulse (Lower BNC)
Sampling Rate	Typically 20, 25, 40, or 50 kHz depending on the pulse upper frequency
Acoustic Power	212 dB ref 1µPa peak at center frequency of system
Input Power	120 or 220 VAC Auto Sensing
Power Amplifier	Type: Two channel, Gain: 33dB per channel, Power output: 2000 Watts peak, Power input: 110-120V/60Hz or 220-240 V/50Hz Manually Switchable
Topside Display Processors w/ Support	EdgeTech, CODA Technologies Ltd., Sea Corp., TEI Inc.
Environment	Temperature: 0 to 40°C, Humidity: 5% to 95% relative, Vibration: Normal ship environment
Enclosure	Portable steel case suitable for transit. Unit can be removed from case and mounted in a 19" rack. Size: 50W x 60D x 33H cm. (19.5x23.5x13 in), Weight: 46 kg (102 lbs.)
Shipping Containers	Size: 109L x 79W x 71H cm. (43x31x28 in), Weight: 150 kg (330 lbs.) Material: Sealed high impact polyurethane case
Options	Diagnostics Kit (Video Display, Keyboard, Mouse), Spare Parts Kit, Optional Pulses

EdgeTech Topside Display Processor

Main processor	SPARC Workstation
Operating System	UNIX
Display	17" Color Monitor
Operator Controls	A/D Gain, Two Stage TVG, Bottom Tracking, Digital Gain, Preamplifier Gain, Horizontal and Vertical Zoom, Direct Path Suppression, Swell Filter, Annotation
Video Displays	Bottom Tracking, Reflection Coefficient, Signal Amplitude, Navigation Map, Scale Lines, Track Lines
Navigation	NMEA 0183, X/Y, N/E, Navigation I/O Utility, Track lines, Event/Fix Marks, Sediment Classification Color vs. Echo Strength
Annotation	Keyboard, RS232 Port
Event Mark	Via Keyboard, Switch Closure, RS232 Port
Printer Support	EPC Models 9800, 8300, 1086, HSP-100, ODECO Model 850 & 1200F, Alden Model 9315 CTP, Ultra Model 183/200
Mass Storage	DAT
I/O Ports	Ethernet, Serial, SCSI, Parallel, Event Mark, Keyboard, Trackball, External Trigger In, Trigger Out, Heave Compensation Input
Power	105-125VAC or 210-250VAC, selectable, 47-63 Hz
Enclosure	Portable steel case suitable for transit. May be removed from cases and installed in 19-inch rack. Size: 50.3W x 50.3D x 15.3H cm. (19.8 x 19.8 x 6 in.), Weight: 32 kg (71 lbs.)
Environment	Temperature: Operating 5°C to 40°C Non-operating -40°C to 45°C. Humidity: Operating 20% to 80% relative humidity, non-condensing. Non-operating 5%-95%. Vibration: Normal ship environment.
Options	Spare Parts Kit, Replay Software, Ethernet Output of Data, Dual Mass Storage, Software Services Agreement

Specifications subject to change without notice.

EdgeTech
THE SOUND SOLUTION

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MODEL GSP-1086 SERIES
GRAY SCALE PRINTER

The EPC Model GSP-1086 is an all purpose, continuous image printer. Photographic quality images are printed using a 2048 pixel thermal printhead with a dot density of eight dots/millimeter. Pixel depth is selectable up to eight bits.

Two LCD displays and a sealed membrane control panel provide the operator with a simple user interface which displays system status at all times. Because the control panel is software defined, the printer can easily be configured for a wide range of custom applications.

Sonar and imaging applications are easily accommodated by the 1086's standard interface suite:
Dual Channel Analog, Centronics Compatible Parallel, and RS-232 Serial I/O.

Keeping with EPC tradition, the 1086 is packaged in a rugged, field-ready sheet metal case. An optional transport case and rack mount kit are available for ship-of-opportunity and fixed based operations, respectively.

The 500 Series incorporates exciting new features like Bandpass Filtering and Time Varied Gain. Data throughput, system diagnostics, and reliability have also been improved in the 500 Series. A mini keyboard, tie-down loops and enhanced documentation are included.

EPC LABORATORIES INC., 42A Cherry Hill Drive, Danvers, MA 01923 USA PHONE: (978) 777-1996
FAX: (978) 777-3955 EMAIL: sales@epclabs.com WEB: http://www.epclabs.com

HARDWARE

Host Processor
486DX2 /66 MHz
CPU Bus
16 Bit Industry Standard Architecture (ISA)
Control Panel
Sealed membrane type, software defined
Displays
Twin 2x40 LCD displays with LED backlights

POWER

Power Supply
350 Watt, auto-sensing, universal input
84-265 VAC, 50-60 Hz
Power Consumption
80 Watts non-printing
130 Watts Peak

PHYSICAL

Dimensions & Weight
17.6"W x 19.3"H x 6.7"D
50 LBS.
Media
Heat sensitive thermal paper or high grade plastic film - 23dB dynamic range
Paper Length: 150 feet
Film Length: 130 feet
Temperature (non-condensing)
0°C to 65°C - Operating
-28°C to 65°C - Storage

PRINTING

Gray Levels & Resolution
Selectable: 8, 16, 32, 64 Levels
Printhead: 2048 Pixels @ 203 DPI
Maximum Line Speeds (nominal)
@ 8 Shades: 15 ms
@ 16 Shades: 18 ms
@ 32 Shades: 26 ms
@ 64 Shades: 43 ms
Chart Speeds (Lines Per Inch)
Fixed: 75, 80, 100, 120,150, 200, 240, 300
Variable: 1.6 kHz max clock, BNC input
1 / 1200th inch per clock

ANALOG INTERFACE

Dual Signal Input
0V to 10V SIGNAL BNC inputs
(2KW Input Impedance)
External Trigger Input (slave)
TTL EXT TRIG BNC input with slope sense
Internal Key Output (master)
TTL KEY OUT BNC with polarity selection
(62.5us pulse width)
Gain, Threshold, Polarity
Independent controls for each channel
Minimum printable signal 150 mV
Time Bases
1.5 MHz A/Ds with 8 Bit resolution
Scan - 5 mS to 10 secs, 1 ms resolution
Key - 5 mS to 10 secs, 1 ms resolution
Delay - 0 secs to 8 secs, 1 ms resolution

PARALLEL INTERFACE

Interconnect
25 Pin Sub D, metal shell
Data Input (Pins 2-9)
Eight Bit Centronics Compatible
2048 bytes per raster line
White = 0X00; Black = selectable
Handshake
Low Active host/STB on Pin 1
Low Active printer/ACK on Pin 10
High Active printer BUSY on Pin 11
BUSY cycles on end of line (2048 bytes)
/ACK cycles on every /STB
Burst Rate Bandwidth: Over 250 kHz
Sustained Bandwidth: Based on gray levels

COMMAND INTERFACE

QWERTY Keyboard
Jack for commands and annotation
RS-232 Serial Data Input (DCE)
9 Pin Sub 'D' for commands & GPS

NEW FEATURES

Time Varied Gain
255 Logarithmic curves to choose from.
Band Pass Filtering
LOW PASS: 1kHz, 1.2kHz, 2kHz, 2.4kHz, 3kHz, 4kHz, 6k and 12kHZ
HIGH PASS: 83Hz, 100Hz, 166Hz, 200Hz, 250Hz, 333Hz, 500Hz and 1kHz.

Warranty: One Year Limited Parts & Labor.

Specification subject to change.

EPC

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