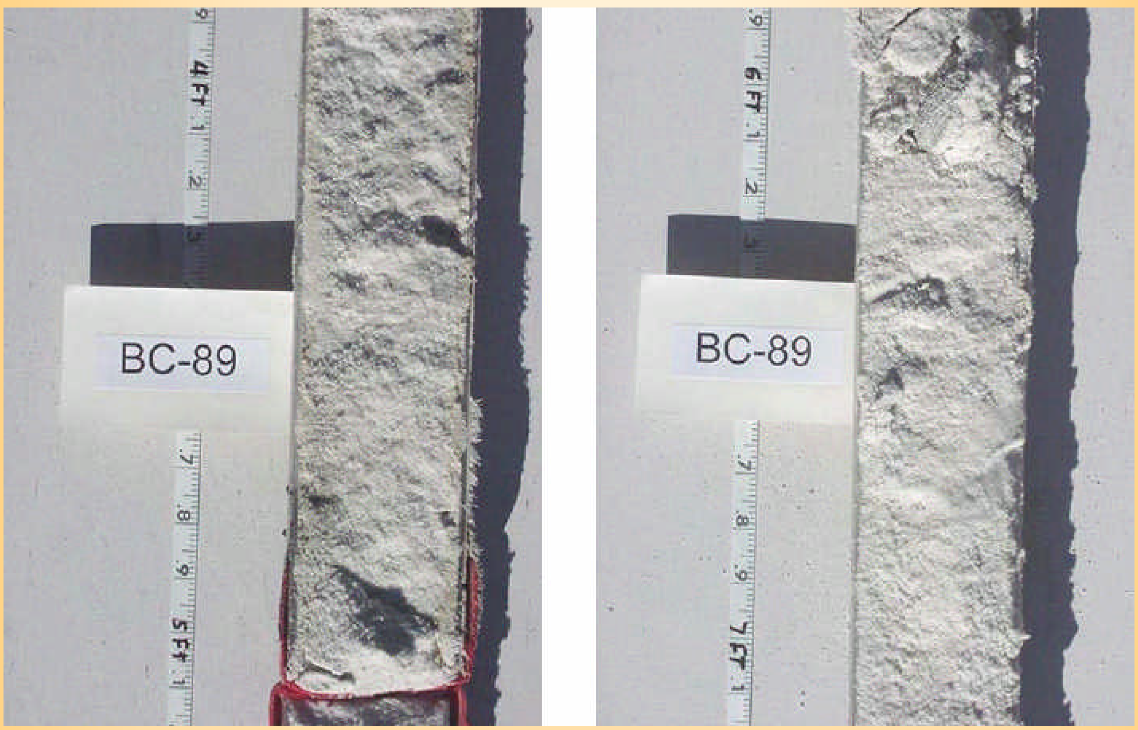
ORANGE BEACH
GULF STATE PARK
GULF SHORES
BEACH RESTORATION PROJECT
BALDWIN COUNTY, ALABAMA

Sand Search Investigation & Analysis of Borrow Site Sediment Characteristics



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August 2003

Submitted To:
City of Orange Beach, AL
Alabama Department of Conservation and Natural Resources
City of Gulf Shores, AL

olsen
associates, inc.
coastal engineering

Orange Beach / Gulf State Park / Gulf Shores
Beach Restoration Project
Baldwin County, AL

Sand Search Investigation & Analysis of Borrow Site Sediment Characteristics

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EXECUTIVE SUMMARY

This report documents the procedures and findings of a comprehensive geotechnical investigation undertaken to identify sources of beach quality sand suitable for the construction of a large-scale, multiple-segment beach restoration project for the City of Orange Beach, the Alabama Department of Conservation and Natural Resources' Gulf State Park, and the City of Gulf Shores, Baldwin County, AL. The three sponsors of the project, hereafter referred to as the OB/GSP/GS Project, contracted with Olsen Associates, Inc., of Jacksonville, FL, to conduct this and other investigations pursuant to the project and to permit, design, and oversee construction by the selected contractor. This report presents the findings of the native beach characterization, a background data review, a Vibracoring program, and the subsequent analysis of the core-boring logs and sediment sampling.

The proposed project consists of four segments, Perdido Key Orange Beach / Gulf State Park, West Beach – Gulf Shores, and West Beach – East of Little Lagoon Pass. In total, the OB/GSP/GS Project calls for the placement of an estimated 5.0 million cubic yards of sand (pay volume) along a combined project length of approximately 11.6 miles. The principal objective of the Sand Search Investigation was to identify borrow areas that could be utilized to cost-effectively construct each segment of the beach restoration project. An additional objective was to characterize the existing sediments throughout State Waters in the Eastern Baldwin County, AL, nearshore area in order to provide valuable data for future uses beyond the present project.

Four borrow areas were developed for use in the project. These areas extend from east of Perdido Pass to west of the western end of West Beach – Gulf Shores. Characteristics of the borrow areas are summarized in Table EX-1. The sites are large enough to construct the project and allow for some flexibility in the construction techniques and sequencing. Sufficient volume overage exists in the borrow areas to account for efficiency losses.

While four potential borrow areas were developed for excavation during the course of this investigation, it is apparent from inspection of all the data that there is only a finite volume of truly "beach-compatible" sand that exists in State Waters off Baldwin County, AL. Further, inspection of historical data in Federal Waters similarly suggests that only a limited amount of desirable material exists beyond the three mile limit. Well offshore, North Perdido Shoals and its offshoots provide a potentially large source of beach-quality sand, but these features are significantly seaward of Baldwin County, thereby representing a more expensive source of sand for the County's beaches. This situation highlights the need to conserve sand at every opportunity. In the short-term, this requirement dictates that existing identified sand borrow sources be excavated to their maximum practicable depths in order to save acreage in viable borrow sites for future use. This approach also maximizes the benefit gained for the acreage of seabed disturbed. Several smaller shoal deposits identified in the present study, some of slightly lower quality, may require closer consideration in future restoration efforts.

Table EX-1 Summary of Weighted Average Borrow Site Statistics
Orange Beach / Gulf State Park / Gulf Shores Beach Restoration Project

Borrow Area	Area (acres)	Volume* (Mcy)	Excavation Depth (ft, NVGD29)	Median Grain Size (mm)	Overfill Ratio	Color
1	156	2.0	-41	0.28	1.0 – 1.2	10 YR 8.3/0.6
2	189	2.6	-38	0.28	1.0 - 1.2	10 YR 8.4/0.7
3	179	2.1	-43	0.29	1.0 – 1.2	10 YR 8.0/0.8
4	131	1.0	-36	0.24	1.2 – 1.7	10 YR 7.5/0.5

*Volume estimates reflect the expected excavation volume. This volume differs from the associated pay volume and the total volume of sand available in each borrow area. The total volume excavated from each site will depend on the construction technique and sequence chosen by the contractor. The actual designed borrow area will be smaller in acreage than that listed in this table. Further, sufficient volume must be provided in all borrow areas to allow for spillage and efficiency losses in order to achieve the desired pay volume on the beach. For these reasons, the volumes listed in this table and elsewhere are considered approximate estimates.

The lack of significant long-term sand sources in the immediate vicinity of Baldwin County highlights the critical importance of proper sediment budget practices at Perdido Pass and Pensacola Pass. These tidal entrances, along with Lagoon Pass, represent substantial "sinks" of sediment from the littoral system, and have acted as such for a great number of years. It is extremely important to the future health of Baldwin County's beaches that proper sand management practices at both inlets be instituted and rigorously followed. These practices include identifying appropriate disposal areas that will allow the sand to easily return to the littoral system, rather than lying in "nearshore disposal areas" that are either a) too far offshore to allow significant onshore transport, or b) too close to the entrance being dredged, such that significant volumes of the dredged sand quickly return to the channels. The 2003 USACE disposal west of Perdido Pass is a significant step in the right direction. To assure that such practice occurs regularly basis, it may be beneficial for local interests to pursue some formal arrangement with the USACE at Perdido Pass, which is authorized as a navigation project, not a shore protection project. Similar cooperative practices could be considered at Pensacola Pass in Florida.

In addition to pursuing proper sand management at Perdido Pass and Pensacola Pass, it is recommended that potential sediment sources lying further offshore eventually be investigated in order to better address the long-term viability of the beaches of Baldwin County. This investigation would include core boring further offshore in Federal Waters, to revisit limited core-borings and assess the quality of sediments lying along northern offshoots of North Perdido Shoals, among other areas.

Orange Beach / Gulf State Park / Gulf Shores
Beach Restoration Project
Baldwin County, AL

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&
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Alabama Department of Conservation and Natural Resources
City of Gulf Shores, AL

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1.0 INTRODUCTION

This report documents the procedures and findings of a comprehensive geotechnical investigation undertaken to identify sources of beach quality sand suitable for the construction of a large-scale, multiple-segment beach restoration project for the City of Orange Beach, the Alabama Department of Conservation and Natural Resources' Gulf State Park, and the City of Gulf Shores, Baldwin County, AL. The three sponsors of the project, hereafter referred to as the OB/GSP/GS Project, contracted with Olsen Associates, Inc., of Jacksonville, FL, to conduct this and other investigations pursuant to the project and to permit, design, and oversee construction by the selected contractor. This report presents the findings of the native beach characterization, a background data review, the Vibracore collection, and the subsequent analysis of the core-boring logs and sediment sampling.

The project consists of four segments, as depicted in the location map in Figure 1.1. Segment No. 1 lies on Perdido Key, east of the tidal inlet at Perdido Pass. Segment No. 1 extends for approximately 1.3 miles from the Alabama/Florida State Line westward to the State Park at Florida Point. Segment No. 2 begins in Orange Beach, AL, west of Perdido Pass. This 5.9-mile segment extends from roughly 1¼ miles west of the west jetty at Perdido Pass (in the vicinity of the private pier at the Four Seasons Condominium) to the boundary of Gulf State Park and Gulf Shores. The Orange Beach portion occupies 3.7 miles of the segment, and Gulf State Park occupies the western 2.2 miles. Segment No. 3 lies in West Beach – Gulf Shores and occupies an alongshore length of approximately 3.3 miles beginning 1,200 to 1,300 ft west of the Entrance to Little Lagoon and extending westward to the entrance to the subdivision community of Laguna Key. The fourth segment, a comprehensive dune restoration project of much smaller volume density, extends just over one mile from the western limit of the 2000-2001 Gulf Shores, AL, Beach Restoration Project (the “East Beach Project” Olsen Associates, 2001a) near 12th Street to Lagoon Pass. These limits are considered to be approximate and may change slightly depending on the shoreline conditions at the time of construction.

In total, the OB/GSP/GS Project calls for the placement of an estimated 5.0 million cubic yards of sand along a combined project length of approximately 11.6 miles. Assuming a factor of 20% for efficiency losses during the construction process, an estimated 6.0 million cubic yards may be required for excavation in order to successfully construct the project (not including spillage within the borrow sites). The principal objective of the Sand Search Investigation was to identify borrow areas that could be utilized to cost-effectively construct each segment of the beach restoration project. An additional objective was to characterize the existing sediments throughout State Waters in the Eastern Baldwin County, AL, nearshore area in order to provide valuable data for future uses beyond the present project.

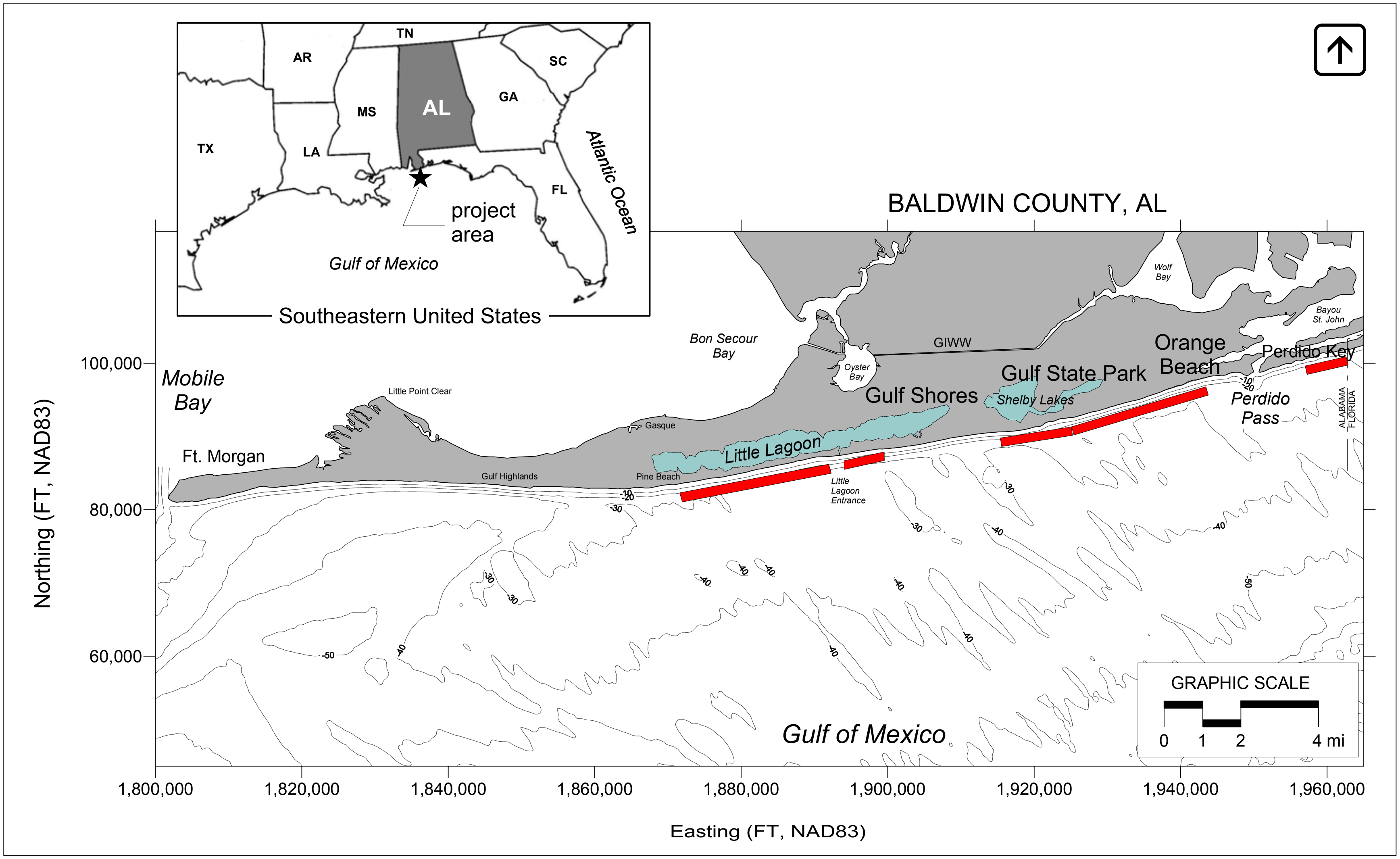

Figure 1.1 Location map, southern Baldwin County, AL. The three principal shoreline segments to be restored are highlighted in red along the developed portion of the Perdido Key shoreline, along West Orange Beach, Gulf State Park, and West Gulf Shores. A fourth segment east of Little Lagoon Entrance is proposed for comprehensive dune restoration.

2.0 STUDY SETTING & SCOPE

2.1 Study Setting

Figure 2.1 depicts the regional bathymetry immediately Gulfward of the Baldwin County, AL, shoreline. In Alabama, the State/Federal boundary lies three nautical miles Gulfward of the shoreline (plotted approximately in Figure 2.2). For economic reasons, the investigation area was generally limited to that area lying in Alabama State waters and within reasonable economic bounds of each project segment (i.e. within reasonable pipeline pumping distances based on the existing geology).

The Baldwin County Gulf of Mexico shoreline extends from Perdido Key, the barrier island east of the tidal entrance to Perdido Pass, westward along the Morgan Point Peninsula for a distance of approximately 31 miles. The City of Orange Beach occupies the easternmost 7.5 miles of the County, including the 2.2-mile length of the Alabama portion of Perdido Key. Perdido Pass, a Federal Navigation Project, separates Perdido Key from Orange Beach and Romar Beach (the west end of Orange Beach). The primary unit of Gulf State Park occupies the next 2.2 miles of shorefront, neighbored to the west by the City of Gulf Shores. Gulf Shores extends just over 8.1 miles along the Gulf of Mexico; its shoreline is intersected by the tidal entrance to Little Lagoon (the division of West and Each Beach Boulevard in Gulf Shores begins at Highway 59, east of Little Lagoon Entrance). Westward of Gulf Shores lies segments of shoreline in the Bon Secour National Wildlife Refuge and the smaller communities of Pine Beach and Gulf Highlands. At the western terminus of the Baldwin County shoreline is Ft. Morgan State Park and the entrance channel to Mobile Bay.

The primary coastal road through the area is State Route 182, which runs from the State line on Perdido Key to the west end of Gulf Shores at the Laguna Key subdivision. The area is accessed by highway from the north by State Route 59, which intersects Route 182 in Gulf Shores at the main City Park, and by Route 292 in Escambia County, FL.

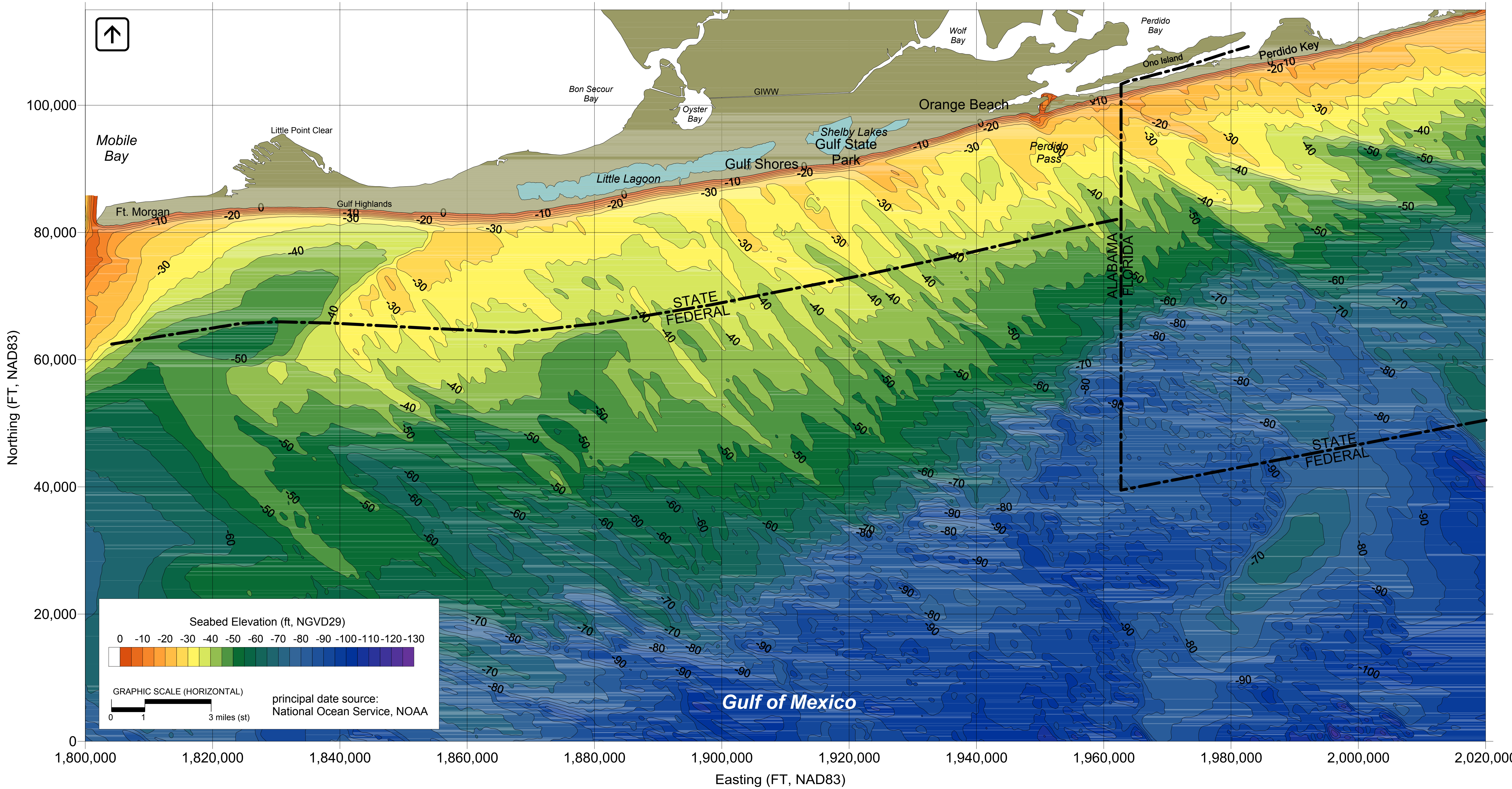

Figure 2.1 Bathymetric chart, Mobile Bay Entrance to Perdido Key, FL. Contours represent seabed elevation in feet (NGVD29).

The bathymetry in the vicinity of the project segments is most notably characterized by the numerous oblique shoreface-attached submerged sand ridges that run in a northwest-southeast orientation. In the project area, no less than six such features can easily be identified. These nearshore ridges have crest elevations approaching 20-ft depth. Additional features include the (relatively) small ebb-tidal shoal at Perdido Pass, and the massive shoal feature west of Gulf Shores. The latter feature extends in a northeast-southwest orientation for over eight miles from the shoreline out to depths exceeding 40 ft. Along the State/Federal boundary, water depths are relatively shallow at 35 to 45 ft. These primary features in State Waters are discussed in detail in subsequent sections.

The larger-scale trend in nearshore bathymetry is the narrowing of the width of the nearshore region from west to east. This trend is directly related to the orientation of the continental shelf along DeSoto Canyon (not shown). The narrowing trend continues to the east into Florida and eastward of the Destin, FL, area. In the nearshore, the bottom slope is very mild out to the 50- to 60-ft contours, which lies between 6 to 8 nmi offshore (1:850 slope). Beyond the 60-ft contour, a bathymetric low exists with maximum depths reaching 95 ft. South of this bathymetric low, a shelf-parallel shoal, North Perdido Shoals, exhibits crest elevations approaching 65-ft in places. North Perdido Shoals follows the continental shelf along DeSoto Canyon and lies more than 15 nmi offshore of Baldwin County, AL. A northern offshoot of North Perdido Shoals can be seen in Figure 2.1, south of Perdido Key, FL, beyond the 9nmi Federal Boundary in Florida[1]. This feature and its potential for future sand source use are also discussed further in subsequent chapters.

[1] A similar northern offshoot of North Perdido Shoals was developed for sand excavation for the 2002-2003 Pensacola Beach, FL, Beach Restoration Project (Browder, 2002). This feature also has a 65-ft ambient depth and a corresponding bathymetric low to its north, but is located only 3.0 to 3.5 nmi offshore in that area.

2.2 Study Scope

The present study benefits substantially from previous data collection efforts in the region by Olsen Associates, Inc., and others. The sand search for the 2000-2001 Gulf Shores, AL, Beach Restoration Project (East Beach), provided significant detailed sediment Vibracore data and seismic sub-bottom information (Olsen Associates, 2001b). Similarly, the sand search for the Pensacola Beach, FL, Beach Restoration Project provided corroborating Vibracore and seismic data (Browder and Olsen, 2001a, b). Other notable investigations include the compilation of previous Vibracores and the new nearshore Vibracores presented in Hummel (1999), and the regional work of McBride et al. (1999), who describe the North Perdido Shoals complex. These and other sources formed the basis for the 2002-2003 geotechnical investigation for the project.

The primary components of the Geotechnical Sand Search Investigation for the Orange Beach/Gulf State Park/Gulf Shores, AL, Beach Restoration Project were:

- Literature survey of relevant previous investigations,
- Native beach sediment sample collection (S. Douglass, April 2003),
- Sediment core-boring collection (December 2002),
- Logging, sampling, and analysis of collected cores (Spring 2003).

All offshore geophysical data acquisition was performed by Alpine Ocean Seismic Survey (AOSS, 2003), Inc., of Norwood, N.J., under the guidance of Olsen Associates, Inc. (report found in Appendix A). The logging, sampling, and analysis of the collected cores and native beach surface samples were performed by Scientific Environmental Applications, Inc., of Melbourne, FL (SEA, 2003). Native beach surface samples were collected by Dr. Scott L. Douglass and Ms. Becky Roland, Mobile, AL. Data from the native beach sampling and Vibracore logging and analyses are provided in Portable Document Format (*.PDF) on the attached CD-ROM disc. The disc contains a map of all core locations and native beach transects and can be 'searched' by clicking on the map on the desired core or beach profile.

3.0 NATIVE BEACH CHARACTERISTICS

The characteristics of the sediments along the native beach within the project area were assessed via analysis of 77 surface grab samples collected along 10 beach profile transects across the area. Samples were collected by Dr. Scott Douglass and Ms. Becky Roland for Olsen Associates, Inc., in April 2003. These transects are listed in Table 3.1 (shading indicates the separation of project segments).

At each profile, six to eight surface samples were collected (typically eight, but dependent on existing beach conditions). For dry beach samples, the upper two inches of sand was removed before the sample was collected. In addition to the 2003 samples, Douglass collected a similar suite of samples for the 2000-2001 East Beach project (November 1999). All samples in the present analysis can be generally classified as quartz, medium- to fine-grained sand (Unified Soils Classification) or coarse- to fine-grained sand (Wentworth scale) with very low percentages of shell content (generally less than one percent, estimated). Data for each sample can be found on the attached CD-ROM disc.

Table 3.1 Beach profile transect locations for native beach sand sampling

Transect # (per Douglass and Roland)	Location	Corresponding Survey Monument	Segment No.
1	West Beach – Laguna Key Subdivision	West Beach Sta 510+00	3
2	2361 W. Beach Blvd	West Beach Sta 420+00	3
3	1881 W. Beach Blvd	West Beach Sta 350+00	3
4	1285 W. Beach Blvd	West Beach Sta 290+00	4
5	Gulf State Park Convention Center	ADEM B-24	2
6	Hilton Garden Inn – Orange Beach	Between B-31 & B-32	2
7	Romar Beach Access	B-34	2
8	Cotton Bayou Access	COE-284	2
9	Windrift Condominium – Perdido Key	B-45	1
10	Flor-Bama (AL/FL State Line)	B-48	1

Samples collected – April 2003 (Douglass and Roland).

Sediment grain sizes are typically described in either phi units, Φ, or millimeters, *mm*. Phi units are commonly used to relate various properties of a sediment sample (e.g. sorting, skewness, etc.). The relationship between diameter expressed in mm versus phi units is given in Equation 3.1.

$$d = 2^{-\phi} \tag{3.1}$$

The median diameter, D_{50}, of a sediment sample is that diameter for which 50% of the sample by weight is coarser (or finer). Median diameters for all the 2003 samples fall within a range of 0.21 mm to 0.46 mm (2.252ϕ to 1.120ϕ). All native samples contain a low percentage of fine material (material finer than the #230 sieve, 0.063 mm). The percentage of fines varies notably with the position along the profile. Samples collected on the dry beach berm have little to no fine material (0.5% or less) while samples collected seaward of the bar and in the trough exhibit fines fractions reaching 3.3%.

The sorting of a sediment sample describes the degree to which all sediments are similarly sized. This value is represented by the standard deviation/sorting coefficient of the sample, given by

$$\sigma_{\phi} = \frac{(\phi_{84} - \phi_{16})}{2} \tag{3.2}$$

The average sorting coefficient for all segments is 0.47 to 0.50ϕ, where West Beach in Gulf Shores exhibits slighter higher sorting values than its eastern neighbors. These values indicate sediments that are generally well-sorted (σ_{φ} < 0.50ϕ), meaning most of the grain sizes in the sample are fairly similar. Sorting coefficients are also seen to vary across the profile, with lower values on the dry beach (0.40ϕ), and higher values at depths offshore of the primary bar (0.5 to 0.6ϕ).

Figure 3.1 plots the grain size distributions of all 77 samples. The figure indicates the envelope of grain sizes that naturally exist (at the time of the data collection). Figure 3.2 illustrates the cross-shore variation of grain size across typical profiles in each of the three project segments.

Figure 3.2 demonstrates the offshore fining of sediments from the upper beach berm to beyond the primary bar. Each data point in the graph represents the average of the samples collected at the respective cross-shore stations for the transects in each segment (two or three values per station). Average median grain sizes along the dry beach typically exceed 0.30mm, with some samples reaching a high of 0.46mm. Seaward of the primary bar, sediments can be as fine as 0.21mm with typical values of 0.22 to 0.23mm.

For purposes of comparing the native beach characteristics to the sediment characteristics in the proposed borrow sites, a representative median diameter and sorting coefficient must be derived for each segment. These values must account for the variation in grain size along the profile. Dean (2000) discusses techniques for developing composite characteristics using spatially weighted averages. Both vertical and horizontal averages may be used, and there are arguments for and against each. Herein, the range of possible values is presented, principally to illustrate the uncertainty in developing a single value and ultimately determining an overfill factor (discussed elsewhere in this report).

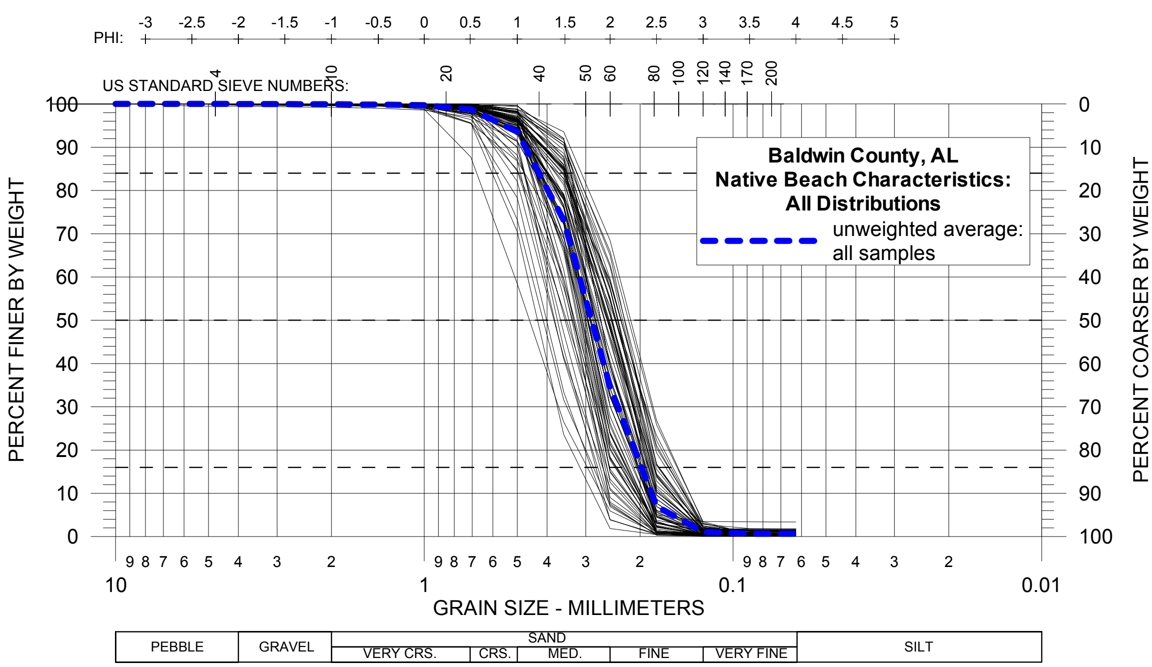

Figure 3.1 Grain size distributions for all native beach samples collected (April 2003).

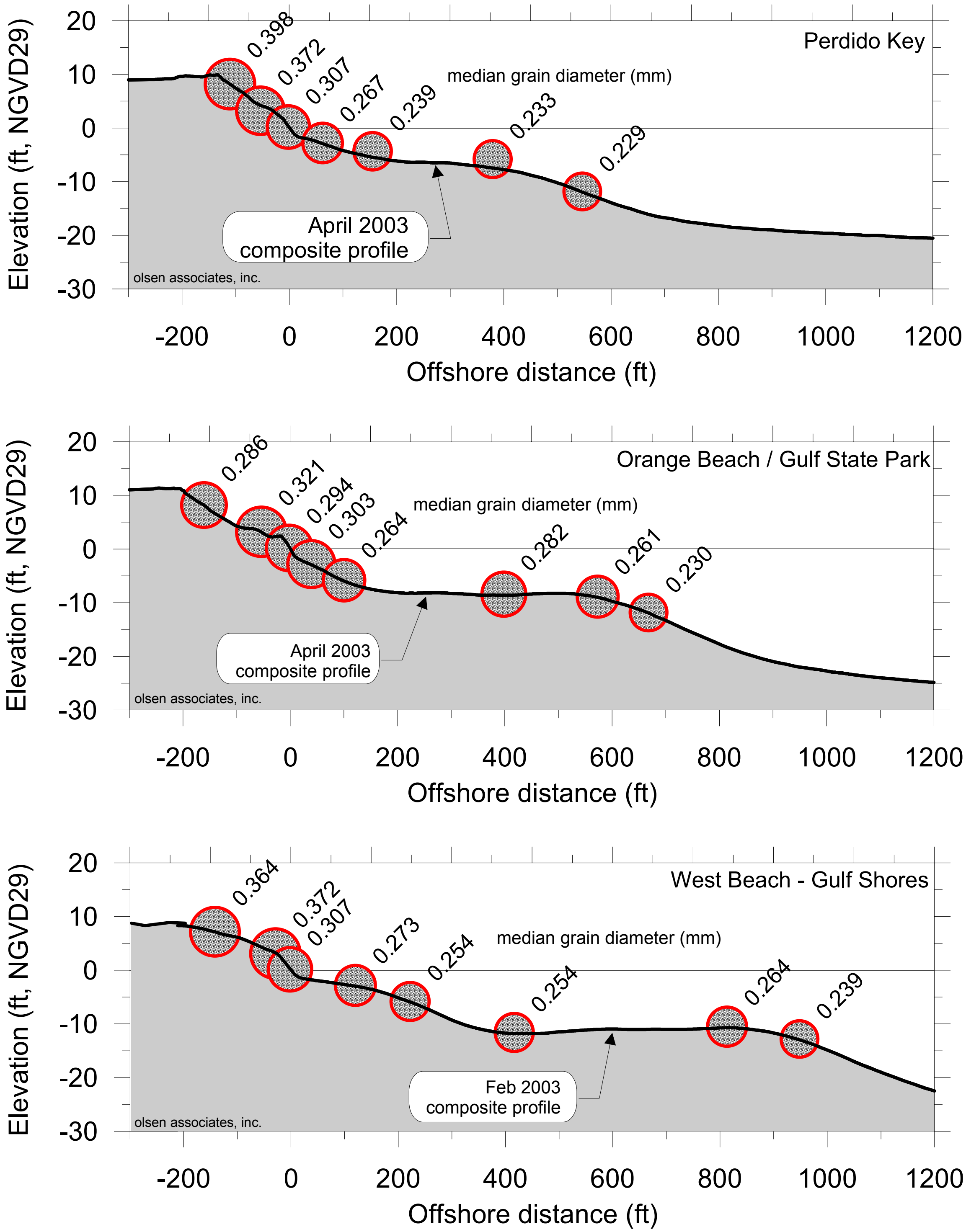

Figure 3.2 Cross-shore variation in median sand grain diameters for each of the three primary project segments. Each point represents the average of three corresponding discrete samples collected along different transects in each segment.

Table 3.2 presents the range of composite median diameters and sorting coefficients determined from the various computational methods. In many regards the differences may seem slight, however, as will be shown in the borrow site analyses, small differences in both median size and sorting coefficient can produce larger differences in overfill factor.

Additional native beach grain size data is available from Olsen Associates (2001b). These data were collected by Douglass in 1999 for the East Beach project. The 1999 samples were collected in November versus April for the present study. The November samples produced higher grain sizes along the submerged portions of the profile and produced a composite median diameter of 0.30mm. Given the variability in the data and the differences in seasonality and computational methods, it would seem appropriate to view the composite values as a small range rather than a single value.

Sediment Carbonate Content and Color Further characterizing the native beach is its shell/carbonate content and its color. The native beach contains very little shell. Previous experience suggests that the shell/carbonate content of the native beach is much less than 1% by weight, although there are shell fragments that can be found along the upper beach. Shell content was so low it was deemed unnecessary to test for carbonate content. Sediment color is described using the Munsell color scale. However, the color of the native beach is much whiter and brighter than the "high end" of the traditional Munsell Soils Color Chart (Browder, 2002). Using the 10YR hue page and the 10YR samples from the Nearly Whites fandeck, both Munsell products, the native sediment color is estimated to be 10YR 9.0/1.5 (all segments). This represents a nearly white sand that has a slight tan or orange cast to it (indicated by the 1.5 designation).

Table 3.2 Composite Native Beach Characteristics by Segment

Segment	**Direct Averaging**		**Horizontal Weighting**		**Vertical Weighting**	
	Median (mm)	**Sorting (σ)**	**Median (mm)**	**Sorting (σ)**	**Median (mm)**	**Sorting (σ)**
Perdido Key	0.29	0.47	0.27	0.49	0.29	0.49
Orange Beach / Gulf State Park	0.28	0.47	0.27	0.49	0.28	0.47
West Beach G.S.	0.29	0.50	0.27	0.53	0.29	0.49

Samples collected – April 2003 (Douglass and Roland).

Regarding the native characteristics of the West Beach – Gulf Shores segment of the project, an emergency beach fill project is scheduled for construction in late Summer 2003. This project is partially funded by the Federal Emergency Management Administration (FEMA). The project is being constructed in response to Tropical Storm Isidore in September 2002 and proposes to place approximately 700,000 cy of sand along the same 3.3-mile West Beach project limits. The sand for the emergency fill will be excavated from overwash deposits found in Little Lagoon, north of the project area (Figure 1.1).

Olsen Associates (2003) describes the sediment characteristics of the borrow sands from Little Lagoon (Table 3.3). The sediments are extremely compatible with the native beach, and exhibit coarser median grain sizes overall. The result of the emergency beach fill project may be the slight coarsening of the West Beach sediments, however, any change is expected to be slight. In general, the addition of coarser sediments from Little Lagoon to West Beach will assist in elevating the overall performance of sediment placed during both efforts (refer to Section 5.3 and 5.4).

Table 3.3 Basic Characteristics of Little Lagoon Borrow Areas for the West Beach Emergency Beach Fill Project (Olsen Associates, 2003)

Borrow Area	Area (acres)	Estimated Volume (cy)*	Representative Vibracore #s	Average d_{50} (mm)	Average Sorting Coefficient (σ)	Overfill Ratios**
1	35	189,000	1, 2, 3, 4, 35	0.36	0.60	1.0, 1.0
2	18	89,000	5, 6, 7, 8	0.33	0.55	1.0, 1.0
3	31	103,000	9, 10	0.34	0.63	1.0, 1.0
4	16	85,000	21	0.33	0.48	1.0, 1.0
5	58	282,000	19, 20, 22	0.29	0.50	1.5, 1.2
6	58	283,000	24, 25, 27, 29	0.32	0.48	1.1, 1.0

*Volume above an estimated excavation depth of -6.0ft NGVD.

**Overfill ratios computed from James (1974), and Dean (1974), respectively (reference Dean 2000).

4.0 OFFSHORE SAND SEARCH / VIBRACORE COLLECTION

The nearshore region seaward of Baldwin County, AL, from the AL/FL State Line to Gulf Highlands, was investigated to identify beach-quality sediment sources in sufficient volumes to cost-effectively construct each segment of the proposed beach restoration project. Generally, the search was limited to State Waters (within three miles of the shoreline). Quality in the present context refers to borrow sediment compatibility with the native beaches in terms of grain size distribution, shell content, and color. The requirements of the project dictated that approximately 6.0 million cubic yards of beach-compatible sand be identified. The expected placement volume, 5.0 million cubic yards, represents 333,000 dump-truck loads of sand (at 15 cy/truck, typical). Such a high volume of sand precludes the efficient construction of the project from upland sources via truck or rail, thus offshore sand sources must be developed.

4.1 Previous Investigations

Figure 4.1 plots the position of core-borings collected in the project area, including the 160 Vibracores collected as part of this study (denoted by the red cross-hair circles labeled "*BC-xxx*"). Prior to the Olsen Associates sand search for the East Beach project in 1999 (Olsen Associates, 2001b), various investigators had conducted limited studies of the geologic makeup of the seabed in the vicinity of Baldwin County, AL. Locker et al. (1988) conducted a Panhandle survey of sub-bottom structure and surface sediment sampling, primarily offshore of Florida but extending westward to Gulf State Park in Alabama. That study included seismic profiling, sidescan sonar, and seabed surface sediment sampling data collection. The Locker study focused more on deep sequence geology and provides little specific guidance for conducting a sand search of the present nature, but the study does describe the transition from the Apalachicola Embayment to the Mississippi Embayment and the Mississippi-Alabama-Florida sand sheet on the west side of the head of DeSoto Canyon.

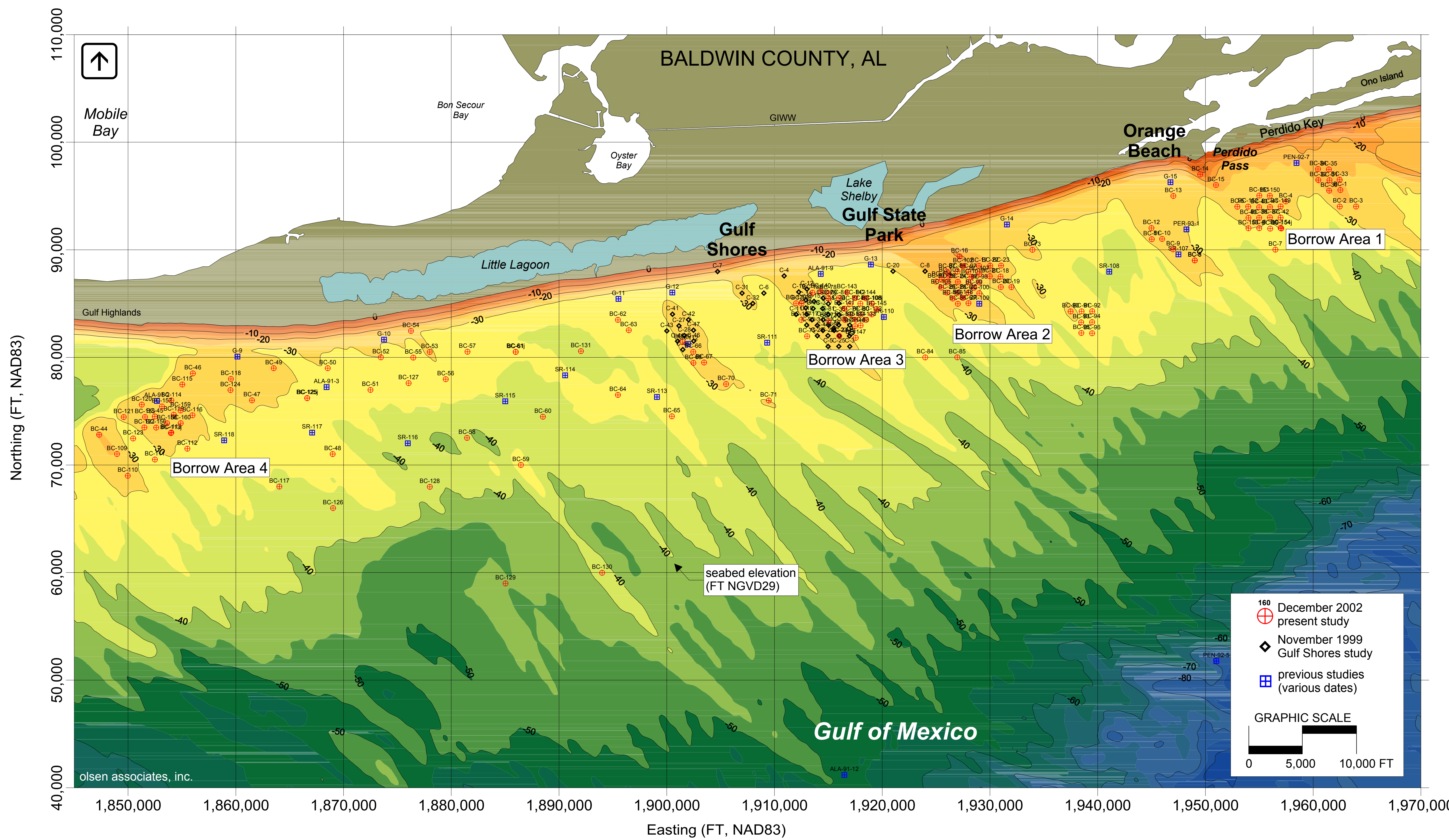

Figure 4.1 Locations of historical and current sediment Vibracores offshore Baldwin County, AL (various sources).

McBride et al. (1999) conducted numerous studies in the Pensacola Pass, FL, to Mobile Bay, AL, area, collecting sediment samples and core borings out to the edge of the continental shelf at DeSoto Canyon. Many of the cores collected in this study were taken in the nearshore region offshore of Baldwin County, all below 30 ft MSL. These cores are identified in Figure 4.1 by the blue cross-hair boxes labeled "*ALA-9x-x*" and similar. The cores reveal several differing sediment types, but generally revealed a thin lens of marine sands overlying relict estuarine silty clays and marine shell beds. The authors present information detailing the shift in the nature of shelf sediments between the Mobile subprovince and the Apalachicola subprovince to the east. The Mobile subprovince receives finer sediments from Mobile Bay and thus has a distinctly finer nature than the Apalachicola subprovince. The writers identify the boundary between the two provinces along the shoreline east of Gulf Shores in the West Orange Beach area.

Parker et al. (1997) present an investigation of nearshore leasable sand deposits for potential beach nourishment use. The authors characterize the area offshore of Shelby Lakes (Figure 4.1, generally south of the cores shown as Borrow Site 3 in Figure 4.1) at the eastern end of Gulf Shores as potentially containing 160 Mcy of clean sand. The sediments are characterized as having clean medium sand with a mean grain diameter of 1.99 φ (0.25 mm) and an average sorting coefficient of 0.86 φ. While these values are finer and more widely distributed than the majority of native Baldwin County sands (Table 3.2), in all likelihood, some fraction of that 160 Mcy deposit is compatible with the native beaches. While it is *unlikely* that the entire area and 160 Mcy are composed entirely of truly "beach compatible" materials, Parker et al. do identify the coarser sediments on the crests of transverse ridges in the area.

Hummell (1999) prepared a study of offshore sand resources in the Morgan Point Peninsula area. The study, sponsored by the Minerals Management Service of the U.S. Department of the Interior, focused on lands lying in Federal waters, more than three miles offshore, although cores lying inside State waters were also included. Hummell lists 91 Vibracores throughout the area, including 35 new cores collected for that study. Some of these cores are located within the limits of Figure 4.1, and are denoted by the blue cross-hair boxes labeled "*G-xx*" and "*SR-xxx*." Hummell identifies the area as a Holocene transgressive fluvial-deltaic and marine fill sequence overlying older estuarine and fluvial deltaic deposits. The writer describes the genesis of the NW-SE oriented transverse ridges also described by Parker et al. (1997). The writer discusses the composition of the additional core borings taken during the study, and identifies potential beach nourishment borrow materials south of the Morgan Point Peninsula. Hummell generally describes the surficial sand sheet as an excellent source of borrow materials, but does recognize that project distances, lens thickness, and other issues may limit the usefulness of some areas. Similar to the Parker study, it is unlikely that the entire surficial sand sheet is "beach compatible," and in fact, analysis of the data in Hummel (1999) and subsequent investigation reveals that much of this sheet is not beach compatible sand.

2000-2001 Gulf Shores, AL, Beach Restoration Project Sand Search - Olsen Associates (2001b), describes the collection of 46 Vibracores collected in 1999 as part of the Sand Search Investigation for the East Beach Project. The locations of these cores are plotted in Figure 4.1 with black diamonds labeled "*C-xx*." This study focused on the area immediate fronting East Beach in Gulf Shores, and identified a borrow area atop the eastern shoreface-attached ridge along the Gulf Shores / Gulf State Park Boundary. Approximately 1.8 million cubic yards of sand was excavated during the construction of the 2000-01 project (Olsen Associates, 2001a).

2002-2003 Pensacola Beach, FL, Beach Restoration Project Sand Search – Browder and Olsen (2001a,b) describe the data collection efforts for the Pensacola Beach project, which included the collection of 122 Vibracores from Pensacola Pass eastward toward Navarre Beach. Although located east of the present project area, the nearshore/shelf bathymetry and geologic features are similar. As discussed above, the overall bathymetry narrows heading eastward, consistently parallel with the shelf break at DeSoto Canyon.

Available Seismic Sub-Bottom Survey Data: Gulf Shores and Pensacola Beach - Olsen Associates (2001b) and Browder and Olsen (2001a) describe the results of seismic sub-bottom surveys conducted in both areas during their respective sand searches. The acoustic surveys, performed by Alpine Ocean Seismic Survey, Inc., Norwood, NJ, consists of the measurement of pulses of sound directed into the seabed. The time of return of various frequencies of the reflected sound pulse provides information regarding changes in density of the material in the upper 50 ft (approximate) of the seabed. In this manner, areas characterized by multiple layers of sediment can be distinguished from areas containing little or no layering. In general, areas containing potential volumes of sandy-type sediments are essentially featureless in the upper 20 ft of the seabed. Areas with significant layering generally have alternating layers of mud or silt with layers of dense sand or clay (obviously undesirable material for a beach).

In Gulf Shores, over 80 miles of offshore tracklines were surveyed near East Beach. This survey principally characterized the borrow site ridge and the adjacent seabed. The Pensacola Beach survey covered over 300 trackline miles. Similar to the Gulf Shores surveys, the seismic results indicated nearshore areas of irregular bedding, except on the crests of the shoreface-atttached ridges. Further offshore, the irregularities diminish into featureless massive homogeneous units (i.e., no significant reflectors are seen in the upper 20 ft). Seismic survey data were not collected as part of the present study. The availability of the Vibracore and seismic data from the two previous efforts described above obviated the need for additional seismic work.

4.2 2002 Vibracore Collection

Based on the available data described above, a test plan was developed for the proposed project to develop borrow sites in sufficient volumes to cost-effectively construct the proposed beach restoration project. Efforts were made to identify sites in close proximity to each of the construction segments. Additionally, it was necessary to take some Vibracores in areas suspected to be of poor quality in order to fully characterize the region and rule out some areas. Figure 4.1 plots the position of each of the 160 Vibracores collected as part of the present study. These Vibracores were collected in December 2002 over a three week period. Alpine Ocean Seismic Survey, Inc., of Norwood, NJ, collected the cores under on-board direction by Olsen Associates, Inc.

The sediment core-borings were collected using a vibrating pneumatic rig (Vibracore) set to collect a 20-ft core sample (Figure 4.2). All Vibracores were prioritized for logging by a professional geologist for sediment composition and color. Composite and discrete sediment samples of each core were analyzed for grain size distribution, color, and shell content. All logs, core photographs, and grain-size data are provided on the attached CD-ROM disc. Once in the laboratory, the cores are split and examined for logging. The logging describes the various layers present within the core. The sediment classifications are based on the Unified Soils Classification System (USCS). Generally, in the USCS, beach quality sediments will have an SP rating. Several cores collected outside of the borrow site areas were rated as SM, ML, or CL sediments, indicating the presence of silts or clays. These sediments have noticeably higher percentages of fine particles or muds and, for that reason, are not analyzed for grain size distribution. These muddy sediments are also typically much darker in color than the sandy materials. Individual samples are taken from various elevations in the core and analyzed for grain size distribution, shell content, percentage of fine material, etc. These procedures were conducted by Scientific Environmental Applications, Inc., of Melbourne, FL.

Figure 4.2 Pneumatic core boring rig (left) on the Research Vessel Atlantic Twin, owned and operated by Alpine Ocean Seismic Survey, Inc., of Norwood, NJ. Twenty-foot sediment core ready for labeling and cutting (right).

4.3 General Trends and Observations from Vibracoring Program

As discussed previously, the nearshore bathymetry of Baldwin County, AL, is dominated by the occurrence of numerous shoreface-attached, obliquely-oriented sand ridges. These features trend in a Northwest-to-Southeast direction, and the larger ridges extend Gulfward beyond the 3-mile State/Federal boundary to typical water depths of 40 to 50 ft. Previous core-boring experience in the area suggests that the highest quality beach-compatible sands are located atop the crests of these ridges.

Sampling Scheme – The pattern of Vibracores collected in December 2002 was designed to identify a sufficient volume of beach-quality sand to cost-effectively construct each segment of the project. In addition, it was necessary to sufficiently characterize the nature of the entire area in order to demonstrate that numerous areas lying closer to project segments would be unsuitable for construction. As depicted in Figure 4.1, the collected Vibracores are clustered atop the shoreface ridges; less-densely spaced cores are located in the broad low-lying areas in between. Further guiding the collection of Vibracores is the need to maintain a sufficient cross-shore distance from the shoreline in order to minimize any potential borrow-site related wave refraction/diffraction impacts (Browder et al., 2003). A limited number of cores were collected offshore of the State/Federal boundary to verify the findings of previous investigators. Each Vibracore is labeled in the order it was collected, and reflects the down days and weather patterns during the collection process, not any horizontal location scheme.

Beach Compatible Sands – In the present context, beach compatible sands are defined as those that provide not only a suitable match of the native beach sands in terms of grain size, but also an acceptable match in terms of color, fines content, and shell content. In particular, sand color is an extremely important issue for an area that relies heavily on tourism.[2] The characteristics of the native beach are described in detail in Chapter 3. Additionally, the beach quality sediment must occur in a sufficiently thick isopach (typically 8ft in thickness or more) to economically justify the excavation of the sediment.

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[2] The Alabama Gulf Coast Convention and Visitors Bureau estimates that the beaches of Baldwin County generated $1.5B in revenue and jobs in 2002 (H. Malone, personal communication).

General Trends - As a general rule, any sand found that appeared to be of beach-quality was found in the vicinity of some sort of ridge feature in the nearshore. Vibracores collected in the broad valley areas between ridges were found to be undesirable material containing high levels of silts and fines, occasional lenses of clay, and/or high levels of crushed shell mixed with fines and clay. These sediments also exhibit much darker color, and frequently contained decaying organic material. This description was found to agree with the general findings of McBride et al. (1999), whose core samples were not sufficiently tightly-spaced to resolve well the differences between the ridges and the valley. Atop *most* of the ridge features, beach-compatible sand was identified, combined with varying low levels of broken shell. Further Gulfward, approaching the 3-mile limit, the ridge and valley features diminish and the sediment characteristics change subtly to a more consistent combination of gray fine sand with crushed shell. This behavior was noted in the Pensacola Beach area by Browder and Olsen (2001a).

Perdido Key – The bathymetry immediately offshore of Perdido Key is characterized by several closely-spaced ridges. The easternmost ridge of interest straddles the State Line and appears as a very distinct feature. The next ridge to the west is somewhat broader but has a distinct southwestern edge. Vibracores were collected along both areas, and beach-quality sand (by the authors' specific standards) was found in both areas. Between and away from these ridges, Vibracores indicated the presence of lenses of gray fine sand with elevated shell content and areas of silt and clay.

While both ridges contain beach quality sands in large volumes, the westernmost site was developed more intensively for use as a borrow site. This area, covering 156 acres (Figure 4.3), will serve as a borrow site for both the Perdido Key segment and the eastern portion of the Orange Beach / Gulf State Park segment. Only a small subset of the entire area was chosen for a borrow site, in order to maximize the quality of sediment placed on the beach and to conserve the remaining sand in the area for future use. Details of the borrow site analyses for this area are found in Chapter 5. Thorough sampling of the ridge at the State Line was conducted, such that this area could be developed for future use as a borrow area.

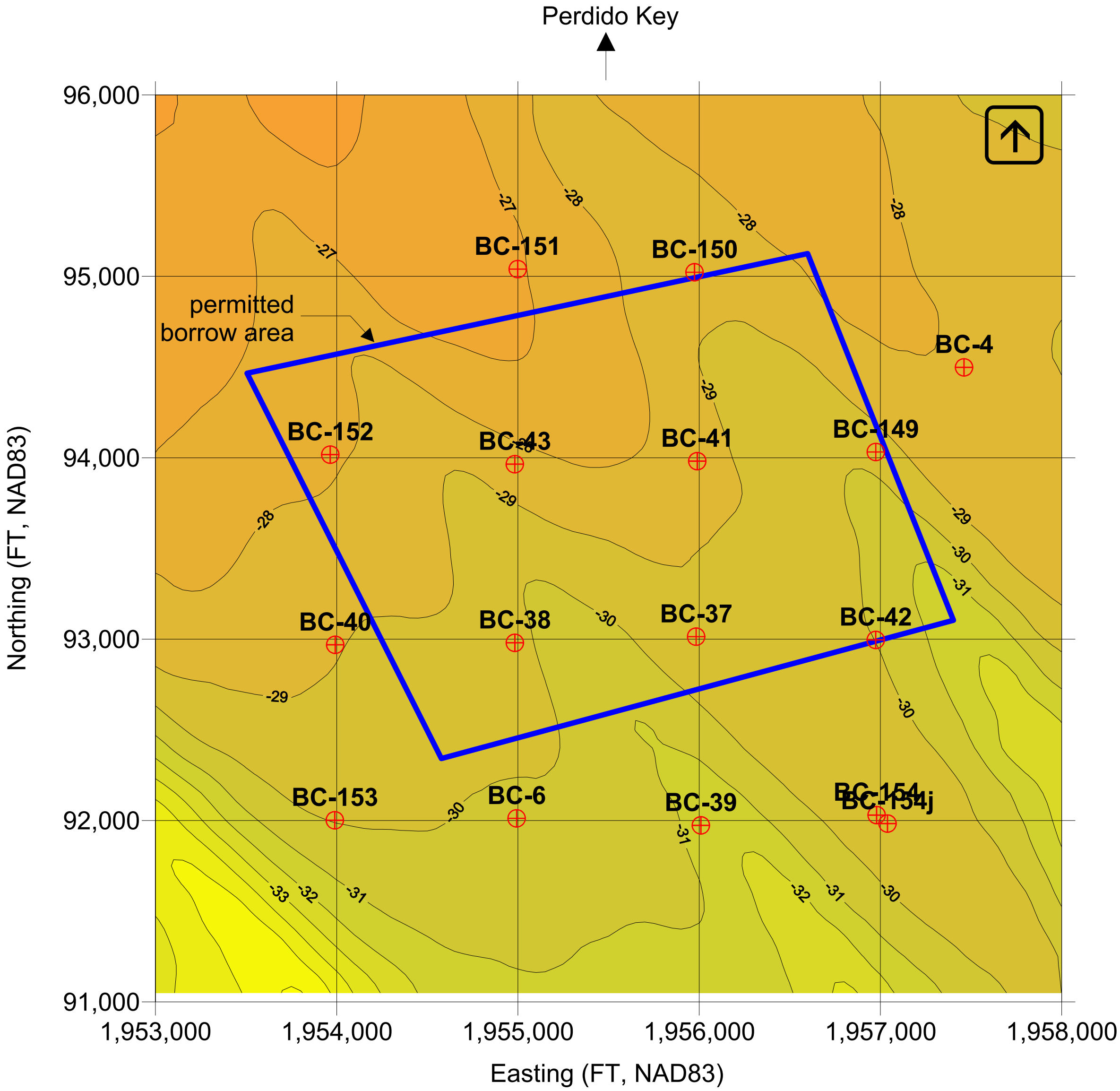

Figure 4.3 Detailed bathymetry in the vicinity of Borrow Area #1, Perdido Key, AL.

Orange Beach – Three areas of interest exist offshore of Orange Beach. First, the ebb shoal at Perdido Pass represents a possible borrow area. A limited number of Vibracores were collected along the outer margins of the ebb-shoal (BC-13, BC-14, and BC-15). BC-14, collected in the heart of the ebb shoal revealed a 19-ft thick sand lens of nearly white fine sands. Some evidence of silts and crushed shell layers were found in fine sands with typical median diameters of 0.20 mm at depth. Just off the ebb shoal to the west, BC-13 revealed only a 4-ft lens of fine sand overlaying a silty sand (SM) layer extending to 12ft below the seabed. Due to the development of other borrow areas, the small volume of sand available in the ebb shoal, and the potential for increased permitting issues, the ebb shoal at Perdido Pass was not developed further. For future use, the ebb shoal could be developed.

To the southwest of Perdido Pass, a broad ridge feature was investigated. This ridge produced a highly variable pattern of sediment quality. While BC-9 and BC-10 contained 10 to 13-ft lenses of acceptable sand, adjacent cores at BC-8, BC-11, and BC-12 revealed thinner, less desirable surface SP layers sitting atop silty sand and clay. Proceeding west, much of the Orange Beach shoreline is fronted by a low-lying featureless area. This area was not heavily investigated in the present study. Prior cores collected in the area and reported by Hummel (1999) reveal a highly bioturbated area to 14ft depth (SR-108) containing a mixture of fine sand, shells (whole and broken), silty sands and silt-sand-clay. Core BC-73 was collected atop a small ridge feature in the Romar Beach area and revealed the presence of a dark gray clay layer 2.5 ft below the surface. Vibracores BC-90 to BC-96 were collected further offshore on a low-relief disconnected shoal feature. These cores revealed a deposit of sands of only slightly lesser quality than the borrow sites identified; this deposit may provide material for future beach nourishment efforts in the area.

At the western end of Orange Beach along the shoreline boundary between Orange Beach and Gulf State Park lies a substantial bathymetric feature consisting of an eastern and western ridge. These two ridge feature merge at the shoreline boundary. This area was intensively investigated for use as a borrow site. Beach quality sands of varying grain size were found across a broad area spanning the two ridges (as shown in Figure 4.1). Vibracores collected along the crest of the eastern ridge revealed a deep lens of high quality sands extending to the southeast, but ending between BC-18 and BC-19 (which curiously revealed a clay layer overlaying the high quality sands). Progressing to the west and southwest to the western ridge, Vibracores were collected to identify the extent of the beach-quality sand deposit. Along the southern and western edges of the ridge feature, on-board inspection of collected samples revealed a strong fining trend. This trend was identified in almost all the ridges investigated. Inspection of laboratory results indicates that sediments fine from .025-0.30mm to less than 0.2mm in many samples along the edges. A 189-acre area was developed as a borrow site across the two ridges (Figure 4.4). This area was chosen to avoid those cores containing very fine sand and is limited to the southwestern shoulder of the eastern ridge in order to leave the ridge crest and its wave sheltering function (refer to borrow site discussion in Chapter 5). This borrow area, combined with borrow area #1, is expected to serve the sand requirements for the Orange Beach/Gulf State Park segment of the project.

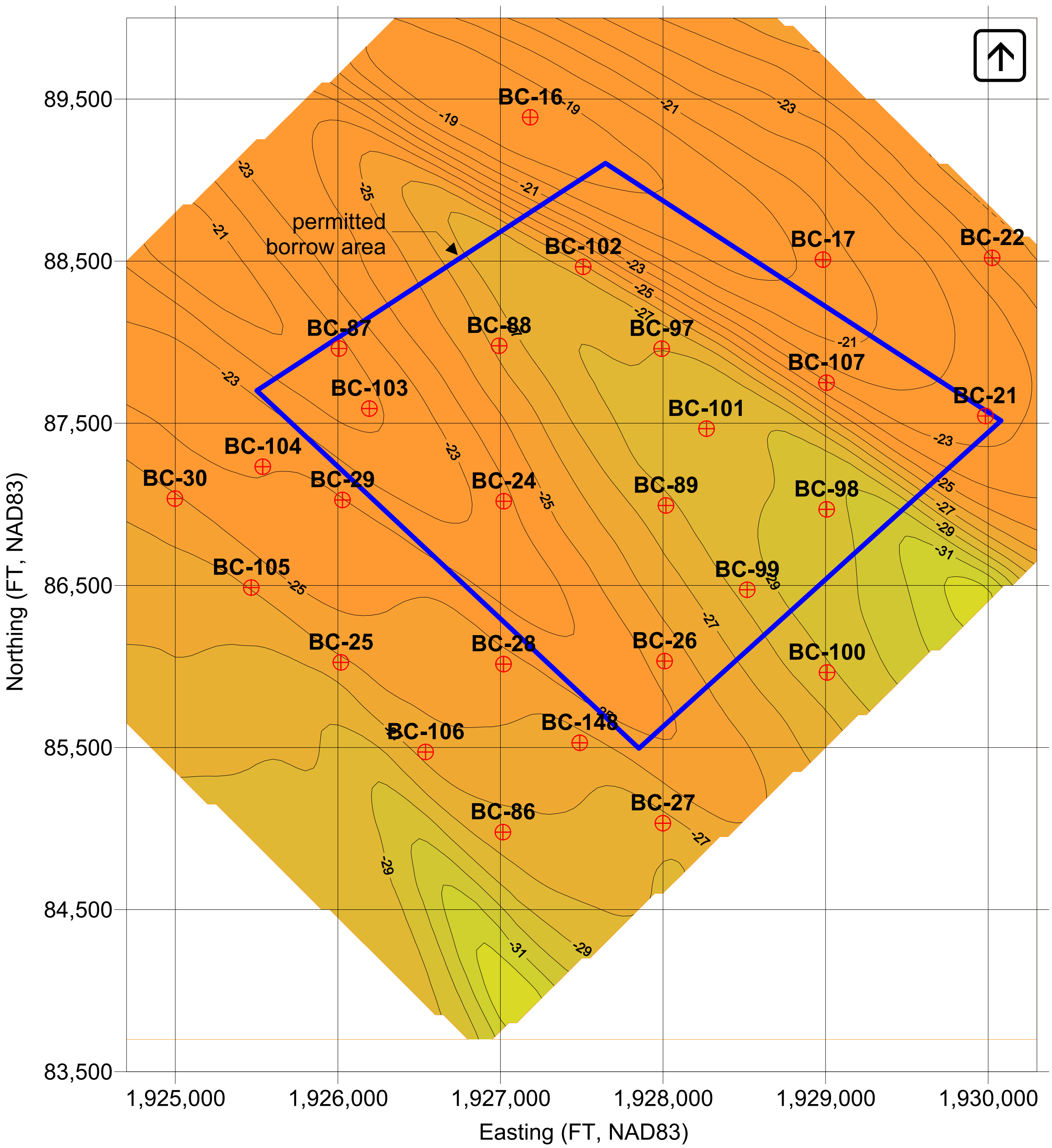

Figure 4.4 Detailed bathymetry in the vicinity of Borrow Area #2, Orange Beach, AL.

Gulf State Park / East Gulf Shores – Figure 4.1 depicts the location of the borrow site used in the 2000-2001 East Beach project. That area was excavated to an average depth of 42ft, only one to two feet above the identified bottom of the sand lens. This site was revisited in 2002 to further define the limits of the deposit of beach-compatible material. In particular, Vibracores were collected to the east of the existing borrow site, extending the investigated area by as much as 4,000 to 5,000 ft east of the 2000-2001 borrow site. Detailed inspection of the bathymetry in the area reveals the presence of a smaller ridge/shoal feature east of the main ridge (Figure 4.5). The area between the old borrow site and the crest of the eastern shoal was developed to expand the borrow site (borrow site details discussed in Chapter 5). This site is expected to serve the West Beach – Gulf Shores portion of the proposed project and to serve for project requirements in the future.

Similar to the Orange Beach/Gulf State Park borrow area, the ridge of the 2000-2001 borrow area and the 2002 extension exhibits a distinct fining trend to the southeast and southwest. Further to the east beyond the proposed extension, Vibracores reveal the typically undesirable "valley" sediment characteristics described previously. Similarly, Vibracores collected north of the proposed extension reveal a high degree of variability. In both the 1999 and 2002 sand searches, Vibracores collected very close to shore exhibited extremely undesirable sediments at the toe of the beach profile (roughly 25ft of water depth and deeper). Even atop most of the ridge features, a sufficient amount of separation distance offshore must be achieved before beach-quality sediments are found.

West Gulf Shores – The remainder of the Gulf Shores shoreline was investigated to attempt to develop a borrow area for the West Beach – Gulf Shores segment of the project. As illustrated in Figure 4.1, there is a ridge approximately three miles west of the 2000-2001 borrow site. This ridge was investigated in the 1999 study for the East Beach project, and was revisited in 2002. Both efforts revealed a highly variable pattern of sediments in the Vibracores, such that no viable borrow site could be developed. The principal difficulty with the sediment in the site, variability notwithstanding, is the lack of a deep isopach and the presence of fine materials. Referring to Figure 4.1 (and the CD-ROM), Vibracores BC-66 to BC-68 revealed a silty SM layer occurring at roughly 7ft below the seabed (Figure 4.6), overlaid by fine sand with occurrences of shell fragments and silt in the upper SP lens.

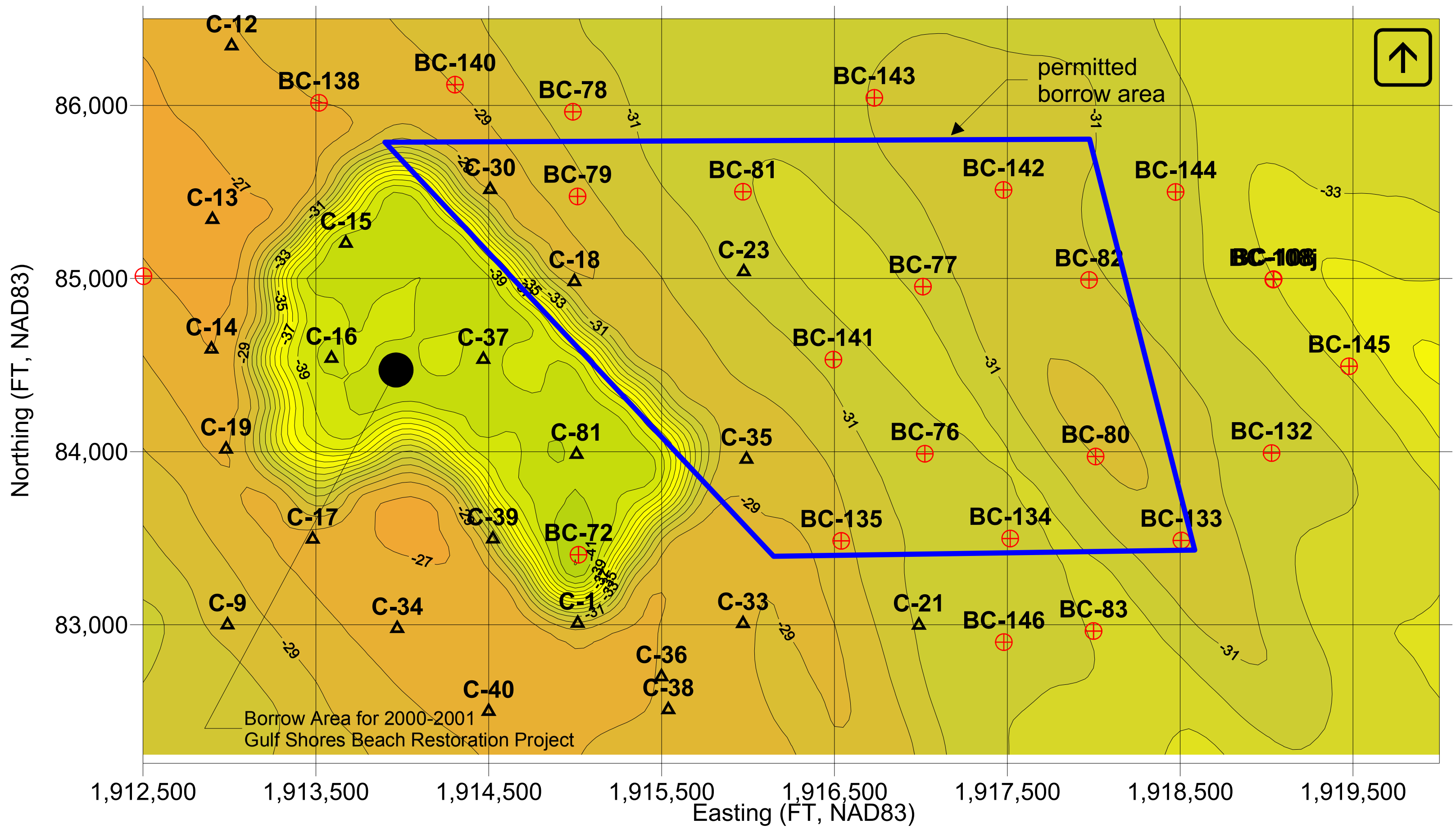

Figure 4.5 Detailed bathymetry in the vicinity of Borrow Area #3, Gulf Shores / Gulf State Park, AL. The 89-acre area excavated for the 2000-01 East Beach project is clearly seen. The black triangular symbols denote Vibracores collected in 1999 for the East Beach project.

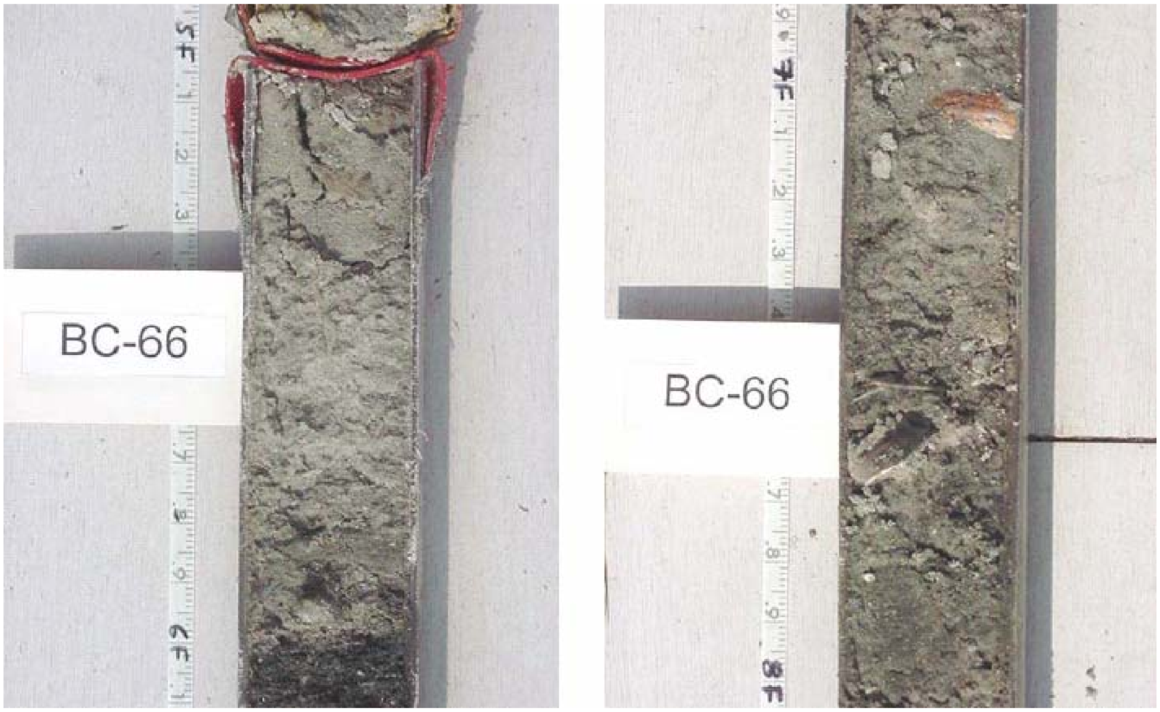

Figure 4.6 Photographs of disconnected segments of Vibracore BC-66, located east of Little Lagoon Entrance, West Beach – Gulf Shores (Figure 4.1). Note the change in material quality below 6ft in the left photo.

In the vicinity of Lagoon Pass and West Beach - Gulf Shores, inspection of the local bathymetry reveals no significant feature (ridge, shoal, or otherwise), occurring in the area. Given the need to develop a borrow area for the West Beach segment, additional cores were invested in the area. Neither the present Vibracores nor the historical data indicate the existence of any beach quality sand in the immediate vicinity offshore of West Beach – Gulf Shores.

Sediments in the immediate nearshore area of West Beach, Gulf Shores, as described by numerous Vibracores collected in the area, are consistently characterized by silty fine sandy sediments interspersed with whole and fragmented shells. The upper SP lens of sand varies in thickness from 1.5 ft to no more than 5.0 feet and is further defined as silty fine sand (median diameters less than 0.25 mm, some as low as 0.19 mm). Below that lens, sediments are defined as predominantly silty (SM material) with scattered shell fragments. In some areas, the SM lens gives way to lenses of shell (SW and GW) clay (ML or CL) and peat (PT, core BC-52). It is noted that this sediment behavior includes the area immediately offshore of the small ebb shoal at the entrance to Little Lagoon.

It is interesting to compare the median grain sizes of the beach profile sediments collected seaward of the primary bar (Figure 3.2) and the grain sizes of the composite sand samples further offshore. The offshore fining phenomenon continues offshore beyond the toe of the beach and beyond the 30-ft contour, although the results are highly variable. One change heading offshore, however, is an increase in shell content.

Inspection of the upper sediments of cores BC-57 and BC-61 (Figure 4.7), immediately offshore of the project area, reveals fine sand in the upper lens of BC-57 (0.24 mm grain size) and ML material in the top of BC-61 (no grain size distribution was obtained on ML samples). The upper layers of BC-62 and BC-63, just east of Little Lagoon Entrance, reveal traces of silt interspersed with fine sand, whole shells, and shell fragments. BC-131 contained no upper SP layer, and is characterized as gray silty sand or silt and clay with abundant whole shells and shell fragments in the upper 2.0 ft of the core. Further west, BC-53 and BC-55 indicate the presence of fine sand in the upper layers, but also indicate the presence of silt and abundant whole shells and shell fragments. These characteristics appear to agree with the description provided by McBride et al. (1999)

One core collected closer to the beach for "scientific purposes," (BC-54), revealed silty fine sand occurring within 1.5 ft of the surface; a grain size distribution performed on a sample collected 1.0 ft below the seabed indicated a mean diameter of 0.30mm, but inspection of the data indicates that the higher value is generated by the shell content in the sample, with fragments collected that were greater than ¼-inch.

Vibracores collected along the toe of the beach profile reveal the high degree of variability of sediments along the -25 ft to -30 ft contour (as mentioned above). The cores described in Hummell (1999) indicate similar variability. Core G-10, west of the West Beach segment limits, is described as muddy sand with scarce to common bioclastic debris and shell fragments throughout its 5-ft length. Core G-11 is also described as sand with shells and shell fragments throughout. Core G-12 is described as muddy sand with common to abundant shell fragments throughout. Vibracore C-4, collected in 1999 in East Gulf Shores in 27-ft of water at the toe of the beach, revealed an upper SP sand lens of 7.6 ft with a median diameter of 0.23 mm, consistent with the surface samples found along West Beach seaward of the primary bar in the profile.

Borrow Area #4 – The lack of a suitable borrow site in the immediate nearshore waters of West Beach - Gulf Shores prompted the expansion of the Vibracoring program to the west[3]. Figure 4.1 illustrates the westerly extents of the search and the general dimension of the large NE-SW trending shoal feature west of Gulf Shores. This feature, much larger than the other ridges, appears to be associated with an ancient alignment of the entrance to Mobile Bay, as it appears as a portion of a relict ebb shoal for a very large inlet. Vibracores were collected along the crest of the ridge and the area east of the ridge, searching for suitable material as close as possible to West Beach. As with the other bathymetric features investigated, only the crest of the ridge produced beach-quality sands. One 131-acre area was developed for potential excavation, although the maximum depth of excavation will be limited to perhaps 10 or 11 ft due to a distinct downward-fining trend in the shoal deposit (Figure 4.8).

Figure 4.7 Photographs of segments of Vibracore BC-61, located immediately offshore of the West Beach – Gulf Shores segment of the proposed project (see Figure 4.1)

[3] The lack of suitable beach nourishment sediments in this area also prompted the development of sand borrow sites within Little Lagoon in order to construct an Emergency Beach Fill Project for West Beach (see Chapter 3).

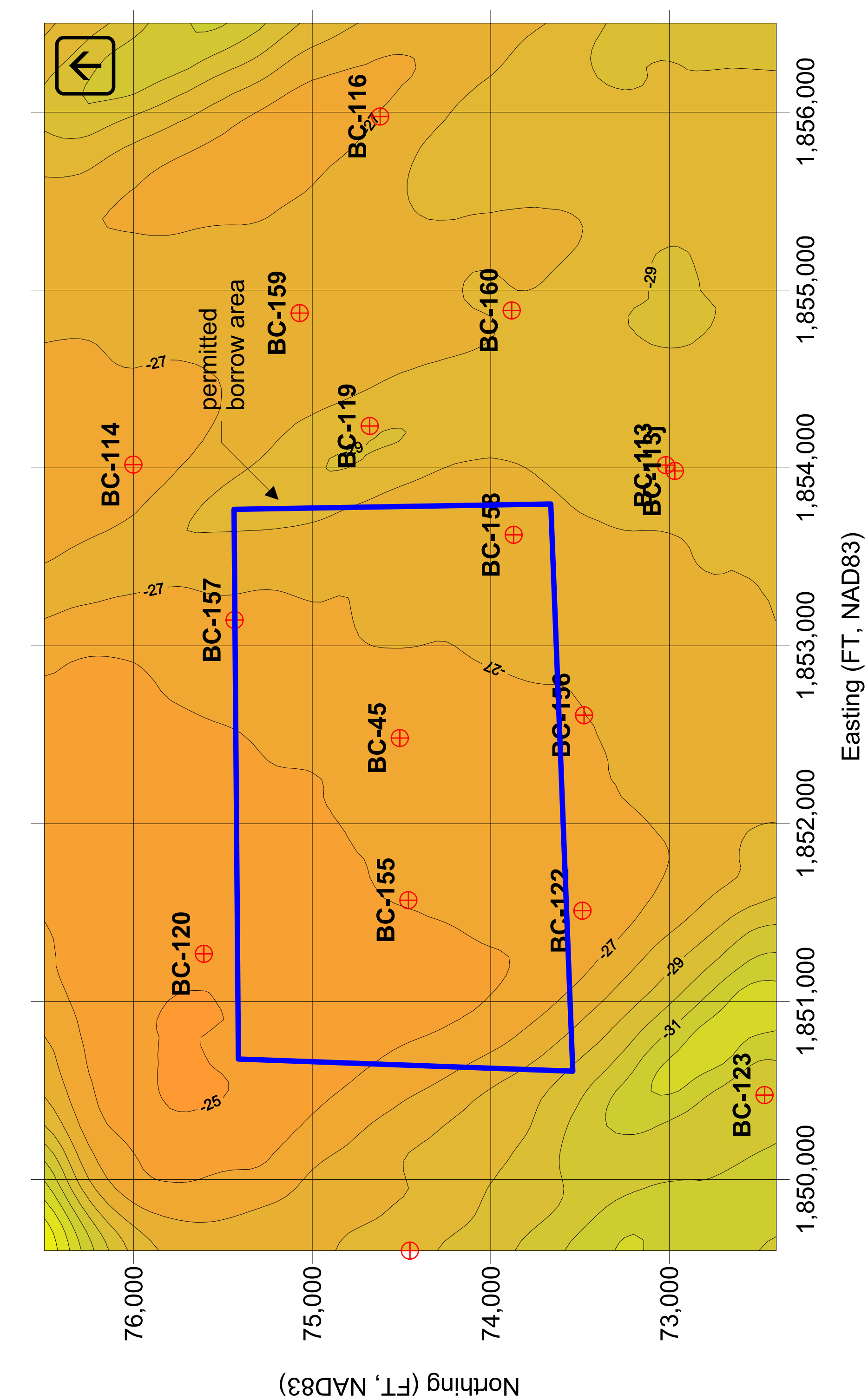

Figure 4.8 Detailed bathymetry in the vicinity of Borrow Area #4, West of West Beach - Gulf Shores, AL.

4.4 Comments on the 2002 Baldwin County Sand Search Investigation

While four potential borrow sites were developed for excavation during the course of this investigation, it is apparent from inspection of all the data that there is only a finite volume of truly "beach-compatible" sand that exists in State Waters off Baldwin County, AL. Further, inspection of historical data in Federal Waters similarly suggests that only a limited amount of desirable material exists beyond the three mile limit. Vibracore data in this area mirrors the findings in Pensacola Beach, where the shoreface attached ridges yield some beach-quality sand, but other areas fail to produce acceptable material. Well offshore, North Perdido Shoals and its offshoots provide a potentially large source of beach-quality sand, but these features are well offshore of Baldwin County, thereby representing a more expensive source of sand for the County's beaches.

This situation highlights the need to conserve sand at every opportunity. In the short-term, this requirement dictates that existing identified sand borrow sources be excavated to their maximum practicable depths in order to save acreage in viable borrow sites for future use. This approach also maximizes the benefit gained for the acreage of seabed disturbed. Several smaller shoal deposits identified in the present study, some of slightly lower quality, may require closer consideration in future restoration efforts.

The lack of significant long-term sand sources in the immediate vicinity of Baldwin County also highlights the critical importance of proper sediment budget practices at Perdido Pass and Pensacola Pass. These tidal entrances, along with Lagoon Pass, represent substantial sinks of sediment from the littoral system. Douglass (2001) discusses the fate of material dredged from Perdido Pass since its stabilization in 1968-69. Douglass estimates the total volume dredged to be on the order of six million cubic yards. Douglass further estimates that as much as eight million cubic yards of sand has been removed from the longshore littoral system by the creation of the stabilized tidal entrance. This value represents the sum effect of dredging disposal out of the littoral system, trapping of sand against both jetties at the inlet, and the formation of the ebb tidal shoal Gulfward of the jetties. Considering that the annual net longshore transport in the area may be no more than 150,000 to 175,000 cy/yr, this represents the loss of between 45 to 53 years of transport.

While some sand has been effectively bypassed around Perdido Pass, sand is still placed in areas where it is effectively lost from the littoral system (upland, immediately east of the entrance, and offshore). In Spring 2003, the U.S. Army Corps of Engineers initiated a demonstration project based on the findings of the Regional Sediment Management program within the Mobile District (USACE, 2002). The demonstration project placed an estimated 150,000 to 250,000 cubic yards of sand dredged from the channel along a ½-mile segment of shoreline beginning ¾-mile west of the west jetty. The objective of this placement is to better assure proper sand bypassing of the material to the beaches west of the Pass. However, this demonstration project is a one-time project; as of the time of this writing, there is no funding or authorization to assure that similar practices are exercised in the future. Steps must be taken to resolve this issue to assure that sand is adequately bypassed around Perdido Pass. With sufficient bypassing, the segments of the present beach restoration west of Perdido Pass will fare much better, significantly extending the renourishment interval of the project.

Similarly, sediment bypassing at Pensacola Pass in Escambia County has historically been lacking. Since 1883, roughly 46 million cubic yards of sand has been dredged from the entrance channel. Only 18 million cubic yards have been placed on adjacent beaches. While the easternmost portion of Perdido Key in Florida is the most severely affected by the dredging practices, the balance of Perdido Key is also affected by the downdrift starvation caused by the channel (Browder and Dean, 1999).

It is extremely important to the health of Baldwin County's beaches that proper sand management practices at both inlets be instituted and rigorously followed. These practices include identifying appropriate disposal areas that will allow the sand to easily return to the littoral system, rather than lying in "nearshore disposal areas" that are either a) too far offshore to allow significant onshore transport, or b) too close to the entrance being dredged, such that significant volumes of the dredged sand quickly return to the channels. The 2003 USACE disposal west of Perdido Pass is a significant step in the right direction. In order to assure that such practice occurs on a regular basis, it may be beneficial for local interests to pursue some formal arrangement with the USACE at Perdido Pass, which is authorized only as a navigation project, not a shore protection project. Similar cooperative disposal practices should be pursued at Pensacola Pass, FL.

5.0 BORROW SITE ANALYSES OF SEDIMENT CHARACTERISTICS

The previous chapter described the collection of 160 Vibracores and the identification of four candidate borrow sites for excavation during the proposed Orange Beach / Gulf State Park / Gulf Shores Beach Restoration Project. This chapter provides detailed analyses of each site in comparison to the characteristics of the corresponding native beach. The Vibracores from the four areas developed as potential borrow sites (Figures 4.3 through 4.6) have been analyzed in detail for the following characteristics:

- Grain size distribution and percentage of fine material (smaller than a #230 sieve, 0.0625 mm diameter),
- Sediment color,
- Shell/carbonate content,
- Heavy mineral content (visual estimate),
- Overfill ratio/Renourishment factor.

Several of these characteristics are generally discussed as follows:

Sediment Color – The nearly white color of the native beach makes the sediment color of nourishment sands a significant issue in this area. To properly grade the color of the sediment, it was necessary to apply color scales that exceed the standard scale used to grade soil color. The traditional scale of soil color is the Munsell Soil Color Charts (Munsell, 1998). This reference describes the variation of soil color for a wide distribution of Hues over Values in a range between 2 and 8 with Chroma numbers between 1 and 8. The Munsell chart is not reproduced in this report as it is extremely difficult to reproduce the colors and match the subtle variations in color between one grade level and the next. The reader is referred to the Munsell charts directly to study these color differences. Additional information on sediment color can be found on the internet at *www.munsell.com*.

Color designations discussed herein apply the following notation, given by example:

10YR 8.0/1.0

In this example, 10 YR represents the **Hue**, 8.0 represents the **Value**, and 1.0 represents the **Chroma**. This notation is used in the core logs found on the attached CD-ROM disc.

Hue. Briefly, the Hue refers to the distinction between colors such as green, blue, red, yellow, or combinations thereof. The Munsell chart assumes all these hues are evenly distributed on a Hue circle. The circle is divided into 10 hues based on principal hues of red, yellow, green, blue, and purple. Intermediate hues lie in between (such that YR stands for yellow-red). An additional scale is added to describe how far toward one principal hue a range of colors is (a five indicates direct association with a hue or hue combination, while a 10 indicates that the color is between classifications). For example at Pensacola Beach, sediments have been classified as a 10 YR. This indicates that the colors of the sediments are between the YR yellow-red family of hues and the Y yellow family of hues. A 5 YR sample would be classified directly in the yellow-red family.

Value. The Value of a sediment sample refers to the lightness of the color. The Value scale extends from 0 for pure black to 10 for pure white. A Value of 10 does not generally occur in nature. Value applies to all hues and the neutral colors (black, white and grays).

Chroma. The Chroma of a sediment sample describes its departure from the neutral color of the same Value and Hue. Neutral colors (i.e., on the grayscale between black and white), have a Chroma of zero. An example of Chroma can be easily identified in the mixing of paint. Typically, the base of a paint is white, meaning that it has a very high Value, but near zero Chroma and no distinguishable Hue. As a particular color is added, green for example, the Chroma increases as the green becomes stronger or more vivid. In this example, the Value may change as well if the added coloring is darker (which is typically the case compared to the nearly white paint base) (Browder 2002).

For the Hue identified for this analysis, 10YR, the standard Munsell Soils Color Chart extends to a 10YR 8/1 designation, where 10 YR is the Hue, 8 is the Value, and 1 is the Chroma. Local ordinances for sand color, based principally on the Escambia County, FL, *Sand and Water Protection Ordinance,* specify that material introduced to the beaches must meet a certain value and chroma within a range of acceptable hues. In Orange Beach, for example, "*any material utilized on Gulf-fronting beaches must exhibit a Munsell color Chart value of 9/1 or higher*". This designation extends beyond the Munsell Soils Color Charts. The specific designation can be found on the Munsell Hue pages or the Nearly Whites Fandeck™. As discussed in Section 3, the native sediments sampled in Baldwin County were found to generally agree with the Value designation of 9/1, but may have a slightly higher chroma, perhaps as much as 1.5, illustrating the slight tan/orange cast of the native sediments.

It is unrealistic to expect that sand discovered in-situ offshore of the Baldwin County shoreline will appear as light/white as the native beach when it is initially pumped onto the beach. One reason for this discrepancy is that the native beach sediments, which have been in place on the beach for long periods of time, have been repeatedly reworked by wind, rain, and wave action and thus have virtually no fines content. Moreover, they have had the benefit of long-term exposure to sunlight (U.V.), which oxidizes any organic fraction within the material. As expected, fill material derived from remote sources, particularly subaqueous sources such as an offshore shoal formation, has not had the benefit of prolonged sunlight exposure, nor has it been constantly reworked by waves, winds, and rain.

However, material dredged from an offshore borrow site can ultimately achieve a higher color rating that does meet or exceed a prescribed level. None of the potential borrow sites demonstrate any significant fraction of heavy mineral content, which would tend to permanently darken the sands and not fade or necessarily winnow out over time. In-situ sediment samples exhibit a low fraction of fine material, which is generally darker, organic, material. Regardless, that fraction of the initial fill volume will essentially wash out during the hydraulic dredging process. The very small percentage of fines that does reside within the initial beach fill template, along with the remainder of the volume of material, will benefit from sunlight exposure (UV). The latter will oxidize any remaining materials, thereby lightening the beach fill further over time.

Included on the enclosed CD-ROM disc are searchable maps of the borrow areas and their associated Vibracore data. The data files include a logging, photographs, and grain size data from each core within the two borrow sites. The logging includes a grading for sediment color, taken in the core itself. This grading may or may not represent an air dry condition, and likely indicates a darker color than that which would be expected following the combined effects of weather exposure and hydraulic fill placement. Additional data sheets describing the fines content and carbonate content of the samples are included on the CD-ROM disc.

Overfill Ratios - Rarely if ever are sediment samples composed entirely of grains of the exact same size (hence the sorting coefficient term introduced earlier) and rarely if ever are two sediment samples or sandy areas composed of the same distribution of grain sizes. Overfill ratios are used to describe the additional volume (or reduced volume) of sand necessary to account for differences between the native beach and borrow source sediments. Dean (2000) provides an overview of the overfill ratio history and methods, as well as the look-up charts used in the methods. The Shore Protection Manual (USACE, 1984) also provides an overfill ratio calculation discussion.

Based on the weighted distributions, overfill ratios for the offshore borrow site were computed using two methods. The first method is that of Dean (1974), which is a modification of the work of Krumbein and James (1965). These methods assume a particular shape of the distribution of sediment sizes within a sample. The methods then seek ways to discount the portion of the borrow material that is not entirely similar to the native beach. Dean (1974) assumed that any portion of the borrow material that was finer than the native distribution would be washed away by the energy in the wave climate[4]. That loss of the finer fraction of the borrow material forms the basis for the overfill ratio of Dean (1974).

[4] In comparison the original Krumbein-James method (1965) discounted both the finer and coarser fractions of the borrow material.

James (1974) modified the Krumbein-James method to only include the loss of the finer fraction of the fill. While both methods consider only the finer fraction of the borrow material, the James method is typically the more conservative of the two methods (i.e., it yields a higher overfill ratio for the same sediments). In addition to the overfill ratio, James presents a renourishment factor that is intended to describe the performance of a beach fill based on the fraction of the fill remaining after the finer fraction winnows out. The methods of James (1974) are presented in the Shore Protection Manual. Figure 5.1 presents a graphical example of two very different sediment samples. The figure illustrates the effect of the difference in sorting coefficient and the effect of a significant difference in mean grain size. The shaded area of the borrow sample curve represents that portion of the beach fill that would be expected to winnow out of the beach fill more rapidly.

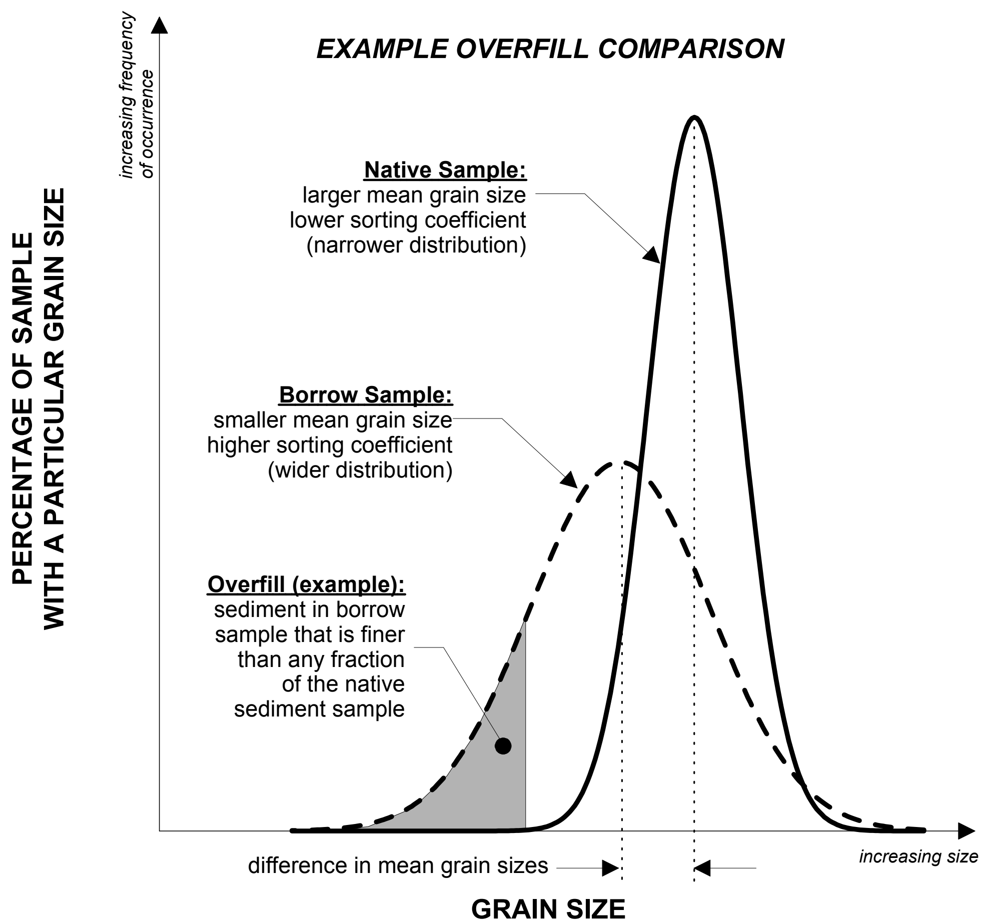

Figure 5.1 Demonstration of comparison of native and borrow site sediment size distributions, forming the basis of the overfill ratio definition.

5.1 Borrow Area #1 – Perdido Key

Figure 4.3 depicts the bathymetry and Vibracores in the vicinity of Borrow Area #1, south of Perdido Key, AL. The Vibracores collected in the area were used to design a 156-acre area to be permitted for excavation for purposes of building the Perdido Key and Orange Beach segments of the project. Figure 5.2 presents a photograph of one segment of core BC-43, located in the center of the proposed borrow site. Depending on the final design of the project segments, the actual area used for construction may be smaller than 156 acres. Assuming a depth of excavation of -41ft NGVD29, this site contains up to 3.0 million cubic yards (Mcy) of sand. While only a portion of the volume will be excavated for project use, it is necessary to provide some excess of material to account for differences in construction techniques and efficiency losses. The pay volume associated with the use of this site may be 1.5 to 2.0 Mcy (a rough, conservative estimate).

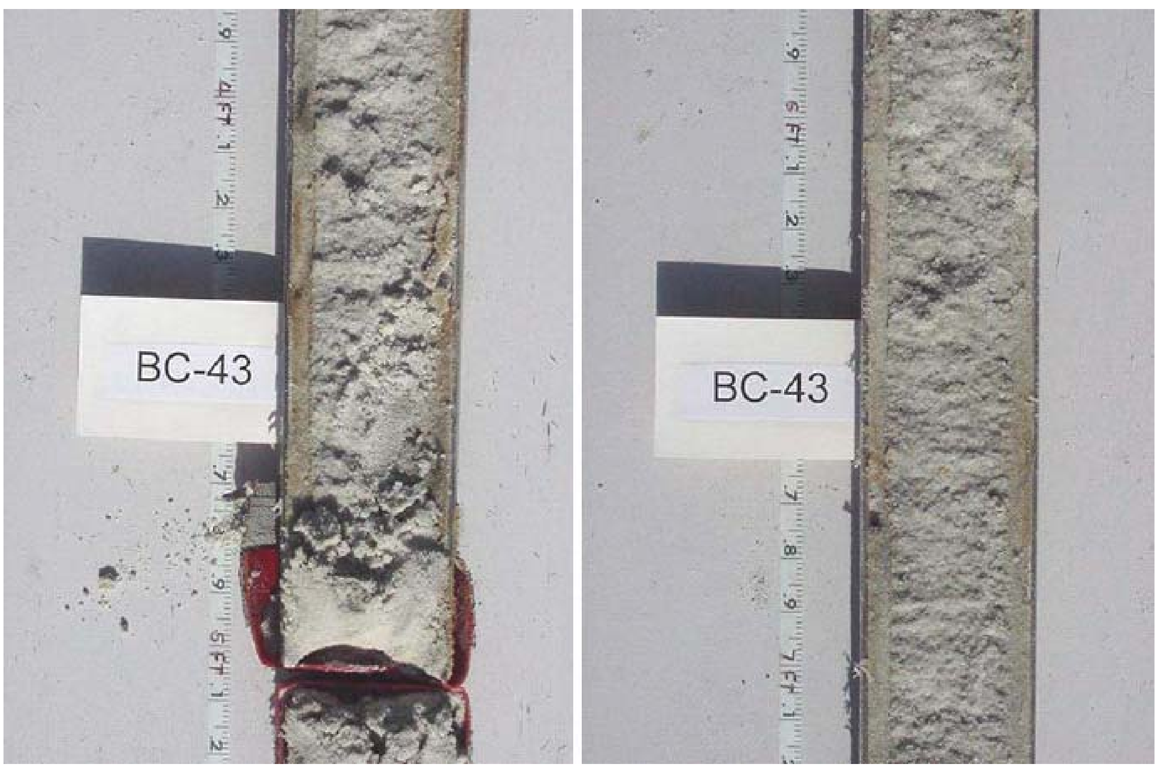

Figure 5.2 Example of Vibracore section from BC-43 in Borrow Area #1, Perdido Key, Baldwin County, AL.

The area depicted in Figure 4.3 was subdivided into individual areas represented by each Vibracore. Further subdivision was performed vertically within each core to determine the relative contribution of each core sample to the overall borrow site. From this analysis, weighted averages for median grain size, sorting coefficient, and sediment color were generated.

Grain Size Distribution - Figure 5.3 plots the grain size distributions for the individual samples in Borrow Area #1. The weighted average median diameter of the borrow area was found to be 0.28mm, just slightly finer than the coarse estimates of the native beach on Perdido Key, and very similar to the median estimates along Orange Beach and Gulf State Park (Table 3.2). It is noted that, in general, the finest sand samples plotted in Figure 5.3 (those curves farthest to the right in the plot), are from depths deeper than that which will be excavated (deeper than approximately -41ft NGVD29). Similarly, the coarsest samples are those found near the surface, indicating the presence of shell or shell fragments. This fact is accounted for in the determination of the weighted averages.

The percentage of fine material within the borrow area was found to be less than 1.1% on average. Fine material is defined herein as the percent of material by weight that is finer than 0.0625mm (the #230 sieve). The percentage of fine material in the borrow area samples ranges from 0.7% to 2.8%, with the finer samples located along the northeast edge of the site. In comparison, the native beach at Perdido Key and Orange Beach exhibits fines contents of 0.03% to 1.85%. During the course of dredging and placement, some fraction of the excavated sand, typically the finest fraction, will be lost in suspension and will not remain on the beach. This phenomenon may result in a slightly coarser distribution of sediment sizes on the beach.

Sorting Coefficient, σ - The weighted average sorting coefficient, σ, was calculated as 0.60 ϕ, indicating that the borrow site material is composed of a somewhat wider range of sediment sizes than the native.

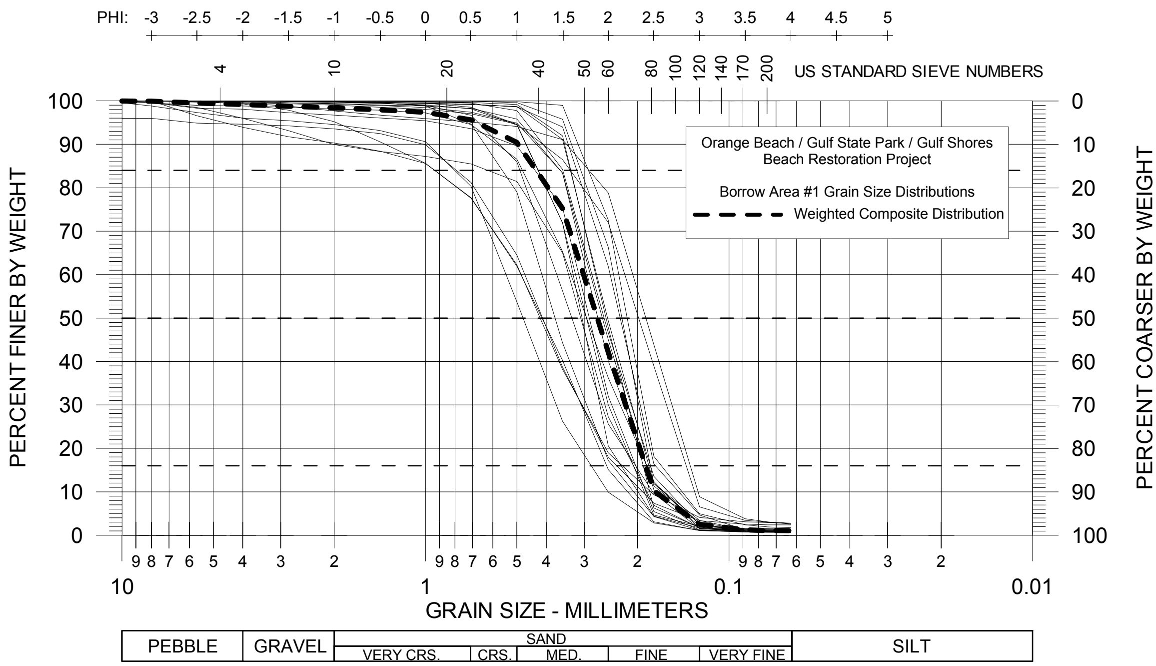

Figure 5.3 Weighted average and individual grain size distributions for Vibracore samples in Borrow Area #1.

Sediment Color - Each distinct segment within the borrow area Vibracores was graded for in-situ color by a professional geologist. These color gradings are noted in the individual Vibracore logs (contained on the attached CD-ROM disc). The weighted average in-situ color grading for the sand in Borrow Area #1 is 10YR 8.3/0.6. It is expected that over the course of six to twelve months the color Value will improve to meet the local ordinances. Much of the improvement will occur in the first few weeks following placement as the sand dries out and oxidizes in the sun.

Shell/Carbonate Content – Two methods are presented for addressing the presence of shell in the borrow sediments. The first method is to assess the percentage of the borrow site material that is composed of carbonate material (presumed to be the primary constituent of shell). This is assessed by burning off the carbonate fraction in a composite sample and comparing the pre- and post-burn weights. The weighted average carbonate content of Borrow Area #1 was measured as 3.5%. The measured values range from 2.4% to 13.8%. The highest, outlier, value comes from Vibracore BC-150, which occupies only a small portion of the borrow area (and may not actually be excavated).

The second means of assessing shell content is to assume that particles larger than a given size are most likely shell fragments or whole shells. Inspection of the Vibracore logs and photos indicates the presence of shell fragments to varying degrees in most of the cores. As shown in the grain size distribution curves of Figure 5.3, some percentage of larger particles are found in the samples. Using one millimeter as a benchmark, the weighted composite distribution indicates that approximately 2.6% of the borrow site, by weight, is composed of particles greater than one millimeter in size. Three samples indicate percentages greater than 10%.

Heavy Mineral Content – No traces of heavy minerals were reported in any of the Vibracore logs in Borrow Area #1 (see attached CD-ROM disc).

Overfill Ratio – Following Dean (1974), overfill ratios of 1.0 to 1.1 were computed, depending on the choice of median grain size for the native beach. Using the method of James (1974), overfill ratios between 1.1 and 1.2 were computed. The renourishment factor was found to be 0.8 to 0.9. Thus, while the overfill ratio is greater than 1.0, the renourishment interval is expected to be extended. This apparent contradiction, that is, more sand may be required initially, but the project should last longer, is explained by the higher value of the sorting coefficient, σ. The larger value of σ indicates that the finer portion of the borrow material will be lost, dictating a higher overfill factor, while the coarser fraction will remain longer, forestalling the required renourishment.

Given the uncertainty in determining the exact characteristics of the native beach[5] and the over-riding economics of project construction, it is assumed for all practical purposes that the overfill ratio is 1.0. As an example, if the overfill ratio for a borrow site were found to be 2.0, it would likely not be practical or economically feasible to double the fill volume. Instead, the overfill ratio is acknowledged as an initial design parameter for the monitoring of the project following construction, particularly in comparison to other segments of this project or other historical projects in the area.

[5] It is noted that it is not necessarily appropriate to treat the characteristics of the native beach as exact or fixed, due to seasonality, storm impacts, etc..

5.2 Borrow Area #2 – West Orange Beach / Gulf State Park

Figure 4.4 plots the outline and core locations for Borrow Area #2. A 189-acre area was developed between the two ridge features. This borrow area will be used to construct the Gulf State Park and western Orange Beach portions of Segment #2. Assuming an excavation depth of -38ft NGVD29, the borrow site contains almost 3.8Mcy of sand. Depending on the final project design, the pay volume associated with the use of this borrow site might be 2.1 to 2.6Mcy (a rough, conservative estimate). Figure 5.4 presents photographs of two segments of core BC-89, located in the center of the proposed borrow site. The reader is referred to the attached CD-ROM disc for photos of all segments of all Vibracores collected. Depending on the final design of the project segments, the actual area used for construction may be smaller than 189 acres. As described previously, Borrow Area #2 was subdivided to determine the relative contribution of each core sample to the overall borrow site. From this analysis, weighted averages for median grain size, sorting coefficient, and sediment color were generated.

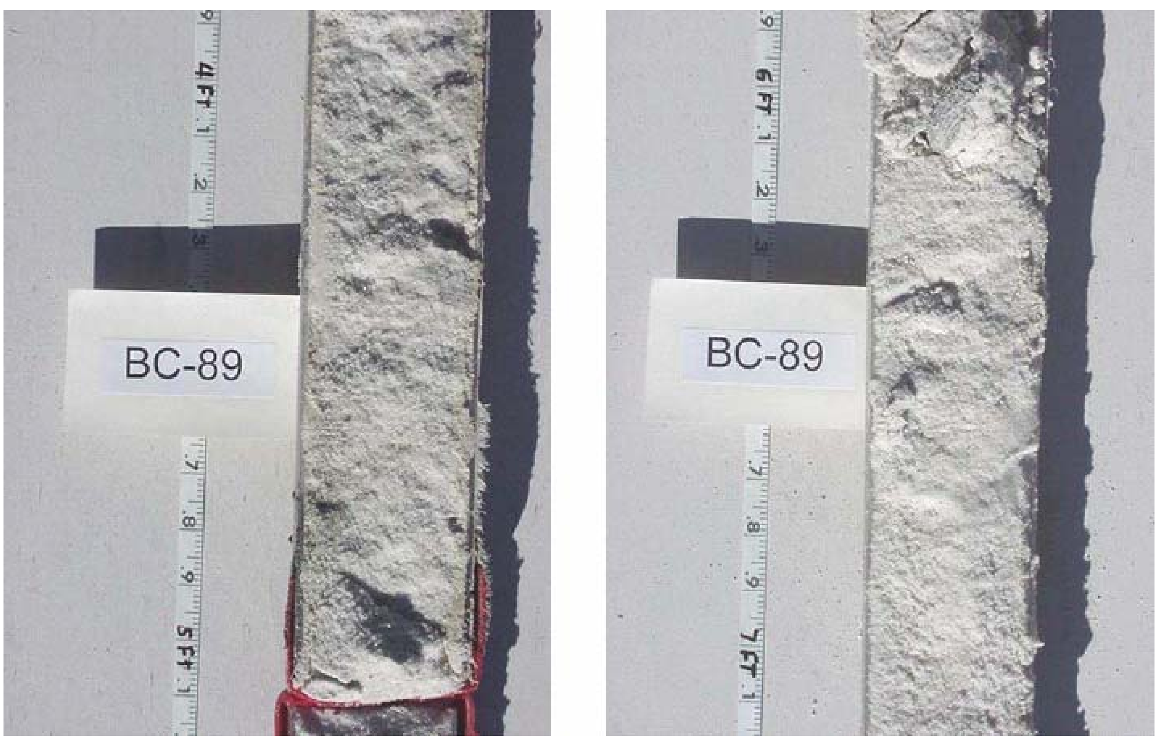

Figure 5.4 Photographs of disconnected segments within Vibracore BC-89 of Borrow Area #2.

Grain Size Distribution - Figure 5.5 plots the grain size distributions for the individual samples in Borrow Area #2. The weighted average median diameter of the borrow area was found to be 0.28mm, very similar to the native median estimates along Orange Beach and Gulf State Park (Table 3.2). It is noted that, in general, the finest sand samples plotted in Figure 5.5 (those curves farthest to the right in the plot), are from depths deeper than that which will be excavated (deeper than approximately -38ft NGVD29). Similarly, the coarsest samples are those found near the surface, indicating the presence of shell or shell fragments. This fact is accounted for in the determination of the weighted averages.

The percentage of fine material within the borrow area was found to be less than 0.9% on average. Fine material is defined herein as the percent of material by weight that is finer than 0.0625mm (the #230 sieve). The percentage of fine material in the borrow area samples ranges from 0.4% to 2.6%, with the finer samples located along the southwest edge of the site. In comparison, the native beach at Gulf State Park and Orange Beach exhibits fines contents of 0.18% to 1.85% in the trough and seaward of the primary bar. During the course of dredging and placement, some fraction of the sand, typically the finest fraction, will be lost in suspension and will not remain on the beach. This phenomenon may result in a slightly coarser distribution of sediment sizes on the beach.

Sorting Coefficient, σ - The weighted average sorting coefficient, σ, was calculated as 0.63ϕ, indicating that the borrow site material is composed of a somewhat wider range of sediment sizes than the native (and only slightly wider than the composite of Borrow Area #1).

Sediment Color – Using the same grading procedures discussed previously, the weighted average in-situ color grading for the sand in Borrow Area #2 is 10YR 8.4/0.7. It is expected that over the course of six to twelve months the color Value will improve to meet the local ordinances. Much of the improvement will occur in the first few weeks following placement as the sand dries out and oxidizes in the sun.

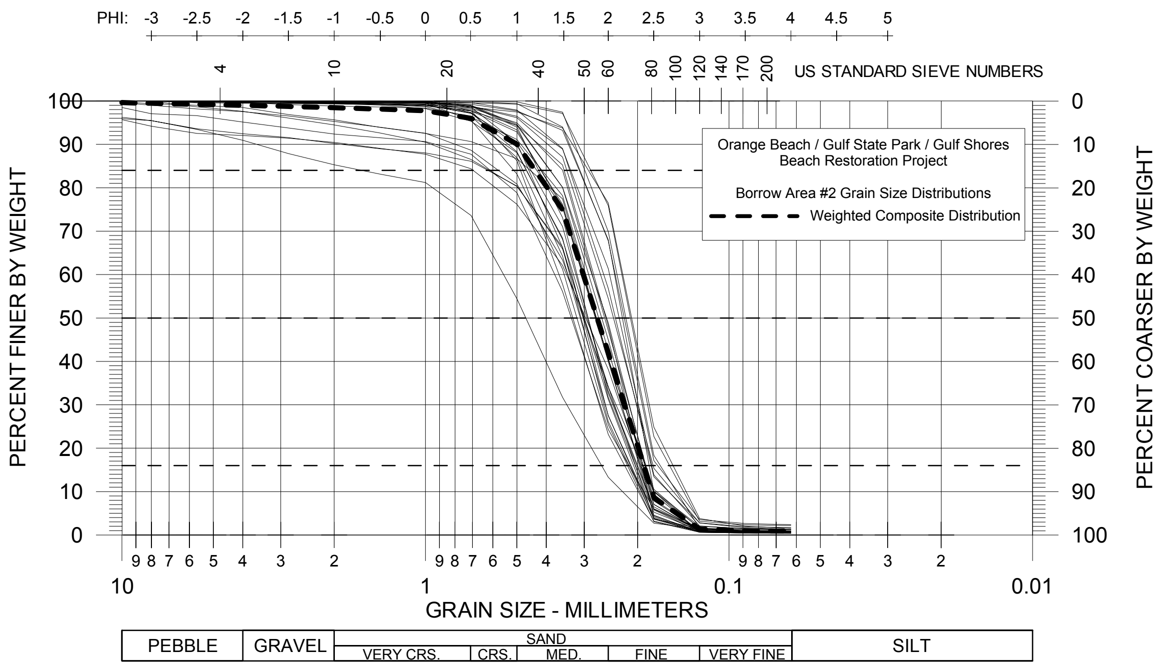

Figure 5.5 Weighted average and individual grain size distributions for Vibracore samples in Borrow Area #2.

Shell/Carbonate Content – Using the carbonate burn technique, the average carbonate content of Borrow Area #2 was measured as 3.0%, with a maximum value of 5.9% and a minimum value of 0.9%. Inspection of the Vibracore logs and photos indicates the presence of shell fragments to varying degrees in most of the cores, especially near the surface. As shown in the grain size distribution curves of Figure 5.5, some percentage of larger particles are found in the samples. Using one millimeter as a benchmark, the weighted composite distribution indicates that approximately 2.2% of the borrow site, by weight, is composed of particles greater than one millimeter in size. Three samples indicate percentages greater than 10%.

Heavy Mineral Content – No traces of heavy minerals were reported in any of the Vibracore logs in Borrow Area #2.

Overfill Ratio – Using the method of Dean (1974), the overfill ratio was computed to be between 1.0 and 1.1, depending on the choice of median grain size for the native beach.

Using the method of James (1974), overfill ratios between 1.1 to 1.2 were computed. The renourishment described by James was found to be 0.7 to 1.0. The slight differences in predicted renourishment factor are attributed to the slightly higher value of the sorting coefficient (the differences in overfill factor occur in the second decimal place, which is appropriately not reported due to accuracy limitations). Given the uncertainty in determining the exact characteristics of the native beach and the over-riding economics of project construction, it is assumed for all practical purposes that the overfill ratio is 1.0.

5.3 Borrow Area #3 – Gulf Shores

Figure 4.5 plots the outline and core locations for Borrow Area #3. A 179-acre area was developed by extending the 2000-2001 borrow site for the East Gulf Shores project roughly 3,000 ft eastward. Development of the borrow area included the use of both the 1999 and 2002 Vibracores. This site will be used to construct some or all of the West Beach Gulf Shores portion of the project (Segment #3), Segment #4 of West Beach, east of Little Lagoon Pass, and possibly a small section of Gulf State Park. Assuming an excavation depth of -43ft NGVD29, the area depicted in Figure 4.5 contains in excess of 3.4Mcy of sand. Not all of this volume will be excavated, as some of it will be held in reserve following the construction plans presented by the successful bidder. The pay volume along Segments #2, #3, #4 *potentially* associated with this borrow area may be as much as 1.8Mcy.

Figure 5.6 presents a photograph of two segments of core BC-141, located in the center of the proposed borrow site. The reader is referred to the attached CD-ROM disc for photos of all segments of all Vibracores collected. Depending on the final design of the project segments, the actual area used for construction may be smaller than 179 acres. Unlike the previous two borrow areas, characteristics for Borrow Area #3 were developed from the composite samples of each Vibracore, in order to be consistent with the 1999 Vibracores (which only had a composite sample analyzed). The composite samples are physically taken directly along the entire useful length of each core. From this analysis, weighted averages for median grain size, sorting coefficient, and sediment color were generated.

Figure 5.6 Photographs of disconnected segments within Vibracore BC-141 of Borrow Area #3.

Grain Size Distribution - Figure 5.7 plots the grain size distributions for the individual samples in Borrow Area #3. The weighted average median diameter of the borrow area was found to be 0.29mm, very similar to the native median estimates along Orange Beach and Gulf State Park (Table 3.2). Similar to the 2000-2001 project, the depth of allowable excavation is approximately -43ft NGVD29. Unlike Borrow Areas #1 and #2, the sands in Borrow Area #3 do not exhibit a consistent downward-fining trend. Accordingly, the coarsest samples depicted in Figure 5.7 are *not* consistently found at the surface. However, the majority of the coarsest samples containing shell and shell fragments are at the surface.

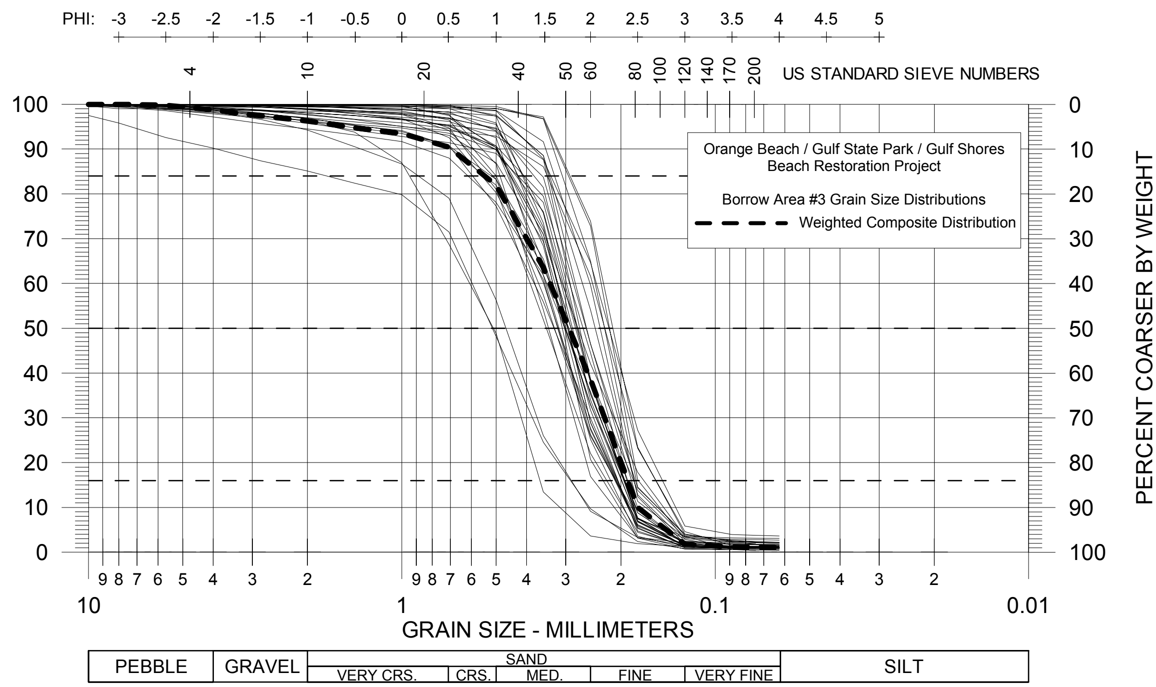

Figure 5.7 Weighted average and individual grain size distributions for Vibracore samples in Borrow Area #3.

The percentage of fine material within the borrow area was found to be less than 1.2% on average. Fine material is defined herein as the percent of material by weight that is finer than 0.0625mm (the #230 sieve). The percentage of fine material in the borrow area samples ranges from 0.4% to 3.8%. In comparison, the native beach at West Beach – Gulf Shores fines contents of 0.1% to 3.3% in the trough and seaward of the primary bar. During the course of dredging and placement, some fraction of the sand, typically the finest fraction, will be lost in suspension and will not remain on the beach. This phenomenon may result in a slightly coarser distribution of sediment sizes on the beach.

Sorting Coefficient, σ - The weighted average sorting coefficient, σ, was calculated as 0.66ϕ, indicating that the borrow site material is composed of a somewhat wider range of sediment sizes than the native (and slightly wider than the composites of Borrow Areas #1 and #2).

Sediment Color – Using the same grading procedures discussed previously, the weighted average in-situ color grading for the sand in Borrow Area #3 is 10YR 8.0/0.8. It is expected that over the course of six to twelve months the color Value will improve to meet the local ordinances. Much of the improvement will occur in the first few weeks following placement as the sand dries out and oxidizes in the sun.

Shell/Carbonate Content – Using the carbonate burn technique, the average carbonate content of Borrow Area #3 was measured as 4.7%, with a maximum value of 7.4% and a minimum value of 1.4%. Inspection of the Vibracore logs and photos indicates the presence of shell fragments to varying degrees in most of the cores, as found in the 2000-2001 project. As shown in the grain size distribution curves of Figure 5.7, some percentage of larger particles are found in the samples. Using one millimeter as a benchmark, the weighted composite distribution indicates that approximately 3.2% of the borrow site, by weight, is composed of particles greater than one millimeter in size. Three samples indicate percentages greater than 10%.

Heavy Mineral Content – No traces of heavy minerals were reported in any of the Vibracore logs in Borrow Area #3.

Overfill Ratio – Following Dean (1974), an overfill ratio of 1.0 was computed. Using the method of James (1974), overfill ratios between 1.1 and 1.2 were computed. The renourishment factor was found to be 0.6 to 0.8, reflecting the higher value of the sorting coefficient, σ. Given the uncertainty in determining the exact characteristics of the native beach and the over-riding economics of project construction, it is assumed for all practical purposes that the overfill ratio is 1.0.

5.4 Borrow Area #4 – West Beach - Gulf Shores

Figure 4.8 depicts the outline and core locations for Borrow Area #4. A 131-acre area was developed west of Laguna Key in West Beach, on the massive ridge/shoal feature extending to the southwest toward the entrance channel to Main Pass at Mobile Bay. This site will be used to construct a portion of the West Beach Gulf Shores segment of the project (Segment #3). Assuming an excavation depth of -36ft NGVD29, the area depicted in Figure 4.5 contains in excess of 2.0Mcy of sand. The pay volume along Segment #3 potentially associated with this borrow area may be as much as 0.7Mcy.

Figure 5.8 presents a photograph of two segments of core BC-155, located in the center of the proposed borrow site. The reader is referred to the attached CD-ROM disc for photos of all segments of all Vibracores collected. Depending on the final design of the project segments, the actual area used for construction may be smaller than 131 acres. The area depicted in Figure 4.8 was subdivided into individual areas represented by each Vibracore. Further subdivision was performed vertically within each core to determine the relative contribution of each core sample to the overall borrow site. From this analysis, weighted averages for median grain size, sorting coefficient, and sediment color were generated.

Grain Size Distribution - Figure 5.9 plots the grain size distributions for the individual samples in Borrow Area #4. The weighted average median diameter of the borrow area was found to be 0.24mm, somewhat finer than the native median estimates along West Beach Gulf Shores. Due to a distinct downward fining trend, the depth of allowable excavation will be limited to approximately -36ft NGVD29. Referring to Figure 5.9, the coarsest samples depicted in Figure 5.9 are found at the surface.

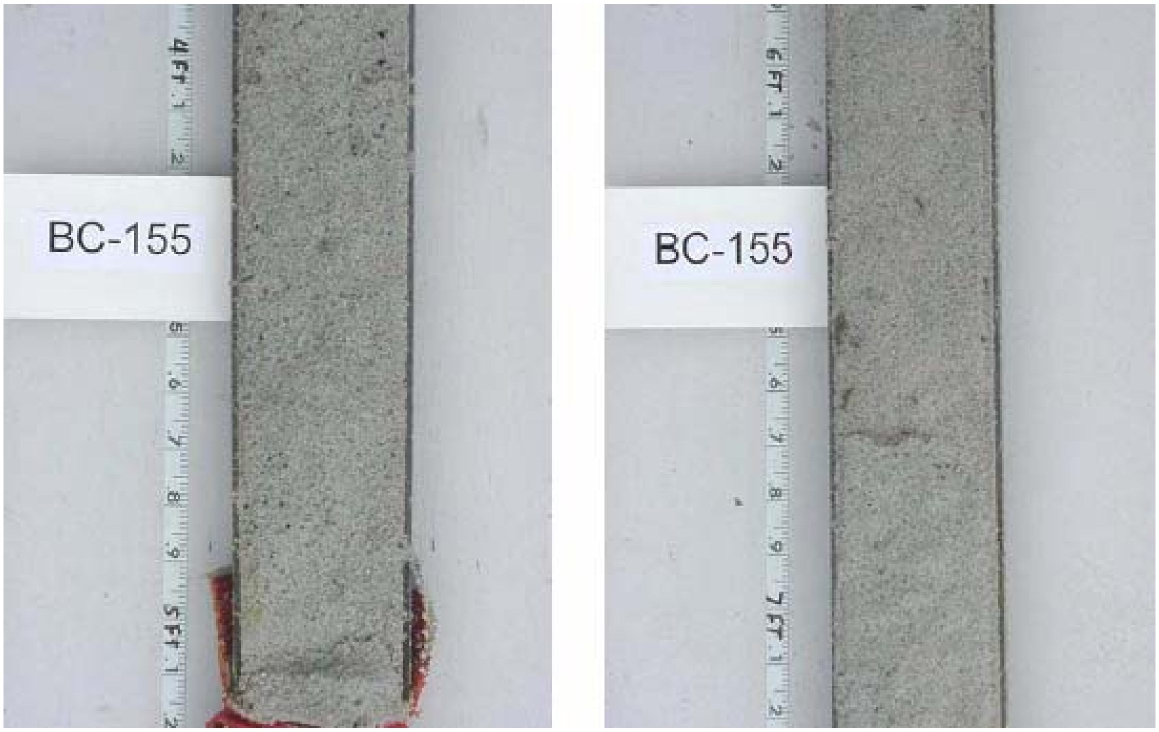

Figure 5.8 Photographs of disconnected segments within Vibracore BC-155 of Borrow Area #4.

The percentage of fine material within the borrow area was found to be less than 1.1% on average. Fine material is defined herein as the percent of material by weight that is finer than 0.0625mm (the #230 sieve). The percentages of fine material in all samples within the borrow area ranges from 0.4% to 7.1%, although the upper limit of fines in samples above the cut depth is less than 3%, further illustrating the strong downward-fining trend within the site. In comparison, the native beach at West Beach – Gulf Shores exhibits fines contents of 0.1% to 3.3% in the trough and seaward of the primary bar. During the course of dredging and placement, some fraction of the sand, typically the finest fraction, will be lost in suspension and will not remain on the beach. This phenomenon may result in a slightly coarser distribution of sediment sizes on the beach.

Sorting Coefficient, σ - The weighted average sorting coefficient, σ, was calculated as 0.60ϕ, indicating that the borrow site material is composed of a somewhat wider range of sediment sizes than the native (although narrower than the composites of Borrow Areas #2 and #3).

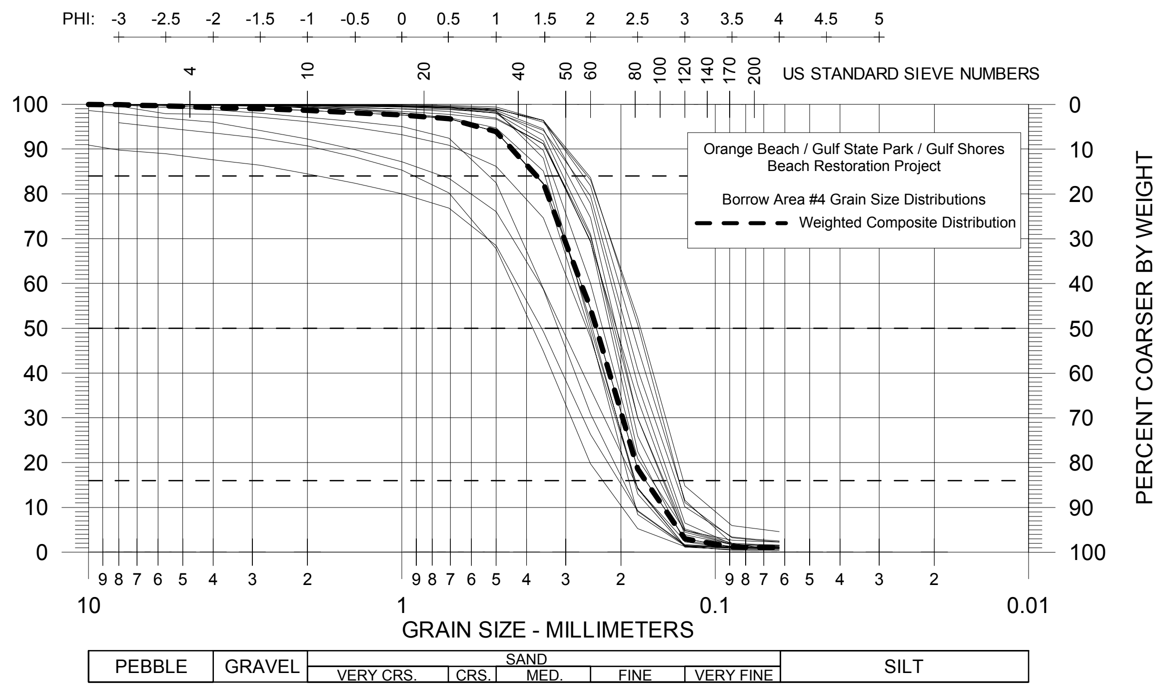

Figure 5.9 Weighted average and individual grain size distributions for Vibracore samples in Borrow Area #4.

Shell/Carbonate Content – Using the carbonate burn technique, the average carbonate content of Borrow Area #4 was measured as 5.4%, with a maximum value of 7.5% and a minimum value of 4.1%. Inspection of the Vibracore logs and photos indicates the presence of shell fragments to varying degrees in most of the cores, as found in the 2000-2001 project. As shown in the grain size distribution curves of Figure 5.9, some percentage of larger particles are found in the samples. Using one millimeter as a benchmark, the weighted composite distribution indicates that approximately 2.4% of the borrow site, by weight, is composed of particles greater than one millimeter in size. Three samples indicate percentages greater than 10%.

Heavy Mineral Content – No traces of heavy minerals were reported in any of the Vibracore logs in Borrow Area #4.

Sediment Color – Using the same grading procedures discussed previously, the weighted average in-situ color grading for the sand in Borrow Area #3 is 10YR 7.5/0.5. This grading indicates that Borrow Area #4 contains sediments slightly darker than the other three borrow areas. It is expected that over the course of six to twelve months the color Value will improve to meet the local ordinances. Much of the improvement will occur in the first few weeks following placement as the sand dries out and oxidizes in the sun.

Overfill Ratio – Following Dean (1974), overfill ratios of 1.2 to 1.4 were computed, depending on the value ascribed to the native median grain size. Using the method of James (1974), overfill ratios between 1.4 and 1.7 were computed. The renourishment factor was found to be 1.2 to 1.5, reflecting the lower value of the median grain size and higher value of the sorting coefficient of the borrow site material.

5.5 Summary

Table 5.1 summarizes the principal characteristics of the sediments found in all four borrow areas. Sufficient volumes of sand were identified to construct the project segments, allowing for some flexibility for the contractor in the construction sequence and approach in order to achieve improved bids. Inspection of all the data in the Vibracores near and in the borrow areas reveals the presence of additional volumes of sand for future renourishment efforts, particularly near Borrow Areas #1 and #3.

The borrow areas were also chosen and sized to allow for pumping efficiency losses (conservatively estimated at this stage to be a factor of roughly 1.5). Further, the limits of the borrow areas were set to attempt to limit any slumping of the post-construction borrow site edges to the area within the permitted limits. In most cases, the actual area of excavation will be smaller than that depicted in the planviews (Chapter 4).

Table 5.1 Summary of Weighted Average Borrow Site Statistics
Orange Beach / Gulf State Park / Gulf Shores Beach Restoration Project

Borrow Area	Area (acres)	Volume* (Mcy)	Excavation Depth (ft, NVGD29)	Median Grain Size (mm)	Overfill Ratio	Color
1	156	2.0	-41	0.28	1.0 – 1.2	10 YR 8.3/0.6
2	189	2.6	-38	0.28	1.0 - 1.2	10 YR 8.4/0.7
3	179	2.1	-43	0.29	1.0 – 1.2	10 YR 8.0/0.8
4	131	1.0	-36	0.24	1.2 – 1.7	10 YR 7.5/0.5

*Volume estimates reflect the expected excavation volume. This volume differs from the associated pay volume and the total volume of sand available in each borrow area. The total volume excavated from each site will depend on the construction technique and sequence chosen by the contractor. The actual designed borrow area will be smaller in acreage than that listed in this table. Further, sufficient volume must be provided in all borrow areas to allow for efficiency losses in order to achieve the desired pay volume on the beach. For these reasons, the volumes listed in this table and elsewhere are considered approximate estimates.

Sand from Borrow Areas #3 and #4 will be used to construct the West Beach Gulf Shores segment of the project. This segment will also receive sediment from Little Lagoon in 2003 as part of the West Beach Emergency Beach Fill Project. The Little Lagoon sands are slightly coarser than the native beach, while the offshore sands are slightly finer to finer than the native. The range of differences is not so large, however, such that significant compatibility issues are not expected. Significant differences in texture, grain size, and color may affect the use of the beach by certain species, such as turtles and beach mice.

While the material in Borrow Area #4 is not as high of quality as the other three borrow areas identified, the material is still of beach quality, particularly when viewed in light of the significant lack of suitable beach quality sand closer to West Beach Gulf Shores, and the overall limited supply of beach quality sand in the region. The quality of the sand and the higher values of overfill ratio must be acknowledged prior to bidding and construction and during the analysis of performance monitoring data following construction.

6.0 DRAFT CULTURAL RESOURCES ANALYSES

The four borrow areas identified during the present study were assessed for their potential to contain historically significant cultural resources (e.g. shipwrecks, etc.). Under the direction of Dr. Gordon P. Watts, Jr., Principal Investigator, a team of archaeologists from Tidewater Atlantic Research, Inc., of Washington, N.C., conducted an archaeological remote sensing survey of all four areas. The survey consisted of historical and documentary research of the area, a proton magnetometer and side-scan sonar survey, and diver assessment/verification of selected targets. The draft report of findings (Watts, 2003), which will be submitted to the State Historic Preservation Officer of Alabama and the U.S. Army Corps of Engineers, can be found herein as Appendix B. The abstract of the report follows:

Abstract

Olsen Associates, Inc. is the design engineer for the towns of Gulf Shores and Orange Beach and the Gulf State park system for a beach renourishment project along the coastal waters of Baldwin County, Alabama. The sand source material for the project is four borrow areas located between Perdido Pass and Mobile Point. In order to determine the proposed project's affects on potentially significant submerged cultural resources, Olsen Associates contracted with Tidewater Atlantic Research, Inc., [TAR] of Washington, North Carolina to conduct a proton precession magnetometer and side scan sonar survey of the four proposed borrow areas. Prior to the fieldwork, a program of historical and documentary research was conducted to provide a proper framework for submerged cultural resource assessment in the Gulf Shores/Orange Beach area. Fieldwork activities were carried out between 16–19 and 26–27 April 2003. Analysis of the remote sensing data revealed a total of nine magnetic anomalies: one in Area 1, one in Area 2, six in Area 3 and one in Area 4. Of those nine targets, four exhibited signature characteristics consistent with submerged cultural resources and were recommended for additional investigation. Under a modification of the contract those four anomalies were relocated and examined by divers on 21 and 22 May 2003. All four were generated by concentrations of wire cable [*NOTE: These four targets lie outside the area to be excavated (Figure 4.5)*]. Based on the remote sensing survey and diver assessment of the potentially significant magnetic signatures no submerged cultural resources will be impacted by the proposed project. No further investigation is recommended in conjunction with the proposed project.

7.0 CONCLUSIONS

This report documents the procedures and findings of a comprehensive geotechnical investigation undertaken to identify sources of beach quality sand suitable for the construction of a large-scale, multiple-segment beach restoration project for the City of Orange Beach, the Alabama Department of Conservation and Natural Resources' Gulf State Park, and the City of Gulf Shores, Baldwin County, AL. The three sponsors of the project, contracted with Olsen Associates, Inc., of Jacksonville, FL, to conduct this and other investigations pursuant to the project and to permit, design, and oversee construction by the selected contractor. This report presents the findings of the native beach characterization, a background data review, a Vibracoring program, and the subsequent analysis of the core-boring logs and sediment sampling.

The project consists of four segments, Perdido Key Orange Beach / Gulf State Park, West Beach – Gulf Shores, and West Beach – East of Little Lagoon Pass. In total, the OB/GSP/GS Project calls for the placement of an estimated 5.0 million cubic yards of sand (pay volume) along a combined project length of approximately 11.6 miles. The principal objective of the Sand Search Investigation was to identify borrow areas that could be utilized to cost-effectively construct each segment of the beach restoration project. An additional objective was to characterize the existing sediments throughout State Waters in the Eastern Baldwin County, AL, nearshore area in order to provide valuable data for future uses beyond the present project.

Four borrow areas were developed for use in the project. These areas extend from east of Perdido Pass to west of the western end of West Beach – Gulf Shores. The sites are large enough to construct the project and allow for some flexibility in the construction techniques and sequencing. Sufficient volume overage exists in the borrow areas to account for efficiency losses and spillage.

While four potential borrow areas were developed for excavation during the course of this investigation, it is apparent from inspection of all the data that there is only a finite volume of truly "beach-compatible" sand that exists in State Waters off Baldwin County, AL. Further, inspection of historical data in Federal Waters similarly suggests that only a limited amount of desirable material exists beyond the three mile limit. Well offshore, North Perdido Shoals and its offshoots provide a potentially large source of beach-quality sand, but these features are well offshore of Baldwin County, thereby representing a more expensive source of sand for the County's beaches. This situation highlights the need to conserve sand at every opportunity. In the short-term, this requirement dictates that existing identified sand borrow sources be excavated to their maximum practicable depths in order to save acreage in viable borrow sites for future use. This approach also maximizes the benefit gained for the acreage of seabed disturbed. Several smaller shoal deposits identified in the present study, some of slightly lower quality, will require closer consideration in future restoration efforts.

The lack of significant long-term sand sources in the immediate vicinity of Baldwin County highlights the critical importance of proper sediment budget practices at Perdido Pass and Pensacola Pass. These tidal entrances, along with Lagoon Pass, represent substantial sinks of sediment from the littoral system, and have acted as such for a great number of years. It is extremely important to the health of Baldwin County's beaches that proper sand management practices at both inlets be instituted and rigorously followed. These practices include identifying appropriate disposal areas that will allow the sand to easily return to the littoral system, rather than lying in "nearshore disposal areas" that are either a) too far offshore to allow significant onshore transport, or b) too close to the entrance being dredged, such that significant volumes of the dredged sand quickly return to the channels. The 2003 USACE disposal west of Perdido Pass is a significant step in the right direction. To assure that such practice occurs regularly basis, it may be beneficial for local interests to pursue some formal arrangement with the USACE at Perdido Pass, which is authorized as a navigation project, not a shore protection project. Similar cooperative practices could be pursued at Pensacola Pass, FL.

In addition to pursuing proper sand management at Perdido Pass and Pensacola Pass, it is recommended that potential sediment sources lying further offshore eventually be investigated in order to better address the long-term health of the beaches of Baldwin County. This investigation would include offshore core boring further offshore in Federal Waters to revisit limited core-borings and assess the quality of sediments lying along northern offshoots of North Perdido Shoals, among other areas.

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APPENDIX A
Alpine Ocean Seismic Survey, Inc., Field Report

FINAL REPORT

BALDWIN COUNTY, ALABAMA
BEACH RESTORATION

Prepared for

Olsen Associates, Inc.
4438 Herschel Street
Jacksonville, Florida 32210

Prepared by:

Alpine Ocean Seismic Survey, Inc.
70 Oak Street, Norwood, New Jersey 07648

January 2003
Reference: Job 1427

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1.0 INTRODUCTION

Alpine Ocean Seismic Survey Inc. under contract to Olsen Associates, Inc. performed vibracore Sampling at one hundred sixty (160) locations for the Baldwin County, Alabama Beach Restoration project. The vibracores were collected offshore Alabama coast between 2 December and 20 December 2003.

1.1 Summary of Operations

1 Dec	Mob vessel and crew to Sportsman Marina, Orange Beach, Alabama.
2 Dec	0645 client rep aboard. 0705 depart marina enroute to work area. 0735 set up vibracore rig and bar check Echosounder. Complete cores BC-1, BC-2, BC-3. BC-4, BC-5, BC-6, BC-7, BC-8 R1, BC-8 R2, BC-9, BC-10, BC-11, BC-12, BC-13, BC-14, and BC-15. 1642 secure rig and return to marina. 1715 vessel secure at dock.
3 Dec	0645 depart marina enroute to work area. 0742 set up vibracore rig and bar check Echosounder. Complete cores BC-16, BC-17, BC-18, BC-19, BC-20, BC-21, BC-22, BC-23, BC-24, BC-25, BC-26, BC-27, BC-28, BC-29, and BC-30. 1606 secure rig and return to marina. 1712 secure at dock.
4 Dec	Standby for weather – S winds 15-20 knots – waves breaking over jetty. Offloaded 15 cores to storage trailer.
5 Dec	Standby for weather and engine repair. N winds 20 knots – seas 5-8'. Offloaded 15 cores to storage trailer.
6 Dec	0645 depart marina. 0718 set up vibracore rig and bar check Echosounder. Completed cores BC-31, BC-32, BC-33, BC-34, BC-35, BC-36, BC-37, BC-38, BC-39, BC-40 BC-41 R1, BC-41 R2, BC-42, BC-43 R1, and BC-43 R2. 1630 secure rig and return to marina. 1706 secured at dock.
7 Dec	0645 depart marina enroute to work area. 0845 set up vibracore rig and bar check Echosounder. Complete cores BC-44, BC-45, BC-46, BC-47, BC-48, BC-49, BC-50, BC-51, BC-52, BC-53, BC-54, BC-55, BC-56, and BC-57. 1530 secure rig and return to marina. 1715 secured at dock.
8 Dec	0645 depart marina enroute to work area. 0815 set up vibracore rig and bar check Echosounder. Completed cores BC-58, BC-59, BC-60, BC-61 R1, BC-61 R2, BC-62, BC-63, BC-64, BC-65, BC-66, BC-67, BC-68, BC-69, BC-70, BC-71, and BC-72. Secure rig and return to marina. 1730 secured at dock.
9 Dec	0645 depart marina enroute to work area. 0730 set up vibracore rig and bar check Echosounder. Completed core BC-73. 0800 secure rig, conditions to rough for coring - Winds force 4, seas 6' – return to marina. 0854 secured at dock. Unload 43 cores to trailer.

10 Dec	Weather standby.
11 Dec	0640 depart marina enroute to work area. 0742 set up vibracore rig and bar check Echosounder. Complete cores BC-74, BC-75, BC-76, BC-77, BC-78, BC-79, BC-80, BC-81, BC-82, BC-83, BC-84, BC-85, BC-86, BC-87, BC-88, and BC-89. 1636 secure rig and return to marina. 1724 secured at dock.
12 Dec	0640 depart marina enroute to work area. 0706 set up vibracore rig and bar check Echosounder. Completed cores BC-90, BC-91, BC-92, BC-93, BC-94, BC-95, and BC-96. Building seas, too rough to core – winds force 5 east – seas 4-5'. 1124 secure rig and transit to Southwind Marina. 1318 loading core liners, caps and spare vibracore head. 1700 secured at Sportsman Marina.
13 Dec	Standby for weather – winds SW force 5, seas 4-6'. Unload 23 cores to storage trailer.
14 Dec	0636 depart marina enroute to work area. 0724 set up vibracore rig and bar check Echosounder. Completed cores BC-97, BC-98, BC-99, BC-100, BC-101, BC-102, BC-103, BC-104, BC-105, BC-106, BC-107, BC-108 R1, and BC-108 R2. 1635 secure rig and return to marina. 1745 secured at dock.
15 Dec	0624 depart marina enroute to work area. 0836 set up vibracore rig and bar check Echosounder. Complete cores BC-109, BC-110, BC-111, BC-112, BC-113 R1, BC-113 R2, BC-114, BC-115, BC-116, BC-117, BC-118, and BC-119. 1630 secure rig and transit to anchorage.
16 Dec	0630 pull anchor set up vibracore rig and bar check Echosounder. Completed cores BC-120, BC-121, BC-122, BC-123, BC-124, BC-125 R1, BC-125 R2, BC-126, BC-127, BC-128, BC-129, BC-130, BC-131, BC-132, BC-133, BC-134, and BC-135. Secure rig and return to marina. 1736 secure at dock.
17 Dec	0636 depart marina enroute to work area. 0742 set up vibracore rig and bar check Echosounder. Completed cores BC-136, BC-137, BC-138, BC-139, BC-140, BC-141, BC-142, BC-143, BC-144, BC-145, BC-146, BC-147, BC-148, BC-149, BC-150, BC-151, BC-152, BC-153, and BC-154. 1745 secure rig and enroute to marina. 1815 secure at dock.
18 Dec	Standby for weather. Unloaded 58 cores into storage trailer.
19 Dec	Standby for weather.
20 Dec	0636 depart marina enroute to work area. 0842 set up vibracore rig and bar check Echosounder. Completed cores BC-155, BC-156, BC-157, BC-158, BC-159, BC-160 and BC-154 R2. 1436 vibracoring project complete, secure rig and transit to marina. 1524

secured at dock – offloaded 7 cores to storage trailer. Demob.

2.0 EQUIPMENT AND PERSONNEL

2.1 Survey Vessel

The R/V Atlantic Twin, a 90 foot steel catamaran hull research vessel with a 7-foot draft, was used as the platform for the vibracoring operations. The vessel has ample laboratory and deck space, anchoring system, hydraulic crane, deck winches and A-frame capability for vibracoring. The navigational equipment and echo sounder, with associated computers, printer and display units were mounted in pilothouse. The vessel has sleeping facilities to accommodate crew and survey staff during the survey period.

2.2 Positioning System

A Trimble NT300D Differential GPS Navigation System was used throughout this operation. The DGPS system consists of a 12-channel satellite receiver and a built-in dual-channel radio beacon receiver, which obtained differential correction signals from the United States Coast Guard GPS transmitter at Mobile Point, Alabama

2.3 Navigation Data Acquisition and Logging System

The WGS-84 Geographic positions obtained by the GPS navigation system were converted into Alabama West State Plane (NAD 83) grid coordinate positions using a computer and Hypack Max navigation software, version 2.6. The system consists of the following components:

1) Pentium IV Computer.
2) Color Video Monitor (Helmsman Display).
3) Hypack Max Software

2.4 Echosounder

An Innerspace 448 Digital Echosounder with a 200 KHz 8° transducer was used to collect water depths at the time of vibracoring. Water depths were reduced to MLLW Datum. Actual MLLW readings were taken from the NOAA tide stations at Pensacola Bay, Florida and Dauphin Island, Alabama and then time and phase corrected to work areas. Note, the difference in tide levels between Entrance to Pensacola Bay and Dauphin Island is less than 0.1'

2.5 Vibracore

A model 271 B Alpine Pneumatic Vibracore configured to take cores 20 feet in length was used on this project. The model 271 B is a self-contained, freestanding pneumatic Vibracore unit. The unit consists of: an air-driven vibratory hammer assembly; an aluminum H-beam which acts as the vertical guide for the vibrator; a set of four steel support pads and legs which hold the beam upright on the sea bottom; a steel coring pipe; a cutting edge; a core retainer; a clear Lexan core liner; and a penetrometer which records time and depth of penetration of the core pipe into the sea bottom. An air hose array provides passage of compressed air from the compressor on deck to drive the Vibracore. Whenever refusal occurred with initial penetration of less than an acceptable depth, or recovery was less than 80% of penetration, the sampled portion was removed from the pipe, a new liner inserted, and a jet pump hose was attached just below the Vibracore head. The rig was lowered to the bottom and jetted to refusal depth, the jet turned off and vibrator turned on taking the additional part of the core.

2.6 Personnel

The following key personnel were involved in this project:

Captain R/V Atlantic Twin	Raymond Dunzelman
Field Supervisor/Geologist	George Wiegman
Vibracore Technician	Ovidio Hernandez

3.0 VIBRACORE DATA PRESENTATION

Vibracores were collected in the field under the supervision of Alpine's geologist George Wiegman and the Olsen representative Al Browder. A core log was kept for each core and the following information annotated: Core ID No., Date, time of start and finish, water depth and core location. Cores were cut into five-foot sections and annotated to preserve orientation and sequence of the core. Field descriptions were made of the sediment at the exposed five-foot intervals. Core sections were capped, sealed and stored in a vertical position on the vessel. At weather intervals and end of project, the core samples were unloaded into a storage trailer set-up at the marina to be delivered to the SEA laboratory in Melbourne, Florida for further analysis.

3.1 Penetration Graphs

The penetration graph shows the time of the vibration for each foot of progress within the sediments. This information is useful in estimating the comparative in-situ density of the sediments.

APPENDIX B
Tidewater Atlantic Research, Inc. – Draft Cultural Resources Analysis

Archaeological Remote Sensing Survey of Four Offshore Borrow Areas, Gulf Shores/Orange Beach/Gulf State Park, Baldwin County, Alabama

Submitted to:

Olsen Associates, Inc.
4438 Herschel St.
Jacksonville, Fl 32210

Submitted by:

____
Gordon P. Watts Jr.

Tidewater Atlantic Research, Inc.
P. O. Box 2494
Washington, North Carolina 27889

21 July 2003

Abstract

Olsen Associates, Inc. is the design engineer for the towns of Gulf Shores and Orange Beach and the Gulf State park system for a beach renourishment project along the coastal waters of Baldwin County, Alabama. The sand source material for the project is four borrow areas located between Perdido Pass and Mobile Point. In order to determine the proposed project's affects on potentially significant submerged cultural resources, Olsen Associates contracted with Tidewater Atlantic Research, Inc., [TAR] of Washington, North Carolina to conduct a proton precession magnetometer and side scan sonar survey of the four proposed borrow areas. Prior to the fieldwork, a program of historical and documentary research was conducted to provide a proper framework for submerged cultural resource assessment in the Gulf Shores/Orange Beach area. Fieldwork activities were carried out between 16–19 and 26–27 April 2003. Analysis of the remote sensing data revealed a total of nine magnetic anomalies: one in Area 1, one in Area 2, six in Area 3 and one in Area 4. Of those nine targets, four exhibited signature characteristics consistent with submerged cultural resources and were recommended for additional investigation. Under a modification of the contract those four anomalies were relocated and examined by divers on 21 and 22 May 2003. All four were generated by concentrations of wire cable. Based on the remote sensing survey and diver assessment of the potentially significant magnetic signatures no submerged cultural resources will be impacted by the proposed project. No further investigation is recommended in conjunction with the proposed project.

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Introduction

Olsen Associates, Inc. is the design engineer for the towns of Gulf Shores and Orange Beach and the Gulf State park system for a beach renourishment project along the coastal waters of Baldwin County, Alabama. The sand source material for the project is four borrow areas located between Perdido Pass and Mobile Point. In order to determine the proposed project's affects on potentially significant submerged cultural resources, Olsen Associates contracted with Tidewater Atlantic Research, Inc., [TAR] of Washington, North Carolina to conduct a proton precession magnetometer and side scan sonar survey of the four proposed borrow areas.

The investigation was designed to provide accurate and reliable identification, assessment and remote sensing documentation of submerged cultural resources in the proposed borrow areas. The survey methodology was developed in terms of the criteria established to comply with the criteria of the National Historic Preservation Act of 1966 (Public Law 89-665), the National Environmental Policy Act of 1969 (Public Law 11-190), Executive Order 11593, the Advisory Council on Historic Preservation Procedures for the protection of historic and cultural properties (36 CFR Part 800) and the updated guidelines described in 36 CFR 64 and 36 CFR 66. The results of the investigation furnished Olsen Associates with the archaeological data required for complying with submerged cultural resource legislation and regulations.

The work performed consisted of a background literature review, a proton precession magnetometer and side scan sonar survey, data analysis and preparation of a report. Field survey activities were carried out between 16 – 19 and 26 – 27 April 2003. Analysis of the remote sensing data revealed a total of nine magnetic anomalies: one in Area 1, one in Area 2, six in Area 3 and one in Area 4. Of those nine targets, four exhibited signature characteristics consistent with significant submerged cultural resources and were recommended for additional investigation. In a modification of the contract, Olsen Associates requested that TAR personnel conduct a diver investigation of the four potentially significant anomalies. That additional research was conducted on 21 and 22 May 2003. All four were generated by concentrations of wire cable. Based on the remote sensing survey and diver assessment of the potentially significant magnetic signatures no submerged cultural resources will be impacted by the proposed project. No further investigation is recommended in conjunction with the proposed project.

Project personnel consisted of Dr. Gordon P. Watts, Jr., principal investigator, archaeologists Raymond Tubby and Michael Lavender and archaeological assistant Colin Arnold. Data analysis and report preparation was carried out by Gordon Watts and Raymond Tubby.

Project Location

The proposed project is composed of four borrow areas located in the coastal waters of Baldwin County, Alabama. Three of the areas are situated between the towns of Gulf Shores and Orange Beach and the fourth is located east of Mobile Point (Figure 1, 2). Borrow Area 1 is located 1 mile southeast of Perdido Pass and is defined as a five-sided polygon approximately 4,000 feet long and 4,000 feet wide at its widest point with an area of 345 acres. Borrow Area 2 is located 4.5 miles west of Perdido Pass and is defined as a four-sided polygon approximately 4,700 feet long and 3,800 feet wide at its widest point with an area of 388 acres. Borrow Area 3 is located 6 miles west of Perdido Pass and is defined as an irregular-shaped polygon approximately 7,200 feet long and 3,300 feet wide at its widest point with an area of 389 acres. Borrow Area 4 is located approximately 9 miles east of Mobile point and is defined as a four-sided polygon approximately 5,800 feet long and 3,100 feet wide at its widest point with an area of 375 acres. Water depth within the study area ranged between 20 and 30 feet at low water. The Alabama State Plane, West Zone, NAD 83 coordinates for the borrow areas are:

Borrow Area 1

Point	Easting	Northing
A	1953500	94500
B	1954500	95500
C	1956500	95500
D	1957500	94500
E	1957500	91500
F	1953500	91500

Borrow Area 2

Point	Easting	Northing
A	1924200	87100
B	1927950	89900
C	1930500	87600
D	1926975	84450

Borrow Area 3

Point	Easting	Northing
A	1913700	86000
B	1918500	86000
C	1920000	84500
D	1918500	82750
E	1914050	82750
F	1912800	83400
G	1912850	84000
H	1915500	84000

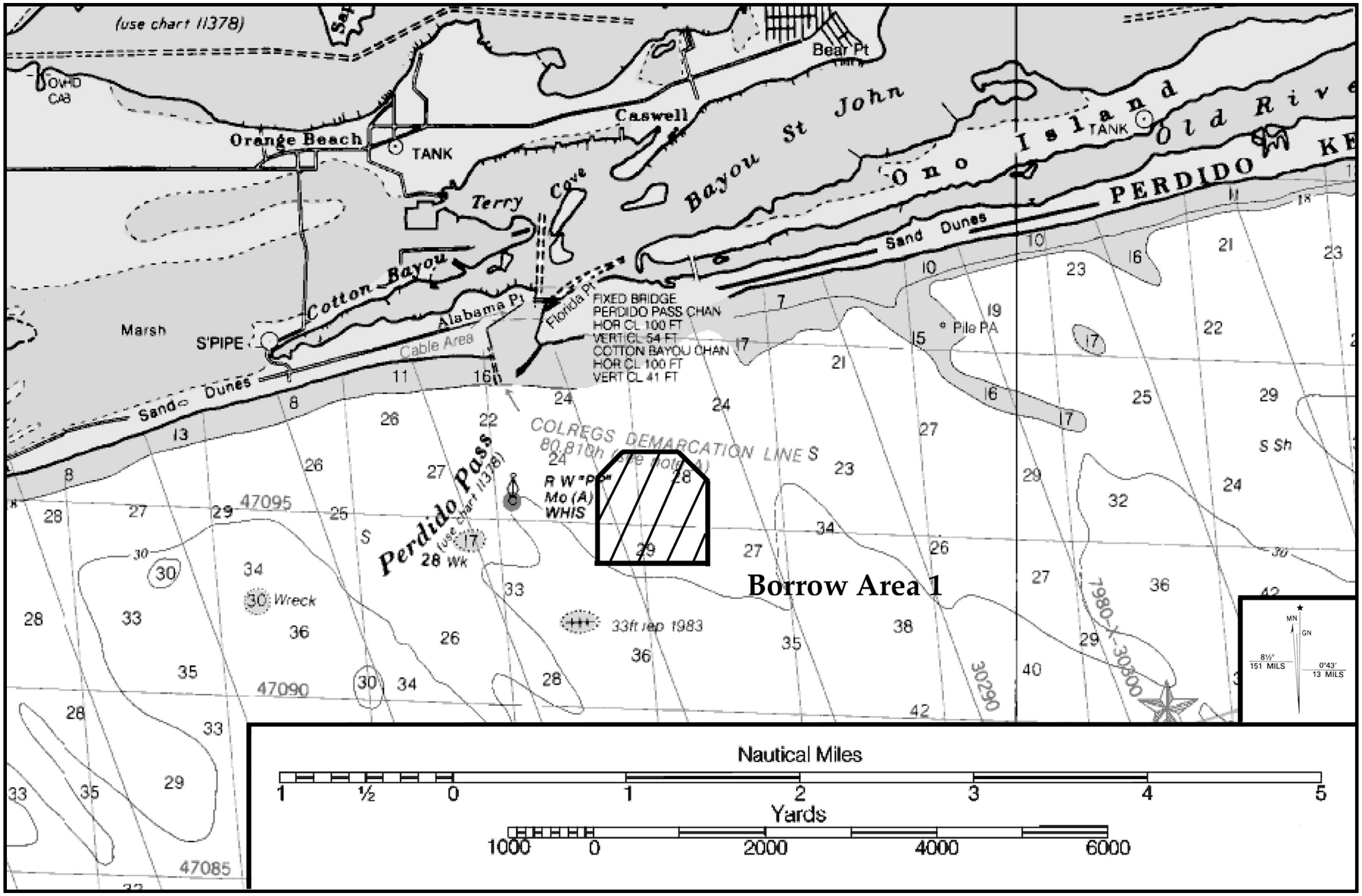

Figure 1. **Project location map, Borrow Area 1 (NOAA Chart 11382, Pensacola Bay and Approaches, 1998).**

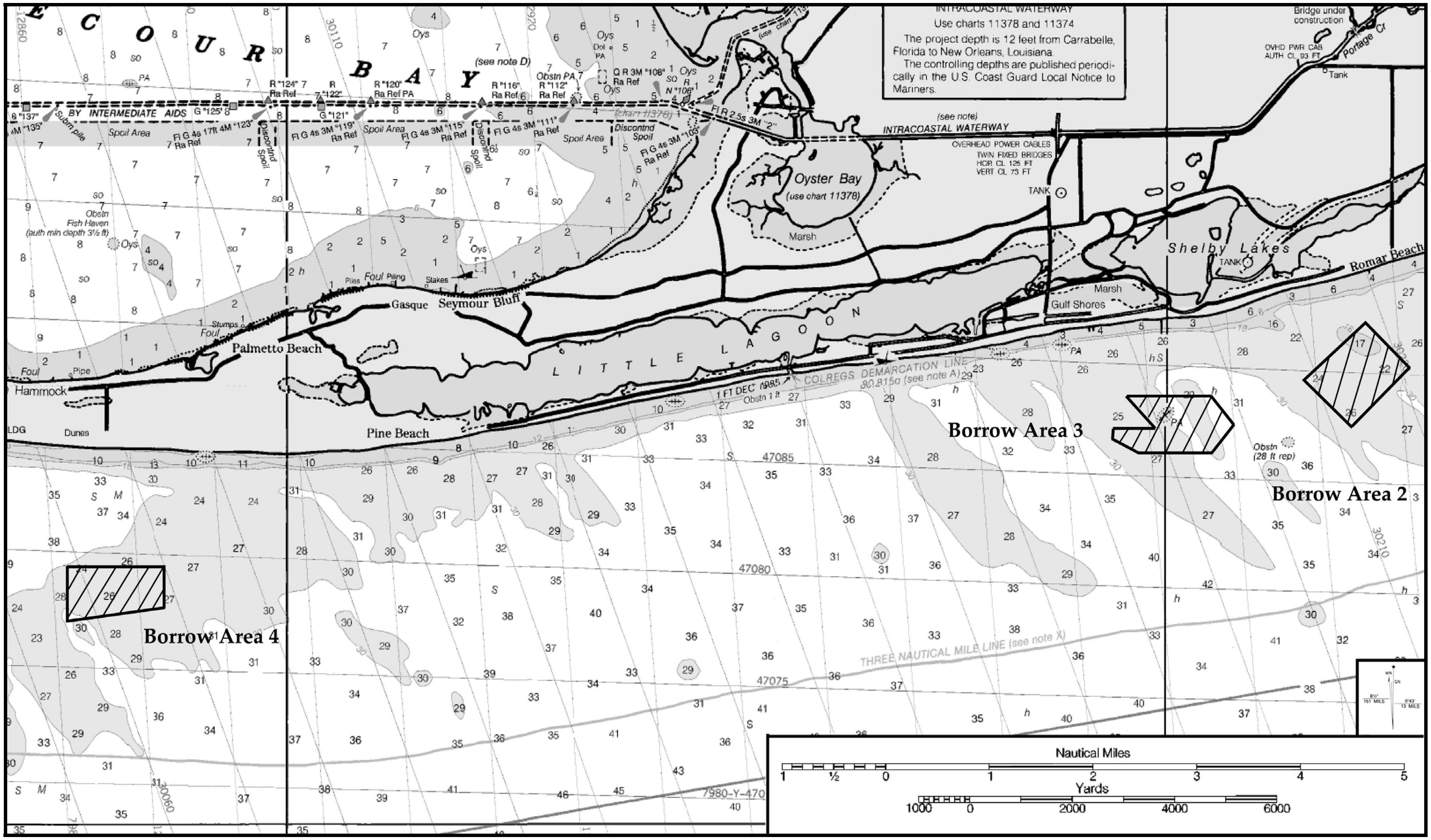

Figure 2. Project location map, Borrow Areas 2, 3 and 4 (NOAA Chart 11376, Mobile Bay, 1998).

Borrow Area 4

Point	Easting	Northing
A	1850250	76000
B	1850250	72875
C	1856000	73450
D	1856000	76000

Research Methodology

Literature and Historical Research

Prior to the remote sensing survey, TAR personnel conducted a literature and records search to identify shipwrecks and historical data to support development of a general background history for the project area. TAR initiated that research by examining source material in its research library gathered from previous investigations of the area. Additional records associated with the historical development of Gulf Shores/Orange Beach were examined from a variety of repositories, including the library at Mobile and the Foley and Orange Beach branches of the Baldwin County library system. The survey focused on documentation of activities such as exploration, colonization, development, agriculture, industry, trade, shipbuilding, commerce, warfare, transportation and fishing that would have been contributing factors in the loss of vessels in the vicinity of the proposed project area.

Preliminary wreck specific information was collected from such secondary sources as *The Encyclopedia of American Shipwrecks* (Berman 1972); *Merchant Steam Vessels of the United States 1790 - 1868* (Lytle and Holdcamper 1952); *Disasters to American Vessels, Sail and Steam, 1841-1846* (Lockhead 1954); *Shipwrecks of the Civil War: The Encyclopedia of Union and Confederate Naval Losses* (Shomette 1973); *Shipwrecks in the Americas* (Marx 1983) and *Shipwrecks of Florida* (Singer 1998). Additional information was generated by a survey of maritime records associated with Baldwin County, the Annual Reports of the Mobile District and the Wreck Information List of the U. S. Hydrographic Office.

Personnel in the Alabama State Site Files in the Office of Archaeological Research at the University of Alabama were contacted to determine if any previously reported sites were located in the project area and if any were listed on the National Register of Historic Places. In addition, local historians and archaeologists were interviewed to collect data concerning unreported sites in the proposed project area.

Remote Sensing Survey

All fieldwork activities were conducted from the 25-foot survey vessel *Atlantic Surveyor* and 29-foot survey vessel *Enrica.* TAR personnel surveyed the project area using a dual channel EG&G GEOMETRICS Model 866 proton precession magnetometer capable of plus or minus 0.1 gamma resolution. The magnetometer sensor was towed just below the water surface at a speed of 3 to 4 knots. Magnetic data were recorded as a data file associated with the computer navigation system and contour plotted using QUICKSURF computer software to facilitate anomaly location and definition of target signature characteristics. Acoustic data were collected using a 600 kHz MARINE SONICS digital side-scan sonar. The side-scan sonar transducer was towed at a depth of approximately 4 feet below the water surface. A 50-meter sonar range scale provided greater than 200% coverage of the bottom surface in the survey area. To ensure sufficient data would be available to locate any potentially significant targets in the project area, sonar and magnetic data were collected along lanes spaced on 50-foot intervals. Upon completion of the general survey, sonar records were examined and anomalies identified.

During the survey, positioning and lane spacing were maintained with a FURUNO GP-35 differential global positioning system [DGPS] interfaced with a Compaq 500mhz laptop computer. Navigation was controlled and data recorded by Coastal Oceanographics HYPACK®MAX Navigation software. This navigation system affords a positioning accuracy of plus/minus 3 feet. All data is related to the Alabama State Plane Coordinate System, West Zone, NAD 83. Positioning data generated by the DGPS unit were correlated to magnetometer records by regular annotations to facilitate target location and anomaly analysis. Annotations included lane number, date, start and finish for each lane and target identification.

Data Analysis

To ensure reliable target identification and assessment, analysis of the magnetic and acoustic data were carried out as it was generated. Using QUICKSURF, magnetic data generated during the survey were contour plotted at 10 gamma intervals for analysis and accurate location of the material generating each magnetic anomaly. Magnetic targets were isolated and analyzed in accordance with intensity, duration, areal extent and signature characteristics. Sonogram signatures were analyzed on the basis of configuration, areal extent, target intensity and contrast with background, and elevation and shadow image and were also reviewed for possible association with identified magnetic anomalies.

Data generated by the remote sensing equipment were developed to support an assessment of each magnetic and acoustic signature. Analysis of target signatures included consideration of magnetic and sonar signature characteristics previously demonstrated to be reliable indicators of historically significant submerged cultural resources. Target assessment includes avoidance options and possible adjustments to avoid potential cultural resources. Where avoidance is not possible the assessment includes recommendations for additional investigation to determine the exact nature of the cultural material generating the signature and its potential National Register significance. Historical evidence was developed into a background context and an inventory of shipwreck sites that identified possible correlations with magnetic targets (Appendix A). A magnetic contour map of the survey area was produced to aid in the analysis of potential targets. All identified targets were listed and described and a map produced that showed their location within the project area.

Target Identification and Assessment

Prior to refining the location of each target, a temporary buoy was deployed at coordinates previously calculated for each target. Passes were then conducted with the remote sensing equipment around each buoy to refine the anomaly's exact location. Once the target's precise position had been determined, a second buoy was deployed at the refined location and the first buoy was recovered. The survey vessel was then moored over the target location and tethered divers using SCUBA equipment and OTS wireless underwater communications systems searched the target areas in measured search patterns starting at the buoy weight. Diver reconnaissance of the targets was conducted using a QUANTRO SENSING hand-held underwater proton magnetometer in a circle search pattern in the area around the buoy. Where the magnetometer identified sub-bottom material, water jet probes and/or induction dredges were employed to remove overburden and expose diagnostic material.

Systematic probing/dredging was designed to determine the relative size and shape of the material generating each signature. Investigation focused on identification and assessment of the nature and significance of the cultural material present. That research was designed to collect sufficient data to support a preliminary assessment of National Register of Historic Places eligibility. Visibility during the target investigations varied between 3 and 8 feet and water depth varied between 24 and 24 feet in the proposed borrow areas, depending on location and tidal state.

Historical Background

Baldwin County, Alabama lies on the east side of Mobile Bay and extends west to the Perdido River. Evidence of a prehistoric populace in the vicinity of the survey area has been confirmed by a significant number of shell middens and burial mounds. Archaeological excavations conducted in Josephine and those near Perdido and Bon Secour Bays have revealed several aboriginal deposits. In addition, kitchen middens including pottery were excavated at sites at Bon Secour Bay and upland along the Bon Secour River (Nuzum 1971:19).

Anthropological studies indicate that the aboriginal population living in the area during initial European contact may have evolved from the Muskhogean ethnic group (Nuzum 1971:13). Extending to the boundaries of contemporary Alabama, these Middle Mississippian Period natives were divided into five primary tribes. The Cherokee and Chickasaws dominated the northeastern and northwestern portions of the state, respectively. Choctaws occupied the Mississippi side of the state, while the Upper and Lower Creeks located villages throughout eastern

Alabama. Historical accounts relate that the Creek controlled more territory than other tribes combined and that all contracts and similar instruments were related in their language (Nuzum 1971:13).

Indians located their villages along streams or other “unfailing” water sources. There, they constructed dwellings and storehouses fashioned of vertical logs. These primitive structures were finished with thatched roofs and clay caulking and were often surrounded by stockade fencing for security. Subsistence strategies consisted of a mixture of horticulture and hunting and gathering. The surrounding forests provided a variety of game such as bear and venison which was supplemented by fish, berries and other wild fruits. Agricultural products further expanded the Native American diet. Production included maize, beans, pumpkins, squash, sweet potatoes, okra and tobacco (Nuzum 1971:16). To facilitate travel and trade, aboriginals navigated the gulf, and adjoining rivers and streams by cypress dugouts and rafts. Tradition relates that Gulf coast inhabitants bartered indigenous products such as dried fish, salt, shells and yaupon. Inland tribes also traded their own natural resources that included mica, flint and copper (Nuzum 1971:18).

Documentation of the earliest European contact along coastal Alabama cannot be verified by extant archival sources. However, a map drawn circa 1507 by German born Waldseemuller detailed the Alabama coastline. Undisputed accounts do indicate that Admiral Alonzo Álvarez de Pineda explored Espiritu Santo (Mobile Bay) and the surrounding hinterland during 1519 (Nuzum 1971:26). Under contract to the Spanish Governor of Jamaica, de Pineda mapped the large bay and wrote about nearby aboriginal villages. Within a decade, another Spaniard navigated along the Alabama coastline. Sailing from the vicinity of modern day Apalachee Bay, Pánfilo de Narváez entered Espiritu Santo (translated as Bay of the Holy Ghost) during 1528 (Nuzum 1971:26). Reception from the native population was reported by this Spaniard explorer to be tense. Due to the hostile atmosphere, Narváez soon departed by ship and abandoned two sailors there.

The interior of Alabama was first explored by Hernando de Soto during his expedition through the southeast in search of gold and other valuable resources. The veteran conquistador anchored in Tampa Bay during the summer of 1539 and traveled by land to Apalachee followed by surveys in Georgia, the Carolinas and Tennessee (Nuzum 1971:27). After entering northeastern Alabama in early summer 1540, de Soto traveled south to the Indian village of Maubila. His intention was to procure gold from this tribe located on the Alabama River. Despite the Spaniard’s decimation of the Indian population, no treasure was found.

In September 1558, under the order of King Philip of Spain, Guido de las Bazares sailed into Bahia Filipina (Mobile Bay) to survey the region. His three-month reconnaissance of contemporary coastal Baldwin County provided important details related to its geography, flora and fauna. A written account by Bazares described territory to the east of Mobile Bay:

> The country to the east of the bay is higher than on the west side. In the bay and its vicinity are many fish and shellfish; there are many pine trees suitable for making masts and yards; there are oaks, live oaks, nut trees, cedars, junipers, laurels, and certain small trees which bear a fruit like chestnuts….All this forest from which ships can be made begins at the water's edge and runs inland. There are many palmettos and grape vines. There are many small streams of fresh water which flow into the bay besides a large mouth at the end of the bay which seems to be a copious river… The forest is open, not thick with underbrush, and underneath it the cavalry might skirmish. Under these trees there is grass for horses and cattle. Around the bay itself there are high red broken lands on the east side where bricks can be made, and near them are building stones….There are many birds, such as eagles, geese, ducks, partridges, doves and many others….There are deer in great number….On that bay were seen Indians and large canoes, which they bring for their service; there were also fish traps….Corn, beans and pumpkins were found in the villages" (Nuzum 1971:29).

A month after Bazares reconnaissance, Tristan de Luna y Arellano lead another expedition to the northern Gulf coast. De Luna decided to make a settlement on Ochuse Bay, modern Pensacola. He arrived in August 1559 with more than 500 soldiers, 1,000 civilians, horses, food, tools, weapons and even breeding stock. Thirteen vessels had been commandeered to transport his impressive colonial expedition. When he arrived in Ochuse Bay, de Luna was extremely impressed with the harbor:

> It is one of the best ports to be found in the discovered part of the Indies; the lowest water it has at the entrance is eleven cubits, and inside it has from seven to eight fathoms. It is a very spacious port and has a width of three leagues fronting the [entrance] (Priestley 1928, II:211-213, 275).

Less than a week after sailing into the bay, disaster struck. On 19 August, a severe storm, probably a hurricane, struck the bay. When the winds subsided 24 hours later, de Luna's fleet was virtually destroyed. Of the original fleet of 13, only two barks and one caravel remained seaworthy. To complicate matters, most of the rations along with other supplies had been lost (Priestley 1928, II:57-61). Despite the hurricane de Luna persisted and established a modest settlement at Pensacola. Explorations were also conducted of the surrounding region including Perdido and Mobile bays. Some of the settlers were shifted to other locations, one of which was along the Alabama River, to ease the impact of the loss of supplies from the hurricane. However, de Luna's settlement would only last less than three years. Unable to sustain the small colony, his power was revoked and de Luna was replaced by Angel de Villafane (Nuzum 1971:30). By 1565, the last de Luna settlement was abandoned and the Spaniards traveled to St. Augustine. The failure of this ill-fated mission marked the end of Spanish attempts to colonize the region between Mobile Bay and Pensacola until the late 17th century.

Foreign intervention in coastal Alabama was nearly nonexistent for the next century, while Europe's dominant nations struggled with wars and domestic problems. France's interest in the region became more pronounced after Robert

Cavelier (LaSalle) led a 1682 expedition to the mouth of the Mississippi (Nuzum 1971:31). There along the shores of the Gulf, LaSalle claimed the following territory for King Louis XI: "…the seas, harbors, ports, bays, adjacent straits, and all nations, peoples, provinces, cities, towns, villages, minerals, fisheries, streams and rivers within the extent of Louisiana" (Nuzum 1971:31).

The French monarch had previously established colonies along the St. Lawrence River and around the Great Lakes, and desired to control the Mississippi River Valley and the entire Gulf coast. LaSalle's strategy to construct garrisons along that geographical boundary to impede settlement by the English impressed King Louis. Unfortunately, the LaSalle expedition ended after his assassination in 1685, and the massacre of his company two years later by Indians (Nuzum 1971:31).

In late 1698, Iberville and Bienville Le Moyne departed from Brest, France with five ships and more than 200 men to reconnoiter along the northern coast of the Gulf of Mexico. After encountering Spaniards firmly entrenched at Pensacola Bay, they continued their expedition navigating westward along the Gulf coastline. Although they had intended to establish settlements along the Mississippi, its swampy shoreline deterred the Le Moynes. Soon thereafter, the French explorers set up an encampment called Fort de Maurepas (contemporary Ocean Springs) (Nuzum 1971:32).

A French Canadian surveying Mobile Bay and environs concurrently as Le Moyne named Bon Secour Bay for a Montreal cathedral (Bonkemeyer 1999:7). The English translation for the patron church of sailors translates as "the best chapel of ease" or "safe harbor." Bon Secour's sheltered harbor would provide refuge for early mariners and later served as a major entrepôt for oystermen and shrimpers for over two centuries. While colonizing the region, the Le Moyne brothers also chose to construct a sportsman lodge near Bon Secour Bay (Nuzum 1971:35). The site was selected for its pleasing climate and abundance of game, finfish and shellfish. In 1702, Iberville Le Moyne relocated the capital of the Louisiana Territory from Fort de Maurepas to "Twenty-Seven-Mile Bluff" which was situated on the Mobile River. In addition, a warehouse and port facilities were established at Dauphin Island to accommodate vessels with drafts too deep for navigation in the shallow waters of Mobile Bay.

The Twenty-Seven-Mile Bluff site, referred to as Fort Louis de la Mobile, also proved to be an unsatisfactory colonial headquarters for the French. For the next seven years, residents faced hardships including a yellow fever, a devastating flood and the perpetual threat of English invasion. In 1711, the crown colony again moved operations in this instance down river to Choctaw Point at the head of Mobile Bay (Nuzum 1971:33). There, the French could better observe activities at the head of the Mississippi River, closely scrutinize Spanish controlled Pensacola and gather intelligence related to British encroachment to the east.

While the new site of Mobile was much improved, the struggling settlers were confronted by additional problems. One of their supply ships grounded on the shifting sand bar at the mouth of Pelican Bay in 1717. Later that year, a fierce storm closed the main channel into Pelican Bay limiting access to the semi-protected anchorage to ships with a draft of 10 feet or less (Summersell 1949:2). Without deepwater access to the Pelican Island anchorage, Port Dauphin had to be abandoned in 1718 (Hamilton 1910:570 ; Surrey 1916:51-52).

Relations during this period, between the native population and French, were in most respects cordial and stable. As a consequence, a lucrative fur trade developed based primarily on barter. Representatives from tribes including Creek and Choctaw would normally offer beeswax, deerskin and fox pelts to the colonists. The French, in turn might trade textiles, vermilion, knives, cooking utensils or other manufactured goods.

Spain's small garrison on Pensacola Bay experienced similar hardships as their French counterparts. The settlement initially consisted of a small wooden fort, called San Carlos, erected on the mainland at the entrance to the bay. The fort was in a constant state of disrepair and poorly located. From the beginning, Spanish support was negligible, primarily because the government in New Spain considered the Pensacola site to be of little use and a drain on their funds. In fact, Spain's only significant economic return from the Pensacola colony was ship masts and timber for the Spanish Navy (Griffen 1959:247).

As mere outposts and neglected by their respective governments the settlements at Mobile and Pensacola conducted a healthy but illicit trade relationship. In 1704, the French supplied Pensacola with 4,000 pounds of flour (Surrey 1916:418). In the following years, the French sold the Spanish garrison not only flour and other foodstuffs, but also dry goods and even weapons (Surrey 1916:419-421). The various governors in French Louisiana attempted to curtail this trade, but were unsuccessful until 1718. When war broke out between France and Spain, the relationship between the two colonies became hostile. Shortly after news of the war reached the colonies, a force of French soldiers and Indian warriors marched overland to Pensacola Bay. With support from four warships, they seized control of Pensacola (Hamilton 1910:101). The French occupied the Spanish colony for four years. In 1723, the war ended and shortly thereafter the French abandoned their claim to Spanish Florida. The Spanish also resumed their illegal trade with French Mobile (Gold1969:10; Surrey 1916:419-421).

With revenues nearly non-existent, King Louis XIV opted to lease the Louisiana colony to an affluent French merchant in 1713 (Nuzum 1971:33). Of more importance, Antoine Crozat was granted exclusive power to govern New France and would also exercise total control of commerce there. Subsequently, Governor Bienville Le Moyne was deposed and replaced by Le Monthe Cadillac. Cadillac's administrative expertise never equaled that of his outstanding predecessor and his rule was soon terminated. With the failure of Crozat's ambitious plans to promote trading and mining coupled with heavy military debt in France, a clever foreigner convinced French benefactors to support his entrée into the region by 1715.

Sponsored by the influential Orleans family, Scotsman John Law devised a scheme to seize economic control of Louisiana. Under the auspices of his Mississippi Company, Law exercised a stranglehold on Louisiana for almost two decades. The venture promoted slave importation and consequently, the establishment of rice, tobacco and indigo plantations. Law's monopoly was ended in 1732 by the French king due to corruption and unsound financial dealings. Governor Bienville was re-appointed and due to a scarcity of food soon sent some Frenchmen to a settlement along the eastern bay (Nuzum 1971:35). That colony, situated on the Fish River, was soon followed by another at present day Mobile.

In 1763, the Treaty of Paris, which ended the French and Indian War, ceded all French territory east of the Mississippi River and Spanish Florida to Great Britain. As a result, Fort Conde (Mobile fortification) was renamed Fort Charlotte and all of southern Alabama was referred to as "Charlotte Country" in honor of King George's consort (Nuzum 1971:38). At the time of the transfer approximately 350 civilians lived in Mobile and roughly 90 French families lived in the surrounding countryside (Brown 2001:42). All were encouraged by the British to stay in the area. In Spanish Florida, on the other hand, the entire population elected to leave with the change in government. Though Pensacola became the capital of West Florida it proved to be a poor colony for the British. The town and the fort were in a dilapidated condition and one soldier described the new capital as: "good for nothing but destroying Englishmen (Brown 2001:44).

An English stronghold was also built at Croftown some 25 miles northwest of modern day Orange Beach after 1767. The fortification offered a healthier post for soldiers plagued by malaria and yellow fever rampant at Mobile (Nuzum 1971:39). For strategic reasons and to facilitate travel between the major seaports of Mobile and Pensacola, the British constructed a roadway across the Perdido River. Prior to the American Revolution, a report submitted by Frederick Handiman described the area east of Mobile Bay. In charge of the crown's "West Florida" operations, Handiman wrote that there were 17 plantations occupied by a total of 39 "white" males, 32 male Negroes and 21 Negro women and children (Nuzum 1971:39).

During the American Revolution, many British loyalists migrated to West Florida, Mobile Bay and Baldwin County from Georgia and the Carolinas. Most early "American" settlements were located near the Alabama River and Tensaw Lake. Family names which often appeared in the county's history included Byrne, Easley, Hall, Killcrease, Mims, Pierce, Sibley and Holmes. Scottish settlers also achieving notoriety in the mid to late 18th century were the McMillan, McLeod, McPherson, McDonald, Campbell and McGillivray families (Nuzum 1971:41).

A respected Pennsylvania botanist surveyed the gulf coast in 1777 and described its vegetation with prosaic language. William Bartram had been commissioned by a London scientist to study the colony's plant and bird species. Published in 1791, Bartram's *Travels* offered this image of the county's gulf coast:

> "What a sylvan scene is here…the pompous magnolia reigns sovereign of the forests…and how sweet the star anise groves…in the fields he found the rich, yellow blooms of the evening primrose…perhaps the most brilliant herbaceous plant yet known to exist… loaded peach and fig trees…the figs a dark-blue purple and the size of pears…canes and cypresses were of astonishing magnitude…the cucumber tree, each branch supporting an expanded umbrella…lagoons containing green, wavy plains of water-lilies, some being seven or eight inches wide and of a lemon yellow…among which were beheld alligators" (Nuzum 1971:43).

Military activity along the northern Gulf Coast during the American Revolution was chiefly the result of a daring Spaniard's strategy. Don Bernardo Gálvez, the governor of Louisiana, submitted an ingenious plan to King Charles III of Spain to assail the British in "West Florida" while they engaged American patriot forces (Nuzum 1971:44). Gálvez believed, along with the king, that they could be defeated if confronted by dual fronts in the colony. This tactic was further strengthened due to Britain's longstanding and costly war with France.

A few weeks after Spain declared war on Great Britain, Gálvez received orders to conquer British possessions along the Gulf of Mexico (Parks 1981:26). Gálvez first took possession of British settlements along the Mississippi River. In February 1780, Gálvez attacked Mobile and forced Governor Elias Durnford to surrender the city. With Mobile as a base and reinforcements from Havana, he planned to immediately attack Pensacola (Johnson 1943:216). In March, a Spanish fleet sailed to assist in the Pensacola campaign, but the planned attack failed to materialize. The Spanish naval commander was convinced that his ships could not silence the guns guarding Pensacola Bay (Starr 1976:176). A second expedition in the fall stalled when the fleet carrying troops from Havana was hit by a hurricane (Parks 1981:27).

On the last day of February 1781, Gálvez left Havana with some 7,000 men and a fleet numbering 38 vessels (Servies 1982:21). Ten days later, the fleet arrived off Pensacola and the troops were landed despite strong opposition from two British sloops, *Mentor* and *Port Royal* (Starr 1976:196; Rush 1966:passim). Nine days after Gálvez's forces arrived, his ships entered Pensacola Bay forcing the British ships to retreat. Pensacola was placed under siege until 8 May when a powder magazine exploded. The following day, the town and the garrison surrendered (Servies 1982:24; Parks 1981:27).

With the Treaty of Paris that ended the American Revolution all of East and West Florida, as well as the Mobile region were ceded to Spain. Baldwin County was once more under the control of Spain, and her influence on the area's religion, culture, and politics soon became evident. As a consequence of the Roman Catholic Church's authority, priests were also recognized as government representatives. Another important change was the transfer of land to settlers of Spanish origin (Nuzum 1971:45). Not surprisingly, difficulties would soon arise between the newly formed American government and Spain in relation to the

31st parallel boundary (Treaty of Paris 1783). Most grievances were resolved through diplomatic channels until America gained permanent control of the region.

In 1803, the United States purchased Louisiana from the French king. Spain vigorously objected to the transfer, but could do nothing about it. The Louisiana treaty made no reference to the status of Florida, but President Thomas Jefferson supported the view that Louisiana included that portion of Florida between the Mississippi River to the west and the Perdido River to the east. In 1810, American expansionists led a revolt, captured the fort at Baton Rouge and declared the entire area to be a part of the United States. In 1812, President James Madison announced American possession of West Florida from the Mississippi to the Perdido. To further frustrate the Spanish, after the outbreak of the War of 1812 American military forces occupied nearby Mobile.

Although Spain was officially neutral in the conflict, she was allied with Great Britain in the struggle against Napoleonic France. American occupation of the Mobile region and British activities in Florida (including agitation of the Creek Indians) practically guaranteed an American invasion of West Florida. Andrew Jackson, after assuming command of American forces in the Gulf region, considered the takeover of the whole of Florida his ultimate objective (McAlister 1957:315-316). As early as July 1812, a marine officer in New Orleans wrote: "We are anxiously waiting for orders to take Mobile and Pensacola," and added, "should the English get possission [sic] of the port of the latter place, we will not be able to dispossess them" (Dudley 1985:410). In August 1814, two British warships arrived in Pensacola Bay and landed marines to occupy the fortifications with Spanish cooperation. In November, Jackson attacked the town and forced the British to evacuate. American occupation, however, was brief. The threat of a British invasion at either Mobile or New Orleans forced Jackson to concentrate his forces in those places.

Unable to defend Florida from outside aggression and under pressure from expansionists from the United States, Spain signed the Adams-Onis Treaty in 1819, renouncing all claims to West Florida and ceding East Florida to the U. S. Mobile's population of approximately 300 at the time of American occupation in 1813 swelled to more than 800 by the time the city was incorporated in the newly created State of Alabama in 1819. The city attracted "adventurers of every description" and by 1822, the population had swelled to approximately 2,800 inhabitants (Doss 2001:65). Many of the new comers were emigrants from England, Scotland and Ireland. The influx of new entrepreneurs led to a brief period of rapid but unregulated growth in the city. That was halted by a fire that destroyed almost two-thirds of the business district and over 150 wooden and log homes in 1827. After that tragedy, municipal ordinances required that buildings be constructed from more fire-resistant materials such as brick and stone. By 1833, Mobile had "risen in all the vigor and beauty of a phoenix" (Doss 2001:67).

Baldwin County was formed in December 1809. The county was created from the lower half of Washington County on the west side of the Tombigbee River. The county was enlarged in 1818 and in 1819 its borders were rearranged following Alabama's statehood (Nuzum 1971:56). In that change, all of Mobile County lying east of Mobile Bay was transferred to Baldwin County and that part of Baldwin situated west of the Mobile and Tombigbee rivers were added to Mobile County. Despite several modifications of the state's borders over the next 50 years, Baldwin County holds the distinction of being Alabama's largest county (Nuzum 1971:56). The county was named for Abraham Baldwin at the bequest of influential Georgians who migrated into the Gulf coast region. Baldwin had served with distinction as a Georgian congressman and senator under the administrations of Washington, Adams and Jefferson. Prior to 1820, the segregated population of Baldwin County was reported to be comprised of: 134 white male adults, 134 white male children, 92 white female adults, 144 white female children, and 1,062 blacks ("mostly slaves") (Nuzum 1971:67,86).

Over the next 40 years, there were major changes in the county including road construction, steamboat commerce, agricultural advances especially in the production of cotton and significant expansion of the lumber industry. Mail routes were established in the county including the Taylor-Kitchen Line, which connected Mobile and Pensacola (Nuzum 1971:79). Roadways that promoted travel by stagecoach across the county also created the need for resting places. As a result, numerous "good houses of accommodations" were built along Baldwin's early thoroughfares (Nuzum 1971:78).

The advent of steamboat travel along Mobile Bay and the region's rivers proved to be beneficial to the area's economic development. Not only were they a practical and lucrative mode of transportation, steamboats could carry and tow freight with speed and regularity that other vessels could not provide. The majority of the larger and faster ante-bellum vessels were designed with side-wheels. However on the rivers, stern wheel steamers also competed for both passengers and freight. The smaller vessels often carried freight that included manufactured imports and agricultural products. Despite the rise of steamboating, sailing vessels remained popular along the coastal routes with several regional merchants operated trading schooners between New Orleans, Mobile and Pensacola.

While lumber, tar and turpentine continued to be important products in Mobile's trade, cotton was rapidly becoming the dominant source of revenue. By 1850, almost 100 vessels were engaged in lightering cargos on Mobile Bay (Doss 2001:68-69). To handle the volume of cotton and imports Mobile merchants increased their wharf facilities to take up virtually all of the riverfront from Government Street in the south to One Mile Creek in the north (Parker 1968:44-45). By 1850, over 300,000 bales of cotton could be stored in more than 40 fireproof brick warehouses and more than forty thousand bales of cotton could be handled simultaneously (*Hunt's Merchant Magazine* 1851:266). By 1859, 440.5 million pounds of cotton were exported annually from Mobile, making it one of the busiest cotton ports in the South. Over 330 vessels cleared and 200 vessels entered the port in 1860 alone. Exports from Mobile amounted to $3,670,183 in 1860 while foreign imports totaled $1,050,310 (Griffith 1972:150).

The Antebellum Period in Alabama was also a time of rapid development for railroads. Alabama entrepreneurs, authorized by the State of Alabama, invested heavily in systems that connected Tuscumbia and Sheffield in the 1830s. The Alabama and Florida Railroad Company built a system that connected Montgomery with Pensacola. By 1860, an extension of that line was built as far as Pollard where it connected with the Mobile and Great Northern. Another extension connected Pollard with Hurricane on the Tensaw River in Baldwin County. Additional lines included the Mobile and Ohio Railroad which connected Mobile with Columbus, Kentucky. It crossed the Memphis and Charleston Railroad, which ran east to west at Corinth, Mississippi. The Alabama and Mississippi Rivers Railroad, the east to west connection with the Mobile and Ohio, tied in at Meridian, Mississippi. From Meridian, the Alabama and Mississippi Rivers Railroad ran eastward toward the Tombigbee River at Demopolis, Alabama and ran westward through Jackson to Vicksburg.

Steamboats and railroads provided Baldwin County residents with important connections to markets in Mobile, Montgomery and Pensacola. While cotton became the most important cash crop, farmers and plantation owners also raised vegetables, corn for cattle and hogs and produced lumber and naval stores. Along Mobile Bay and the Perdido River small vessels were built to support fishing and transportation. A brick making industry also developed as suitable clay was an abundant natural resource. Bricks were used residentially and commercially in Mobile and Pensacola and lighthouses and fortifications constructed to protect both harbors required an extensive supply (Dibble 1974:31-34).

At the outbreak of the Civil War, events at both Pensacola and Mobile impacted the lives of residents of coastal Alabama. During the first week of January 1861, rumors reached Pensacola that Florida state troops were planning to seize the forts and navy yard (Bearss 1957:126). In response, U. S. military personnel began to evacuate provisions, guns and ammunition to Fort Pickens where it was believed Union forces could withstand an attack until relieved. On 12 January 1861, a military force of Alabama and Florida troops arrived and took over the navy yard. Within a few days Southern troops were in complete control of Pensacola and the surrounding area except for Fort Pickens on Santa Rosa Island (Pearce 1980:71-72).

By the middle of March, the United States government had assembled a large naval force off Pensacola consisting of the warships *Wyandotte*, *Sabine*, *St. Louis* and *Brooklyn* (Bearss 1957:142). On 13 May, the senior naval officer on station declared a blockade of the harbor stating: "No coasting vessels will be permitted to enter or depart [Pensacola]" (Pearce 1980:73). In September 1861, a Union force boarded and sank the blockade-runner *Judah* in Pensacola Bay. The following month, a sizable Confederate force landed on Santa Rosa Island but failed to take and destroy the fort's batteries. The Battle of Santa Rosa Island was the last attempt to force Union forces to evacuate Fort Pickens (Pearce 1980:75).

By March of 1862, Confederate forces had abandoned Pensacola. The navy yard, guns, equipment, machinery, the steamer *Fulton*, three small steamers and other small boats were burned, as well as were two gunboats under construction at Milton (Pearce 1980:78-79; Bearss 1961:350). Although the yard was, according to Commander David Porter, "a ruin" when occupied by Union forces, it still offered "more facilities for repairs than could be found anywhere else [on the Gulf Coast]" (Pearce 1980:80). By September 1862, the yard was ready for service again. Throughout the remainder of the war, the warships of Admiral David Farragut's West Coast Blockading Squadron would use Pensacola as their base of operations and supply depot.

At the start of hostilities, Governor Andrew B. Moore of Alabama authorized the seizure of federal properties near Mobile. In addition, two companies from the Alabama militia seized forts Morgan and Gaines at the mouth of Mobile Bay. Both were still under construction at the outbreak of the war. Governor Moore, believing Mobile was the most likely point of attack by the enemy because of its coastal location, moved quickly to defend the city. He order the forts reinforced; interior planters responded by offering the services of slaves to help in defense construction. By early 1861, engineers employed nearly 150 laborers at Fort Morgan.

Early in the war, the Confederate navy at Mobile consisted of a few small vessels, each armed with a single cannon, the revenue cutter *Lewis Cass* and the lighthouse tender *Alert.* Victor M. Randolph, former commander at the Pensacola Naval Yard and naval commander on the York River in Virginia, assumed command of the naval squadron at Mobile in February 1862. Shortly after his arrival, the naval fleet received two new gunboats: the wooden side-wheel steamers *Morgan* and *Gaines*. Each gunboat carried 10 guns, but only had iron plating protecting the bow and engines.

On 3 April 1862, the two gunboats were sent to try and break the blockade. Newspaper accounts indicate that both sides exchanged only a few shots before the Confederate gunboats returned to their station near Fort Morgan. Neither side suffered any casualties or damage. Shortly after the engagement, Randolph requested money for the construction of ironclads. The ram *Baltic* was attached to the fleet after the Alabama legislature appropriated funds for military conversion of the vessel. *Baltic* had light iron plating covering most of its sides, but parts of the super structure was only protected by cotton bales. The vessel's armament consisted of four heavy guns and two light guns.

An additional number of ironclads were also under construction in yards located on the Alabama and Tombigbee rivers. In early 1863, the ironclads CSS *Huntsville* and CSS *Tuscaloosa* were added to the naval force. These vessels were 152 feet long, carried an armament of three 32 pounders and one 6.4 inch rifled cannon and were protected by 4 inches of iron plating (Silverstone 1989:207).

However, because of week motive power both ironclads were reduced to little more than floating batteries and were mainly kept in the upper bay to protect the approaches to Mobile. A far more powerful ironclad, the CSS *Tennessee* joined the fleet in early 1864. That vessel was 209 feet long, carried an armament of two 7 inch and four 6.4 inch rifled cannons and was protected 5 to 6 inches of armor (Silverstone 1989:209).

Mobile was not seriously threatened by Union forces until early 1864. In February of that year, the Union fleet initiated a bombardment of Fort Powell as diversion for a planned attack on the Mobile and Ohio Railroad in Meridian, Mississippi by Major General William Tecumseh Sherman. Though bad weather hampered the naval effort and forced an early withdrawal of the fleet it did achieve its ultimate objective by tying up Confederate forces and allowing Sherman to destroy the railroad.

By August 1864, the Union navy was ready to close off the Confederacy's last major seaport on the Gulf. Admiral Farragut planned for a joint naval and military operation against the shore defenses protecting the mouth of Mobile Bay. General Gordon Granger was to land 1,500 infantrymen, four artillery batteries and an engineer battalion on Dauphin Island concurrently with an attack by Farragut's fleet into the bay on 4 August (Hearn 1993:75). The main body of the Union fleet consisted of 18 ships, mounting a total of 174 large caliber guns (Hearn 1993:213). Four ironclads, USS *Tecumseh,* USS *Manhattan*, USS *Chickasaw* and USS *Winnebago* were also included to provide covering fire for the more vulnerable wooden vessels and to engage the *Tennessee*.

Defending Mobile Bay against the Union were Forts Morgan and Gaines and a small squadron of Confederate warships. Leading the Confederate squadron was the formidable ironclad CSS *Tennessee*. Despite some design problems, the ironclad was the most powerful vessel in the Confederate squadron and was selected by Admiral Buchanan, whom replaced Randolph in September 1862, to be his flagship. Accompanying the ironclad were the three lightly armored gunboats CSS *Morgan*, CSS *Gaines* and the CSS *Selma*. The ordnance of Fort Morgan supported the small squadron in protecting the bay. The fort had a total of perhaps 18 rifled guns ranging in size from 5.82-inches to 10-inches covering the approaches to the bay and an additional sixteen 32-pound Columbiads covering the field of fire within the bay.

In anticipation of the inevitable attack, the Confederates had also taken several defensive measures to prohibit entry through a major section of the entrance channel to Mobile Bay. Pilings stretched from Dauphin Island across an expanse of shoal water to the edge of the channel near Fort Morgan. From the end of the pilings, three rows of torpedoes obstructed the channel. Those obstructions forced vessels seeking safe passage within 200 yards of Mobile Point. A solitary red buoy marked the limit of obstructions (Mahan 1883:224, 225).

The USS *Tecumseh* initiated the battle for Mobile Bay with a gun shot on Fort Morgan. Gunners at Fort Morgan returned fire, and were joined later by the Confederate warships as the advancing monitors and wooden warships moved into range (Mahan 1883:244). As the Union ironclads forced their way into the pass, the *Tecumseh* was rocked by the explosion of a torpedo, sinking almost immediately. As a result, the USS *Brooklyn* backed down to avoid a similar fate and forced the USS *Hartford* and USS *Richmond* to halt to prevent a collision. Admiral Farragut witnessed the near debacle from the rigging of his flagship and angrily ordered the *Hartford* forward. The vessel hauled off to port, passed the *Brooklyn* and successfully traversed the minefield without incident. While Farragut made his passage into the bay, the *Richmond*, *Brooklyn* and the surviving monitors engaged Fort Morgan (Mahan 1883:235). Following the example of the USS *Hartford*, the rest of the fleet navigated the pass as the monitors and warships engaged the Confederate fortification**.**

Confederate naval forces responded to the Union's penetration of the mine field. The *Tennessee* advanced towards the *Hartford* in an attempt to ram the Union vessel. Buchanan intended to ram or engage the wooden warships before the Union monitors could arrive. Although his attack damaged several vessels, including the *Brooklyn, Monongahela* and *Ossipe,* he was unable to effectively ram and sink any of Farragut's warships. Buchanan's ship had received the combined broadsides of almost every Union warship but little damage had been done to the casemate or the ship's vitals. Union fire had partially collapsed the smokestack, causing a reduction in speed and almost every exterior fitting had been shot away, but the ship was still in fighting trim (Hearn 1993:100).

While Buchanan made his daring, but largely futile counter-attack on the Union force, his three gunboats paralleled the column and caused extensive damage to the *Hartford*. The *Gaines*, steaming abeam the *Hartford,* was the first Confederate ship to succumb to the broadsides of the Union fleet. A shell from either the *Hartford* or *Richmond* sprang open the *Gaines*' planking, causing flooding in the after magazine compartment. Lieutenant Bennett, the ship's commanding officer, ordered the vessel away from the battle and tried to beach his gunboat near Fort Morgan. The *Gaines* ran aground 200 yards from shore north of Fort Morgan. Although the stern sank in water deeper than the bow, the crew salvaged their ordnance and abandoned their ship (Broadfoot Publishing Company [BPC] 1997:589-590).

After engaging Fort Morgan, the surviving Union monitors started firing their heavier guns at the *Tennessee*. A 15-inch shell from the *Manhattan* finally damaged the casemate of the *Tennessee*. The *Chickasaw* positioned itself on the stern of the *Tennessee* and fired a barrage of 11-inch shells at the *Tennessee*'s steering chains which ran through exposed channels in the iron plate in the stern. The chains were eventually shot away and the *Tennessee* became unmanageable. After additional shelling jammed most of the gun port shutters and shot away the smokestack Captain Johnston, who had taken commend of the ship when Buchanan was wounded, decided that the situation was hopeless and surrendered the ship (BPC 1997:581).

With the surrender of the *Tennessee*, the naval battle of Mobile Bay ended. Fort Powell, guarding Grant's Passage behind Dauphin Island, surrendered hours after the *Tennessee* surrendered. Fort Gaines surrendered on 8 August and Fort

Morgan fell on 23 August after federal troops cut its lines of communication. The City of Mobile at the head of the bay grimly held out against Union advances until General Joseph E. Johnston surrendered all Confederate forces east of the Mississippi on 26 April 1865.

During the Civil War, Baldwin County continued to produce cotton as high prices made running cargos through the Union blockade to Cuba very rewarding for the successful ventures. In addition, farmers began to raise more corn, wheat, vegetables and even peanuts for subsistence. A number of salt works were constructed along the bay at Bon Secour. Without refrigeration, salt was essential for the preservation of meat. Much of the forage for the fortifications that protected Mobile Bay from Union attack came from Baldwin County.

Slave labor was an important aspect of the economy of Antebellum Baldwin County. As early as 1820, blacks outnumbered whites almost two to one and most of those were slaves. The end of the Civil War and Reconstruction brought an end to slavery in America and a restructuring of the southern economy. The southern plantation system was dismantled and farming was conducted by both white and black sharecroppers, who worked the land for absentee owners.

In 1868, the Mobile Board of Trade was organized to promote a revitalization of the city's commerce. A jetty system constructed after the war failed to produce the desired results and in 1873, the USCAE initiated a program of dredging designed to improve navigation in the bay below Mobile. By 1877, moderate-sized ships and steamers with drafts under 13 feet could serve Mobile (Summersell 1949:47). The development of railroads in the post-Civil War period provided service to Mobile. However at the same time, railroads altered the patterns of inland trade. A good deal of the cotton and forest products and imports that came through Mobile prior to the war began to be carried by rail to other ports and inland centers of trade (Summersell 1949:48-49). While the cotton and lumber trade never recovered, coal and iron mining brought new materials to Mobile via the Tombigbee-Black Warrior. Coal and iron were not all exported as Mobile witnessed an unprecedented rise in industrial manufacturing late in the 19th century.

Timber and forest products also provided Mobile with the raw materials to support a local shipbuilding industry. While trans-oceanic trade declined, vessels were built to support a revival of fishing and oystering on Mobile and Perdido bays. Local watermen benefited from a dramatic rise in the demand for oysters and fish and many vessels were built in small yards at Mobile, Fairhope, Foul River, Fish River, Shell Baks, Bayou La Batre, Bon Secour and Mon Louis. Larger vessels were built by firms like Ollinger and Bruce in Mobile (Mistovich and Knight 1982:21).

During the First World War Alabama Drydock and Shipbuilding Company, formally the firm of Ollinger and Bruce, became the largest industrial employer in the Mobile area. Before the end of hostilities, five other shipbuilding firms were at work building vessels at Mobile. Mobile builders also responded to the demand for tugs and barges that was stimulated when the Gulf Intracoastal

Waterway opened after 1936. Today, the Alabama State Docks open the Port of Mobile to international shipping and dredging maintains the channels necessary for deep draft vessels (McLaurin and Thomason 1981:106-112).

Tourism became a major industry in the county at the turn of the century. To support this influx of visitors, a number of hotels were constructed at Daphne, Fairhope and Point Clear (Mistovich and Knight 1982:21). Agricultural occupations remained the primary commercial activity in Baldwin County throughout the 20th century. Finfish and shellfish industries are led by the harvesting and shipping of Bon Secour oysters. However, the excursionist traditions of the late 19th century continue to support the economy of the county in 2003.

Summary of Findings

Although historical research confirmed a significant amount of maritime activity in the coastal waters of Alabama, no evidence of that activity was reflected in the archaeological record in the survey area. A total of nine magnetic target signatures were identified in the project areas (Figure 3, 4, 5, 6). None of the targets had an associated sonar signature. Analysis of the data identified four targets, 3-01, 3-03, 3-04 and 3-06, which have a moderate potential for association with shipwreck material. Diver investigation of those anomalies revealed that all four were generated by concentrations of wire cable. The remaining five targets contain signature characteristics consistent with modern material such as wire rope, pipes, anchors or other debris. No additional investigation of those sites is recommended in conjunction with the proposed beach renourishment.

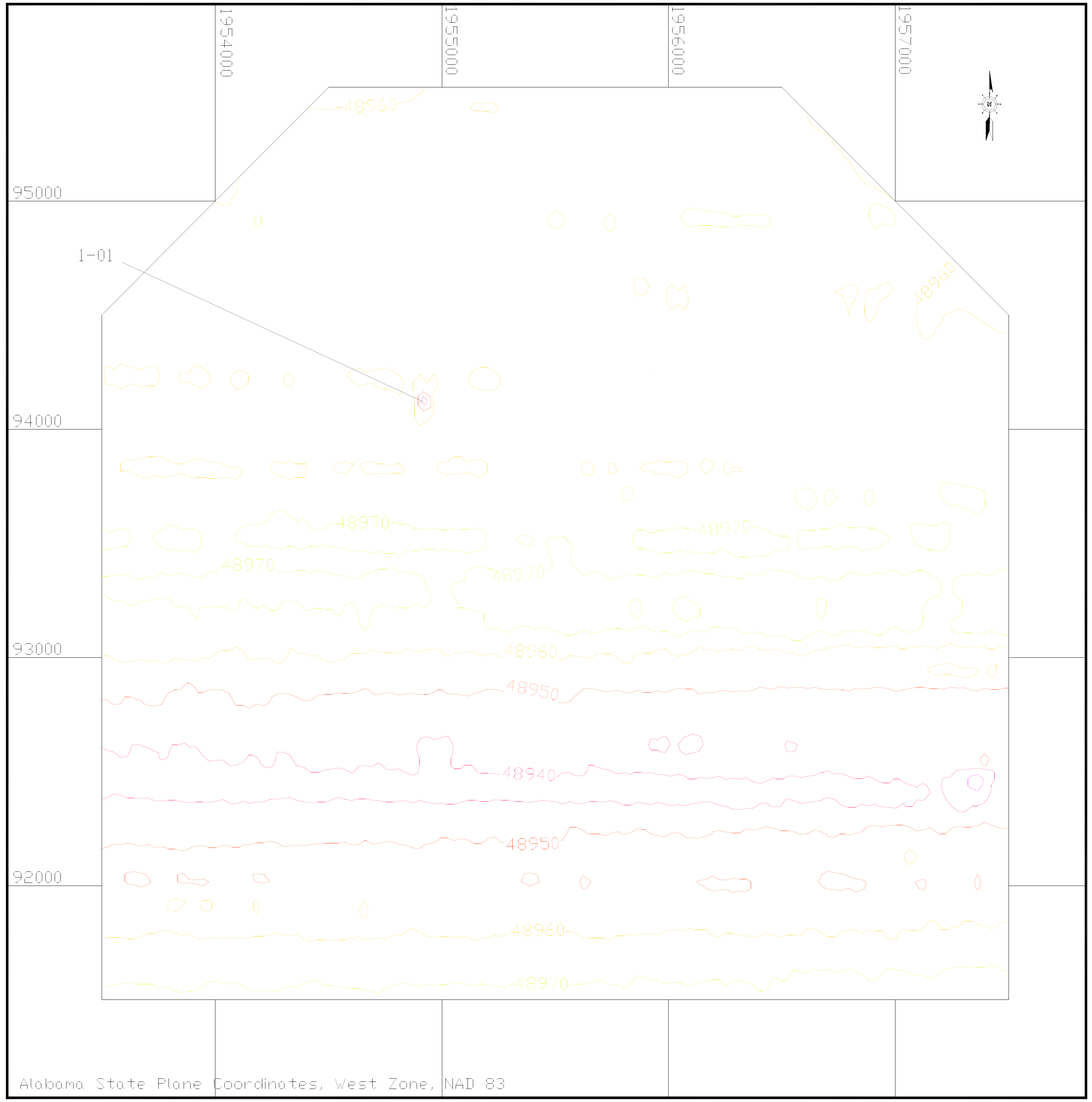

Figure 3. Area 1 magnetic contour map.

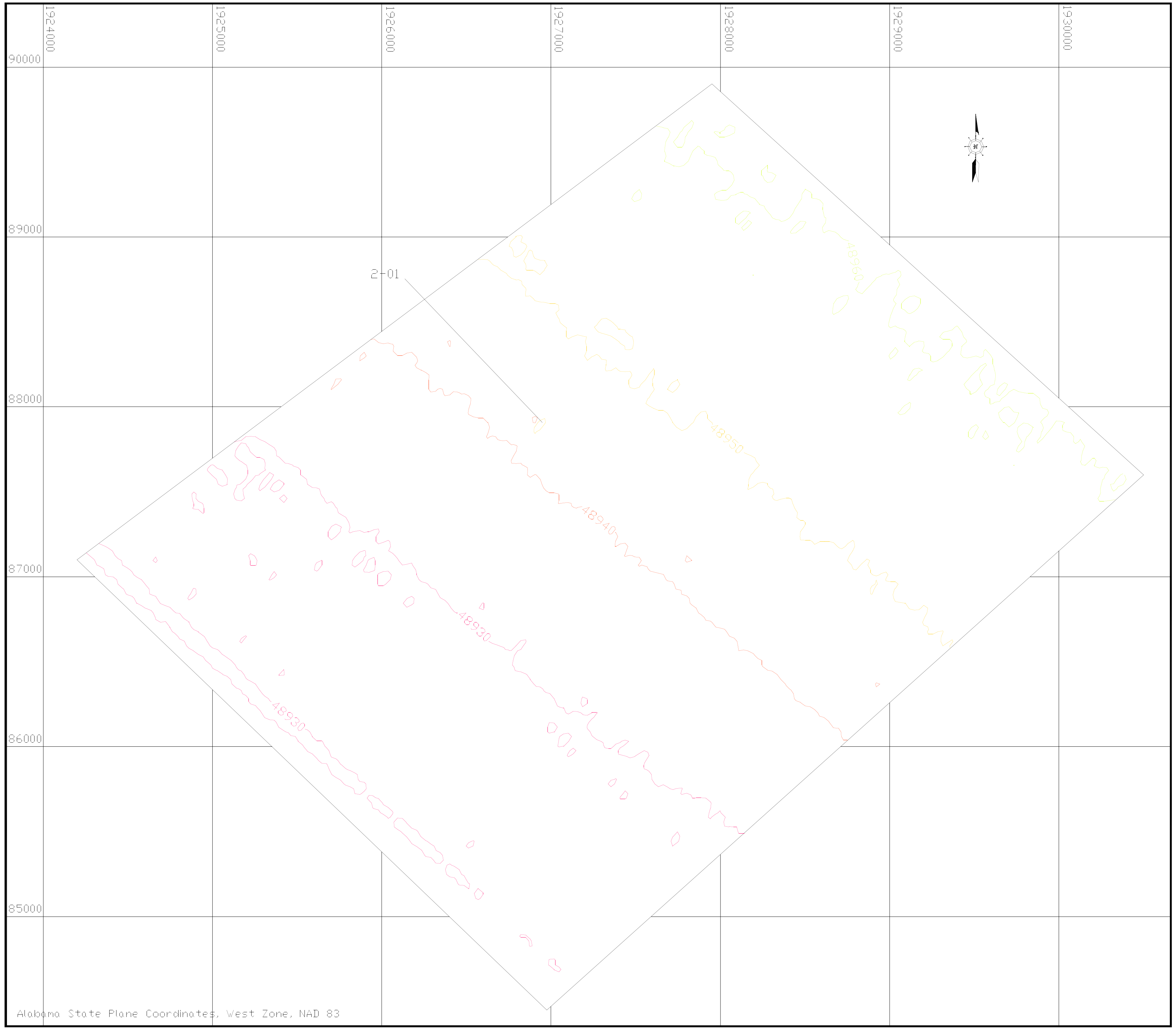

Figure 4. **Area 2 magnetic contour map.**

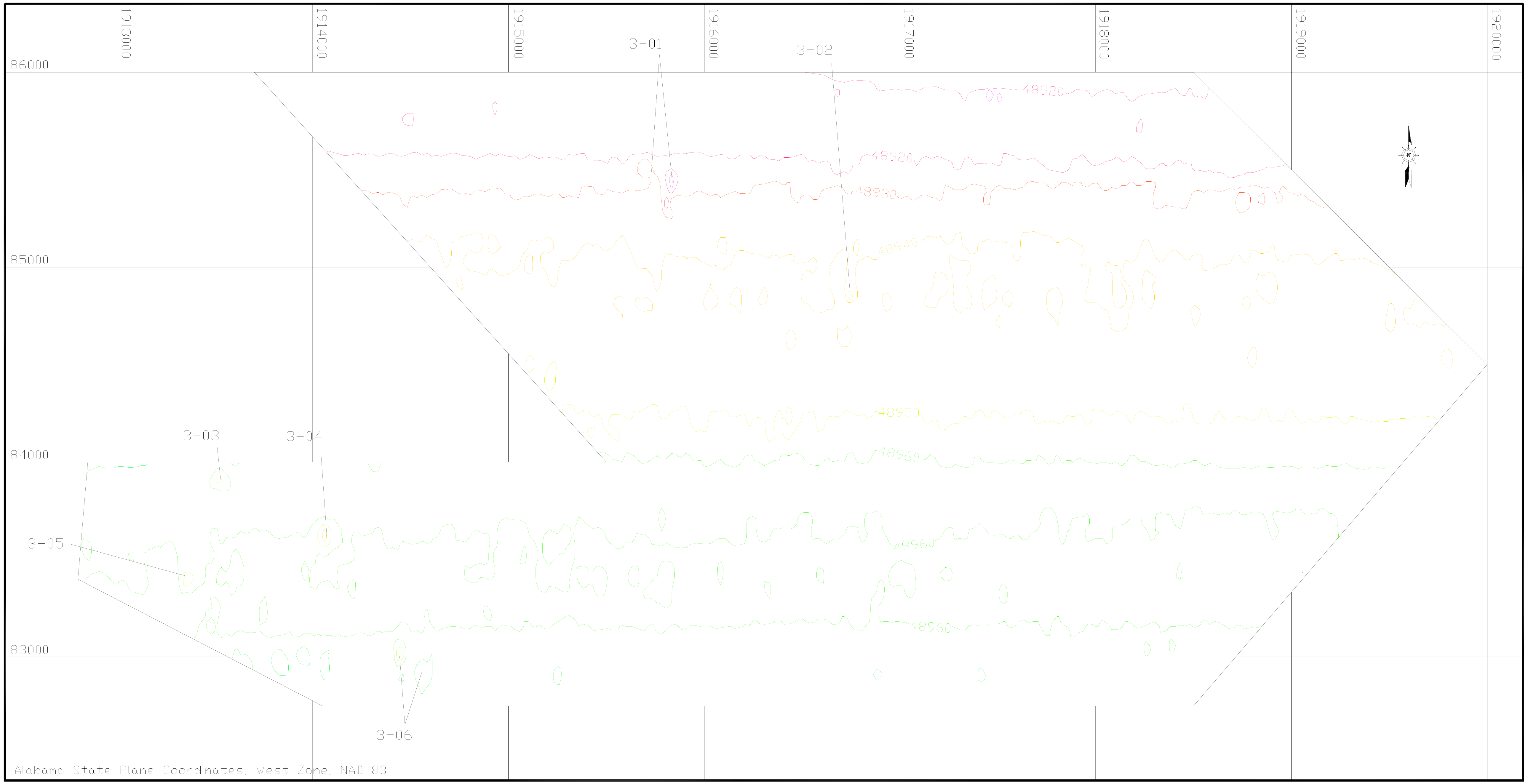

Figure 5. **Area 3 magnetic contour map.**

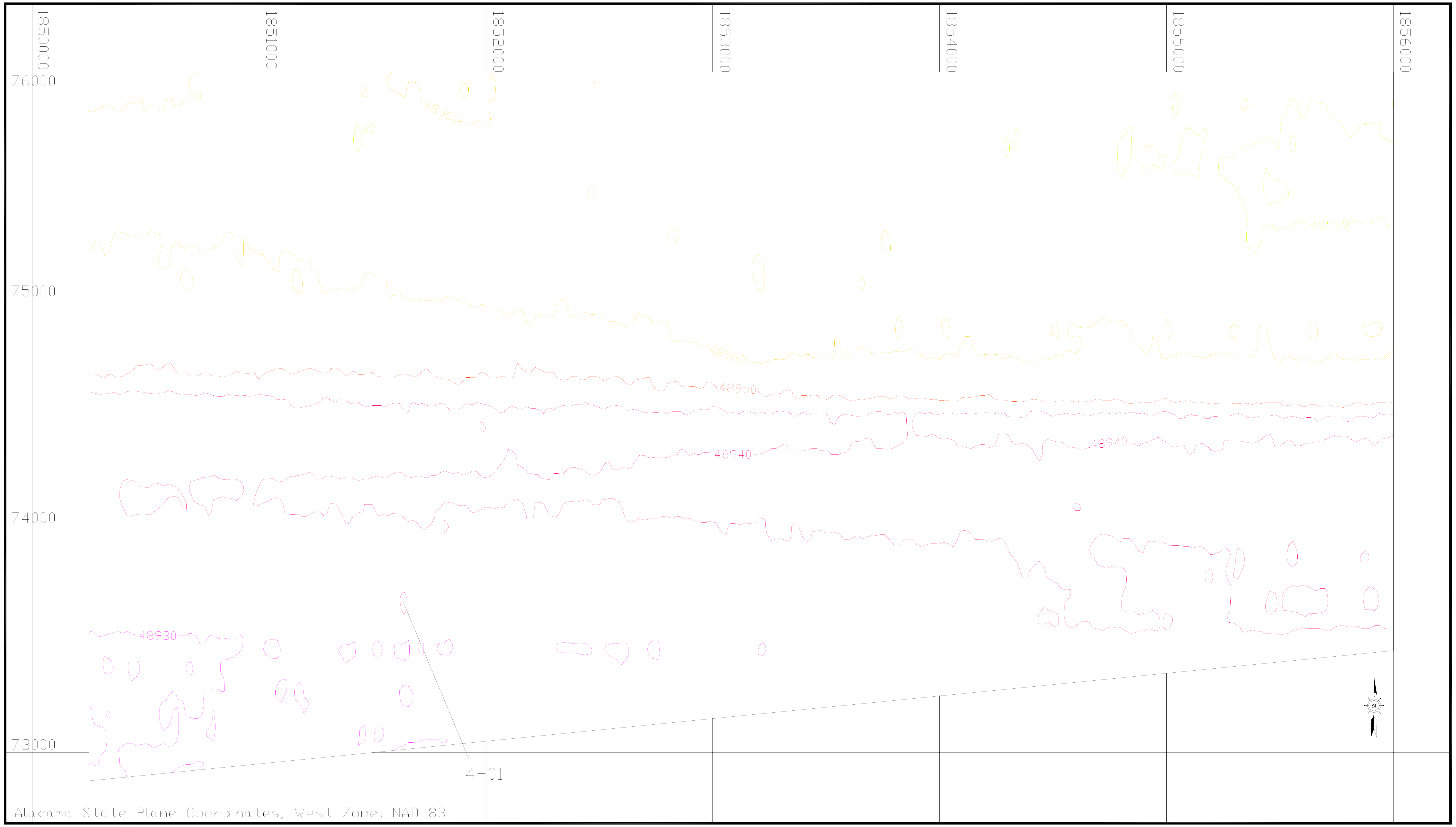

Figure 6. **Area 6 magnetic contour map.**

Borrow Area 1

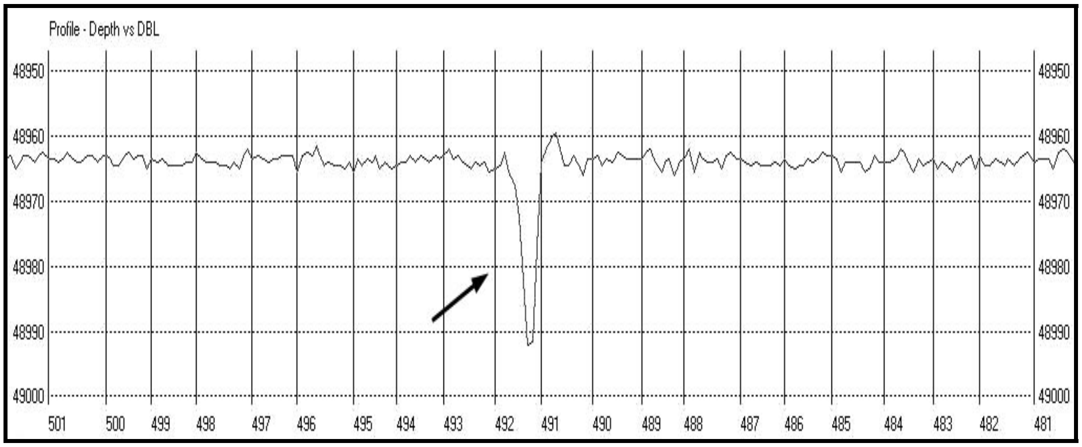

Figure 7. Magnetic target 1-01.

Target Designation	Easting	Northing	Gammas	Duration
1-01	1954928	94121	32	105′

Priority: Low

Target 1-01 was found in the north central part of the survey area on lanes 53 and 54. The detectable signature had a maximum intensity of 32 gammas and a maximum duration of 10 seconds over a distance of 105 feet (Figure 7). The contoured positive monopolar signature covered an area of approximately 14,000 square feet. Water depth at the site was approximately 28 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest an object of low ferrous mass relative to size such as small diameter iron rod or pipe, wire rope, small boat anchor or other modern debris. Because the signature is suggestive of a single object and does not compare favorably with more complex signatures associated with vessel remains, no additional investigation of the target is recommended.

Signature characteristics of target 1-01 were developed from the following lane specific data:

53-p32g10s100ft	1954989	94090
54-n16g7s105ft	1954919	94121

Borrow Area 2

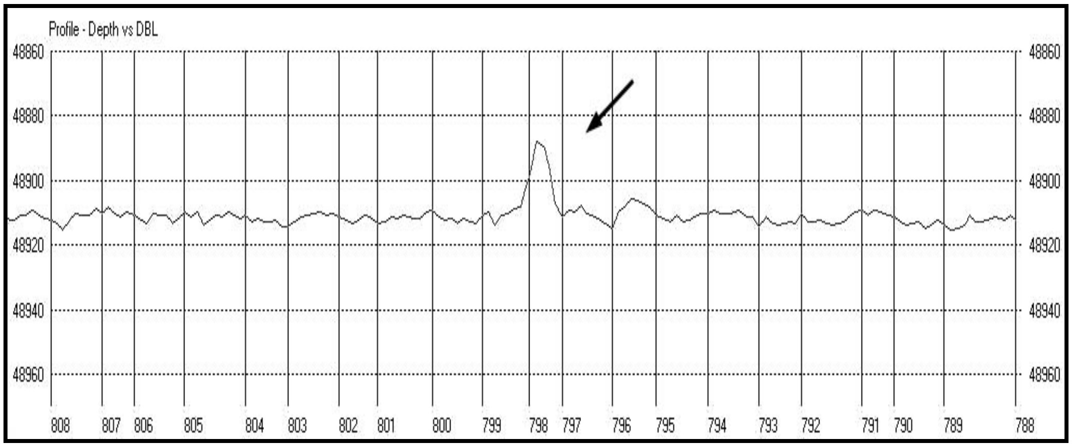

Figure 8. Magnetic target 2-01.

Target Designation	Easting	Northing	Gammas	Duration
2-01	1926928	87911	23	100′

Priority: Low

Target 2-01 was found in the north central part of the survey area on lanes 51 and 52. The detectable signature had a maximum intensity of 23 gammas and a maximum duration of 9 seconds over a distance of 100 feet (Figure 8). The contoured negative monopolar signature covered an area of approximately 6,600 square feet. Water depth at the site was approximately 24 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest an object of low ferrous mass relative to size such as small diameter iron rod or pipe, wire rope, small boat anchor or other modern debris. Because the signature is suggestive of a single object and does not compare favorably with more complex signatures associated with vessel remains, no additional investigation of the target is recommended.

Signature characteristics of target 2-01 were developed from the following lane specific data:

51-p19g9s75ft	1926948	87907
52-n23g8s100ft	1927004	87880

Borrow Area 3

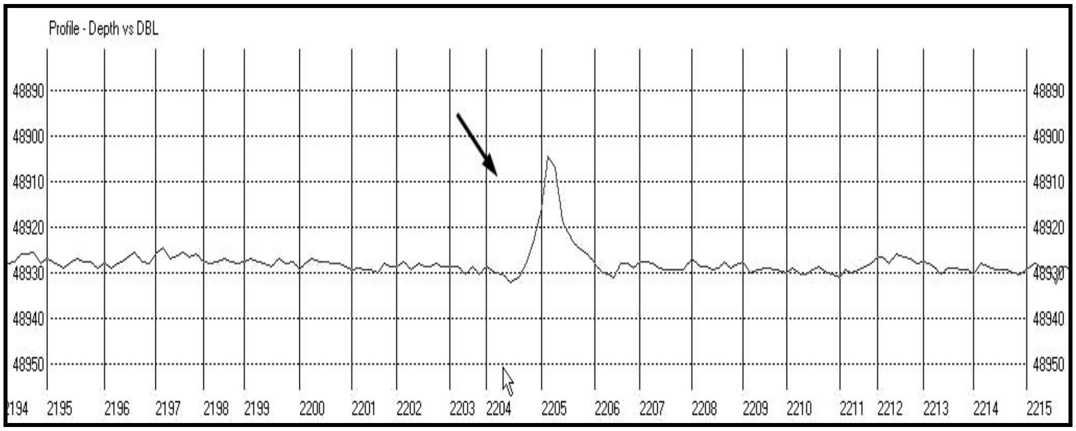

Figure 9. Magnetic target 3-01.

Target Designation	Easting	Northing	Gammas	Duration
3-01	1915695	85532	27	140′
	1915828	85434		

Priority: Moderate

Target 3-01 was found in the northern part of the survey area on lanes 9, 10 and 11. The detectable signature had a maximum intensity of 27 gammas and a maximum duration of 20 seconds over a distance of 140 feet (Figure 9). The contoured multi-component signature covered an area of approximately 47,500 square feet. Water depth at the site was approximately 30 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest a large, single object or cluster of objects of low ferrous mass relative to size. Signatures of this type have been found in association with both modern debris, such as wire rope or cable and historic shipwrecks. Because the signature may be associated with a shipwreck additional investigation of the target is recommended.

Investigation of the target site revealed a 2 1/2-inch-diameter cable buried approximately 1 1/2 feet below the bottom surface. Probing around the target location revealed no other associated objects. No further investigation of the target is recommended.

Signature characteristics of target 3-01 were developed from the following lane specific data:

9-p12g20s140ft	1915695	85532
10-n10g16s100ft	1915871	85534
11-n27g10s125ft	1915828	85434

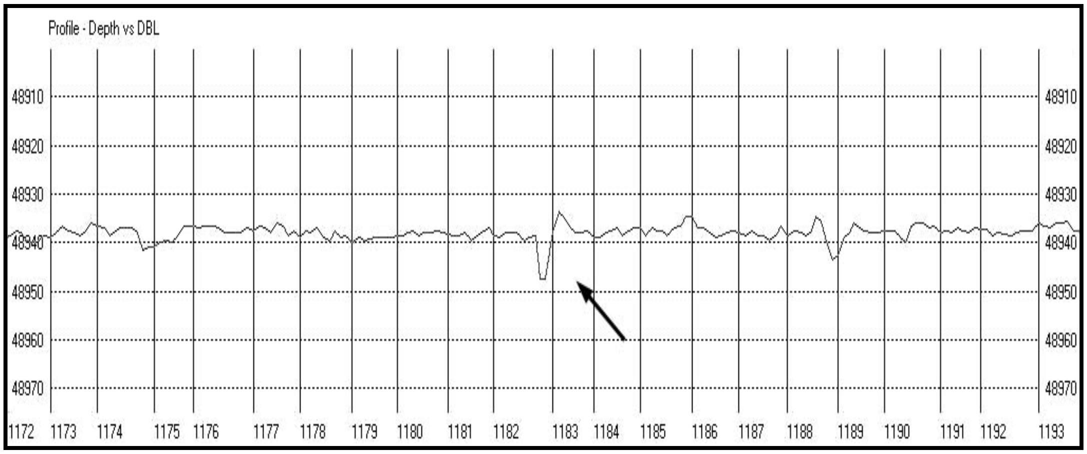

Figure 10. Magnetic target 3-02.

Target Designation	Easting	Northing	Gammas	Duration
3-02	1916725	84881	14	50′

Priority: Low

Target 3-02 was found in the central part of the survey area on lane 22. The detectable signature had a maximum intensity of 14 gammas and a maximum duration of 4 seconds over a distance of 50 feet (Figure 10). The contoured positive monopolar signature covered an area of approximately 3,800 square feet. Water depth at the site was approximately 30 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest a single object of low ferrous mass and size such as small diameter iron rod or pipe, small boat anchor or other modern debris. Because the signature is suggestive of a single object and does not compare favorably with more complex signatures associated with vessel remains, no additional investigation of the target is recommended.

Signature characteristics of target 3-02 were developed from the following lane specific data:

22-p14g4s50ft	1916725	84881

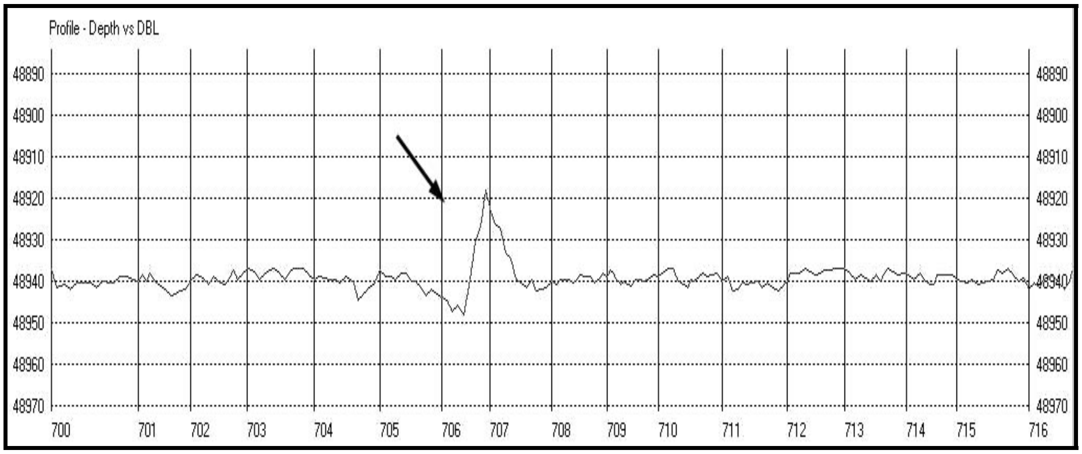

Figure 11. Magnetic target 3-03.

Target Designation	Easting	Northing	Gammas	Duration
3-03	1913516	83908	30	165′

Priority: Low

Priority: Moderate

Target 3-03 was found in the south western part of the survey area on lanes 40 and 41. The detectable signature had a maximum intensity of 30 gammas and a maximum duration of 20 seconds over a distance of 165 feet (Figure 11). The contoured dipolar signature covered an area of approximately 18,500 square feet. Water depth at the site was approximately 30 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest a large, single object or cluster of objects of low ferrous mass relative to size. Signatures of this type have been found in association with both modern debris, such as wire rope or cable and historic shipwrecks. Because the signature may be associated with a shipwreck additional investigation of the target is recommended.

Investigation of the target site revealed a 1 1/2-inch-diameter cable buried approximately 1 foot below the bottom surface. Probing around the target location revealed no other associated objects. No further investigation of the target is recommended.

Signature characteristics of target 3-03 were developed from the following lane specific data:

40-p30g10s80ft	1913505	83977
41-n19g8s120ft	1913514	83916
41a-d30g20s165ft	1913523	83932

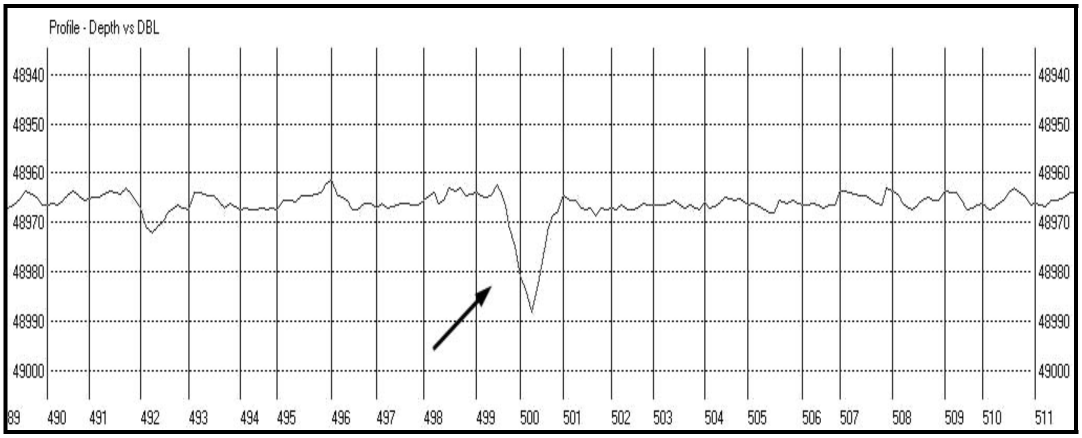

Figure 12. Magnetic target 3-04.

Target Designation	Easting	Northing	Gammas	Duration
3-04	1914064	83625	26	160′

Priority: Low

Target 3-04 was found in the southwestern part of the survey area on lanes 47 and 48. The detectable signature had a maximum intensity of 26 gammas and a maximum duration of 16 seconds over a distance of 160 feet (Figure 12). The contoured positive monopolar signature covered an area of approximately 31,400 square feet. Water depth at the site was approximately 30 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest a large, single object or cluster of objects of low ferrous mass relative to size. Signatures of this type have been found in association with both modern debris, such as wire rope or cable and historic shipwrecks. Because the signature may be associated with a shipwreck additional investigation of the target is recommended.

Investigation of the target site revealed a 1 1/2-inch-diameter cable buried approximately 1 1/2 feet below the bottom surface. Probing around the target location revealed no other associated objects. No further investigation of the target is recommended.

Signature characteristics of target 3-04 were developed from the following lane specific data:

47-n24g16s160ft	1914064	83625
48-p26g12s130ft	1914150	83558

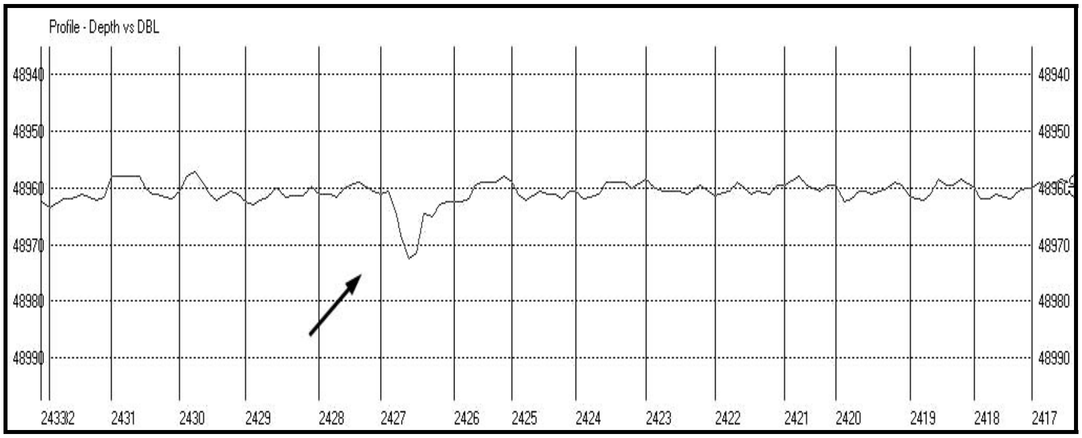

Figure 13. Magnetic target 3-05.

Target Designation	Easting	Northing	Gammas	Duration
3-05	1913350	83414	11	75′

Priority: Low

Target 3-05 was found in the southwestern part of the survey area on lane 51. The detectable signature had a maximum intensity of 11 gammas and a maximum duration of 8 seconds over a distance of 75 feet (Figure 13). The contoured positive monopolar signature covered an area of approximately 3,800 square feet. Water depth at the site was approximately 31 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest a single object of low ferrous mass and size such as a small diameter iron rod or pipe, small boat anchor or other modern debris. Because the signature is suggestive of a single object and does not compare favorably with more complex signatures associated with vessel remains, no additional investigation of the target is recommended.

Signature characteristics of target 3-05 were developed from the following lane specific data:

51-p11g8s75ft	1913350	83414

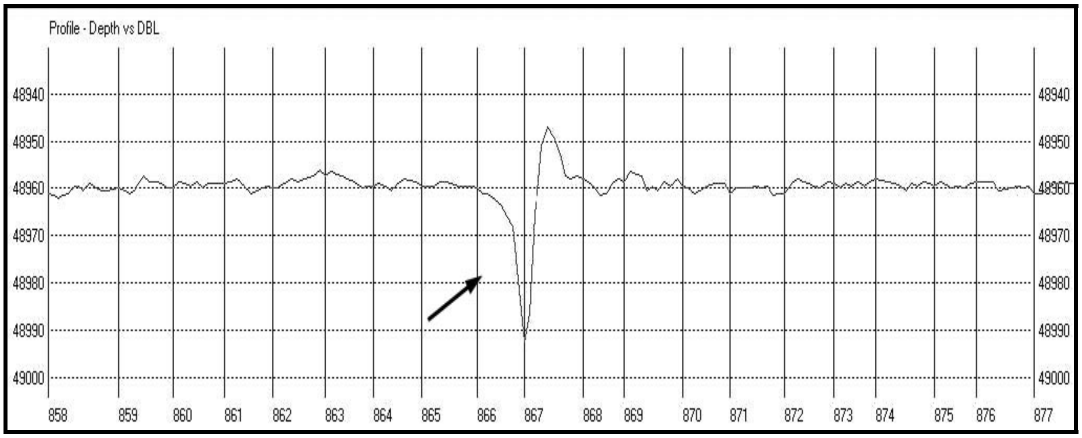

Figure 14. Magnetic target 3-06.

Target Designation	Easting	Northing	Gammas	Duration
3-06	1914447	83024	45	125′
	1914569	82924		

Priority: Low

Target 3-06 was found in the southwestern half of the survey area on lanes 59, 60 and 61. The detectable signature had a maximum intensity of 45 gammas and a maximum duration of 11 seconds over a distance of 125 feet (Figure 14). The contoured multi-component signature covered an area of approximately 49,300 square feet. Water depth at the site was approximately 32 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest a large, single object or cluster of objects of low ferrous mass relative to size. Signatures of this type have been found in association with both modern debris, such as wire rope or cable and historic shipwrecks. Because the signature may be associated with a shipwreck additional investigation of the target is recommended.

Investigation of the target site revealed several loops and two end sections of 2 1/2-inch-diameter cable exposed on the bottom surface. Probing around the target location revealed no other associated objects. No further investigation of the target is recommended.

Signature characteristics of target 3-06 were developed from the following lane specific data:

59-n35g8s55ft	1914447	83024
60-d45g11s125ft	1914529	82975
61-p8g8s110ft	1914572	82897

Borrow Area 4

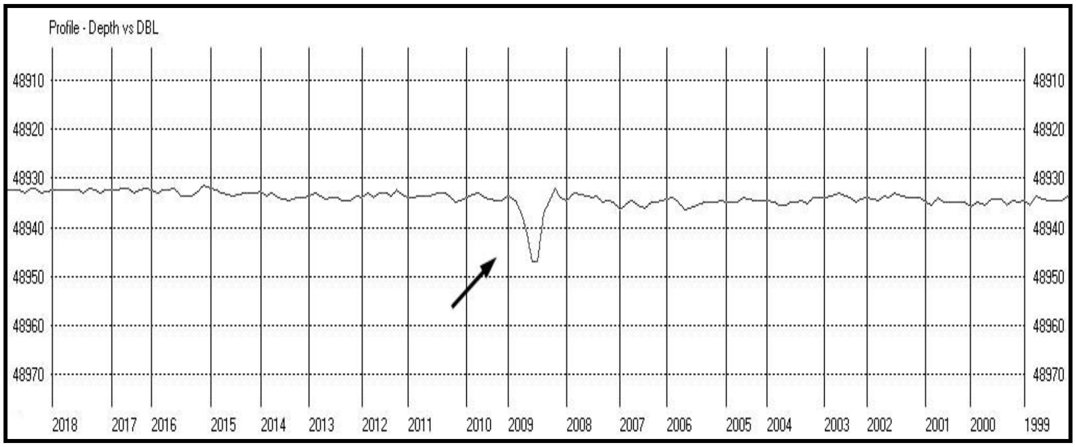

Figure 15. Magnetic target 4-01.

Target Designation	Easting	Northing	Gammas	Duration
4-01	1851635	73663	15	80′

Priority: Low

Target 4-01 was found in the southern part of the survey area on lane 46. The detectable signature had a maximum intensity of 15 gammas and a maximum duration of 8 seconds over a distance of 80 feet (Figure 15). The contoured positive monopolar signature covered an area of approximately 3,200 square feet. Water depth at the site was approximately 27 feet mlw. No sonar signature was associated with the material generating the magnetic signature. Signature characteristics, intensity and duration suggest an object of low ferrous mass and size such as small diameter iron rod or pipe, small boat anchor or other modern debris. Because the signature is suggestive of a single object and does not compare favorably with more complex signatures associated with vessel remains, no additional investigation of the target is recommended.

Signature characteristics of target 4-01 were developed from the following lane specific data:

46-p15g8s80ft	1851635	73663

Conclusions

A survey of historical and archaeological literature and background research confirmed evidence of sustained maritime activity associated with both Mobile to the west and Pensacola to the east of the project area. Documented exploration, colonization, trade and transportation activities along the west Florida and southeastern Alabama coastline date from the second half of the 16th century. The Alabama/Florida border became a focus for European activities as early as the 1539 when one of Hernando DeSoto's officers entered Pensacola Bay. However, permanent European inhabitation of the area was not attempted until October 1558, when Tristan de Luna y Arellano led an expedition to Florida. De Luna's attempt to colonize the area failed and permanent settlement of the Alabama/Florida region would not occur until the late 17th century. During that period the Spanish returned to Pensacola and the French settled on Mobile Bay.

As a result of European development on both Mobile and Pensacola bays the coastal bottomlands in the vicinity of the proposed project can be considered a high priority area for submerged cultural resources. Shoal waters, storms and warfare have made navigation along this stretch of the Gulf Coast hazardous. While there are no specific references to historic shipwrecks in the survey areas, there is a potential for undiscovered sites. The compiled list of ships known to have been lost along the Gulf Coast in the project vicinity cannot be considered exhaustive and unrecorded wrecks, especially from the earlier periods, may be present. No wrecks from the project vicinity, however, have been listed with the Alabama State Site File (Steelman 2003).

Analysis of the remote sensing data revealed a total of nine magnetic anomalies: one in Area 1, one in Area 2, six in Area 3 and one in Area 4. One target was identified in Area 1, the eastern borrow site off Perdido Pass. That signature is suggestive of a small single ferrous object such as modern debris or an anchor and is not recommended for additional investigation. That being the case there does not appear to be anything of National Register of Historic Places significance that will be impacted by the proposed dredging in Area 1.

One target was identified in Area 2 off the Perdido Key State Recreation Area. That signature is also suggestive of a small single ferrous object such as modern debris or an anchor and is not recommended for additional investigation. There does not appear to be anything of National Register of Historic Places significance in Area 2 that will be impacted by the proposed dredging.

A total of six targets were identified in Area 3 off Gulf Shores. While those signatures are individually suggestive of small single ferrous objects such as modern debris or anchors, they could be a scatter of material associated with a shipwreck site. Additional investigation of targets 1, 3, 4 and 6 was recommended to identify and assess the significance of material generating those anomalies in the event that the sites cannot be avoided.

One final target was identified in Area 4 off western Gulf Shores. That signature is also suggestive of a small single ferrous object such as modern debris or an anchor and is not recommended for additional investigation. There does not appear to be anything of National Register of Historic Places significance that will be impacted by the proposed dredging in Area 4.

In order to identify and assess the historical significance of the material generating the signatures recommended for additional investigation, TAR personnel returned to Orange Beach/Gulf Shores to conduct an archaeological diver investigation of each of the anomalies. Each target was relocated using DGPS and a magnetometer. Scuba equipped archaeologists identified the source of each of the four signatures as concentrations of modern wire rope. It is possible that the wire represents debris associated with previous dredging in the area. Probing of the sediment at each site confirmed that the wire was not associated with any additional cultural material.

Based on the data generated by the survey and target identification and assessment investigation, no historically significant submerged cultural resources will be disturbed or destroyed by the proposed dredging. As a consequence of the remote sensing survey of the proposed borrow areas and diver identification and assessment of the four anomalies, no additional investigation is recommended.

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Appendix A

Known Shipwrecks Located in the Vicinity of Gulf Shores, Orange Beach and Gulf State Park, Baldwin County, Alabama

Name of Vessel	Type of Vessel	Tons	Date of Construction	Date Lost	Cause	Location
Unknown	Fleet of Spanish vessels			1553	Wrecked	off Mobile and the Florida Panhandle
Unknown	French Ship			1766	Wrecked	On coast between Pensacola and Mobile
Queen Mary	Norwegian ship			Dec. 1869	Stranded	Near Perdido Inlet
Charles A. Swift	Schooner	24	1885	10 June 1899	Stranded	West side of channel off the Perdido Bar
Hilary	Schooner	38 (22)	1893		Stranded	At Perdido

Shipwreck File, Pensacola Museum.

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