

Sand Source Availability Investigations; the Search for Sand for Duval County, Florida Beach Renourishment

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Abstract

The primary source of beach-quality sands for Duval County's beach restoration program is a sand deposit 7.5 miles offshore of its coast. This source was dredged for the initial project in 1978-1980 and subsequent renourishments. These beaches also receive periodic replenishment through the maintenance dredging of the St. John's River Channel. As part of a larger project, the Florida Geological Survey (FGS), in cooperation with the Minerals Management Service (MMS) and in close coordination with the U.S. Army Corps of Engineers (USACE) and the U.S. Geological Survey (USGS), has been conducting a reconnaissance study to identify potential beach quality sand resources lying in federal waters offshore of Duval County. To date, over 230 miles of subsurface acoustic profile data have been collected offshore of both Duval County and Nassau County. This data has been interpreted to identify locations thought to have been favorable for the deposition of beach-quality sand. Several features indicative of high potential for the occurrence of beach restoration-quality sand in federal waters offshore of southern Duval County have been identified, and an extensive joint FGS and USACE vibracoring program instituted. Initial analyses by FGS personnel of the vibracore data collected in 2003 indicate localized potential reserves of up to 198.5 million cubic yards (mcy) of restoration-quality sand offshore of southern Duval County. Guided by this information, the USACE conducted an additional investigation to define an offshore sand source to meet their immediate and near term localized needs. This investigation, which included 57 line miles of resistivity data and 49 vibracores, focused on the region immediately adjacent to the area previously dredged offshore of southern Duval County. Based on this additional data and using an average sand thickness of 9.5 feet, an estimated volume of 22.876 mcy immediately adjacent to the west and south of the previously dredged area was calculated by the USACE's consultant. Assuming a content of 10% or less fines passing a #230 sieve analysis of the vibracores collected to date, the data suggests probable reserves immediately adjacent to the area previously dredged and possible total offshore reserves of restoration-quality sand in a broader area adjacent to the previously dredged area of approximately 21.66 and 218.2 mcy respectively. Assuming a content of 5% or less fines passing a #230 sieve the area immediately adjacent to the previously dredged area contains an estimated 8.0 mcy of beach-quality sand.

Introduction

Since 2002, the FGS has been investigating the potential resources of beach-quality sand in federal waters off the northeastern coast of Florida. This study has been conducted under a cooperative agreement with the MMS in coordination and consultation with the USACE. Specific goals of this investigation include the location and characterization of the areal extent and volume of available sands suitable for beach renourishment. This includes an estimate of potential resources of beach-quality sand lying in federal waters off the northeastern coast of Florida in general and off Duval County in particular. This is being accomplished through the use of subsurface acoustic profiling, grab sampling and vibracoring. This study has become even more important in the aftermath of the hurricane season of 2004. The impact of that season's storms on Duval County

beaches, which were previously slated for replenishment, has been particularly severe and the need to proceed expeditiously even more pronounced.

Prior History of Work in the Area

Since 1925, beach-quality sand has been dredged from Pilot Town and Bar Cuts in the St. John's River. Until 1963, the material was disposed of offshore. In 1963, the first nourishment of the Duval County beaches was implemented at the request of the Navy. The USACE placed 0.282 mcy of sand on the beach at the United States Naval Station at Mayport. Maintenance material from the St. Johns River, that had traditionally been dumped offshore, was now being placed on the beach. Maintenance material from Bar Cut and Pilot Town Cut has been used since then for beach fill material, supplementing renourishment cycles.

In 1965, a Beach Erosion Control Study on Duval County was conducted by the USACE to examine the need for renourishment along the county's beaches. In the study, three inland borrow areas were investigated along Pablo Creek, for use as the primary borrow source. The three sources were tidal marshes located along the east side of the Intracoastal Waterway. Thirty-six dry rod probes and twenty-two core borings were taken within the marshy areas. The borrow sources, which contained several million cubic yards of sand for the initial nourishment, were overlain by an average of six feet of silt and organic material. At the time of the report, this was an acceptable source of borrow material.

Meisburger and Field (1975, 1976) discussed the results of their investigations of the Florida inner continental shelf from Cape Canaveral to the Georgia border. In their studies, they collected and analyzed more than 1,153 nautical miles of high resolution seismic reflection profiles and data from 197 vibracores acquired in the late 1960's as part of the Inner Continental Shelf Sediment and Structure (ICONS) Program. Nocita et.al. (1991) further analyzed vibracores collected for the ICONS Program and, based on low mud to high sand percentages, suggested that the region had several concentrated sites with low mud percentages that may be good potential borrow sites. These studies discuss the geomorphology and shallow sub-bottom structure of the continental shelf as well as the surficial and sub-bottom sediments in the study area.

In 1975, a General Design Memorandum was completed by the USACE concerning the initial nourishment of the beaches. The original plan of using the marsh borrow sites had been discarded due to environmental concerns over the removal of large amounts of organic material and leaving holes up to 40 feet deep once the sand was removed. Within the area of interest, offshore of southern Duval County, Meisberger and Field (1975) used seismic reflection lines, supplemented by shallow cores, to identify the type and thickness of the sand deposits.

In 1974, a two-phase core boring program was developed to locate a new source of sand to meet the renourishment needs. The first of the two vibracoring programs was conducted 4,000-5,000 feet offshore parallel to the length of the county and was termed the "nearshore investigation". This investigation included extracting twenty-three vibracores, 5-10 feet deep, with subsequent grain size analysis on representative samples. It was found that the first mile south of the jetty contained an estimated 2.5 million cubic yards of beach-quality sand. The sand was fine to very fine grained, and while not ideally suited for beach nourishment, it was still useable. Beyond one mile south of the inlet the material was composed of sand mixed with silt and clay, unsuitable for use as borrow material. It was later found that the Germans had placed mines at the entrance to the St. John's River during WWII. Prior to 1989, the coast chart designated half of this area as a "Danger Area", due to residual mines. This danger area was removed in post-1989 coast charts. This situation has discouraged the use of this area to date.

The second phase of the vibracoring investigation was performed 4 to 6 miles offshore of the inlet. The area investigated is comprised of a "channel" trending northwest to southeast which Meisburger and Field (1975) believed to be associated with the ancestral mouth of the St Johns River. This

area is shown as feature A5 on Figure 1. 29 twenty foot long vibracores were taken, of which 13 cores contained ten to twenty feet of beach-quality sand. The borrow area contained a potential 40 million cubic yards of useable material. An additional 27 vibracores were taken in 1975 to define the borrow area for the immediate nourishment. This area was later abandoned due to the concerns of the Northeast Florida Shrimper's Association that prime shrimp harvesting areas would have been disturbed by dredging in this area.

In 1977, further investigations were made in an area 7 to 8 miles offshore, 2 to 4 miles south of the inlet. This area was referred to as the "alternate borrow area". This feature, described by Meisburger and Field (1975) as a low linear shoal trending parallel with the coast line eastward of the "channel" feature A-5, was identified by them as A4, as shown on Figure 1. Forty-eight core borings were drilled to delineate a new borrow source. An area was developed containing an estimated 20 million cubic yards of beach-quality material. This material was used for the initial two-phase construction of the beach in 1978 and 1980 where 2.8 million cubic yards of material was placed. This borrow source has been used for the subsequent beach renourishments in 1986-87 and in 1995.

Other investigations of potential sand sources have included using an established upland disposal area along the St. Johns River called "Buck Island". A core boring investigation collecting 27 core borings was conducted by the USACE in 1998 and 2000 to define material that was beach compatible. The disposal area proved too costly to use and the idea was set aside.

In 2001 and 2003, 11 core borings were collected by the USACE in the vicinity of the entrance to Ft. George Inlet, just north of the St. Johns River. The intent was to use shoal material that has built up within and on the south side of the inlet as a borrow source. The material proved compatible but, as the area is a bird sanctuary, environmental constraints have sidelined the use of the inlet as a sand source in the near future

Florida Geological Survey Investigations

In 2002, the FGS and the MMS entered into a multi-year cooperative agreement. The specific goals to this agreement were to locate and characterize both the areal extent and volume of available sands, suitable for beach renourishment, lying in federal waters adjacent to state submerged lands off the northeastern coast of Florida. In Year 1 of that study:

- Over 230 miles of sub-bottom profile data was collected off Nassau and Duval Counties and interpreted to determine locations thought to have been favorable for the deposition of beach-quality sand.
- A total of 34 beach sampling locations on the beaches of Nassau and Duval Counties were identified and 106 surface samples collected.
- A total of 18 offshore seabed grab samples were collected off of Nassau and Duval Counties.
- 3 push cores were collected on the ebb tidal delta of the Nassau River.
- Descriptions were made and grain size distributions were determined for all beach and offshore seabed grab samples and push cores.
- A preliminary seismic stratigraphic analysis of the sub-bottom profiler data collected was completed.

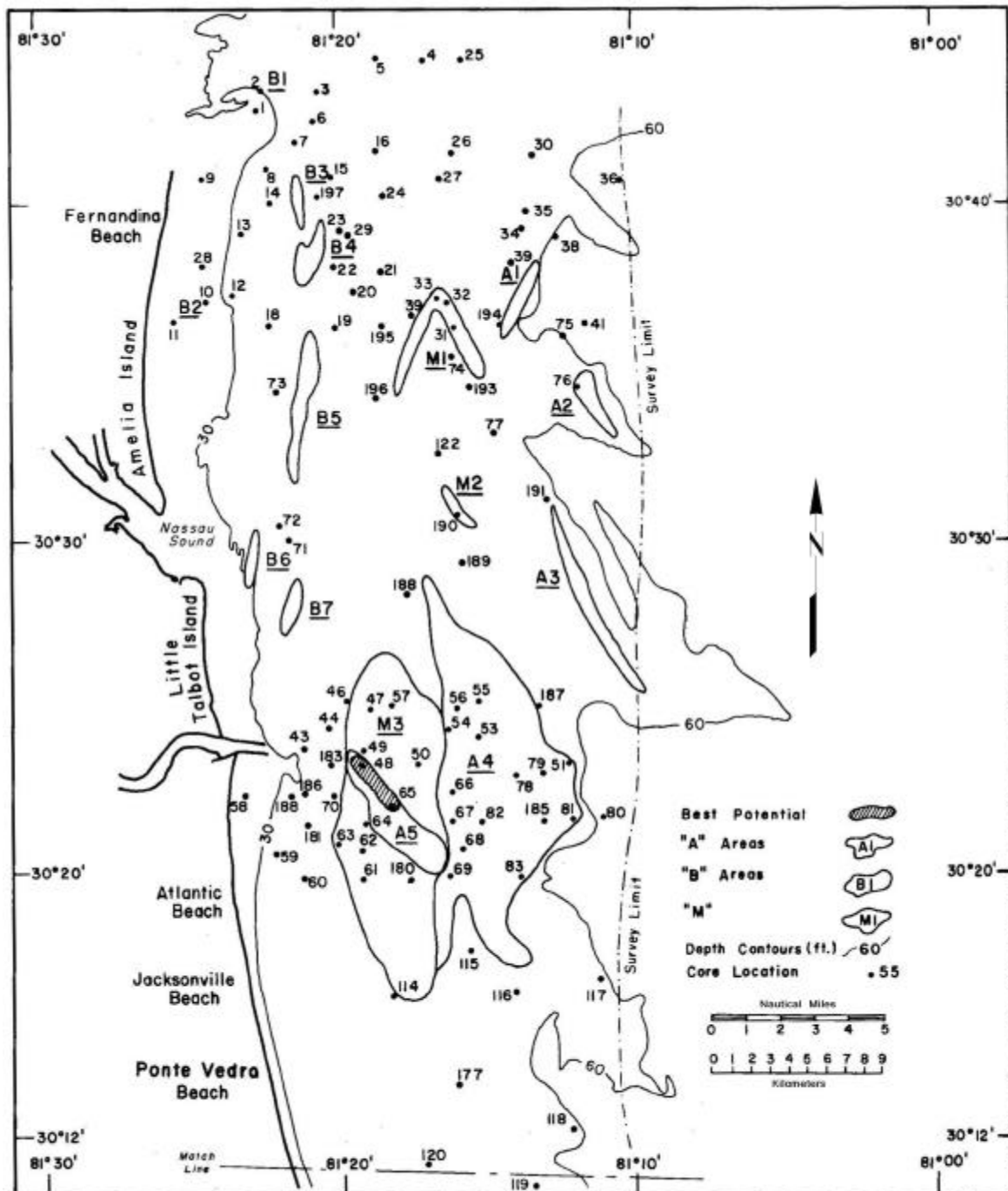


Figure 1. Potential offshore sand borrow areas off the Fernandina-Jacksonville area.
 From Meisburger, E. P., and Field, M. E., 1975

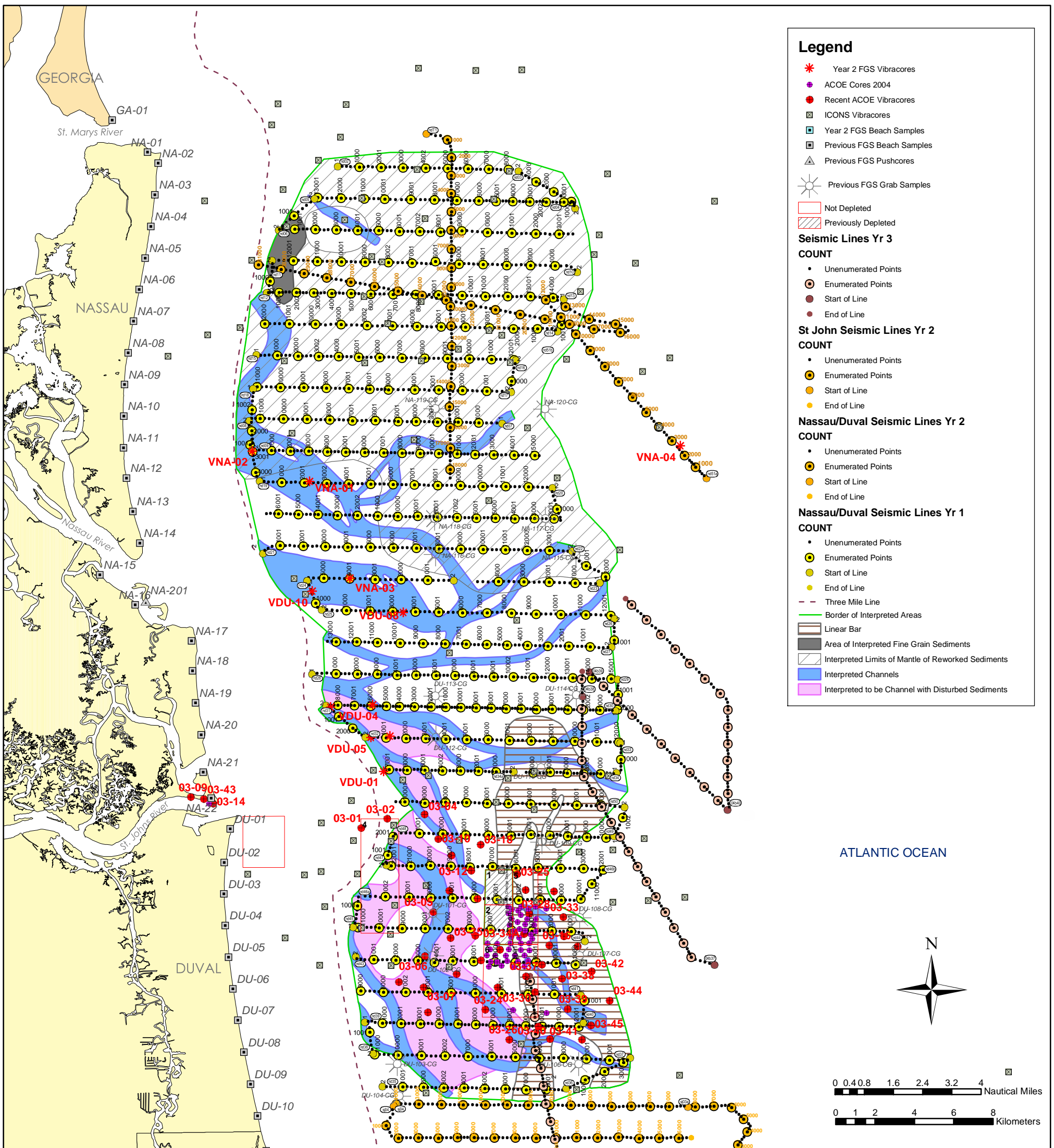


Figure 2. Nassau-Duval Survey Area

A map showing where the data was collected and the FGS's preliminary seismic stratigraphic analysis is shown as Figure 2. As a result of the FGS's preliminary seismic stratigraphic analysis, several features were located that have a high potential for the occurrence of beach restoration-quality sand in federal waters off Duval County. This analysis was discussed with representatives of the USACE Jacksonville District Office and a copy of the preliminary work map delineating those features provided to them. From that data, the USACE identified 45 locations in an area immediately adjacent to the previously-used borrow area offshore of southern Duval County that were of particular interest to them preparatory to the initiation of the USACE's Jacksonville Beach Nourishment Project projected to occur in 2005. The results of the FGS's investigations in the first year were detailed in Phelps et al. (2003).

Data collection in Year 2 of the FGS's continuing study concentrated primarily on the areas offshore of Nassau and Duval Counties as well as the northern half of St. Johns County. In Year 2 of the FGS's study:

- Over 190 miles of seismic data were collected offshore of Nassau, Duval, and northern St. Johns Counties consisting of infill and tie-line data intended to supplement and complete the reconnaissance collected in Year 1 and a reconnaissance survey offshore of the northern half of St. Johns County.
- A total of 52 vibracores were collected offshore of Nassau and Duval Counties, with 11 vibracores collected by the FGS and 41 collected by the FGS's subcontractor Athena Technologies Inc. (Athena).
- An additional 3 vibracores were collected by Athena Technologies Inc. in the mouth of the St. Johns River.
- All the vibracores collected were described, and most were photographed, sampled and granulometrically analyzed.

The results of the tasks completed in Year 2 of the FGS's investigation are detailed in Phelps et al. (2004).

In 2003 the FGS, in their Year 2 vibracoring program, began a comprehensive investigation of the sediments offshore of Nassau and Duval Counties. The objectives of that investigation were to investigate the potential for restoration-quality sand in channel deposits contemporaneous with those identified as area A5 on Figure 1, and to investigate the shoals indicated as worthy of further investigation in Meisburger and Field (1975). Based on vibracores previously collected by the USACE, areas A2 and A4 were selected for initial investigation.

For the shoal identified as area A2, Meisburger and Field (1975) reported that vibracore 76 found "...clean quartz sand with a median diameter range of 0.330 to 0.268 millimeters (1.6 to 1.9 phi)." However, vibracore 76 was only 3 feet long. The FGS's vibracore VNA-4, south of but on the shoal's axial trend with their vibracore, was 6 feet long and encountered restoration-quality sand throughout its entire length. Diver reconnaissance in the immediate vicinity of vibracore VNA-4, conducted at the time that vibracore was collected, suggests that this accumulation of restoration-quality sand is laterally extensive. Further vibracoring to investigate this feature, and three bathymetrically similar features immediately to the south, are planned for Year 3 of the investigation.

The shoal identified as area A4, as noted on Figure 1, was selected for investigation as it has previously been a source of sediments for beach replenishment. In 2003, with onboard oversight provided by the FGS, 44 vibracores were collected off of southern Duval County by Athena Technologies (Athena) for the USACE. These cores were processed by Wolf Technologies Inc. (Wolf). With 41 vibracores devoted to it, this vibracoring program was intended to more fully

investigate area A4. The FGS's initial analysis in 2003 of the Athena vibracore data set suggests that significant reserves of restoration-quality sand remain offshore of the southern half of Duval County both east and southwest of the area previously dredged. Based on the data collected in 2003, the FGS estimated that there were potential reserves of approximately 198.5 million cubic yards (mcy) of restoration-quality sand offshore of southern Duval County in the vicinity of Area A4.

The identification of several features with a high potential for the occurrence of beach restoration-quality sand in federal waters off of southern Duval County in Area A4 prompted an extensive joint FGS and USACE vibracoring program in 2004 to define an offshore sand source to meet both immediate and near term needs for beach-quality sand. The investigation to date includes the collection of an additional 50 vibracores and 57 line miles of resistivity data immediately adjacent to the east and south of the sand borrow area previously utilized. Using this data, the USACE's consultant, Dredging Exploration Mining Consultants (DEMCO), estimated an average sand thickness of 9.5 feet and a volume of 22.876 mcy of possible reserves of restoration-quality sand lying in the immediate vicinity both east and south of the previously dredged area, (Brabers, 2004). These investigations were more narrowly focused within the area previously vibracored in 2003. This additional vibracore data set suggests that localized occurrences of cobble-sized shell beds, not encountered in the vibracores previously collected, may, in some areas, adversely impact sediment usability.

In addition to the vibracores obtained in conjunction with the USACE, the FGS independently obtained 11 vibracores offshore of Duval and Nassau Counties north of area A4. When organic material of a "woody" nature was observed in these vibracores, selected samples were obtained for radiocarbon age dating to permit an estimate of average sediment accumulation rates. One of these samples, processed by Beta Analytic, Inc. yielded the following results:

Beta	FGS Sample	Measured Radiocarbon Age	Conventional Radiocarbon Age
188958	VDU-01-16.8-RC	14,160 +/- 60 YBP	14,140 +/- 60 YBP

This would indicate deposition at the end of the Pleistocene and would suggest that the base of the Holocene in this core would either be at the bottom of the clay seen at approximately 10 feet below the seabed, where the sediments abruptly change to a sandy clay, or at approximately 14 feet below the seabed, where the sediments transition into a clean sand. Calculated sedimentation rates from sample VDU-01-16.8-RC to the seabed would be 0.3621 mm per year +/- 0.0015 mm. Considering the effect of natural compaction as well as compaction inherent in the vibracoring method and the effect of any recent erosion of the seabed, this figure would probably be more representative of the rate of deposition of the clay sequence above the sand in which the organic material was found (i.e. that of the Holocene) rather than that of the sand itself. It is believed that this figure would set an approximate lower limit on the average Holocene sedimentation rate locally.

Figures 3 and 4 depict vibracore based cross sections and are labeled A - A', and B - B' respectively on Figure 5. Cross section A - A' runs from north to south and lies east of the area previously dredged. Cross section B - B' runs west to east and lies to the south of the area previously dredged. The cores depicted on these cross sections were collected in 2003 and 2004. Depths to the base of conjectured reserves of restoration-quality sand are shown on these cross sections. Interpreted depths to the base of possible reserves are based primarily on granulometric analyses of specific sedimentary units and only secondarily on lithologic descriptions.

In 2004, the FGS collected infill seismic profiler lines offshore of Nassau and Duval Counties. The FGS further analyzed the seismic profiler data available in southern Duval County immediately adjacent to the east and west of the previously used sand borrow area. The seismic profiler section shown as Figure 6 is interpreted to show the

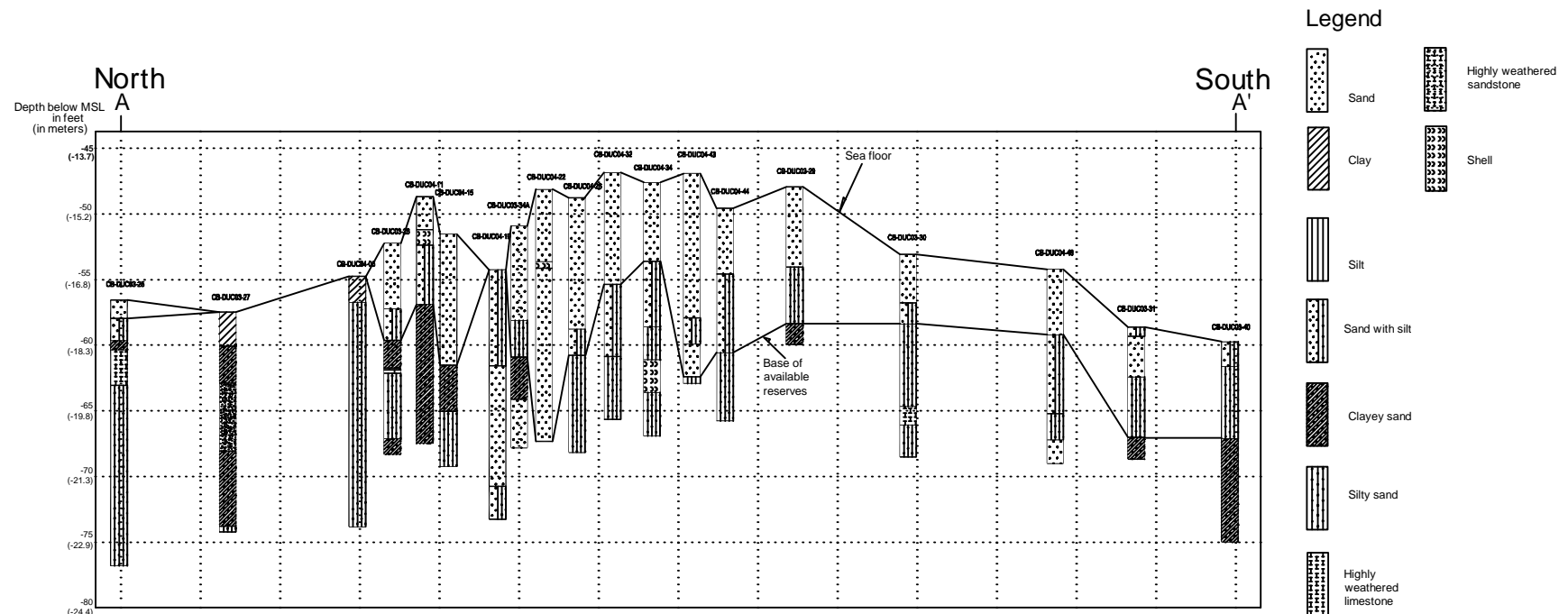
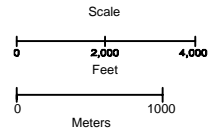


Figure 3. Vibracore based cross sections from A-A'. See Figure 5 for cross section location.



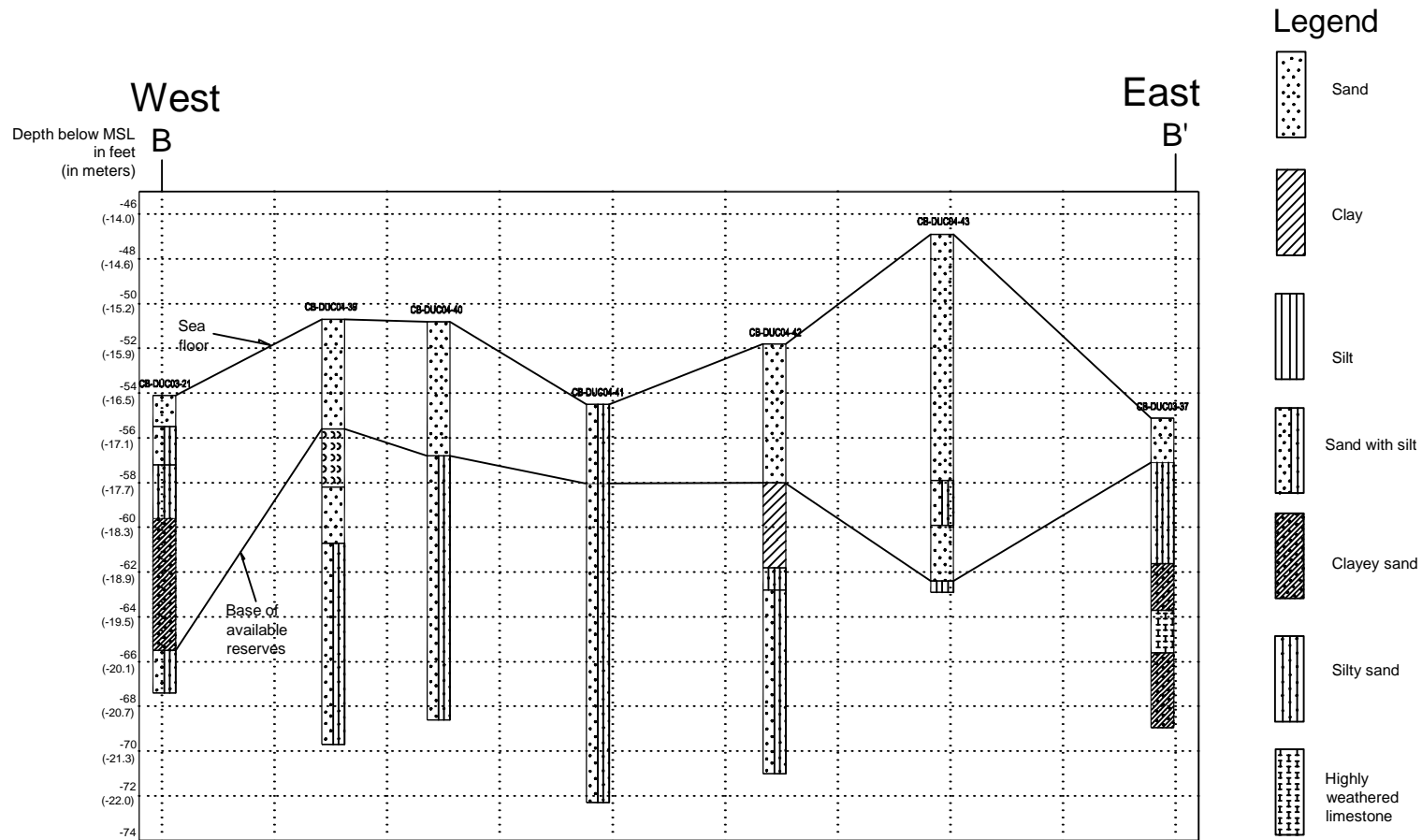


Figure 4. Vibracore Based Cross Sections from B-B'. See Figure 5 for cross section location.



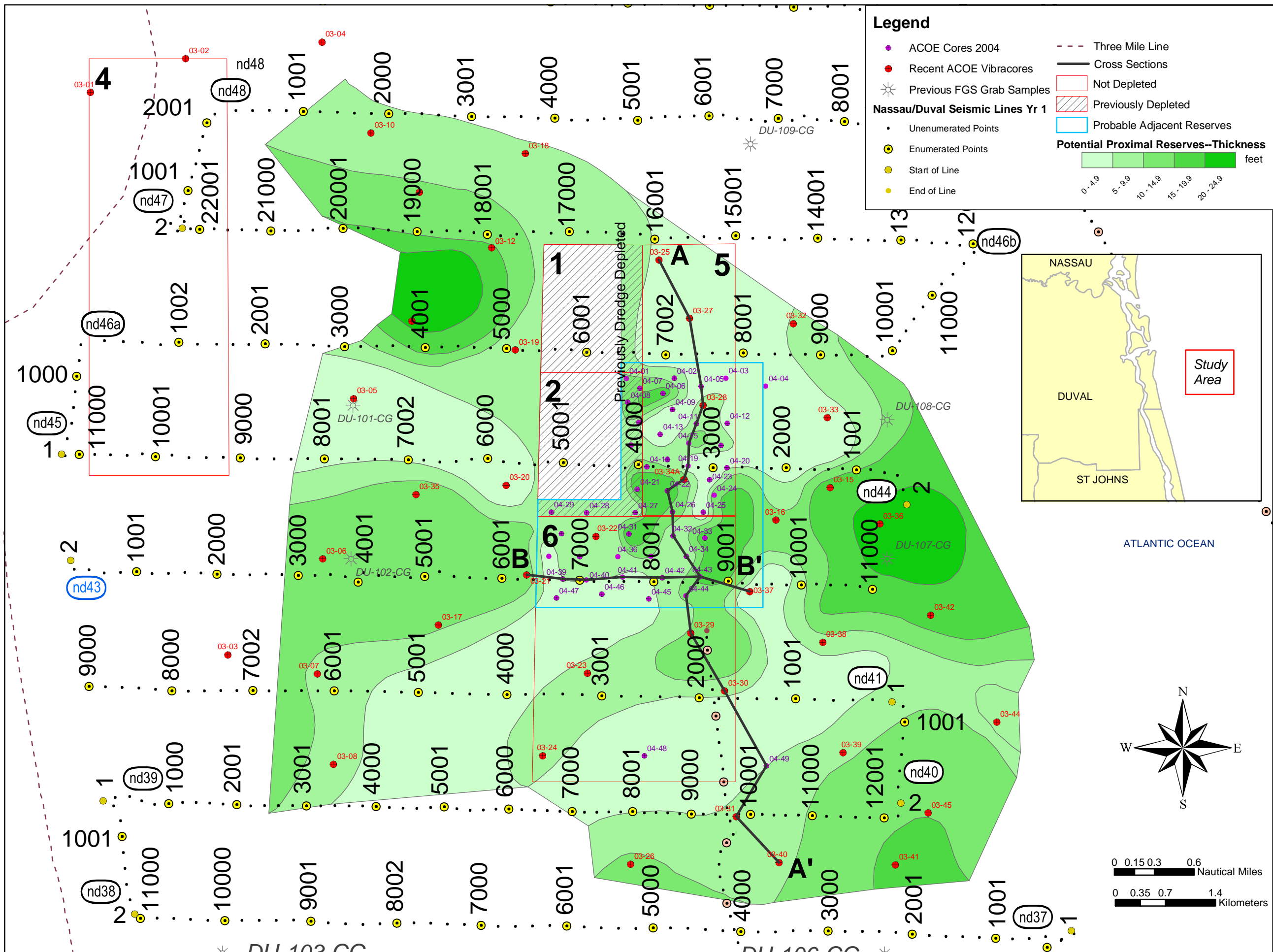


Figure 5: Sand Thickness (Isopach) Map

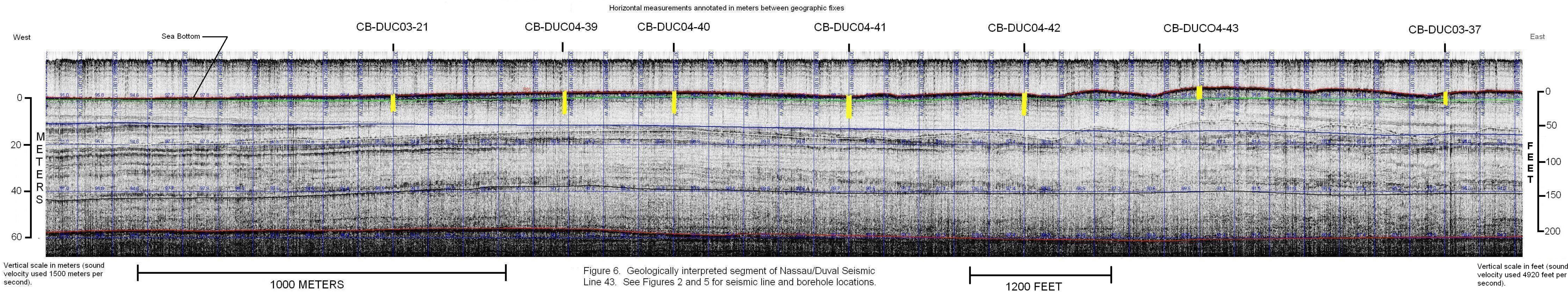


Figure 6. Geologically interpreted segment of Nassau/Duval Seismic Line 43. See Figures 2 and 5 for seismic line and borehole locations.

conjectured base of Recent marine sediments. This horizon is depicted in green with the seabed delineated as the red horizon above it. Between the green horizon and the blue horizon below it are Pliocene and Pleistocene undifferentiated sands, clays, and shell. Contained within this sequence, as evidenced in the vibracores, are occasional laterally discontinuous thin beds of highly weathered limestone. The blue horizon, an erosional unconformity on this seismic section, is believed to be at or near the top of the Hawthorn Group. The black horizon shown on this section is interpreted to be a reflector within the Hawthorn Group. The lowest red horizon delineated on this section is conjecturally interpreted, based on Scott (1988), Odum et al. (1997) and Davis et al. (2001), to be at or proximally above the top of the Ocala Limestone. Please note that the white reflector shown on this section is the first water bottom multiple and as such is purely an artifact of data collection. The locations of the cores forming cross section B - B', shown as Figure 4, are annotated on this section as well.

Although a substantial number of cores collected in 2003 and 2004 in area A4 contained sand to the limit of penetration, a number of other cores consisted of sands underlain either by clay or limestone. It is important to note that the thicknesses of available restoration-quality sand are determined in part by their percent fines content. Sand resources calculated as available for beach restoration can be limited vertically by the depth at which the fines content exceeded 5% as specified in Florida Administrative Code 62-41.07(5J). Fines in this instances are defined as that material that will pass through a 4.00 phi, 63 micrometer/0.0025 inch mesh opening, #230 sieve. Discussions with the Bureau of Beaches and Coastal Systems of the Florida Department of Environmental Protection have revealed that the 5% limit should be regarded as rough guidance for what is desired. The 5% fines content is not limiting as sediments containing up to a 10% fines fraction are routinely accepted for use in beach restoration. Grain size distributions for all samples collected were thus examined with the aim of adjusting prospective sand reserves to include vibracores containing a fines content of less than 10%.

In calculating reserves of available sand, an effort was made by the FGS to include in those calculations only those sequences which were described, sampled and granulometrically analyzed rather than basing sand reserve calculations on core descriptions alone. This is an important distinction to make because the cores, as described, typically exhibit sands to greater depths than were analyzed, albeit often with an admixture of clay and/or silt as a minor component. Thus, our sand reserve calculations are based primarily on granulometric analysis of specific sedimentary units within the cores and only secondarily on lithologic descriptions. Lithologic descriptions were used only to establish the base of such sedimentary units as were analyzed. To delineate possible available sands, a sediment thickness contour interval of 5 foot was chosen, with 5 feet of sand thickness being selected as the minimum acceptable sand thickness for the purposes of sand reserve calculations. Based on the limits established by the above referenced provisos, 218.2 mcy of possibly available restoration-quality sand was calculated in the area cored in 2003 and 2004. Figure 5 is a sand thickness map of these possible reserves. Within the smaller area outlined in blue on Figure 5 and extensively cored in 2004, lying immediately adjacent to the previously dredged area, 21.66 mcy of probable restoration-quality sand were calculated. Confidence in the reserves calculated within that smaller area, based as they are on a grid of significantly closer spaced individual vibracores, is considered to be the strongest of the two reserve calculations. The borrow area for the 2005 beach renourishment is located within the upper section of the area outlined in blue from approximately vibracore 04-13, northward (figure 5). This area contains an estimated 2.0 mcy of beach-quality sand containing 5% or less fines passing the # 230 sieve. The remainder of the blue outlined area is being permitted for near future use and contains approximately 6 mcy of sand meeting the same specifications.

Conclusions

As a result of a literature review, granulometric analysis of bottom grab samples, and vibracores and seismic stratigraphic analysis, several features with a high potential for the occurrence of beach restoration-quality sand in federal waters off Duval County were identified. This analysis was discussed with representatives of the USACE Jacksonville District Office and a copy of the preliminary work map delineating those features provided to them. From that data, the FGS and the USACE identified a feature offshore of southern Duval County of particular interest preparatory to the initiation of the USACE's Jacksonville Beach Nourishment Project projected to occur in 2005. Over the space of two years, 91 vibracores were recovered in the area and an additional 11 vibracores were recovered offshore of Nassau and northern Duval Counties. Assuming a content of 10% or less fines passing a #230 sieve, analysis by the FGS of the vibracore data suggests probable sand reserves of 21.66 mcy immediately adjacent to the area previously dredged offshore of southern Duval County. Using the same assumption, possible total offshore reserves of restoration-quality sand proximal to the previously dredged area are calculated to be 218.2 mcy. The first of these figures is in substantial agreement with the 22.876 mcy volume of probable sand reserves calculated previously by DEMCO. The second figure, pertaining to the area proximal to the previously dredged area illustrated on Figure 5, is in general agreement with the 198.5 mcy volume of possible sand reserves previously calculated by the FGS. That earlier calculation was based on the data collected in 2003. The borrow area for the 2005 beach renourishment is located within the upper section of the area outlined in blue from approximately vibracore 04-13, northward (figure 5). Assuming a content of 5% or less fines passing a #230 sieve this area contains an estimated 2.0 mcy of beach-quality sand. The remainder of the blue outlined area, if permitted for near future use, contains approximately 6 mcy of sand meeting the same specifications.

Ignoring the effect of natural compaction and that inherent in the vibracoring method, calculated sedimentation rates for the first 16.8 feet of sediments, based on radiocarbon dating, would be 0.3621 mm per year +/- .0015 mm. It is suggested that this figure would set an approximate lower limit on the average Holocene sedimentation rate locally.

Acknowledgements

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