FINAL REPORT

FLORIDA NORTHEAST COAST RECONNAISSANCE OFFSHORE SAND SEARCH (ROSS)

Prepared for
Florida Department of Environmental Protection
Bureau of Beaches and Shores
3900 Commonwealth Boulevard
Tallahassee, Florida 32399

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URS

CPE
Coastal Planning & Engineering, Inc.

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In January of 2001 The Florida Department of Environmental Protection (FDEP) Office of Beaches and Coastal Systems (OBCS) contracted with URS Corporation to develop a database that can be addressed, searched and manipulated through an online query builder as well as ArcIMS Geographic Information System (GIS) routines that provide access over the Internet (Web) for compiling and disseminating available coastal and nearshore data. The project was titled the "Reconnaissance Level Regional Sand Search for the Florida Panhandle" or SandPan for short.

The project involved gathering together into one central enterprise database the relevant data from historical, present and future studies conducted in the Panhandle region of the Florida Gulf Coast. Granulametric, geophysical, and spatial data were included, as well as an annotated bibliography of all references related to nearshore and coastal processes which were instrumental in locating and characterizing sand sources for use in the overall context of the Florida coastal management plan. This data is instrumental in minimizing the cost of initial data searches needed for each nourishment project undertaken by FDEP contractors.

In February of 2003, the OBCS, at that time renamed the Bureau of Beaches and Wetland Resources (BBWR), again contracted with URS to continue development of the database and the online components of the Sandpan database project with Florida's southwest Gulf Coast as the project area. One benefit of this new project was the teaming of URS with Coastal Planning and Engineering (CPE) of Boca Raton, Florida. With the addition of a more project-focused coastal engineering firm, the Sandpan reconnaissance framework could be more focused at the individual beach nourishment project level. With the union of the two fundamental ways of searching and viewing the available data(i.e., the Online query builder and the ArcIMS GIS) , it was determined by BBWR that Sandpan needed to be expanded to include the new classes of data that can be of value in engineering beach nourishment operations. This new database and associated Web site was called the "Reconnaissance Offshore Sand Search" or ROSS (Figure 1-1).

With the completion of the Southwest Gulf Coast Sand Search, the newly named Bureau of Beaches and Coastal Systems (BBCS) approved the continuation of the ROSS project to encompass the entire Florida Atlantic coast. The work was organized and authorized into a series of "Phases". Four Phases correspond to three regional sand search areas for the Atlantic Coast and an east coast field study plan. Phase I is the southeast and includes Dade, Broward and Palm Beach Counties, Phase II is the central region made up of Martin, St. Lucie, Indian River and Brevard counties, Phase III is the northeast region which includes Volusia, Flagler, St. Johns, Duval and Nassau counties and Phase IV is the field work portion of the contract. The regional sand searches were set up on an overlapping time schedule, with the field work to be run concurrently. The overall work for each sand search Phase was designed along the same parameters to produce similar outcomes. This report represents the third of a three report series for the Florida Atlantic Coast.

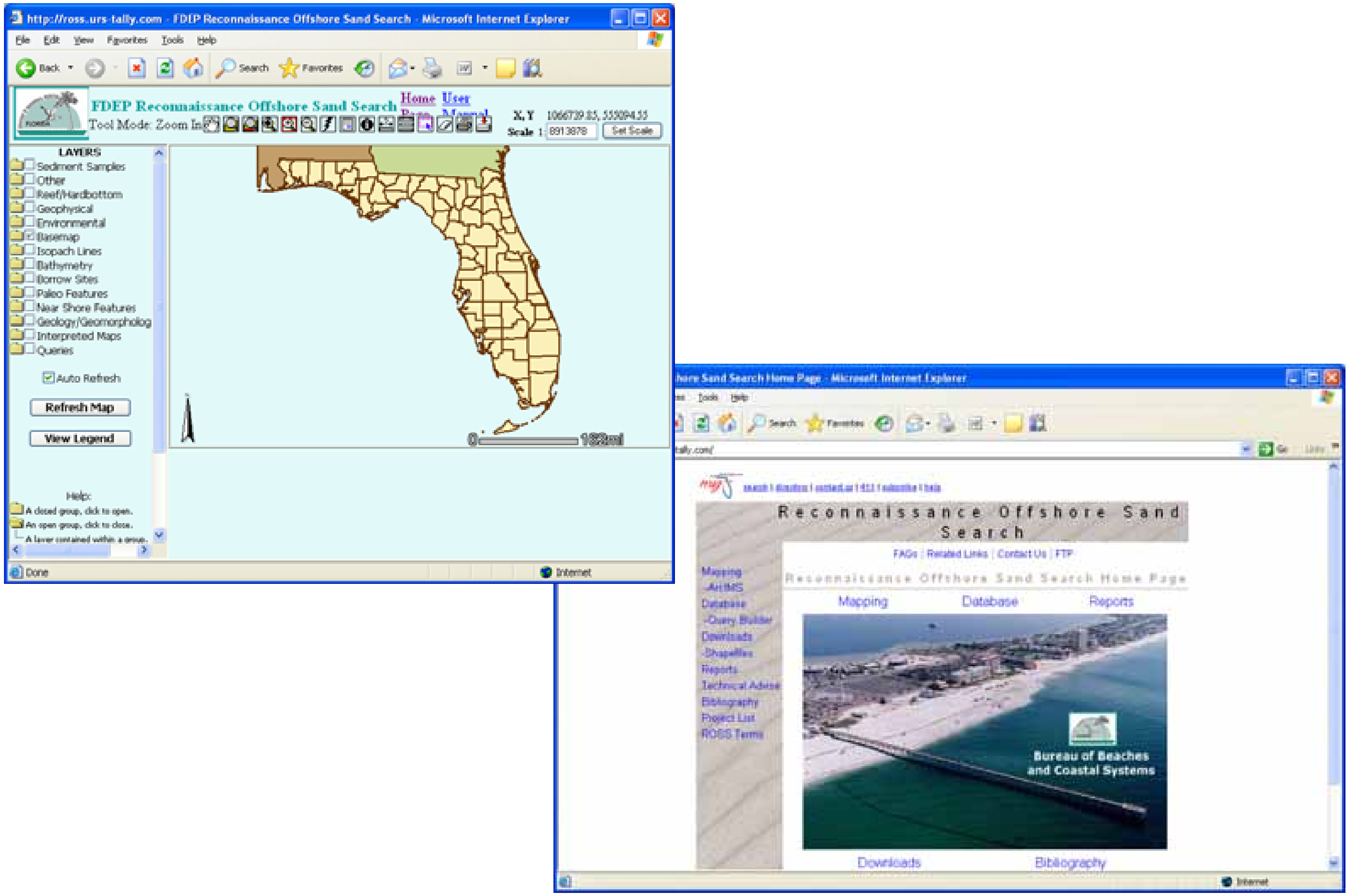


Figure 1-1. The Reconnaissance Offshore Regional Sand Search (ROSS) Home Page and the ROSS Internet Map Service (IMS) Page.

LEGACY DATA THE SEARCH PROCESS

Using the same approach that was used during the original Sandpan and subsequent Southwest Florida Gulf Coast projects, URS and CPE conducted an exhaustive literature search for relevant applicable data. This included all previous reports, core logs, sediment sampling data, isopach maps and other geotechnical, geophysical, bathymetric or sedimentological data available that specifically identified or studied the distribution of offshore sand resources of the Florida Southeast Atlantic coast. This information was obtained from the BBCS, the Florida Geological Survey, the University of Florida, the University of South Florida, the Florida State University, the U.S. Army Corp of Engineers, the U. S. Geological Survey, the Minerals Management Service, and from previous studies conducted by various consultants contracting with the BBCS.

Additionally the Florida Atlantic Coast Sand Search presented opportunities that were not available in the Panhandle and Southwest Gulf Coast sand searches, chief of which was the effort individual counties extended with their own beach management programs. This led to the development of expertise among these entities that was used as an aid to determine the types and amounts of data in the region, as well as to contribute in the development of the sand resource and geological conceptual model.

As of this report date, 41 datasets have been added to ROSS for the Northeast Phase III region. This brings the number of datasets to 256. These include theses, dissertations, Government reports and Consultant reports. Approximately 1,131 samples, 617 cores, and 1,321 miles of geophysical data have been added during this phase of the project. This has increased the database to approximately 14,000 sand samples, 4,600 cores, 220 jet probes and over 8,800 miles of geophysical data in the form of sub-bottom profile images.

DATA SELECTION PROCESS FOR ROSS

With the need to focus on data which enhances the database without diminishing storage capacity, and therefore slowing down the search and retrieval process, URS and CPE developed a Data Acquisition and Entry Plan. This plan was used as the framework for deciding what data would be incorporated into ROSS and what data would be archived outside of the database for the Southeast project. An example of this selection process could include data from a previous study of a borrow site. If there were a series of cores taken from a site that was subsequently developed, storing all the sample data from these cores could be unnecessary. Taking a representative sample of the cores which adequately describes the area would be adequate. Storing only this data would save space, as well as limit the return hits from the database, consequently speeding up the query process. The original individual records would be kept in an electronic archive, but they would not be in the database or on the associated ftp site.

THE DATABASE

Data Types

Two basic types of data are stored in the database. The first is tabular data used to store information about sediment properties. The original Sandpan database schema consisted of thirteen data tables that include three associated look-up tables. These tables contained data related to the sediment sample itself. Included were fields for sediment grain size, texture, mineralogy, both Munsell and descriptive color, organic content, shell content, heavy mineral content, collection method, location information, core layer information, the analytical methods used in analysis, and both Wentworth and USC classification schemes. Project information like project name, managing agency, contact names, project date, driller and collection methods were also included. Several other geologic parameters like sphericity, angularity, and gradation were also been recorded.

The new ROSS database schema is an expansion of the Sandpan schema and currently includes thirty-three relational data tables. The database has been expanded and enhanced to allow for a more comprehensive search and comparison function than previously available. Several new tables were added so that searches could be structured that would return data on the descriptive properties of sediment layers found within cores. Included are tables, which store layer structure, lithology, and textural qualifiers. The capabilities for using descriptive information about sediment and sediment layer properties have been enhanced by adopting the U.S. Army Corps of Engineers standard core description procedures for characterizing sediments and core layers.

With the addition of the more project-focused analysis that includes storing data on core layers, the expanded database now contains these column headings:

AGENCY_ID
AGENCY_NAME
ANALYTICAL_METHOD_ID
ANALYTICAL_METHOD_NAME
ANALYTICAL_METHOD_DESCRIPTION
ANGULARITY_ID
ANGULARITY
PK_BIBSUMMARY
AUTHOR
AUTHOR_LAST_NAME
AUTHOR_INITIALS
TITLE
KEYWORDS
PAPER_YEAR
ABSTRACT
PUBLISHER
CALCULATION_METHOD_ID
CALCULATION_METHOD_NAME
CALCULATION_METHOD_DESCRIPTION
COLLECTION_METHOD_ID
COLLECTION_METHOD
COLLECTION_METHOD_DESCRIPTION
COLOR_DESCRIPTOR_ID
COLOR_DESCRIPTOR
COLOR_MATRIX_ID
CT_COLOR_TONE_ID
CD_DESCRIPTOR_ID
COL_COLOR_ID
COLOR_TONE_ID
COLOR_TONE
COLOR_ID
COLOR
CONTACT_ID
CONTACT_NAME
CONTACT_PHONE
CORE_LAYER_QUALIFIER_ID
CL_CORE_LAYER_ID
STX_SOIL_TEXTURE_ID
SD_SOIL_DESCRIPTOR_ID
ST_SOIL_TYPE_ID
L_LITHOLOGY_ID
S_SORTING_ID
QUALIFIER
CORE_LAYER_ID
CORE_CORE_ID
LS_LAYER_STRUCTURE_ID
USCS_USCS_CLASSIFICATION_ID
CMTX_COLOR_MATRIX_ID
BOTTOM_OF_LAYER_INTERVAL
TOP_OF_LAYER_INTERVAL
MUNSELL_HUE_WET
MUNSELL_VALUE_WET
MUNSELL_CHROMA_WET
CORE_LAYER_COMMENTS
CORE_LAYER_IDENTIFIER
CORE_ID

COLOR_TONE_ID
CM_COLLECTION_METHOD_ID
PRJ_PROJECT_ID
DRL_DRILLER_ID
COLLECTION_DATE
CORE_TOP_ELEVATION
CORE_LENGTH
CORE_DIAMETER
X_COORD
Y_COORD
STATE_X
STATE_Y
STATE_ZONE
LONGITUDE
LATITUDE
LORAN_X
LORAN_Y
PENETRATION_DEPTH
RECOVERED_LENGTH
DIRECTION
OVERBURDEN
DEPTH_RX
GROUNDWATER_ELEVATION
PERCENT_RECOVERED
CORE_IDENTIFIER
DRILLER_ID
DRILLER_NAME
DRILL_TYPE
AGN_AGENCY_ID
GUEST_NAME
PK_GUESTBOOK
GUEST_ORG
GUEST_EMAIL
GUEST_DATE_VISIT
GUEST_COMMENT
GUEST_EMAIL_UPDATE
LAB_ID
LAB_NAME
LAB_ADDRESS
LAYER_STRUCTURE_ID
SAMPLE_DATE
SAMPLE_COMMENTS
ANALYSIS_DATE
LAB_REMARKS
X_COORD
Y_COORD
STATE_X
STATE_Y
LAYER_STRUCTURE
LAYER_STRUCTURE
LITHOLOGY
HUE
VALUE
CHROMA
CMTX_COLOR_MATRIX_ID
PROJECT_ID
AGN_AGENCY_ID_POSSESSING
AGN_AGENCY_ID_MANAGING
CON_CONTACT_ID
PROJECT_NAME
PROJECT_DATE
PROJECT_LOCATION
HORIZONTAL_COORDINATE_SYSTEM
HORIZONTAL_DATUM
VERTICAL_DATUM
PROJECTION
SAMPLE_ID
PRJ_PROJECT_ID
LAB_LAB_ID
AM_ANALYTICAL_METHOD
SLU_SPHERICITY_ID
ALU_ANGULARITY_ID
CM_COLLECTION_METHOD_ID
USCS_USCS_CLASSIFICATION_ID
CMTX_COLOR_MATRIX_ID
MUNSELL_HUE_DRY
MUNSELL_VALUE_DRY
MUNSELL_CHROMA_DRY
MUNSELL_HUE_WET
MUNSELL_VALUE_WET
MUNSELL_HUE_WASHED
MUNSELL_VALUE_WASHED
MUNSELL_CHROMA_WASHED
MUNSELL_HUE_UNKNOWN
MUNSELL_VALUE_UNKNOWN
MUNSELL_CHROMA_UNKNOWN
SAMPLE_IDENTIFIER
CARBONATE_DISSOLVED
HEAVY_MINERALS_DISSOLVED
ORGANICS_REMOVED
SHELL_FRAGMENTS_REMOVED
PHI
USCS_COBBLE
USCS_COARSE_GRAVEL
USCS_FINE_GRAVEL
USCS_COARSE_SAND

STATE_ZONE
LORAN_X
LORAN_Y
LONGITUDE
LATITUDE
RANGE_MONUMENT
RM_TRANSECT_LOCATION
TOP_OF_SAMPLE_INTERVAL
BOTTOM_OF_SAMPLE_INTERVAL
GRAB_ELEVATION
MEAN
MEDIAN
STD
SKEWNESS
KURTOSIS
MEAN_ORIGINAL
MEDIAN_ORIGINAL
STD_ORIGINAL
SKEWNESS_ORIGINAL
KURTOSIS_ORIGINAL
CALC_CALC_METHOD_ID_MEAN
CALC_CALC_METHOD_ID_MEDIAN
CALC_CALC_METHOD_ID_STD
CALC_CALC_METHOD_ID_SKEW
CALC_CALC_METHOD_ID_KURT
PCT_FINES
PCT_PAN_FRACTION
PCT_CARBONATE
PCT_SHELL_FRAGMENTS
PCT_HEAVY_MINERALS
PCT_ORGANICS \
SAMPLE_DATA_YN
CORE_DATA_YN
DISPLAY_GROUP
SOIL_DESCRIPTOR_ID
SOIL_DESCRIPTOR
SOIL_TEXTURE_ID
OIL_TEXTURE
SOIL_TYPE_ID
USCS_MEDIUM_SAND
USCS_FINE_SAND
USCS_SILT
USCS_CLAY
WW_BOULDER
WW_COBBLE
WW_GRAVEL
WW_PEBBLE
WW_VERY_COARSE_SAND
WW_COARSE_SAND
WW_MEDIUM_SAND
WW_FINE_SAND
WW_VERY_FINE_SAND
WW_SILT
WW_CLAY
WW_COLLOID
SAMP_SAMPLE_ID
CL_CORELAYER_ID
VIRTUAL_SAMPLE
PK_SITEINFO
SITE_QUESTION
SITE_INFO
USERMAN
USERMAN_LOCATION
COLUMN_NAME
ALIAS
DESCRIPTION
DISPLAY_ORDER
DISPLAY_YN
PHI_RANGE
SOIL_TYPE
SORTING_ID
SORTING
STANDARD_DEVIATION
SPHERICITY_ID
SPHERICITY
USCS_CLASSIFICATION_ID
CLASSIFICATION_NAME
CLASSIFICATION_DESCRIPTION

The second type of data stored in the database is spatial data. Spatial features along with their accompanying attributes reside in the ORACLE relational database as Spatial Database Engine (SDE) layers. These spatial features are stored much like any other data types as a string of characters or as a number. This enables the end user to optimize the abilities of this corporate database management system to manipulate large datasets and to relate them to geographic locations on the earth.

Important issues that users need to understand are the restrictions and caveats involved with any of the data sets. To accomplish this goal, metadata (or data about the data) have been created for each data set and for each spatial layer. These metadata conform to the Federal Geographic Data Committee (FGDC) requirements. The FGDC coordinates the development of the National Spatial Data Infrastructure (NSDI). The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. The 17 federal agencies that make up the FGDC are developing the NSDI in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector. For more information, see www.fgdc.gov.

Accessing the Database

Access to the ORACLE database is possible using one of three methods. The most direct is to click on the Query Builder link found on the ROSS homepage (Figure 2-1). This link will take you directly to the online Enhanced Query Builder page (Figure 2-2).

The Enhanced Query Builder is a custom-built application that allows the user to create Structured Query Language (SQL) statements. These SQL statements access real-time data from the ORACLE relational database. Unique WHERE clause statements may be constructed by the user that could be added to an SQL statement one criteria at a time. These SQL statements are what tell the computer to retrieve all of the data for which the set of conditions are true. These statements may be set to return data from all of the thirty-three tables residing in the ROSS database. Once the query is executed, the data matching the search criteria are returned on the Sand Sample Query Results page.

At the bottom of the Sand Sample Query Results page there are three other options provided to the user. These are accessed by clicking on one of the three buttons found at the bottom of this page. These will enable the user to either “Download Data”, in a Tab delimited format, “Go Back” to the Enhanced Query Builder to perform another query, or spatially “View in ArcIMS” the data that was returned by the query. A detailed Users Guide for the Enhanced Query Builder can be found in Appendix 1.

The second way to access the ROSS database is through the online Internet Map Service (IMS) which is accessible through the ROSS homepage ArcIMS link. The IMS site was initially developed using the ESRI “out of the box” ArcIMS software. Appendix 2 contains the users guide for the ROSS Interactive Mapping site.

Figure 2-3 is a screen capture of the on-line mapping page within the ROSS Web site. On the left side of the image are folders, which contain the many different “layers” with which the user may interact. These layers are the spatial representations of the tabular data residing in the Oracle database. Most of these layers have been created especially for this project, with data generated by this project. However, some of these layers, including the Artificial Reefs, Sea Grass Beds, and others, were downloaded from other sites and incorporated into the ROSS on-line mapping. This illustrates the versatility of on-line mapping. Designers can combine data and information accessed over the Internet with local data for display, query, and analysis. For instance, environmental issues in potential renourishment areas are a concern. As an on-line search of state government spatial data repositories was conducted many shapefiles dealing with environmental issues were found at the Florida Geographic Data Library (FGDL). These shapefiles were subsequently downloaded from the FGDL site, re-projected and added to the ROSS site.

The third way to access data residing in the ROSS database is to download the data directly to the users own workstation. By using the Downloads link on the ROSS homepage the user is taken to a location where all the data residing in the database is available for quick and easy download (Figure 2-4).

This data is stored as SDE layers in both spatial and tabular format. Spatial data is in shapefile format therefore allowing the user to add these to their own Geographic Information System (GIS), combining them with other shapefiles that the user may have developed or received from other sources. Shapefiles contain data from a relational database management system (RDBMS). The RDBMS may be pulled out of the shapefile as a stand-alone portable format to be used with the ArcView software on a local machine. Downloading the tabular data is accomplished through the Enhanced Query Builder. This data may be downloaded in a Tab delimited format compatible with several analytical and graphing software packages. The user may download all or part of the data.

By design, the ROSS site currently does not include tools used for composite statistical analysis. The reason is that the BBCS does not desire to constrain the design professional to any particular suite of analytical products. The intent of this project web site is to allow the user to view the data spatially over the Web, to be able to query the data on several different levels and to download this data to their own workstation for advanced analysis.

DATA ENTRY

To accommodate the various entities that will supply data for inclusion into the ROSS database, two separate data entry tools will be made available. The first is a purpose-built Microsoft Access front end and the second is the commercially available software gINT.

The Microsoft Access front end is a customized data entry form that makes use of a user-friendly graphical user interface or GUI. From the main page of the front end the user will be able to access the appropriate page for data input (Figure 2-5).

A PROJECT INFORMATION page includes places to enter pertinent information on the project (Figure 2-6). This includes Project name, location, managing agency, and contacts.

Project level parameters are also defined. These parameters are entered in fields that define the projection information and horizontal and vertical datums. There is a Grade Scale field that allows the user to select which of three grain size-recording measures were used, phi, millimeter, or sieve size. For example by choosing phi, as shown in Figure 2-6, the user then checks the appropriate boxes for the phi values used. This information will later determine, in the Add a Sample page data entry form, which fields will be available for data entry. This acts as a quality control feature to help eliminate incorrect data entries.

Once Project Information is recorded, the user may proceed to enter data. If there have been cores collected in the project the user needs to click on the CORES button on the main page of the front end, pulling up the Core Entry page. Here data relative to the collection location, elevation, penetration, recovery and other detailed information of the core is entered (Figure 2-7).

After data on the core is entered, information on the actual core layers may be added. This is a new feature of the *enhanced* ROSS database. In the old Sandpan design, only the core location information was stored. With the ROSS design the user may add data describing the core layers themselves. Click on the Add Layer Information For This Core button and the Core Layer Information page appears (Figure 2-8). On this page a user will be able to enter layer structure, composition, texture, lithology and sediment type. There is also a comments field for use in adding any other information the user finds pertinent.

The next step in entering data is to input individual sample information. This data entry tool recognizes two Sample types, Samples from a Core and Grab Samples. To enter information about a Core Sample, click the Add Sample To This Core button on the Core Entry form. To enter information about Grab Samples, click the Grab Samples button on the Main Page. The Sample Entry Page (Figure 2-9) is used for adding data related to the individual sample. Included are fields for all data columns residing in the database relating to sediment samples. On the bottom portion of the page is a series of boxes of which some are shaded out.

The open boxes with values beside them are the same ones set as the phi ranges on the Project Information page. When the user originally set up the project and chose the phi sizes, these were then transferred to this page, therefore only allowing data to be input into the correct fields. This eliminates the likelihood of the user placing data values in the wrong category.

The second data entry tool was chosen because of its multi-faceted abilities. This is the commercially available gINT software. The data output formats for core logs and various other engineering and geological tools from the gINT software have been adopted by the Jacksonville District Army Corps of Engineers (ACOE). The developers of gINT have taken the database table structure created for the ROSS database and incorporated it into a commercially available software for contractors. Contractors will then be able to input data into this structure and deliver it to BBCS for almost seamless entry into the ROSS DATABASE.

OTHER FEATURES AND TOOLS

The Annotated Bibliography

Another feature of the ROSS Web site is the searchable Annotated Bibliography (Figure 2-10). There are currently over 900 references in the database covering topics on sediments found on the continental shelf, sedimentary processes, sea level curves and fluctuations, and the resulting changes in the shoreline over the last 12,000 years.

A large portion of these references are theses, dissertations and reports not readily accessible. The Annotated Bibliography page is designed so the user can search by the Author’s last name, title of the paper or key word(s). There may also be an accompanying summary or abstract of the paper provided, copyrights permitting.

Web Site (ross.urs-tally.com)

The ROSS Web site is the means to an end. By navigating through the Web site, all the ROSS data, on-line interactive mapping, query builders to access the database, data downloads, reports, shapefiles and the annotated bibliography are available at the touch of a button. There is a New Users page with frequently asked questions that may help in understanding the functions of this Web site. New questions and answers will be posted as they are received and answered.

The ROSS database and Internet Map Service were created to provide a wide variety of users online access to both spatial and tabular data. This site will enable BBCS staff, coastal engineers, the academic community and the general public the ability to view and download all relevant data from historical, current and future studies conducted around the state of Florida.

The ROSS Web site was designed with three intentions. The first was to allow users to view data spatially over the web and be able to download this data in both tabular and shapefile format to a personal workstation for advanced analysis. The second was to give the coastal engineering community the ability to cut the cost of an initial design and permitting phase of a beach nourishment project. By compiling all the available data together in one easy to use location, a more detailed evaluation of sand deposits needed for these projects may be conducted. Finally, the database has located and digitally preserved a large portion of data that once resided in perishable formats.

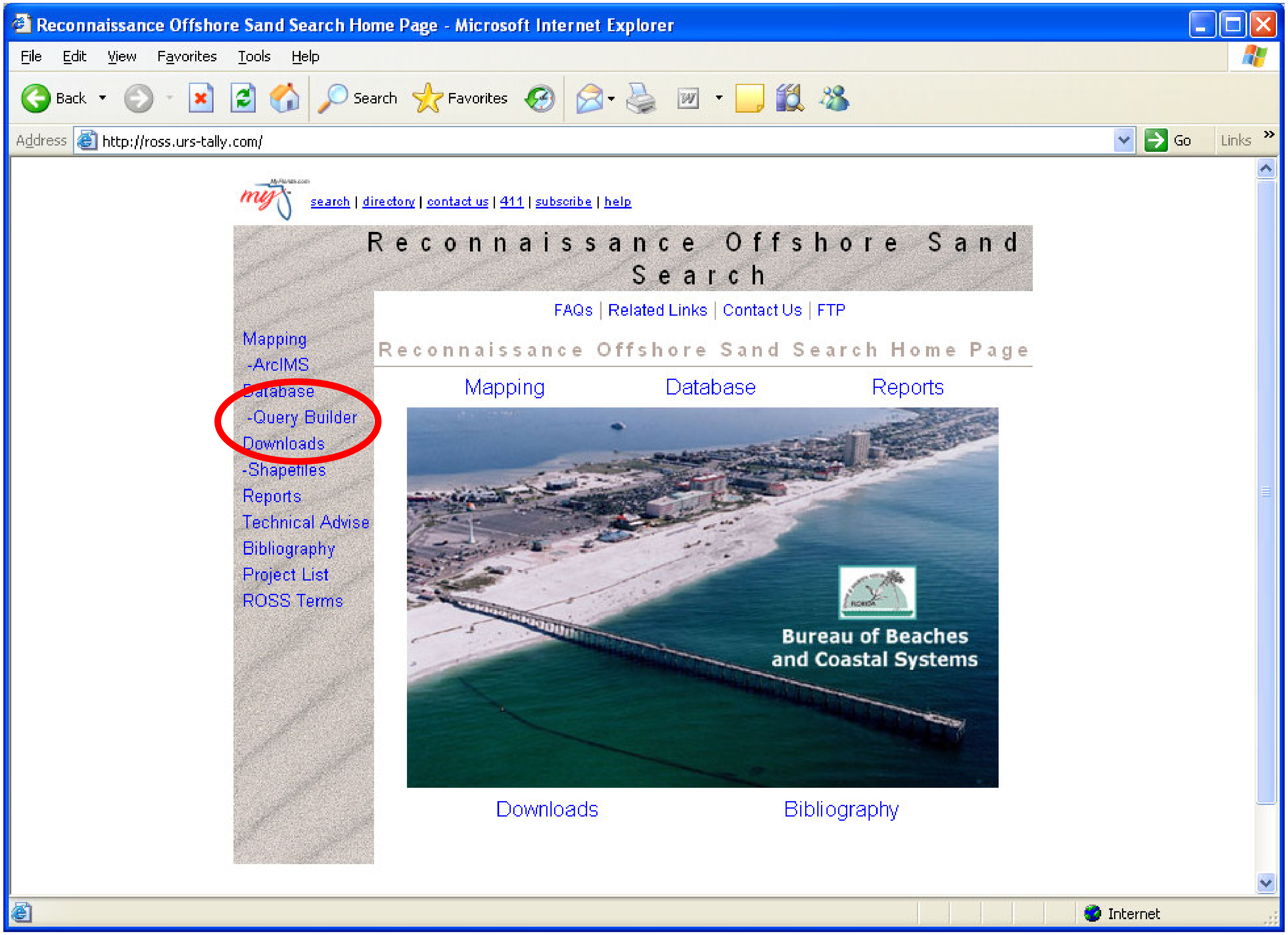


Figure 2-1. The ROSS home page showing the Query Builder link.

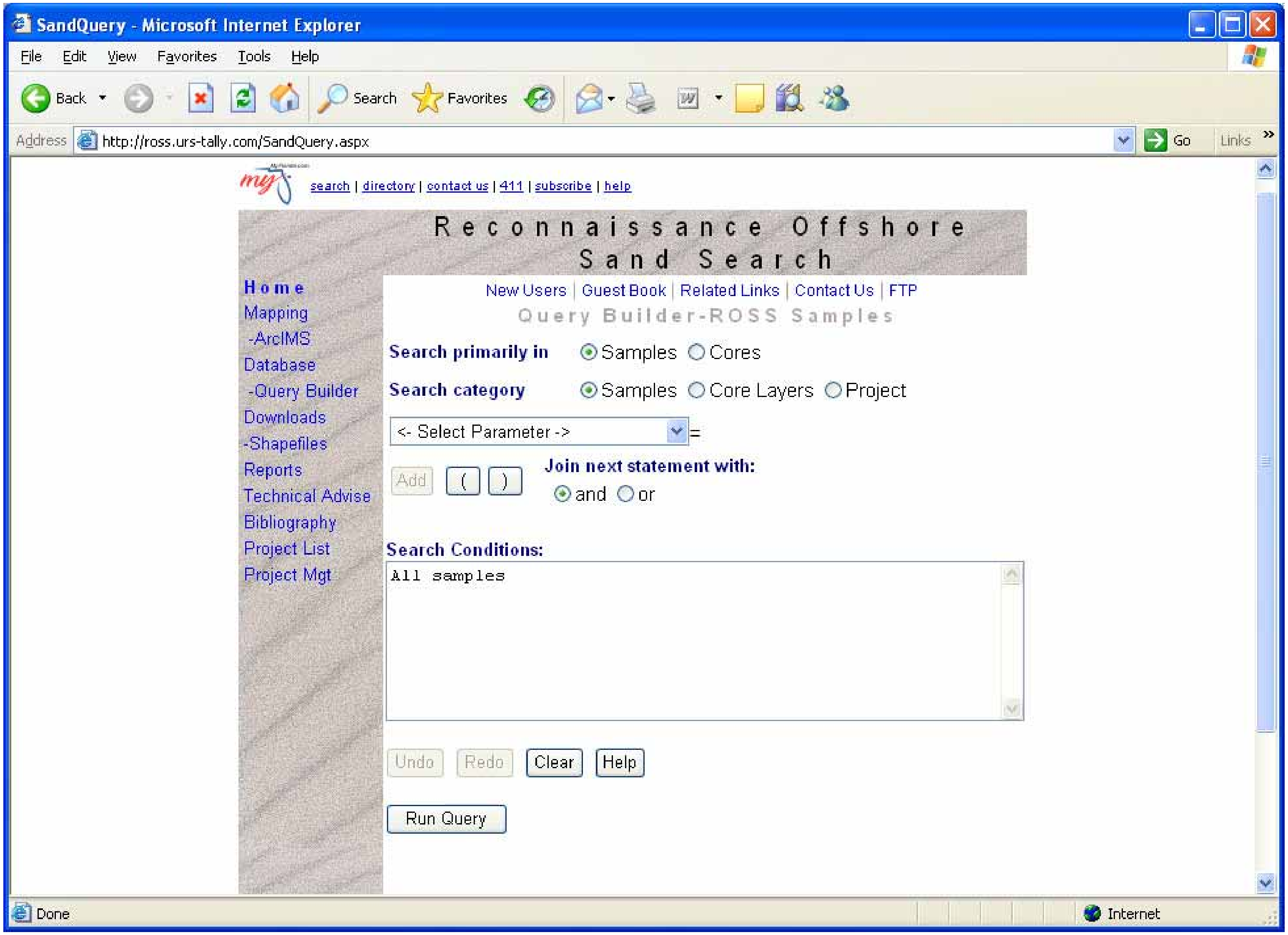


Figure 2-2. The Enhanced Query Builder page.

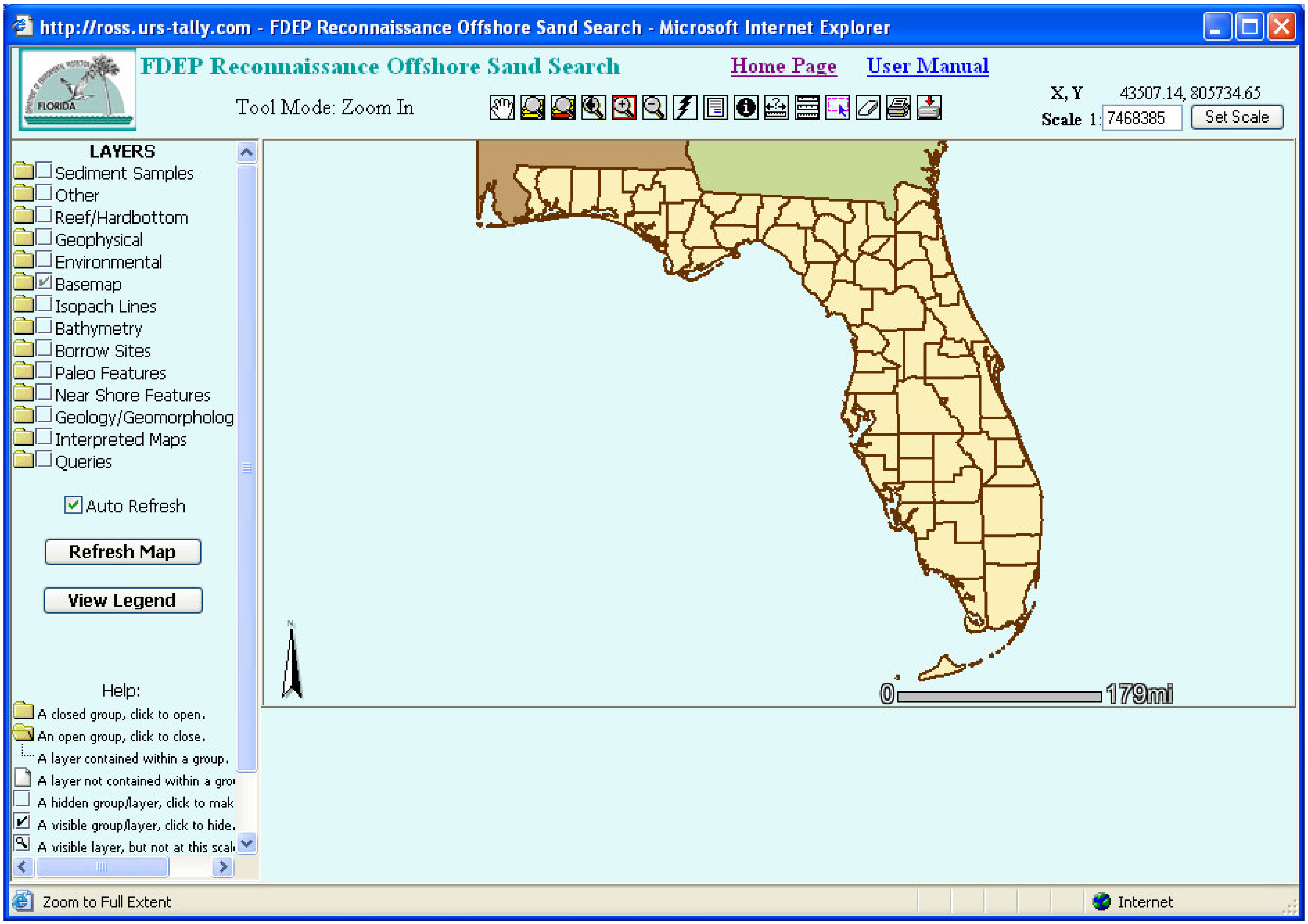


Figure 2-3. The ROSS on-line mapping page.

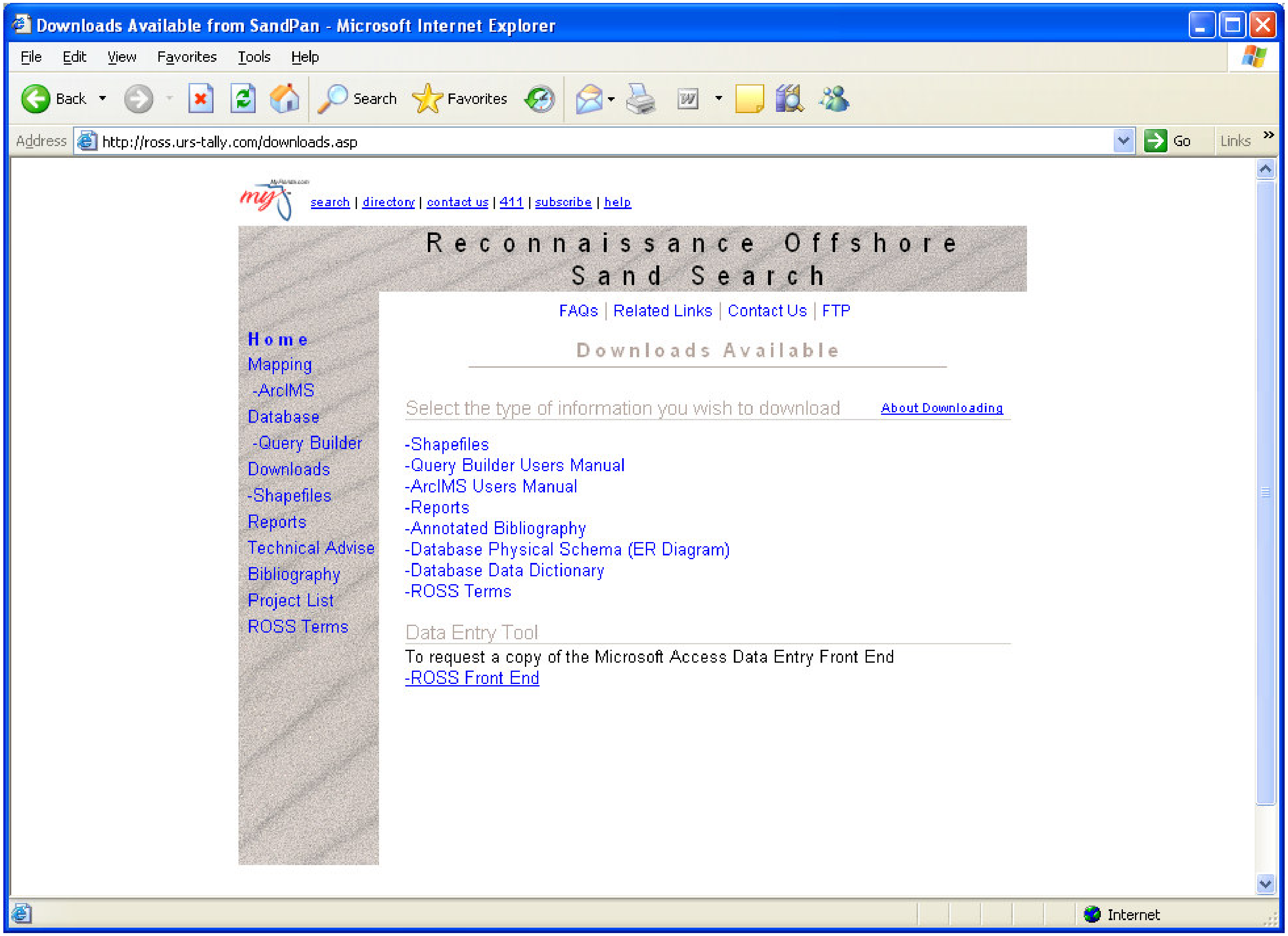


Figure 2-4. The ROSS Downloads page.

Figure 2-5. The ROSS Front End main page.

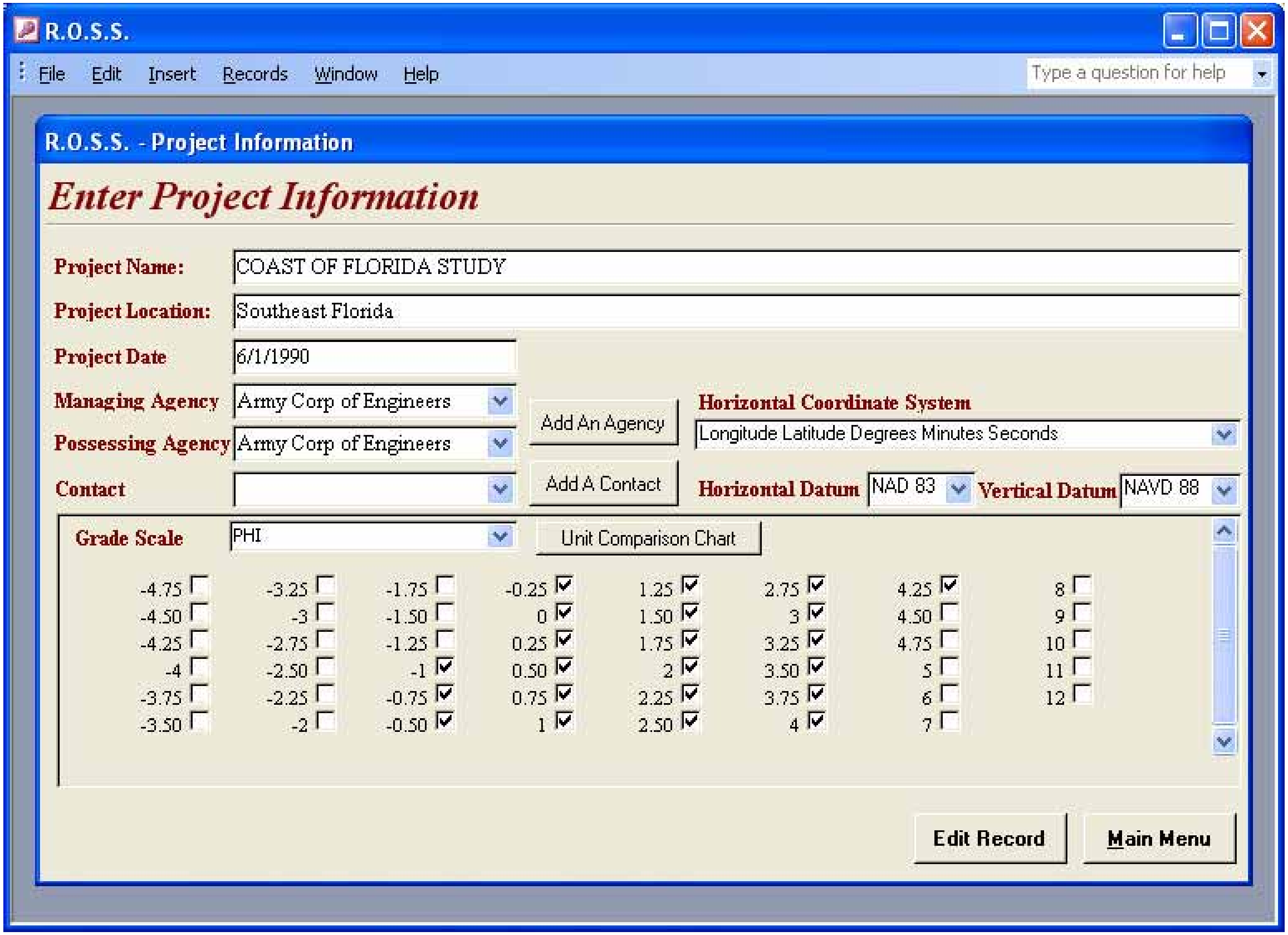


Figure 2-6. The ROSS Front End Project Information page.

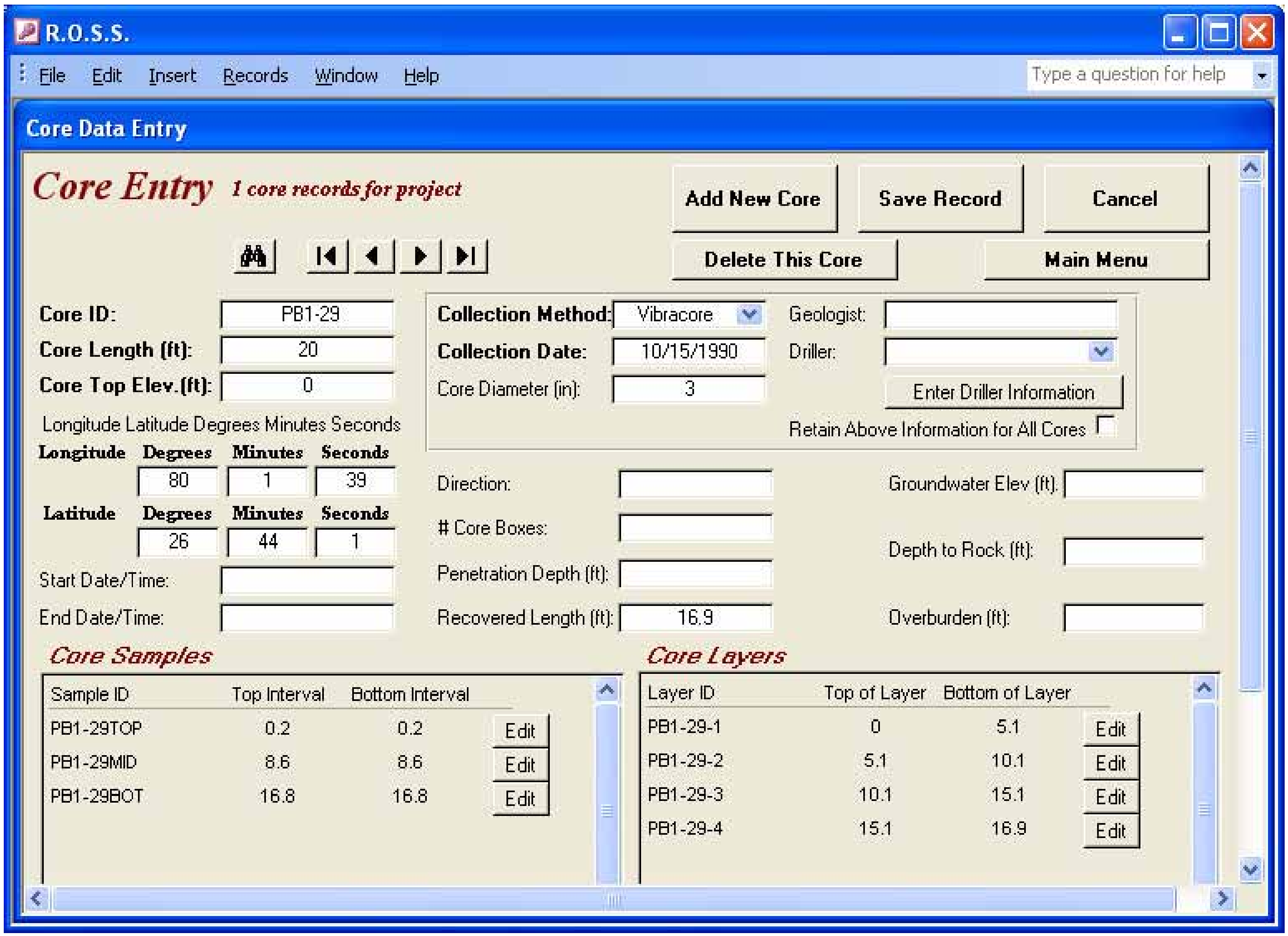


Figure 2-7. The ROSS core entry interface.

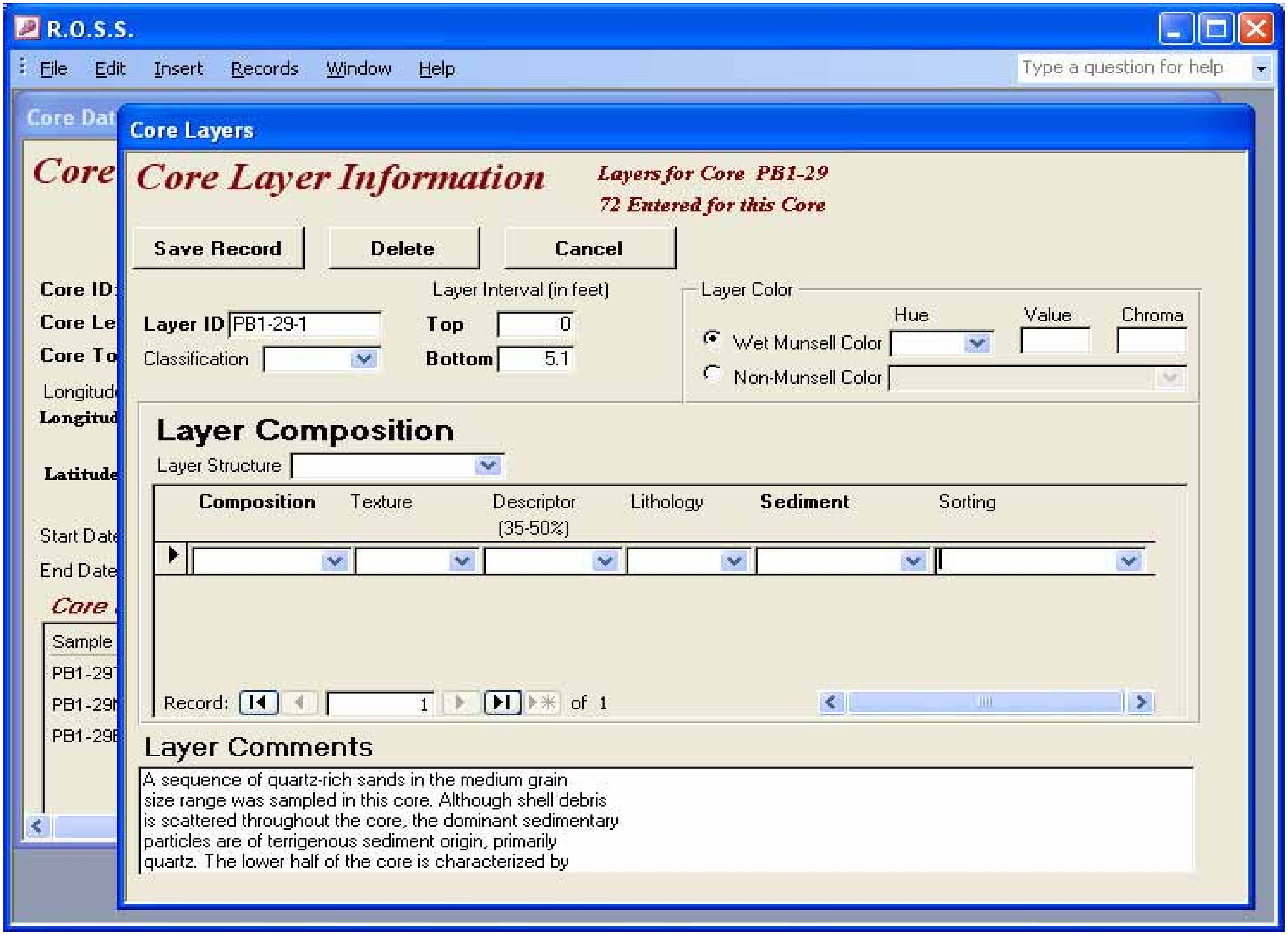


Figure 2-8. The ROSS core layer information interface.

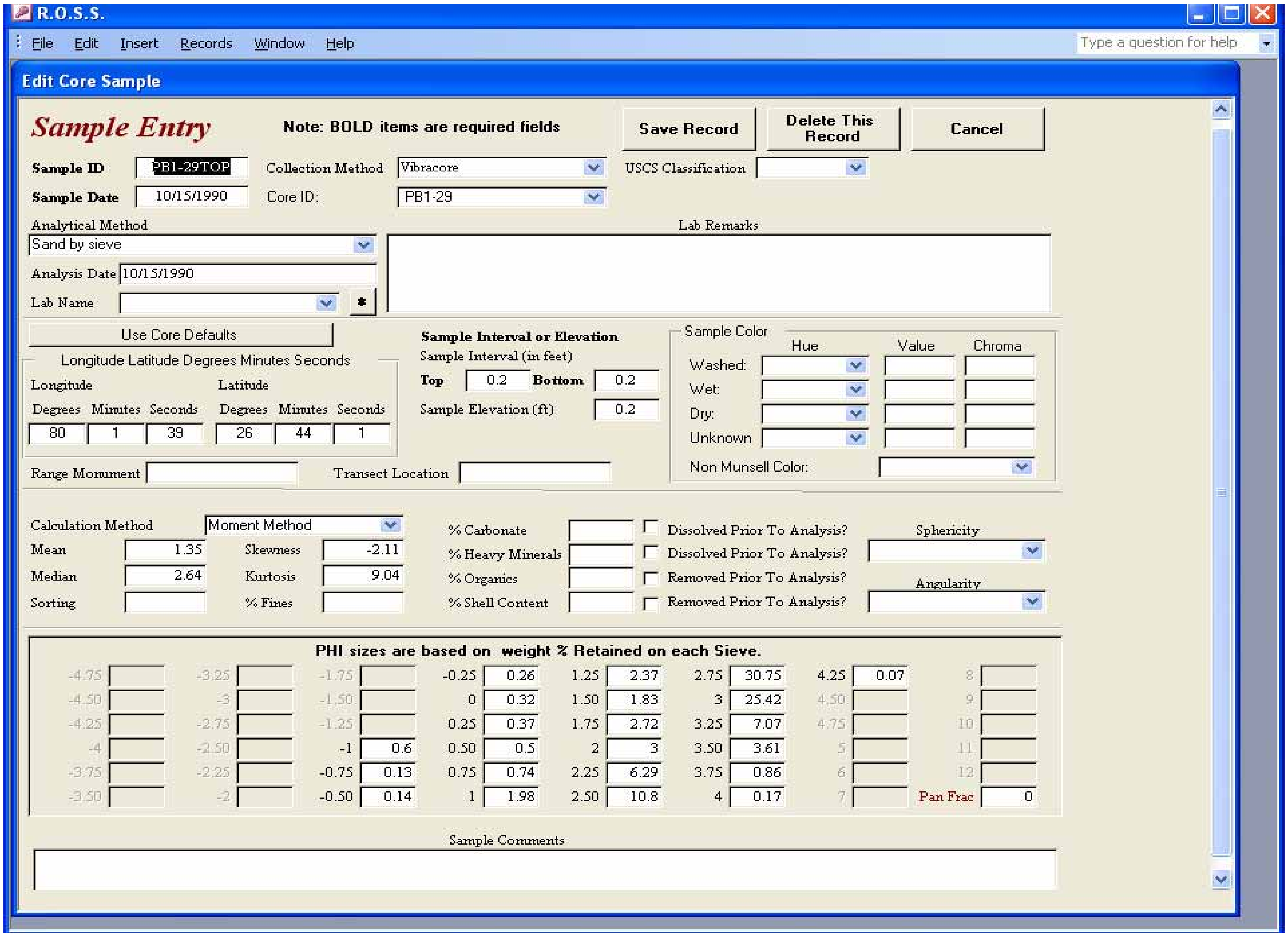


Figure 2-9. The ROSS sample information interface.

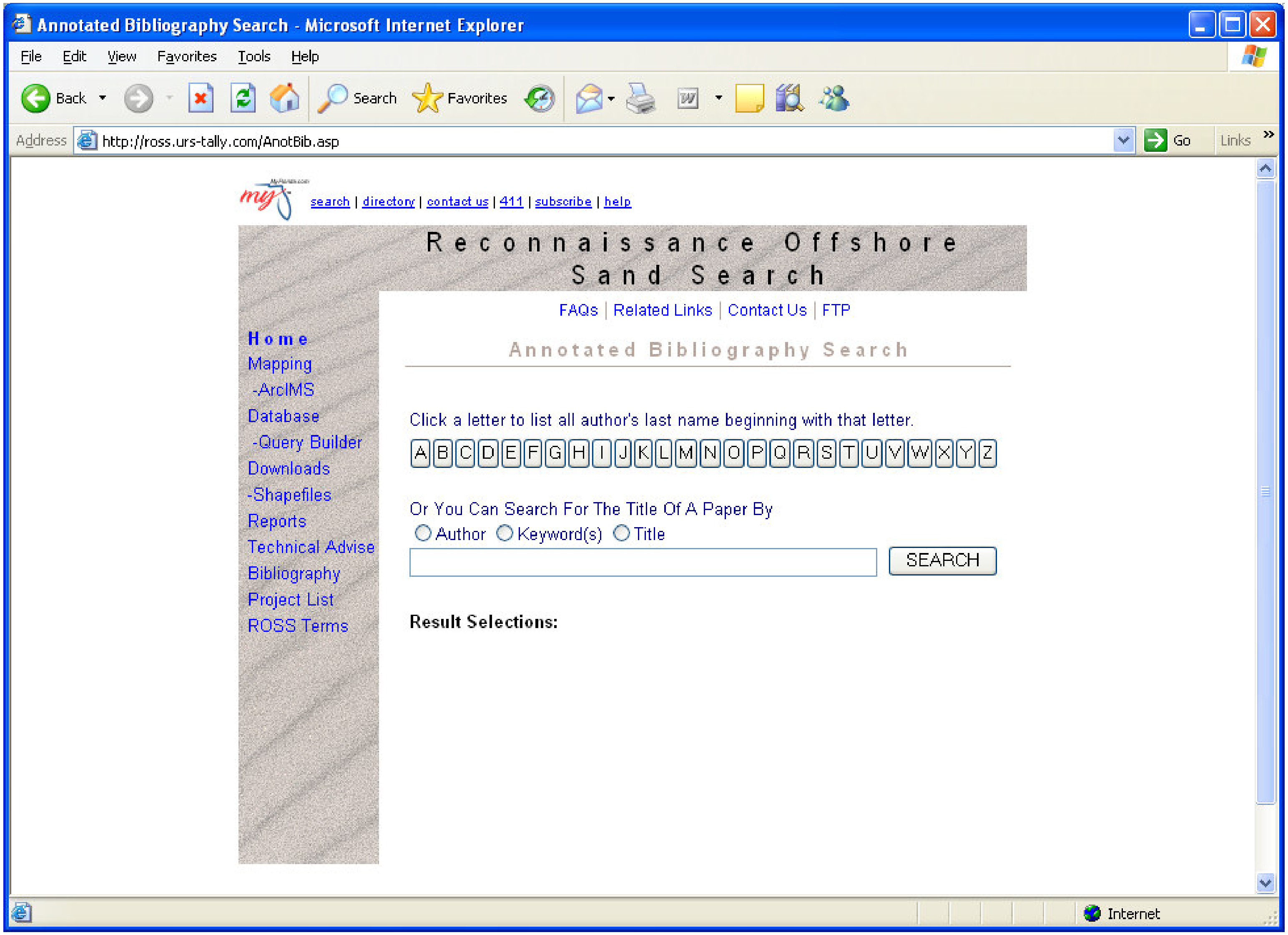


Figure 2-10. The Annotated Bibliography page.

PURPOSE GOAL AND PROJECT DESIGN

The overall purpose of this reconnaissance-level project is to determine the sand resource potential on the continental shelf along the northeast Florida Atlantic coast. The results of this project will be incorporated into the ROSS (Reconnaissance Offshore Sand Search) database for the State of Florida, Bureau of Beaches and Coastal Systems (BBCS). Critical to this assessment of sand resource potential is the determination of areas previously investigated (areas actually exploited for sand as evidenced by borrow pits), areas that were investigated but not exploited, and areas that have not been investigated. In this way, a comprehensive overview of the status of sand resource investigations can be compiled that will provide guidance for future work. Development of a coastal geological framework is part of the scope of work because it facilitates comprehension of sediment distribution patterns, provides background for a better understanding of the types of sedimentary bodies that occur in the study area, and indicates geological and geomorphological constraints on the evolution and maintenance of sedimentary deposits on the shelf.

Key to this study was the availability of NOAA bathymetric data offshore Nassau, Duval, St. Johns, Flagler, and Volusia counties. Although limited by quality of the data, the NOAA bathymetry provided a convenient basis for mapping seafloor topography, determining geomorphological units, and establishing a submarine land topology that could be related to morphosedimentary bodies. Analyses of sandy seafloor areas could thus be conducted in a GIS environment, based on iterative queries to ascertain specific types of sedimentary bodies. By calculating sediment volume from maximum and minimum elevations of seafloor mapping units (morphosedimentary bodies) using computerized techniques, it was possible to estimate potential sediment volumes by mapping units and areas within each county. Results of this study indicate potential sand resources by types of deposits and their locations on the continental shelf.

INTRODUCTION

The most prominent geological and geomorphological features along the northeast coast of Florida include sand flats and ebb-tidal deltas on the inner shelf; sand waves, shoals, and banks on the middle shelf; and large sand ridges on the outer shelf. Deepwater ridges occur along the seaward margin of the study area in water depths ranging from 90 to 150 ft Sand ridges are a pervasive morphological feature throughout the study area. Shoreface-attached sand sheets occur along the entire length of the study area and are overlain inshore by ebb-tidal deltas, mostly in the northern part of the study area in Duval and St. Johns counties. Other minor sedimentary features include transverse bars alongshore Nassau County and ebb-tidal deltas on the inner shelf offshore Nassau, Duval, and St. Johns counties. Salient morphological properties of these seafloor features and their sand resource potential are summarized in this report. These morphosedimentary features are described in relation to their position on the continental shelf along with reference to the state-federal offshore boundary, water depth, and distance from shore (location of potential borrow sites for beach renourishment projects).

Study Area and Coastal Geological Framework

The study area is located off the northeast Florida Atlantic coast. It spans about 145 miles of shoreline from the Florida-Georgia border to Brevard County. Taking in approximately

1,407,718 ha (5323 mi^2), the mapping on the continental shelf extends about 45 miles offshore along the northern boundary (Florida – Georgia state line) and about 25 miles seaward along the offshore extension of the Volusia-Brevard county line. Figure 3-1 shows the area of study on the continental shelf in plan view. Although this bird's eye view shows a differentiation of bathymetry in terms of color-ramped data cells, the oblique image in Figure 3-2 (isometric diagram) better emphasizes differences in seafloor elevations, especially sand ridges and dissected margins of banks and sand waves. Figures 3-1 and 3-2 should be perused in conjunction with each other to best appreciate the variety of seafloor morphological units. These figures, produced by the conversion of bathymetric data points into digital terrain models of seafloor topography, should be visualized as a backdrop to historical descriptions of shelf morphology, sedimentary cover, and potential sand resources. Each morphological feature will be described in relation to its sand resource potential. It should be noted that these terrain models show the seafloor in a dynamic format that was not available to early researchers making observations of shelf morphology. New technologies and increased computer power allow researchers to significantly improve morphological interpretations.

The study area along the northeast coast of Florida (as shown in Figures 3-1 and 3-2) occurs in the Atlantic and Gulf Coast Physiographic Province (Walker and Coleman, 1987). The seaward side of the study area contains a portion of the Atlantic continental shelf. The Atlantic margin continental shelf varies considerably in width, gradient, and morphologic complexity over the 1800 miles it extends along the east coast of the United States. Almost all of it is covered by a surficial sand sheet, often with some gravel (Hollister, 1985). South of the former glaciated area, the shelf is characterized by fields of linear, northeast-trending shoals (Duane *et al*., 1972). These shoals form a small angle with the coa

.0s0t (usually less than 35°), display complex bathymetry, have up to 32 ft of local relief, and have side slopes of a few degrees. As well-organized morphologic features, they extend from water depths of only a few meters out to depths of about 200 ft Even though they show large variation in size, complexity, and distribution along the eastern seaboard, they nevertheless can be grouped into arcuate (inlet and cape-associated) and linear shapes (Duane *et al*., 1972).

The shoals, composed of Holocene sands, rarely attain thicknesses greater than 32 ft and generally rest on horizontal strata of marsh, lagoon, and estuarine deposits. Radiocarbon dating of the underlying material indicates that the shoals postdate the last transgression and are, therefore, less than 11,000 years old (Walker and Coleman, 1987). The shoal sands, which bear evidence of recent modification by current and wave activity, are generally well-sorted, medium-grained sands that are similar in lithology to present shoreline beaches. Although there are numerous theories concerning their origin, it is generally accepted that they were formed by nearshore processes (Duane *et al.,* 1972; Hollister, 1985; Walker and Coleman, 1987). Shoals that are now isolated on the shelf are judged to have been formerly shoreface-connected and subsequently detached during the coastal retreat that accompanied the last rise in sea level.

Carbonate sediments occur on most modern continental shelves (Ginsburg and James, 1974). The various skeletal and nonskeletal grains have not moved far from their environments of formation. Therefore, their distribution is a reliable tool for interpreting the history of Holocene deposition on continental shelves. Holocene shelf carbonates, summarized by Ginsburg and James (1974), are grouped into two intergrading categories: open shelves (*e.g.* eastern Gulf of Mexico) and rimmed shelves (*e.g*. south Florida). Rimmed shelves are those in which a continuous rim, a semicontinuous rim, or a barrier lagoon on the shelf margin restricts circulation and wave action on the adjacent shelf lagoon. The rim along the southeast Florida coast is a barrier reef, which terminates just south of the Martin – Palm Beach County line.

The thin accumulation of surface sediments on open shelves is largely relict and formed in shallow water earlier in the Holocene. The deposits of rimmed shelves, especially the shallower ones, are often thick, young (<6000 years old) and continuous. Sand and granular-sized grains are the most frequent and widespread form of carbonate on modern shelves. Coral algal reefs and algal hardgrounds are characteristic of shelf margins in tropical seas. Lime muds and mixtures of lime mud and sands are limited to lagoons rimmed by shelf-margin barriers.

Surface sediments of the western North Atlantic shelf are relict and were deposited in shallow water earlier in the Holocene, as described by Emery (1968), Emery and Uchupi (1972), and Milliman, Pilkey and Ross (1972). From Cape Hatteras south to Miami, the percentage of carbonate increases progressively. Milliman, Pilkey and Ross (1972) mapped nine assemblages of carbonate sand grains on the southern shelf. North of Jacksonville, molluscan debris predominates over the interior shelf with zones of ooid-peloid and coralline algae near the margin. From Jacksonville to Miami, where the percentage of carbonate is higher, ooid-peloid sands are more extensive, barnacle fragments are a significant component, and the molluscan sand zone is narrower. According to Macintyre and Milliman (1970), the age of the ooid sand near the shelf margin off Florida ranges from 9000 to 14,000 years BP.

From Cape Hatteras to Cape Kennedy, the ridges of the shelf margin are interpreted as erosional remnants of Pleistocene limestone, capped by shallow-water calcarenite and coralline algal limestone. Milliman and Emery (1968) and Milliman, Pilkey and Ross (1972) radiocarbon-dated samples of the algal limestone, their results revealed the age of these samples ranged from about 12,000 to 27,000 years BP. From Cape Kennedy to Palm Beach the ridges are relict dunes or beach ridges capped with a prolific growth of living branched corals (*Oculina* sp.) (Macintyre and Milliman, 1970). From Palm Beach to Miami the single ridge is an 'inactive' reef of hermatypic corals, octocorals, and sponges, with a narrow halo of carbonate sand rich in fragments of algae (Ginsburg and James, 1974).

Geological Development of the Northeast Atlantic Coast of Florida

The northern boundary of the basement structure supporting the Florida Platform was a linear structural basin located between the Peninsular Arch and the Paleozoic (4500 to 544 Ma) rocks of the southeastern United States. This structural zone was originally related to a suture zone and an accreted continental terrain associated with the final closing of the Iapetus Ocean (proto-Atlantic Ocean). During the Jurassic Period (when seafloor rifting and continental drift separated the Americas from Africa), the initial carbonate stratigraphic sequences onlapped from the south onto the Peninsular Arch basement rocks. As the Peninsular Arch became covered with shallow water carbonates (due to subsidence and sea-level rise) during the Early Cretaceous era (146 to 65 Ma) to form the Suwannee Saddle (variously called the Suwannee Strait, Channel or Seaway; the Gulf Trough; or the Georgia Channel System) and the seaway that flooded it (Hine, 1997), this basin and seaway were paramount in maintaining the carbonate sediment producing environment to the south.

The continental shelf off the northeast coast of Florida is a wedge shaped platform with the apex pointed southward. The perspective shown in Figure 3-3 (a composite diagram that merges terrestrial satellite imagery with bathymetry) shows a wider shelf area in the northern part of the study area and narrow in the south, the seaward boundary of study being marked by the 147 ft isobath. The shelf is about 75 miles wide off Jacksonville but narrows to about 30 miles wide off Cape Canaveral to the south. The shelf area is described here in terms of its geological framework, geomorphology, and sedimentology.

In terms of geological evolution, the shelf off northeastern Florida is relatively complicated with different hypotheses presented to account for some of the major features. Although the geological framework retains a complicated evolutionary history, some of the major developments are briefly mentioned here as a background to the description of major structures and processes that affect the geomorphology of the seafloor and surface sediments contained thereon.

There are two fundamentally different views concerning the topographic complexity of the early basement structure underlying the Florida-Bahamas region. In one view, Mullins and Lynts (1977) postulate that the Bahamas Bank was formed during the Jurassic on top of rift-generated horst-and-graben topography. This interpretation forms the basis for the so-called *graben hypothesis*. During long-term subsidence associated with the regional passive margin-setting, carbonate derived sedimentation on the megabank kept pace, forming thick (up to 8.7 mile) shallow-water limestones. Sheridan *et al*. (1988) and Leg 101 Scientific Party (1988), on the other hand, envisioned a carbonate megabank that extended from the West Florida Escarpment (in the Gulf of Mexico) to the Blake-Bahamas Escarpment (east side of the Straits of Florida and western margin of the Blake Plateau-Bahama Bank). Because this megabank seemed to have formed by the Late Jurassic on a basement terrain not segmented into large horsts and grabens, it has been referred to as the *megabank hypothesis*. Whether horst-and-graben or megabank, karst (subsurface and exposed sinkholes) developed in Paleocene, Eocene, and Oligocene limestones to produce subsurface local stratigraphic deformation in the form of folds and sags (Meisburger and Field, 1975; Popenoe *et al*., 1984). These folds have about 260 ft of subsurface relief. Karstification (dissolution of limestone rocks) proceeded during the late Oligocene to early Miocene sea-level low stands. This surface karst topography and chemico-physical modification of the limestone structures probably control modern coastal morphology and shelf topography viz. Cape Canaveral, St. Lucie River estuary.

Geomorphological interpretation of the karstified terrain refers to several major physiographic features that resulted from geological structures (*e.g.* lineaments, folds, sags), subaerial weathering processes and subterranean dissolution and sedimentation. The study area is located on the southern extension of the East Coast Shelf, which is defined by Uchupi (1968) as a gently seaward-sloping submarine plain bordering the Atlantic coast from Cape Cod to the Florida Keys. The East Coast Shelf is bounded by the 3-mile limit to the west (which marks the boundary between state and federal waters) and the Florida Hatteras Slope to the east. The north Florida Atlantic shelf area is part of the southeastern shelf. Following Price's (1954) geomorphological terminology, Meisburger and Field (1975) subdivided the northeast Florida shelf into three main units: shoreface, shelf floor, and shelf edge. Exposed during glacio-eustatic sea-level lowstands during the Pleistocene, relict stream drainage patterns formed on the shelf (i.e. off Fernandina and St. Augustine) along with weathering profiles and Pleistocene soils.

From a sedimentological point of view, sediments occurring on the shelf are highly variable in terms of grain size characteristics, particle shape, and mineralogy (Meisburger and Field, 1975). Trends in sediment distribution appear to be related to both shelf and surface morphology and subbottom (geological) structure. Anomalous surface sediment patterns are related to the surface exposure of older underlying strata. In general, surficial sediments are detrital quartz sands that overlie older carbonate-rich quartz sand deposits. The overall distribution patterns of surface sediment on the shelf floor are largely the result of the thin and discontinuous nature of Pleistocene and Holocene sediments, but large volumes of quartz sand occur in spatially large but topographically subdued positive features. Adjoining patches of the shelf surface often contain sediments deposited at different times and under contrasting environmental conditions. Sediments as old as late Miocene and as young as Holocene are locally exposed in adjacent surface patches. Boundaries between these patches are sharp. They are not gradual as with facies changes in contemporaneous deposits. Thus, lithologic and faunal assemblages of the different patches may be strikingly different. In addition to the exposure of sediments of different age at the surface, there are lateral gradations within contemporaneous deposits and the disposition of surface sediments in detail is locally complex and irregular. However, there is a relatively uncomplicated dominant sediment distribution pattern – poorly sorted fine quartz sands that mantle the entire shoreface from Georgia to Cape Canaveral. The contact or boundary between shoreface facies and inner shelf facies commonly occurs at about the 3-mile limit, which occurs between the 30- and 50-foot isobath (see Figure 27 in Meisburger and Field, 1975) except just south of Flagler Beach where the shoreface narrows.

The thickness and spatial distribution of lithologic units on the shelf are organized by Meisburger and Field (1975) into three primary patterns: Georgia border to Jacksonville, Jacksonville to St. Augustine, and St. Augustine to Cape Canaveral. Most of the shelf region between Georgia and Jacksonville is covered by fine- to coarse-grained quartz sand deposits 1 ft to 3 ft thick but ranging up to 6.5 ft thick in places. Off Fernandina and Jacksonville, quartz sand is thicker (up to 8.2 ft) and more uniform in lateral extent, probably due to the presence of the St. Johns and St. Mary's Rivers. Late Tertiary dolomite silts and white foraminiferal sands occur several feet below the surface of the sea floor. Weathered materials representing the remains of Quaternary soils or groundwater profiles also occur below the surficial blanket sediments. Organic-rich muds and peats (radiocarbon-dated at 9625 YBP) also occur in the area at -59 ft MLW.

In the Jacksonville to St. Augustine segment, the overall sediment character is similar to distribution patterns to the north. The relative distribution of the different sediment types changes significantly, however, both laterally and vertically. Fine- to medium-grained quartz sands are thicker and more laterally extensive. Pre-Pleistocene dolomite silts and foraminiferal sands are less abundant and more restricted in lateral extent. Reconnaissance vibracores from this area show relatively thick (>8.2 ft) sequences of quartz sand. The Georgia region is a likely source for the north Florida shelf sands, based on the presence of (a) an unstable (they reflect derivation from Piedmont rocks without having passed through a sedimentary cycle of deposition, lithification, and subsequent erosion) heavy mineral assemblage similar to that of Georgia coastal sediments and reflecting a metamorphic-igneous provenance and (b) a fine-grained low carbonate nature suggesting modern fluvial derivation.

In the St. Augustine to Cape Canaveral segment, sediment character changes as the surface Quaternary sediments thicken and display facies changes that are quite marked. Clayey silt and muddy shell deposits, not present north of St. Augustine, occur near Daytona Beach. Silt and shell deposits may be related to shoreward migration of the Mosquito Lagoon barrier in response to rising sea level.

Sand resources on the shelf of northern Florida beyond the 3-mile limit are now relatively well known. Reconnaissance studies by Meisburger and Field (1975), for example, indicate the presence of quartz sand sheets up to 6.5 ft thick and linear ridge-like shoals off Fort Pierce and Cape Canaveral and south of Daytona Beach. Bank shoals, flat-topped masses of irregular outline and low relief, occur throughout the area and contain several feet of quartz sand atop these topographic highs. Some show promise as sand sources, such as the shoal located 6 miles offshore from Jacksonville and St. Augustine where the sand volume is estimated by Meisburger and Field (1975) to be on the order of 177.9 x 10^6 cy (178 million cubic yards). Deposits off Ormond Beach and Marineland are estimated to contain about 46 x 10^6 m^3 and 30 x 5.3 x 10^6 m^3 (60 and 40 million cubic yards), respectively. A buried channel of the St. Johns River contains reasonably clean, medium- to coarse-grained quartz sand under a shallow overburden. Because some other channels are filled by silty sand and clay, detailed exploration is required to locate sand-filled channels. Linear shoals, such as those lying off Amelia Island, may contain thick sand accumulations. A sand ridge near St. Augustine, for example, is estimated to contain at least 6.9 x 10^6 cy (7 million cubic yards) of sand in a layer 4 to 6 ft thick.

Morphosedimentary Features of the Continental Shelf

The study area occurs on the southern extension of the major physiographic unit identified by Uchupi (1968) as the East Coast Shelf. The Florida Hatteras Slope occurs seaward of the shelf break. The East Coast shelf is a gently seaward-sloping submarine plain bordering the Atlantic coast from near Cape Cod to the Florida Keys. The northeastern Florida Atlantic shelf area is part of the southeastern shelf. Following Price's (1954) geomorphological terminology, Meisburger and Duane (1971) subdivided the central Florida shelf into three main units: shoreface (low water line to about -40 ft), inner shelf plain (-40 to -75 ft MLW), and outer shelf that is transitional from the 'flat' inner shelf to the top of the Florida-Hatteras Slope lying at -78 to -2230 ft MLW. The slope break generally falls between the 65 and 78 ft depth contour. These shelf units were mapped by Finkl and Andrews (2007) from the Palm Beach County – Martin County line to the Brevard County – Volusia County line.

Meisburger and Field (1975) subsequently subdivided the northeast Florida continental shelf into two main physiographic units: shoreface and shelf floor ("ramp" of Price, 1954). In this report, the shelf floor is further divided into three subunits, following physiographic units on the central Florida shelf: inner shelf floor (-40 to -65 ft MLW), mid shelf floor (-65 to 78 ft MLW), and outer shelf floor (-278+ ft MLW) (Figure 3-4). Because the continental shelf becomes wider with distance north, the upper slopes of the Florida-Hatteras Slope occur seaward of the mapping area beyond 147 ft depth. The shoreface extends from the low water line to about -40 ft. These units are shown in Figure 3-4 with major morphosedimentary boundaries superposed. The boundaries of morphosedimentary features are shown here in reference to physiographic subdivisions of the continental shelf in support of subsequent discussion. Future references to the geographic location of morphosedimentary features in relation to their positions within physiographic subdivisions of the continental shelf are keyed to Figure 3-4. These physiographic subdivisions of the continental shelf help to define coastal ocean process zones, as discussed for portions of the southeast Atlantic coast by Khalil (1999) and Finkl and Khalil (2000) that in turn can be related to contemporary and relict bedforms. Most of the larger morphosedimentary features on the seafloor are relict (Holocene in age) but contain clear evidence of subsequent reworking by more recent processes in the late Holocene since sea level reached its present position about 3000 to 5000 years ago. Downdrift extensions of shoreward margins of ridge fields and distal erosion of banks and sand waves are examples. Smaller bedforms occur nearshore but are mostly absent from the reformatted NOAA bathymetry due to scalar parameters of the acquired data.

METHODOLOGY

The basic methodology of this reconnaissance assessment of offshore sand resources on the continental shelf off the northeast Florida Atlantic coast involved acquisition and manipulation of digital bathymetric data from NOAA (NOAA-GEODAS bathymetry), graphic display of the reformatted data points, and interpretation of the resulting spatial distribution patterns of bathymetric highs and lows in terms of seafloor physiographic units. Bathymetric patterns were interpreted as morphosedimentary bodies in terms of sand flats, ridge fields, sand waves, transverse bar systems, banks, and shoals. About twenty-nine mapping units were derived from the bathymetric data, including four ebb-tidal delta complexes at major inlets.

Historical (published and unpublished) data were perused to gather background information about the area and to assess sand resource potentials. Some historical data was general in scope while other data was point specific. Geotechnical (grab samples and vibracores) and geophysical data (seismic reflection profile surveys) were, for example, assessed from a variety of sources including the Florida Geological Survey and Minerals Management Service (Phelps *et al*., 2007). By combining seafloor mapping units, geotechnical, and geophysical data, it was possible to estimate sediment volumes by geomorphological mapping unit. The latter procedure was accomplished in a GIS platform where various criteria could be queried. Each methodology is briefly described as follows.

Reformatting Hydrographic Survey Data and Creation of Data Reliability Diagram

Bathymetric data (NOS Hydrographic Survey Data) were obtained from the NOAA Geophysical Data Center (NGDC at www.ngdc.noaa.gov). The hydrographic data consists of historic survey information from 1924 to 1999. Original spacing of data varied from about 100 to 1500 feet, as shown in the reliability diagram inserted into Figures 3-4, 3-5A, 3-5B, 3-6A, and 3-6B. The 500-foot grid (Zone C) was generally extended about 6 miles offshore except seaward from the general latitude of southern St. Johns County to the offshore extension of the Flagler – Volusia county line. Most of the offshore area was mapped using a 1000-foot grid (Zone D). Approachways to the St. Johns River (Port of Jacksonville), where greater accuracy of depth information is required, were surveyed on 125-foot grids (Zone A). A small nearshore area off Jacksonville Beach was mapped using a 400-foot grid (Zone B). Zone G, in the nearshore off the St. Augustine Ebb-Tidal Delta, is based on a 400-foot grid. A small Zone H at the navigational entrance to Mayport was based on a 100-foot grid. Zone E designates a small area near the center of the offshore study area where no bathymetric information was available. Occurring far offshore is part of a broad scale survey area (Zone F) that is based on 1500-foot grid spacing.

Perusal of the data reliability diagram shows that a range of spatial resolutions were used to compile the 3D bathymetric (terrain) model that forms the basis of this reconnaissance sand resource investigation. New 250-foot bathymetric grids, which used historical grid spacings indicated above by zone, were created using Surfer® to interpolate the original hydrographic data by equally spaced intervals so that resulting spatial distribution patterns would better resemble recognizable topography that could be color ramped. The result is a rasterized image that provides spatial continuity of point data in a format that represents a topographic surface. Differences in elevation can thus be shown as continuously varying spatial units that are amenable to color coding.

Creation of Terrain Models of the Continental Shelf

The basic mapping procedure was to group similar, spatially-related seafloor features into discrete mapping units. Recognition of seafloor features from the color-ramped bathymetry depends on the experience and knowledge of the interpreter. Variations in bottom topography are visualized using a color ramp that grades from reddish tones nearshore through yellowish tones on the middle shelf to brownish tones seaward in preference to bluish tones that are traditionally used to show water depth. The new color ramp was produced here to show submarine topography (morphosedimentary features), which is the subject of this report, not water depth. The map product thus produced is the result of interpretation and deductive reasoning. The essential points of the mapping procedures are described, for example, by Benedet *et al*. (2004); Finkl and Warner (2004); Finkl (2005); Finkl, Benedet and Andrews (2005, 2006); and Finkl and Andrews (2007). The present work is an extension of the geological models for the continental shelf off the southern and central Atlantic coast of Florida, as prepared for the ROSS database project (Finkl, Andrews and Benedet, 2007; Finkl and Andrews, 2007).

Determination of Sediment Volume in Morphosedimentary Features

Sediment volume calculations were based on reformatted bathymetric data (NOS Hydrographic Survey Data) that were obtained from the NOAA Geophysical Data Center (NGDC at www.ngdc.noaa.gov). These are the same data that were used to prepare the terrain models of seafloor units, based on hydrographic data consisting of historic survey information from 1924 to 1999 (see above). These data were provided as a *.csv file of northing, easting and z points. The data were converted to a shapefile using the ArcGIS® 9.2 “XY Event Tool”. Using the ArcGIS 9.2 “Select by Location” function, individual polygon units were used to select the corresponding elevation point data. A 500-foot buffer was applied during the selection process to enable complete coverage of the unit during TIN (Triangulated Irregular Network) creation. A TIN is a data structure used to model surfaces such as elevation as a connected network of triangles. TINs are assembled from a series of data points with *X*, *Y*, and *Z* values that partition geographic space into contiguous, non-overlapping triangles (called faces). The nodes of each triangle are the elevation or surface points. To eliminate the overlap edges due to the triangulation creation process of the TIN unit, these individual TINs were edited by the three-dimensional individual unit polygon they were designed to represent. The resulting TIN was then imported into ArcScene®. Using the “Spatial Analysis” function within ArcScene, an estimated volume and area was obtained for each individual unit. This tool examines each of the individual triangles in the network and determines its contribution to the overall area and volume. The baseline for estimated sediment volume is the lowest elevation within the morphosedimentary unit. All calculations were set to determine area and volume above this elevation. To determine potential sand volume, a three-dimensional rendering in ArcScene of each unit was visually analyzed, such as ridge fields, for percent ridge coverage. This visually determined percentage was used to calculate potential sand volume from the estimated total sand volume of each morphosedimentary unit. The percentage coverage of specified bathymetric features within morphological units is tabulated at appropriate locations in this report. The computer program thus uses the difference between maximum and minimum elevations within the unit to calculate volume, but also takes into account other differences in elevation within the unit as determined by TINs.

Characterization of Seafloor Mapping Units

Morphological units comprised of combinations of depth, shape, and arrangement of soundings, and shadow patterns were drawn in the paper chart (at a scale of 1:40,00) by freehand and then digitized on screen. This dual procedure was followed because it was easier to identify and follow patterns on a large chart than by scrolling multiple computer screens. Screen resolution was better than print resolution and patterns marked on the reformatted NOAA bathymetric charts could be modified on screen when digitizing in ArcView (ArcGIS). The final digital product was thus compiled in a spatial context that facilitates analysis and computation of selected parameters such as areas for sand flats, sand waves, ridge fields, banks, and shoals (Figures 3-5A and 3-5B).

Prior to embarking on the actual mapping process based on image interpretation, the color-ramped chart (3D model of the seafloor topography) was visually inspected and partially mapped in an effort to ascertain the range of features that could be identified in the study area, as described by Finkl, Benedet and Andrews (2004, 2005) and Finkl and Andrews (2007). A list of topographic features that occurred on the chart was compiled to a master list to make a comprehensive legend. Twenty-eight major landform features (Table 3-1) were found to occur in the survey area. These features are organized in terms of a geomorphological classification scheme. There are many possibilities for interpretation of features and the orientation depends on the purpose, which in this case was production of a geomorphological map for the purpose of assessing potential sand resources. The classification scheme is summarized in Table 3-1, where mapping units are organized by their primary mode of occurrence as transverse bars, sand flats, ridge fields, shoals, sand waves, banks, ebb-tidal deltas, and undifferentiated sea floor.

Because the development of a morphological classification scheme can be an endless task, it is necessary to focus on the purpose of the survey and to rationalize procedures for consistently recognizing morphological features that are identifiable at specific scales of observation. The nominal scale of observation for the northeast Atlantic coast of Florida was determined for ease of paper handling (at a scale of 1:40,000) and to match maps of submarine topography and potential sand resources along the central and southeastern Florida Atlantic coasts. In this way, a contiguous database is provided for the shelf area from about the latitude of Brevard County to the Florida-Georgia state line, an alongshore distance of about 374 miles and an area of about 2,044,742 ha.

For large-scale reconnaissance mapping purposes, the printed map sheets provided sufficient detail for the recognition of major features while still showing general spatial trends. It was thus possible to identify a range of features while not becoming bogged down by too much detail, as might occur on dissected margins of sand banks and sand waves where there are complex patterns of ridge and valley topography. The other point to be considered is the balance between what can be seen, what can be mapped, and what is useful or practical to delineate at a reconnaissance scale for estimating potential sand resources. The natural spatial heterogeneity of morphological units on the seafloor determines to a large extent what should be mapped. In a sense, then, most natural units are predetermined and they reflect the types of units that have been mapped and described by other researchers working elsewhere.

The main morphological features occurring in the study area are summarized in Table 3-1 in terms of sandy bottom types, sedimentary deposits arranged on the seafloor as long ridges, shoals, sand banks, sand waves, and related features. Mapping unit morphometrics, summarized in Table 3-1, are used to describe the various morphosedimentary features. From the point of view of area occupied, banks, sand waves, sand flats, and ridges are the most extensive. The Farmton Sand Flat occupies about 202,000 ha and is followed by the Volusia Bank (about 167,000 ha), St. Johns Bank (about 137,000 ha), and the Duval Ridge Field (about 142,000 ha). Shoals, sand waves, ebb-tidal deltas, and transverse bars take in less territory but may contain important sand resources closer to shore.

This classification of seafloor morphological types is open-ended and can be amended as required. These units, which are keyed to the reformatted NOAA color-ramped maps (Figures 3-5A and 3-5B), represent an initial attempt to characterize the nature of the continental shelf along the northeast Atlantic coast of Florida. Seafloor mapping units are described by the morphological group to which they belong as follows: bars, ridge fields, sand flats, sand waves, shoals, banks, ebb-tidal deltas, and undifferentiated seafloor.

REGIONAL DISTRIBUTION OF SEAFLOOR MAPPING UNITS

The study area shows a diverse range of morphological features that are comprised by extensive unconsolidated sedimentary deposits. Twenty-nine distinct types of submarine geomorphological units were identified and mapped. These units include subdivisions of sand ridges, shoals, banks, sand flats, sand waves, ebb-tidal deltas, transverse bars, and undifferentiated seafloor. The continental shelf area off each county is thus generally characterized by distinct submarine physiographic units (see Figure 3-4), not the least of which are sedimentary bodies that support exploitation of sand resources for beach nourishment.

The following brief description summarizes the overall geographic distribution of morphodynamic sedimentary units on the continental shelf in the study area. The purpose of this summary is to show regional (cross-county) continuity of mapping units and spatial interrelationships between units as they occur on different shelf floor environments (see Figures 3-4, 3-5A, and 3-5B). Ebb-tidal deltas are associated with major river inlets and occur on the shoreface. The four deltas recognized include the St. Augustine (centering on R120, St. Johns County), St. Johns (centering on R002, Duval County), St. Mary's (centering on R010, Nassau County), and Tisonia – Nassau Sound (centering on R75, Duval County). The deltaic deposits merge with the continuous shoreface-attached sand sheet that makes up the Farmton Sand Flat mapping unit on the inner shelf floor, which extends northward from the Cape Canaveral cuspate foreland in the central Florida survey area (Finkl and Andrews, 2007). The Beverley (offshore R40, Flagler County), Allandale (offshore R90, Volusia County), and Oak Hill (offshore R210, Volusia County) shoals occur as enclaves within the Farmton Sand Flat and are transitional to the middle shelf floor. Banks, ridge fields, and sand waves on the middle and outer shelf floor occur seaward of shoreface-attached sand sheets and transitional shoals. Banks and sand waves tend to occur in deeper water seaward of the main ridge fields. The Duval Ridge Field mapping unit extends from the Georgia State line to about mid St. Johns County off R150 and is flanked shoreward by the Farmton Sand Flat and seaward by the Nassau Bank and the Sawgrass Bank.

Offshore sand waves (Summer Haven, Palm Coast, and Flagler) on the middle and outer shelf floors are extensive off southern St. Johns County and Flagler County. These units merge seaward with the St. Johns Bank off St. Johns and Flagler counties. The Volusia Bank, occurring offshore Volusia County on the middle and outer shelf segments, is abruptly terminated shoreward by the Korona and Edgewater ridge fields. Undifferentiated seafloor occurs along the seaward margins of the study area on the outer shelf floor. Although punctuated by large-scale bathymetric features, these areas of seafloor do not show detailed features at 1000 foot data spacing (Figures 3-5A and 3-5B, Data Reliability Zone Map, Zone 'D'). Primary features in Zone D include pronounced sand ridges with distinctive patterns that are linear, anastamosing, or transverse. Undifferentiated outer shelf seafloor merges shoreward with banks and sand waves.

Salient morphometric properties of seafloor topographic units are described by county from north to south, starting with Nassau County and ending with Volusia County. Parts of the offshore continental shelf in all counties are designated as 'Undifferentiated Seafloor' due to low-resolution bathymetric data (see insert Data Reliability Zone Map, Figure 3-4). The mapping units described by county in the following discussion are shown in Figures 3-4, 3-5A, and 3-5B.

Sand Flats

Sand flats are broad and often featureless (lacking clearly defined bedforms at the mapping scale) expanses of seafloor with an unconsolidated sediment cover that is mostly sandy, as defined by Warner (1999), Finkl and Warner (2004), Finkl *et al*. (2007), and Finkl and Andrews (2007) to characterize seafloor units along the southeast and central Florida Atlantic coasts. Sand flats are extensively mapped on the continental shelf along the southeast coast where they occur in inter-reef positions between rock and coral-algal reefs (Finkl, Andrews and Benedet, 2007). They also occur extensively along the central Florida shelf where the barrier reefs of the Florida Reef Tract are missing. Here, the shoreface-attached sand flats are flanked seaward by ridge fields and banks, as described by Finkl and Andrews (2007). Only one sand flat occurs in the present study area, a northward extension of the Farmton Sand Flat of the central coast. The Farmton Sand Flat was previously defined by Finkl and Andrews (2007) in terms of summary morphometrics.

Farmton Sand Flat

The Farmton Sand Flat mapping unit (201,528 ha) (Table 3-1), defined by Finkl and Andrews (2007) along the central Florida Atlantic shelf, extends along the whole span of the study area from the Brevard County line to Georgia, a distance of about 140 miles. This extensive shoreface-attached sand sheet extends offshore on the inner shelf floor. It is narrowest in St. Johns County offshore R050 (Figure 3-5A) and widest in Volusia County offshore from the coastal segment between Ariel and Shiloh (Figure 3-5B) where its seaward extent reaches 12 miles offshore. Although continuous along the shore, offshore, the Farmton Sand Flat interdigitates with sand ridges that encroach upon this sand sheet. Some of the sand ridges are continuous for 7.5 miles. Encroaching ridges include the Amelia Sand Ridge, extending southwards from the Georgia border to about R020 in Duval County. Extended downdrift margins of the Duval Ridge Field in Nassau, Duval and St. Johns counties cross the federal-state boundary where they form large alternating finger ridges interspersed by broad sand flats.

Similar extended downdrift ridge fingers are associated with the Cresent Ridge Field mapping unit in St. Johns County offshore R160 to R200. The second widest seaward extension of the Farmton Sand Flat is interrupted by the Bunnel Ridge Field and Korona Ridge Field off Flagler and Volusia counties (Figure 3-5B). Still more extended downdrift ridge fingers, dissecting the seaward margins of the Farmton Sand Flat, are associated with the Edgewater Ridge Field offshore Volusia County between R180 and R230.

In addition to seaward splintering of the sand flat by downdrift extensions of ridge fields, shoals (Allandale, Beverly, and Oak Hill) occur as enclaves within the Farmton Sand Flat mapping unit. Where not bounded by ridge field units, the sand flat merges seaward with sand waves, for example offshore R010 and R060 in Flagler County, or banks offshore R100 in Volusia County and southwards near the border with Brevard County (Figure 3-5B).

Transverse Bars

Transverse sand bars in the nearshore run obliquely to the longshore trend of the beach (Komar, 2005). They tend to occur in more or less rhythmic patterns as stand-alone features or welded to the shore. As described by Konicki and Holman (2000), these types of transverse sand bars may extend seaward from both the shoreline (trough transverse bars) and the shore-parallel sand bar (offshore transverse bars). Numerous origins have been suggested for the formation of these sand bars, but it is generally observed that when waves break at pronounced angles to the beach, the offshore bars that were originally parallel to the shore and segmented by evenly spaced rip currents, rotate to align themselves with the incoming wave crests (Komar, 1983). This may be the origin of the large sand bars that make up the Talbot mapping unit, as defined in this study (Table 3-1).

Talbot Transverse Bar

The Talbot Transverse Bar field occurs updrift from the Tisonia – Nassau Sound Ebb-Tidal Delta on the shoreface and inner shelf floor (Figure 3-5A) along the nearshore of Nassau County. Occupying about 6000 ha, the bar field extends about 9 miles alongshore by about 3 miles in width and merges with the Farmton Sand Flat mapping unit where sand flats occur interspersed between large bars. The unit eventually grades offshore into the Farmton Sand Flat. Some bars extend up to 2.5 miles in length along 55° to 80° azimuths (Table 3-1). Individual larger bars range in width from 650 to 2000 ft.

Ebb Tidal Deltas

An ebb-tidal delta is an accumulation of sand that has been deposited by ebb-tidal currents. Modified by waves and tidal currents, these deltas exhibit a wide variety of forms that respond to energy levels in the region as well as geologic controls (Davis, 1994, 1997). Ebb-tidal deltas in the study area tend to exhibit asymmetric configurations with the swash platform (the broad shallow sand platform located on both sides of the main ebb-channel) deflected downdrift.

Measurement of delta size (area and thickness) shows spatiotemporal variability due to reports at different times by Dean and O'Brien (1987), Finkl (1994), and Powell, Thieke, and Mehta (2006). There are other complicating factors such as years when volume estimates were made and the parametrics applied, which are often complicated in complex deltaic areas where there is more than one discrete delta. The morphometrics applied in this study (Table 3-1) are based on the 3D terrain model derived from reformatted NOAA bathymetric data.

Four ebb-tidal deltas are defined in this study as the St. Augustine, St. Johns, St. Mary's, and Tisonia - Nassau Sound. The first three names coincide with previous usage but the last designation refers to the complex delta at the entrance to Nassau Sound by the term Tisonia - Nassau Sound.

St. Mary's Ebb Tidal Delta

The St. Mary's ebb-tidal delta (Figure 3-5A) occurs at the mouth of the St. Mary's River in Nassau County along the northern most extent of the study area. Occupying an area of about 4163 ha (Table 3-1), the delta is about 8 miles alongshore and extends 3 miles seaward. The delta is cut by a major navigation channel that is about 4.3 miles long. The deltaic sands are surmounted by transverse bars up- and downdrift of the inlet. Distal margins of the delta merge with the Farmton Sand Flat.

St. Johns Ebb Tidal Delta

The St. Johns Ebb-Tidal Delta (Figure 3-5A) occurs at the mouth of the St. John River from about R020 to R050 in Duval County. Occupying area of about 1840 ha (Table 3-1), the delta stretches alongshore for a distance of about 5.5 miles and extends offshore about 1.2 miles from the updrift margin. Distal margins of the delta merge with the Farmton Sand Flat.

St. Augustine Ebb Tidal Delta

The St. Augustine Ebb-Tidal Delta (Figure 3-5A) occurs at the mouth of the Guano Tolomato River and Matanzas River junction in St. Johns County. Occupying an area of about 5680 ha, the delta extends about 15.5 miles alongshore from about R080 to R165. The updrift margin extends about 1.8 miles offshore. Distal margins of the delta merge with the Farmton Sand Flat.

Tisonia - Nassau Sound Ebb Tidal Delta

The Tisonia - Nassau Sound Ebb-Tidal Delta (Figure 3-5A) occurs at the mouth of Nassau Sound in Nassau and Duval counties. The delta, occupying are area of about 1400 ha (Table 3-1), stretches about 4.6 miles along the shore from R060 in Nassau County to about R010 in Duval County. The delta reaches 1.2 miles offshore at its widest extent. It overlies a small portion of the Farmton Sand Flat and is flanked by bypassing transverse bars on its updrift (northern) margin.

Sand Ridges

Sand ridges are mounds of mostly sandy sediments that have been heaped up by currents to form linear mounds that have positive relief above the surrounding seafloor. These features have been described along continental shelves in numerous locations as prominent morphosedimentary features (*e.g*. Stahl, Koczan and Swift, 1974; Houbolt, 1976; Swift *et al*., 1978; Swift and Field, 1981; Swift, McKinney and Stahl, 1984; Parker, Lanfredi and Swift, 1982; Belderson, 1986; McBride and Moslow, 1991; Snedden *et al*., 1994; Dyer and Huntley, 1999; Snedden and

Dalrymple, 1999; McBride, 2005). In general, sand ridges tend to be semi-permanent features that migrate slowly over time. These distinctive features have been found in many regions (see previous discussion) and they are no less prominent along the Florida Atlantic shelf, occurring from south of Miami (Meisburger and Duane, 1971; Duane *et al*., 1972; Field, 1974; Field and Duane, 1974; Finkl, Andrews and Benedet, 2007), along the central Florida Canaveral coast (Finkl and Andrews, 2007), to the Georgia State line. It is clear from the shoreward margins of these ridges that predominant southward-flowing currents have channeled seafloor sediments into extended downdrift ridge fingers that are parallel to the shore. Eight discrete sand ridge fields, as defined in this study (Table 3-1), are recognized as follows: Amelia, Bunnel, Crescent, Duval, Edgewater, Fort Clinch, Espanda, and Korona.

Amelia Sand Ridge

The Amelia Sand Ridge (Figure 3-5A) occurs in the northwestern part of the study area on the inner shelf offshore Nassau and Duval counties. The single large ridge is about 14 miles long by 2.8 miles wide (Table 3-1). It is surrounded by the Farmton Sand Flat and lies about 2.5 miles to 3.7 miles from shore. With a general azimuth of about 90 degrees, it is situated nearly parallel to the shore in state and federal waters. The ridge lies in water depths that range from 40 to 60 ft.

Bunnel Ridge Field

The Bunnel Ridge Field (Figure 3-5B), occupying about 8000 ha (Table 3-1), lies wholly in Flagler County on the seaward margin of the Farmton Sand Flat. It is flanked on it seaward margin by the Flagler Sand Wave. Lying on the Middle Shelf Floor, the ridge field occurs in water depths that range from 52 to 72 ft. The ridge field occurs about 5 miles to 6.2 miles offshore.

Crescent Ridge Field

The Crescent Ridge Field (Figure 3-5A), occupying about 9000 ha (Table 3-1), occurs offshore the southern part of St. Johns County. It is flanked shoreward by the Farmton Sand Flat and seaward by the Summer Haven Sand Wave and Espanda Ridge Field. Lying on the Inner Shelf Floor, the ridge field occurs in water depths that range from 52 f. to 65 ft. The ridge field occurs about 4.3 to 6.2 miles offshore.

Duval Ridge Field

The Duval Ridge Field (Figures 3-5A and 3-8), occupying about 142,000 ha (Table 3-1), is a very large mapping unit on the continental shelf that extends offshore from Nassau County, through Duval County, and into central St. Johns County. The unit is flanked on its shoreward margins by the Farmton Sand Flat. It seaward margins merge with the Nassau Bank, Sawgrass Bank, and Undifferentiated Seafloor with Transverse Ridges. This massive ridge field, approximately 12.4 miles long by about 16 miles wide, occurs in water depths that range from 40 ft to 85 ft mostly on the Inner Shelf Floor. Most sand ridges occur in federal waters but parts of some extended down current fingers occur in state waters. As shown in Figure 3-7, the Duval Ridge Field is a large shore-parallel mapping unit that contains numerous sand ridges. The ridges, interspersed by valleys, form a ridge-and-valley topography that becomes more shoal-like, with distance south. Shoreward margins of the ridge field are dissected into discrete downdrift-trending segments that surmount the Farmton Sand Flat.

Edgewater Ridge Field

The Edgewater Ridge Field (Figure 3-5B), occupying about 16,000 ha (Table 3-1), occurs offshore southern Volusia County. The ridge field, lying about 3.7 to 6.2 miles offshore, is flanked on shoreward margins by the Farmton Sand Flat and on seaward margins by the Volusia Bank. No part of the ridge field occurs in state waters.

Fort Clinch Ridge Field

The Fort Clinch Ridge Field (Figure 3-5A) is a small area of ridge sets that occupy about 6000 ha (Table 3-1). The ridge field occurs offshore southern Nassau County on inner shelf floor. Lying about 3.73 mi offshore, the ridge field surmounts the Farmton Sand Flat, which surrounds this mapping unit. Ridges in the unit increase in size with distance north, becoming markedly pronounced north of the Florida-Georgia state line.

The unit, which is bifurcated into a larger northern segment and a smaller southern segment, is a discontinuous extension of the Amelia Sand Ridge to the south, being separated from it by a narrow 1/2 mile wide corridor of the Farmton Sand Flat. One large sand ridge on the southwestern margin of the mapping unit extends across the Farmton Sand Flat into the Talbot Transverse Bar field.

Espanda Ridge Field

The Espanda Ridge Field (Figure 3-5A), occupying about 3400 ha (Table 3-1), occurs offshore southern St. Johns County and northern Flagler County on Middle Shelf Floor. Lying about 6.2 miles offshore, the ridge field is flanked on its shoreward margins by the Farmton Sand Flat and Crescent Ridge Field. Seaward margins merge with the Palm Coast Sand Wave. No part of the ridge field occurs in state waters.

Korona Ridge Field

The Korona Ridge Field (Figure 3-5A), occupying about 21,000 ha (Table 3-1), occurs mostly on the Inner Shelf Floor offshore southern Flagler County and northern Volusia County. The unit is flanked on its seaward margin by the Volusia Bank and shoreward by the Farmton Sand Flat. Lying about 5 miles to 7.5 miles offshore, no part of the ridge field occurs in state waters.

SHOALS

A shoal is a shallow place in a body of water, more specifically a sandy elevation of the bottom of a body of water, constituting a hazard to navigation; a sandbank or sandbar. The term also includes a stretch of shallow water full of submerged reefs or sandbanks; "reefy shallows"; "shoaly waters" [synonyms: reefy, shelfy, shelvy, shoaly]. As applied in this study of bottom types and sand resources, the term shoal is used in a loose geomorphological sense to denote an area that lies at a shallower depth than the surrounding isobaths. In some cases, the shoals are comprised by broad singular sand ridges that are more or less equant in shape and isolated from other ridges. Three shoals are recognized in the study area: Allandale, Beverly, and Oak Hill.

Allandale Shoal

The Allandale Shoal (Figure 3-5B), occupying about 675 ha (Table 3-1), occurs on the Inner Shelf Floor off northern Volusia County in about 52 ft water depth. This small shoal, an enclave within the Farmton Sand Flat, lies mostly in federal waters but its shoreward extent occurs in state waters. Lying about 2.5 miles offshore, the shoal represents a positive relief feature on the otherwise normally topographically subdued surrounding sand flat.

Beverly Shoal

The Beverly Shoal (Figure 3-5A and B), occupying about 1200 ha (Table 3-1), occurs on the Inner Shelf Floor off central Flagler County. This small shoal, an enclave within the Farmton Sand Flat, lies mostly in federal waters but its shoreward extent occurs in state waters. Lying about 2.5 miles offshore, the shoal represents a positive relief features on the otherwise normally topographically subdued surrounding sand flat.

Oak Hill Shoal

The Oak Hill Shoal (Figure 3-5B), occupying about 1800 ha (Table 3-1), occurs in the Inner Shelf Floor off Volusia County. This small shoal, an enclave within the Farmton Sand Flat, lies mostly in state waters but its seaward extent occurs in federal waters. Lying about 2.5 miles offshore, the shoal represents a positive relief feature on the otherwise normally topographically subdued surrounding sand flat.

BANKS

The term ‘bank’ generally refers to extensive sandbanks that are covered by shallow water, but most usage tends to be somewhat vague. Although banks occur throughout all the oceans (Agassiz, 1880; Illing, 1954; Ginsburg and James, 1974; Stride *et al*., 1982), the definition is problematic. Most banks, however, are characterized as platforms that show a very large diversity of morphology and structure, from extremely wide carbonate systems (*e.g*. Great Bahamas Bank), to narrow oceanic reefs, (*e.g.* Les Glorieuses, France, Indian Ocean), and to atolls (*e.g*. Chinchorro Bank). Intuitively, banks should be almost entirely submerged when compared to atolls and other oceanic reefs. Reef formations were frequently named "banks" to refer principally to an area of shallow water. Lack of early clear geomorphological references and different administration likely explain the lack of consistency and homogenization. In any case, in this study, the term bank refers to sediment platforms that lie at relatively or comparatively shallower depths than the surrounding seafloor and which are generally characterized by low local relief and monotonous seafloor surface. Five banks are defined in this study: Nassau, O’Neal, Sawgrass, St. Johns, and Volusia banks.

Nassau Bank

The Nassau Bank (Figure 3-5A), occupying about 55,000 ha (Table 3-1), occurs on the Middle and Outer Shelf Floors off Nassau and Duval counties. The bank, more or less equant in shape, ranges up to 34 miles in length by 9 miles in width. Lying about 18 miles offshore in water depths that range from 52 to 98 ft, the bank takes up a relatively large area of seafloor that is flanked shoreward by the Duval Ridge Field and seaward by Undifferentiated Seafloor with Anastomosing Ridges. The downdrift extended arms of the southeast-northwest trending bank interdigitate with the northeast-southwest trending Sawgrass Bank. Average water depths on the bank range from 65 ft to 92 ft.

O'Neal Bank

The O'Neal Bank (Figure 3-5A), occupying about 31,000 ha (Table 3-1), occurs on the Middle and Outer Shelf Floors off Nassau and Duval counties. The bank, more or less equant in shape, ranges up to 16 miles in length by 15 miles in width. Lying about 25 miles offshore in water depths that range from 60 ft to 90 ft, the bank takes up a relatively large area of seafloor that is flanked shoreward by the Nassau Bank and seaward by Undifferentiated Seafloor with Anastomosing Ridges. Sand ridges surmount the general level of the rolling bank surface on its northern margin along the Florida - Georgia state line. Bank morphology in this mapping unit differs from that of the adjacent Nassau Bank in that it lacks surface expression of underlying structural control. Average water depths on the bank range from 65 ft to 78 ft.

Sawgrass Bank

The Sawgrass Bank (Figure 3-5A), occupying about 87,000 ha (Table 3-1), is a northeast-southwest trending bank that extends from the Inner Shelf Floor to the Outer Shelf Floor. At its closest point, the bank is about 10.5 miles offshore, but it extends up to 49 miles offshore on its seaward margin. The bank is flanked shoreward by the Duval Ridge Field, to the north by Nassau Bank and Undifferentiated Seafloor with Anastamosing Ridges, and to the south by Undifferentiated Seafloor with Transverse Ridges. Water depths on the bank range from 59 ft to 110 ft. As depicted in Figure 3-8, the Sawgrass Bank is an area of extensive sandy bottom with smooth rolling topography that is punctuated by sand ridges that surmount the general level of the bank. Sand ridges are less prominent on the seaward extension of the bank.

St. Johns Bank

The St. Johns Bank (Figures 3-5A and 3-5B) is a large offshore mapping unit that occupies about 137,000 ha (Table 3-1). The bank occurs about 18 to 30 miles offshore and is about 112.5 miles wide by 43.5 miles long. On its seaward margin, it merges with Undifferentiated Seafloor with Sand Ridges. To the north it is cut off by the Undifferentiated Seafloor with Transverse Ridges and to the south by the Flagler Sand Bank and the Volusia Bank. On its shoreward flanks, the bank merges with the Summer Haven Sand Wave, the Palm Coast Sand Wave, and the Flagler Sand Wave. Water depths on the bank range from 78 ft to 105 ft.

Volusia Bank

The Volusia Bank (Figure 3-5B) occupies about 167,000 ha on the Middle and Outer Shelf Floor from southern Flagler County through offshore Volusia County. The bank occurs about 6 miles to 8 miles offshore and is about 15.5 miles wide by 50 miles long. On its seaward margin, it merges with Undifferentiated Seafloor with Sand Ridges. To the north it is cut off by the Flagler Sand Wave. Shoreward, the mapping unit is flanked by the Farmton Sand Flat, except where intervened by the Korona Ridge Field and Edgewater Ridge Field. Water depths on the bank range from 52 ft to 105 ft. As depicted in Figure 3-9, the Volusia Bank is a large shore-parallel bank that is surmounted by widely-spaced transverse sand ridges. Shoal areas occur in the southern part of the bank offshore from R200 to R230.

Sand Waves

Sand waves are types of sand structures that are commonly observed on an offshore seabed. From a geological point of view, a submarine sand wave is a large ridge-like primary structure resembling a water wave on the upper surface of a sedimentary bed that is formed by high-velocity air or water currents (Van Veen, 1935; Harvey, 1966; McCave, 1971; Terwindt, 1971; Ludwick, 1972; Caston and Stride, 1973; Boggs, 1974; Bokuniewicz, Gordon and Kastens, 1977; Allen, 1980; Field et al., 1981; Fenster et al., 1990). In a kumatological sense, sand waves were recognized in early research as being related to the process of sand bank formation (Cornish, 1899; 1901a, b), and part of the larger study of waves and wave-structures. Sand waves are in general characterized by downcurrent migration, as described by Hennings *et al.* (2004) for typical occurrences in the North Sea, where they observed complex configurations of different bedforms in four-dimension in space and time using radar and optical mapping methods. The sand waves occurring offshore the Florida northeast Atlantic coast are mega-sand waves in the sense they form large-scale features that are many miles across. A fair impression of the waveform, depicted in the location diagrams (Figures 3-1, 3-2, and 3-3) offshore St. Johns and Flagler counties, is emphasized by large volumes of sand being moved southwards by currents. Three large sand waves, representing major submarine geomorphological features, are defined in this study as the Flagler, Palm Coast, and Summer Haven sand waves.

Flagler Sand Wave

The Flagler Sand Wave (Figure 3-5B) contains east-west extending morphosedimentary features that occupy about 57,000 ha. Occurring about 10 to 25 miles offshore, the sand wave is about 22 miles wide (E-W extent) by 14 miles long (N-S extent). It is bounded seaward by the St. Johns Bank, to the north by the Palm Coast Sand Wave, and to the south by the Flagler Sand Bank and the Korona Ridge Field. Shoreward, the bank is truncated by the Bunnel Ridge Field. Water depths on the sand wave range from 52 ft to 85 ft.

Palm Coast Sand Wave

The Palm Coast Sand Wave (Figures 3-5A and 3-5B) is an east-west extending morphosedimentary features that occupies about 25,000 ha. Occurring about 7.5 to 10 miles offshore, the sand wave is about 18 miles wide (E-W extent) by 6 miles long (N-S extent). It is bounded seaward by the St. Johns Bank, to the north by the Summer Haven Sand Bank, and to the south by the Flagler Sand Wave. It is bounded shoreward by the Espanda Ridge Field. Water depths on the sand wave range from 60 to 90 ft.

Summer Haven Sand Wave

The Summer Haven Sand Wave (Figure 3-5A) an east-west extending morphosedimentary features that occupies about 56,000 ha. Occurring about 6 to 9 miles offshore, the sand wave is about 28 miles wide (E-W extent) by 6 to 12 miles long (N-S extent). It is bounded seaward by the St. Johns Bank, to the north by Undifferentiated Seafloor with Transverse Ridges, and to the south by the Palm Coast Sand Wave. It is bounded shoreward by the Crescent Ridge Field. Water depths on the sand wave range from 52 to 91 ft. As shown in Figure 3-10, the Summer Haven Sand Wave is a shore-perpendicular sand wave with a strongly dissected distal southern margin. This clip of the overall terrain model shows the geographic position of the sand wave on the shelf in relation to surrounding morphological units. Although the bank surface contains some widely spaced sand ridges, its main character can be summarized in terms of a large shoal area along its proximal northern half and eroded southern segment. As with many other morphosedimentary units in the study area, the Summer Haven Sand Wave is surmounted by large sand ridges.

These large ridges are more or less pervasive throughout the shelf area and do not change the overall character of the recognized mapping unit. In the example seen here, it is clear that most mapping units are complex intergrades that retain vestiges of prior development earlier in the Holocene when sea level was lower and the shoreline was farther seaward. Rising sea levels throughout the Holocene brought changing environmental conditions that modified the surface of the sand wave in the form of more recent sand ridges transgressing relict forms. The sequence of events is shown in Figure 3-10.

Undifferentiated Seafloor

Part of the study area could not be adequately depicted in the three-dimensional terrain model. These locations mostly include seaward portions of Zones D and F (Figure 3-4, Data Reliability Zone Map) where bathymetric data spacing was on the order of 1000 to 1500 feet. Only large-scale features with dimensions on the order of several thousands of feet can be differentiated when analyzing the low spatial resolution data. Unless there was a salient or pronounced bathymetric feature such as a large sediment ridge, broad expanses of seafloor were thus shown as more or less homogenous spatial entities that could not be differentiated on the basis of bathymetric inequalities that could be interpreted in terms of discrete (individual) landforms or landform assemblages.

Sediment ridges in Zones D and F attained sufficient local relief to be distinguished from surrounding seafloor. Local relief was generally in the range 6.5 to 13 ft to show up at nominal mapping scales. Three distinct spatial patterns of sediment ridges occur in these offshore areas: ridges that run transverse to the shore, more or less parallel to the shore, and ridges that divide and re-intersect (anastamosing configuration). Large areas of seafloor are unremarkable, except for the distinct ridge patterns that are so evident in the bathymetric model (*e.g*. Figure 3-3).

Undifferentiated Seafloor with Transverse Ridges

This complex shore-normal deepwater seafloor region (up to 40 miles in length, extending in a NE-SW direction) retains ridges that are up to 9 miles in length (Figure 3-5A). The dominant directions of ridge crests range from 45° to 50° azimuth (Table 3-1). This seafloor zone also contains numerous dissected small bank areas on the shoreward part of the outer shelf floor and on the middle shelf floor. Relatively flat expanses of seafloor (as mapped at this scale) occur between ridges in water depths ranging from 65 to 90 ft. Local relief of the ridges ranges up to 20 ft. The mapping unit is bounded along its northern boundary by the Sawgrass Bank and to the south by St. Johns Bank and the Summer Haven Sand Wave.

Undifferentiated Seafloor with Linear Sand Ridges

This mapping unit is a complex shore-normal deepwater seafloor region with sediment ridges (Figures 3-5A and 3-5B), up to 9 miles in length, that show dominant 45° to 50° azimuths (Table 3-1). Most ridges are rectilinear, but some are slightly curvilinear in planform, especially in the southern part of the unit. The offshore zone, about 9 miles wide by about 40 miles long, occurs along the seaward margins of the study area from central St. Johns County to southern Volusia County in water depths that range from 78 to 130 ft. Extensive low local-relief seafloor intervenes between ridges. Shoreward margins of the mapping unit merge with the St. Johns Bank and Volusia Bank. To the north, the unit is terminated by transverse ridges on undifferentiated seafloor offshore central St. Johns County.

Undifferentiated Seafloor with Anastomosing Ridges

Anastomosing sediment ridges occur in the northeast part of the offshore study area off Nassau and Duval counties (Figure 3-5A). This mapping unit occupies an offshore area of about 25 miles by 27 miles and contains sediment ridges that range up to about 9 miles in length (Table 3-1). This complex deepwater seafloor region, which contains numerous ridges that separate and re-unite, also features small bank areas and undifferentiated low-relief topography. The ridges stand about 13 ft above the surrounding seafloor. Occurring in deep water ranging from 65 ft to 110 ft, the mapping unit is flanked along its shoreward margin by the Nassau Bank and on its southern boundary by the Sawgrass Bank. Relatively flat expanses of seafloor (as mapped at this scale) occur between ridges in water depths ranging from 90 ft to 105 ft. Local relief of the ridges ranges from 6.5 to 20 ft.

PREVIOUS BEACH NOURISHMENTS

Numerous beach nourishments have taken place along the northeast Florida Atlantic coast. The few beach nourishment projects discussed below are but brief summaries of files obtained from the Bureau of Beaches and Coastal Systems (Tallahassee, Florida). Additional information for the beach nourishments in Nassau, Duval and St. Johns counties (five projects) can be obtained from the Florida Department of Environmental Protection's Beach Erosion Control Project Monitoring Database Information System (http://beach15.beaches.fsu.edu/). The summary table developed here for the study area puts the lengths of beach renourishment projects into perspective, relative to length of beachfront and project length (Table 3-7). Total beach length in the study area (all five counties) amounts to 768,966 ft (~145 miles). Flagler and Volusia counties respectively contain 95,741 ft and 259,051 ft of beachfront, but are not included in Table 3-7 because no beach renourishment projects were on file in the Beach Erosion Control Project Monitoring Database Information System.

It is interesting to note that about one-quarter of the beach lengths in Nassau and Duval counties have been protected by beach renourishment. The percent of shoreline protected by renourished beaches for the study areas as a whole is rather small, mainly due to the fact that projects are not recorded for the southern-most two counties (Flagler and Volusia counties).

Nassau County South Amelia Island

The South Amelia Beach Restoration project included about 2,600,000 cy that was placed between R060 and R078 (19 32 ft shoreline length) in 1994 (Figure 3-6A, Table 3-7). The volume density was estimated to be about 153 cy/ft along about 26.34% of county beachfront. The borrow source was located about 3000 to 3900 ft offshore the south end of the project. The South Amelia Island Design Parameters project (May to September 1997) took place between R073 and R078 (1273 m). The volume placed was about 300,000 cy giving a volume density of about 67 cy/ft. The borrow source was the Intracoastal Waterway through Nassau Sound. The South Amelia Island Shore Stabilization, Phase I – Beach Restoration project (June to September 2002) placed about 1,900,000 cy of fill between R060 and R079.5 (about 5679 m) to give a volume density of about 106 cy/ft. The borrow source was located about 4600 to 11,700 ft offshore the south end of the project.

Duval County

In the Duval County November 1995 Beach Nourishment project (Figure 3-6A, Table 3-7), about 1,187,279 cy of fill were placed (June to November 1995) between R045 to R080 (about 10,366 m shoreline length) along a coastal segment where the alongshore transport rate is estimated to be on the order of 111,000 cy per year to the south. The constructed berm width was 135 ft. The volume density was about 32 cy/ft along about 27% of county beachfront (Table 3-7).

St. Johns County

The St. Johns County Shore Protection project (Figure 3-6A, Table 3-7) took place between T132 and R152, from September 2001 through January 2003, along 3.8 miles (6136 m) of beach. The volume placed was about 4,383,000 cy to give a volume density of about 218 cy/ft. The average construction beach width was about 315 ft (construction berm width of about 200 ft). The longshore drift rate is estimated to be between 200,000 and 300,000 cy/yr. The borrow source was the St. Augustine ebb-tidal delta.

AREAS NOT TESTED ENOUGH TO DETERMINE SAND RESOURCE POTENTIAL

Large areas of the continental shelf were covered by low-resolution NOAA bathymetry that could not be reformatted to grid spacing closer than 1000 feet (Zone D) or 1500 feet (Zone F). As a result, large tracts had to be mapped as undifferentiated seafloor in federal waters. The area accounts for about 409,860 ha seaward of the state-federal boundary (Table 3-8) and is comprised by the following mapping units: Undifferentiated Seafloor with Anastamosing Ridges

(133,671 ha), Undifferentiated Seafloor with Transverse Ridges (101,440 ha), and Undifferentiated Seafloor with Linear Sand Ridges (174,749 ha). Of the total federal shelf area mapped, about 30% is comprised by the Undifferentiated Seafloor mapping unit (Table 3-8).

For state waters, the problem of low resolution bathymetric data is most prevalent in northern Nassau County where there are no surveys based on 500-foot data spacing (Zone C). A small nearshore section occurs as an extension of Zone A along the northern coast of Nassau County. New, more detailed bathymetric surveys are required in these areas to estimate sand resource potentials. Perusal of Figures 3-5A and 3-5B indicates that there is no reason to suspect that the seafloor mapped as 'undifferentiated' is any different than adjacent areas. The fact that large-scale banks, sand waves, and ridge fields could be interpreted from the low resolution bathymetric data in 'undifferentiated' areas indicates that similar features are likely to occur in these areas and that they will be identified using the new bathymetry. With the present bathymetric data, it is not possible to produce reliable interpretations of seafloor morphologies in areas now designated as 'undifferentiated' (Zone D), except for the presence of large-scale bathymetric features such as mega sand ridges.

Most of the shelf area based on reformatted NOAA data in Zone D contains acquisition bathymetric data points that are too widely spaced for meaningful interpretation of seafloor morphology. Except for shelf areas in northern Nassau County, most of the Undifferentiated Seafloor mapping unit occurs seaward of the 3-mile limit and extends to the seaward mapping boundary at 147 ft isobath. Mapping of morphosedimentary units in Zone C is considerably more reliable than seaward data grids. New estimates of potential sand resources on the continental shelf along the northeast Florida Atlantic coast will undoubtedly increase if new bathymetric data is obtained at grid scales of 500 feet or less.

For the remaining areas of seafloor that have been interpreted in terms of morphosedimentary units (*i.e*. transverse bars, ridge fields, sand flats, banks, sand waves, and shoals), it is emphasized that the interpretations are based on reconnaissance NOAA bathymetry that was reformatted to closer grid spacing where possible. Assumptions were made as to the thickness of sedimentary bodies, based on local relief as measured from the bathymetry. These assumptions, summarized in Tables 3-2 through 3-6, provided a means of measure for this reconnaissance survey but require refinement for more detailed investigations.

Numerous small detailed bathymetric surveys occur throughout the offshore zone in Nassau, Duval, and St. Johns counties. These survey areas are shown along with Minerals Management Service (MMS) seismic reflection profiling surveys in Figures 3-7A and 3-7B. Collectively, these more detailed surveys cover small parts of the following morphosedimentary features: Fort Clinch Ridge Field, Amelia Sand Ridge, Duval Ridge Field, Farmton Sand Flat, and the Espanda Ridge Field. MMS seismic surveys also cover small segments of the O'Neal Bank, Nassau Bank, Sawgrass Bank, Summer Haven Sand Wave, Palm Coast Sand Wave, Flagler Sand Wave, and Bunnel Ridge Field. Thus, in some way and at various levels of investigation, parts of morphosedimentary features in federal waters from the 3-mile limit to about 11 miles seaward have been studied. These areas require more detailed study to better estimate potential sand resources. Nevertheless, at this point it is possible to identify salient morphological features that are obvious targets that are in addition to or partly included in MMS surveys.

In order to narrow down future searches for potential sand resources, areas of interest are identified here in terms of primary search areas that occur shoreward of the 3-mile limit and secondary search areas that occur seaward of the state-federal boundary. Primary search areas, indicated by red-colored polygons, are discussed for the nearshore zone by reference to Figures 3-6A and 3-6B. Offshore secondary search areas identify search areas that are beyond the state-federal boundary ranging from 5 to 21 miles offshore. This arbitrary offshore distance is based on the premise of keeping dredging costs down by looking at potential sand resources closer to shore rather than farther from shore. Because potential sand resources contained in ridge fields, banks, and sand waves extend long distances offshore, potential search areas more seaward can be identified at a later point in time if the sites closer to shore do not prove out. Some areas of interest identified here have been variously sampled or studied at different levels of investigation. The areas identified are thus not exclusive of previous investigations but should nonetheless be (re)examined in closer detail than the information that is now generally available.

Surveys that are more detailed will no doubt identify additional areas to be looked at more closely. In the case of the Farmton Sand Flat, for example, it is quite possible that diabathic channels may occur alongshore as was the case in Palm Beach County. These features, described by Finkl, Benedet and Andrews (2006) and Finkl and Andrews (2007), contain good quality beach sand and are viewed as a new sand source for beach nourishment that lies close to shore. The present scale of reformatted NOAA bathymetry does not show these smaller-scale bed features on the sand flats, if they indeed exist in the study area. For now, the following areas of interest should be regarded as worthy of future survey for beach-quality sands.

Areas of Interest in State Federal Waters Offshore Nassau County

The following areas within the 3-mile limit, identified by morphosedimentary features, should be investigated more carefully: Talbot Transverse Bar field (R040 to R080) and St. Mary's Ebb-Tidal Delta (R000 to R035). Morphosedimentary features seaward of the 3-mile limit that should be studied in more detail for sand resource potential include the Fort Clinch Ridge Field (3.7 to 7.5 miles offshore), the Amelia Sand Ridge (4.9 to 7.5 miles offshore), and part of the Duval Ridge Field (5.5 to 10.5 miles offshore) (Figure 3-6A). Although the preceding three seafloor features were partly investigated by MMS seismic reflection profiling, individual ridges in these ridge fields (within the yellow-colored polygons) should also be surveyed in more detail.

Areas of Interest in State Waters Federal Offshore Duval County

The following areas of interest within the 3-mile limit, identified by morphosedimentary features, should be investigated more carefully: Amelia Sand Ridge (2.5 miles offshore), Talbot Transverse Bar field (bars extending seaward of the Tisonia – Nassau Sound Ebb-Tidal Delta), and Farmton Sand Flat (specific areas not shown, but where there are sequences of subdued sand ridges) (Figure 3-6A).

Seaward of the 3-mile limit, individual sand ridges throughout the Duval Ridge Field require more detailed investigation, especially on the shoreward shoaling flanks of the ridge field demarcated by the yellow-colored polygon outline (3.7 to 10.5 miles offshore).

Areas of Interest in State Federal Waters Offshore St Johns County

Obvious areas shoreward of the 3-mile limit to further investigate include sand ridges of the Duval Ridge field offshore from R000 to R010, R020 to R050, and R120 to R145 (Figure 3-6A).

The subdued ridge extension from R055 to R100 on the Farmton Sand Flat off the northern distal flank of the St. Augustine Ebb-Tidal Delta along with the individual ridges in the Duval Ridge Field seaward of the 3-mile limit (up to 9 miles or so offshore) should be further investigated for potential sand resources. Individual ridges within the Crescent Ridge Field (about 6 miles offshore) should be additionally tested for sand resource potential.

Areas of Interest in State & Federal Waters Offshore Flagler County

The Beverly Shoal (Figure 3-6B) is the most obvious area that should be investigated shoreward of the 3-mile limit. This morphosedimentary feature has been investigated by the MMS seaward of the state-federal boundary. Other seafloor features partially surveyed by MMS seismic reflection profiling include the Espanda Ridge Field, the Bunnel Ridge Field and the Flagler Sand Wave.

Areas of Interest in State & Federal Waters Offshore Volusia County

Morphosedimentary features lying in state waters off Volusia County that should be further investigated for sand resource potential include the Allandale Shoal (R090 to R105), Oak Hill Shoal (R200 to R230), and Canaveral Transverse Bar field (Figure 3-6B) just north of the Volusia – Brevard county line. Parts of the Allandale and Oak Hill shoals lying in federal waters should also be studied for sand resource potential. Shoreward parts of the Korona Ridge Field (Figure 3-6B), lying about 3.7 to 5 miles offshore (R020 to R120), and the Edgewater Ridge Field (R120 to R165 and R200 to 240), as well as a shoal portion of the Volusia Bank (offshore R200 to R230) (about 11 miles offshore) about 1.2 miles seaward of the seaward of the Edgewater Ridge Field. These determinations were made from a review of existing data where applicable or from interpretation of the bathymetric features seen in figure 3-4.

PROMISING AREAS NOT PREVIOUSLY INVESTIGATED

Sand flats occur in state waters on the northeast Florida Atlantic coast. At the present scale of mapping and grid spacing of bathymetric data (500-foot NOAA data reformatted to a regular 250-foot grid in Zone C), it is not possible to reliably break down the sand flat units into smaller morphosedimentary units. More detailed bathymetry of the shelf area under state jurisdiction will permit interpretation of seafloor features that will contain the same kinds of morphosedimentary bodies already identified in adjacent areas (as occur along the central Florida Atlantic coast) where bathymetric control is sufficient for feature recognition. At this juncture, it is not possible to single out potential sand targets on sand flats that would have priority over more obvious sand resources as occur in ridges, banks, sand waves, and shoals. Nevertheless, sand flats contain enormous sediment volumes and they should not be neglected as potential sand resources, especially when they occur close to shore.

An important consideration in the appraisal of areas not previously investigated is the recognition of mapping unit homogeneity. The location maps showing seafloor physiographic units (Figure 3-4) and the subdivision of these units by the characteristics of their sedimentary covers in the form of morphosedimentary units (Figures 3-5A and 3-5B) contains broad-scale reconnaissance mapping units. These mapping units are mostly made up of complex sedimentary bodies that have more than one morphological expression. That is, swales or intervening lower-elevation areas must exist in order for a unit to have positive topographic expression. Mapping units for ridge fields thus comprise ridge and swale topography and may include wider lower-lying areas between sand ridges. Spacing of NOAA bathymetric grids determines what can be extracted from the bathymetric data giving limits to levels of interpretation.

Since most areas that have not been previously investigated have no detailed bathymetric surveys, this study relied on broadly spaced bathymetric data points. The quality of the mapping units would be increased by re-surveying the continental shelf area. The reformatting of the NOAA bathymetric data was a stopgap effort to extract as much information from the digital files as possible. Digital geospatial information in the form of bathymetric data to a large extent determined the scale of observation and the level of classification of seafloor features.

The precision of any predictions (*e.g*. targets for future sand searches) that are made using the classification presented in this study is dependent on the homogeneity of the mapping unit and on the spatial variability within mapping units. The spatial variability is typically not ascertained, and without a measure of the spatial variability within each mapping unit, little is known regarding the reliability of the modal morphosedimentary unit. Continuous classification is made possible by using different types of geostatistical tools that are capable of accounting for the continuous nature of mapping units and allow an individual morphosedimentary unit to be assigned totally, partially or not at all to a particular class. For the purposes of this study, the typology that resulted from visual inspection of bathymetric patterns was considered adequate for reconnaissance work.

Promising areas not previously investigated as borrows for beach renourishment include the primary and secondary areas of interest previously identified in Figures 3-6A and 3-6B. Although these areas are not strictly 'not previously investigated' because some MMS seismic reflection profiling lines occur in part of some morphosedimentary units, the features identified here should be investigated in more detail to determine their sand resource potential.

LIMITATIONS OF SAND RESOURCE POTENTIALS

Sand resource potentials are limited by the quality of the bathymetric data that were used to interpret seafloor features. Because the grid spacing of data points varied with bathymetric surveys, seafloor topography was not mapped uniformly over the study area. Large areas of the continental shelf contained low resolution (widely spaced data points) bathymetric data and it was not possible to reliably interpret seafloor features. These areas were mapped as undifferentiated seafloor, that is, they were not interpreted. From the 3-mile limit to the 150 ft isobath, about 409,860 ha were not mapped (except for large sand ridges) due to low resolution bathymetric data (Table 3-8).

Of the morphosedimentary features that were mapped (for areas see Table 3-8), several assumptions were made regarding unit thickness. Local relief, determined from the digital bathymetric maps in a GIS platform, was acquired for each type of morphological feature and noted as a minimum, maximum, and average. This information was presented by morpho-sedimentary feature by county in a series of tables, Nassau County (Table 3-2), Duval County (Table 3-3), St. Johns County (Table 3-4), Flagler County (Table 3-5), and Volusia County (Table 3-6). In addition to local relief, another variable was the estimated mean areal coverage of sediment ridges *per se* in the ridge field mapping unit. Actual ridges might cover only 30% of the ridge field mapping unit, for example, and so it was important to disclose the estimate of areal coverage. Error in the estimation of percent coverage would affect volume calculations.

Sand resource potentials also depend on interpretation of seafloor topography in terms of morphosedimentary units such as sand ridges, shoals, sand flats, transverse bars, *etc*. The morphological interpretation is based on experience and requires familiarity with marine geomorphology and topographic expression as depicted in bathymetric data. Whether a particular unit is interpreted as a shoal, bank, sand wave, or ridge field may not be as crucial as recognition of a positive relief feature and its spatial relationships with surrounding relief forms. Thus, the salient point here is recognition of morphosedimentary features and determination of their morphometric properties, which are in turn used to calculate sediment volumes.

In sum, there are thus several caveats related to interpretation of bathymetric features and calculation of potential sediment volumes. In a general reconnaissance survey such as this, recognition of primary features is a first cut in the bathymetric data in hand. Work that is more detailed will improve spatial delineation and volume calculations.

DISCUSSION

There are many ways to describe seafloor conditions, ranging from remote sensing techniques to actual physical sampling. Depending on the nature of the information that is being sought, several techniques are commonly used in conjunction in order to acquire the most complete information possible. Typical remote sensing techniques focus on tomographic approaches where slices of sub-bottom are obtained in cross-section as, for example, in seismic reflection profiling. Images of the seafloor surface are often obtained by sidescan sonar surveys and physical samples are acquired for geotechnical purposes via grab samples and vibracores. Bathymetric surveys provide information on water depth. In the present study area, most of these techniques have been applied at various levels of detail in different areas.

Because the purpose of this study was to attempt to locate areas of potential sand resources for beach nourishment, it was clear that data acquisition had to be based on techniques that provided information on the spatial distribution of seafloor features that could be interpreted in terms of bottom types. The survey procedures had to be regional in scope and the scale requirement eliminated seismic reflection profiling due to its limited scope along track lines. Sidescan sonar surveys were not available, but there was complete bathymetric coverage of the entire study area. The presence of NOAA bathymetric data points (ranging from surveys in 1929 through 1999) throughout the study area was good news. The bad news was that the survey grid spacing was highly variable, ranging from data points spaced 1000 to 1500+ feet apart to small detailed surveys where data were acquired on 100-foot grids. Putting all this together in some sort of easy to map format presented quite a challenge, one that was eventually resolved by merging disparate data sets into one contiguous map sheet that contained different acquisition grid resolutions. Low resolution data occurred farther offshore with more detailed survey data lying closer to shore and especially in navigational corridors to major ports. Settling on a compromise grid spacing of about 250 feet, the NOAA bathymetric data sets were reformatted into a single new data set that integrated numerous prior surveys into a new map of seafloor topography. A Data Reliability Zone Map was thus created for the study area to show how the data sets were compiled (see Figure 3-4, for example).

The resulting reformatted map based on modified NOAA bathymetry showed a myriad of morphological features, but in offshore areas data quality was generally degraded to the point where it was not possible to reliably identify bottom types beyond pronounced large-scale features such as sand ridges. Although Zone D bathymetric patterns are interpretable from widely spaced data points, it must be appreciated that more detailed descriptions are not possible here. Bathymetric detail associated with Zones A and C, for example, indicate that more closely spaced data points provide better spatial resolution of seafloor topography and that this detail most likely occurs throughout Zone D but cannot be seen in the present data. Nevertheless, it was still possible to subdivide the seafloor into distinct topographic regions where similar landforms were grouped. Similarly, because of these landform assemblages, it was possible to differentiate zones of dissimilarity and thereby regionalize spatial distribution patterns of bottom topography.

This explanation of mapping procedures is offered because of its importance to this project. Use of NOAA data that were not reformatted would not have produced usable maps that met the needs of this project. This procedure is thus emphasized because this project is based solely on the premise that the reformatted NOAA data sets and resulting maps of seafloor topography could be interpreted in terms of morphological units and backup collateral data from prior reports and geophysical-geotechnical surveys. Patterns of variation in seafloor topography were clear enough to distinguish recognizable morphologies that could be interpreted in terms of unconsolidated sedimentary deposits. Prior reports (*e.g*. Duane et al., 1972; Milliman, 1972; Swift et al., 1972; Field and Duane, 1974; Meisburger and Field, 1975; Dean and O'Brien, 1987; Hollister, 1985; Marino, 1986; Hine, 1997; Powell, Thieke, and Mehta, 2006; Finkl and Andrews, 2007) verify the general sedimentary nature of the shelf surface with widely distributed sand deposits, especially ridges, shoals, and ebb-tidal deltas. More recent studies of MMS seismic reflection profiles in the northern parts of the study area (in federal waters) verify the presence of sediment accumulation on the shelf floor (Phelps *et al*., 2007). The seafloor topography is thus interpreted as morphosedimentary units where shape and form are combined with material composition, mostly fine- to medium-grained sands.

These morphosedimentary units form the basis for mapping units on this sediment-rich continental shelf where there are very large accumulations of relict (mostly Holocene in age) sand deposits that take the form of sand ridges, banks, shoals, sand waves, or flats. This regionalization of the northeast Florida Atlantic continental shelf provides a rational basis for understanding and managing sand resources within the context of a geological model. Without the advantage of a geological model that shows spatial relationships between different types of seafloor units, it is not possible to make sense of a bewildering array of sub-bottom profiles, surface grab samples, and scattered vibracore logs. These maps of morphosedimentary features thus pull together a wide range of factors that bear on solutions for locating suitable sand resources. The maps provide feature continuity that was previously not available so that individual sand ridges, for example, can be identified and tracked in the spatial context of the geological model.

The geological model and associated morphosedimentary maps provide a rational basis for recommending future search areas where more detailed information would be useful for estimating sand resource potential. Whether in state or federal waters, the suggested areas for further investigation (Figures 3-6A and 3-6B) are logically based on known morphosedimentary features where further investigation would seem warranted. Sand resource potential can in this way be better estimated using the geological model in preference to blanket exploratory surveys that by chance cross over parts of morphosedimentary features.

There are limitations to applying the geological model to identify potential sand resources on the continental shelf. The model is based on reformatted NOAA bathymetry that cannot improve the input data. The model therefore provides a starting point for additional work that can be based on the morphosedimentary units already recognized. Anticipated future work should focus on refinement of the units already recognized. More detailed information obtained from meso- and micro-scaled survey work will increase the usefulness of this seminal description of seafloor mapping units along the northeast coast of Florida. More detailed surveys will supersede limitations of the present work by building on knowledge so far acquired by reformatting old NOAA bathymetric data.

Potential sand volumes were estimated by interpreting the reformatted NOAA bathymetry to produce a reconnaissance classification of bottom types in terms of morphosedimentary units. Morphometric properties of the various units were then determined in an effort to quantify volume estimates on a sound basis, even though the effort was conducted on large-scale features. Total sediment volumes indicated the presence of massive sand resources on the continental shelf. Summarized by county, total potential sand resources are: Nassau County (8.1 x 10^9 cy), Duval County (17.7 x 10^9 cy), St. Johns County (36.6 x 10^9 cy, Flagler County (11.8 x 10^9 cy), and Volusia County (28.4 x 10^9 cy). Although extensive sand resources occur in sand flats, the most easily extractable deposits are most likely associated with shoals, banks, bars, and ridges. Suggested sand targets worthy of more detailed investigation, as summarized in this report, are indicated as a first cut in regional assessments. Detailed studies in the form of strategic sand searches, as described by Finkl, Khalil and Andrews (1997) and Finkl and Khalil (2005), are required for more accurate determination of sand reserves. These volumes, determined from reconnaissance surveys, indicate the presence of significant offshore sand resources along the northeast Florida Atlantic coast of Florida.

Buried fluvial channels on the continental shelf have been mapped by the MMS and Florida Geological Survey off Nassau, Duval, and St. John counties (Phelps *et al*., 2007). The paleochannels are reported to contain variable quality sediments ranging from fine-grained materials to coarse sands that might be suitable for beach renourishment. The channels are covered by relatively thin overburden that could be removed to exploit the underlying fluvial sediments. Quantities of potential sediments in these paleochannnels are not yet quantified and so it is not possible to estimate the sand resource potential. In any case, there are so many other surficial morphosedimentary units that are worthy of more detailed investigation that they should be investigated first. Parts of the paleochannels are overlain by sand flats and sand ridges that are readily accessible to dredging, suggesting that the easiest (exposed on the surface of the seafloor) sand resources should be evaluated prior to or in conjunction with subsequent more detailed surveys. Although paleochannels on the continental shelf are always an option for further study, they are not recommended here as primary or secondary targets of study. As tertiary sand resources, the channels provide opportunity for further study as an ancillary resource.

CONCLUSIONS

By reformatting reconnaissance NOAA bathymetric data, it was possible to map large areas of seafloor along the central Florida Atlantic coast. Of the total survey area (1,470,718 ha; 5678 mi^2), about 409,860 ha (about 28% of the survey area) was designated as 'Undifferentiated Seafloor' due to low resolution bathymetric data. The remaining area (1,060,858 ha; 4096 mi^2) contained bathymetric grid spacing of sufficient density to identify large-scale seafloor features. These features were classified and mapped to produce a seafloor topology that would provide a basis for estimating sand resources. The unifying mapping principle was based on the shape, form, and spatial distribution patterns of morphologically similar features that could be grouped together in relatively homogeneous patterns. Since the shelf floor is dominated by sedimentary cover, the morphological units were interpreted as morphosedimentary units where form and material composition were indicative of dynamic coastal ocean processes. These morphosedimentary features, which were described in terms of bars, ridge fields, sand flats, sand waves, banks, shoals, and ebb-tidal deltas account for about 102.7 billion cubic yards of sediment that have potential as sand resources. Although sand flats are areally extensive and contain large sediment volumes, banks, shoals and ridge fields are also obvious targets for further study. It is recommended that geophysical surveys in federal waters be extended shoreward into state waters to better understand the nature and distribution of the morphosedimentary features that make up sand resource potential on the continental shelf. Additionally, more detailed bathymetric surveys in state and federal waters are required to better estimate spatial distribution patterns of sedimentary bodies that have potential as sand resources for beach nourishment.

Table 3-1.
Submarine physiographic units on the inner continental shelf (extending offshore to the 45-m isobath) along the northeast Florida Atlantic coast.

Physiographic Province	Morphometry[1]	Description	Comments/Source
Bars	Based on examples of: Davis (1994), Brooks (1982), Dean & O'Brien (1987), Konicki & Holman (2000), FitzGerald (2005)		
Talbot Transverse Bars	Bars 650 to 1600 ft wide, up to 1.8 mi long, 55 to 80° azimuth, (5974 ha).	Bar field 10 mi long by 3 mi wide, wavelengths about 1300 ft, 19 to 32 ft water depth, sand flat units interspersed between bars.	Defined in this work. Occurs on the shoreface updrift from the Tisonia – Nassau Sound delta. By-passing bars to the south.
Ridge Fields	Based on examples of: Stahl *et al.* (1974), Meisburger & Field (1975), Off (1976), Swift & Field (1981), Parker *et al*. (1982), Swift *et al.* (1984), McBride & Moslow (1991), Dyer & Huntley (1999), Snedden & Dalrymple (1999), Freedenberg *et al*. (2000), Finkl & Andrews (2007), Finkl, Benedet and Andrews (2007), Phelps *et al*. (2007)		
Amelia	Ridge 1.1 mi (south) to 2.8 mi (north) wide, 14 mi long, 90° azimuth, 2.5 to 3.7 mi offshore, 6.5 to 13 ft local relief (4,168 ha).	Main ridge field (3 mi by 6 mi) to north with one large downdrift extended finger, surrounded by sand flats.	Defined in this work. Occurs on the inner shelf floor.
Bunnel	Ridges .6 to 3 mi wide, 15.5 mi long, 90-100° azimuth, 5-6 mi offshore, 6.5 to 16.5 ft local relief (8438 ha)	Main ridge field (3 to 6.2 mi) to north with 3 main downdrift extended fingers, sand flats between ridges.	Defined in this work. Occurs on the middle inner shelf.
Crescent	Ridges 0.3 to 1.2 mi wide, 8 mi long, 90° to 100° azimuth, 4.3 to 6.2 mi offshore, 6.5 to 13 ft local relief (9268 ha).	Broad ridge field (3 mi by 3 mi) to north with 5 main downdrift extended fingers, sand flats between ridges.	Defined in this work. Occurs on the inner shelf floor.
Duval	Ridges 0.3 to 1.2 mi wide, up to 12.4 mi long, 290° azimuth, 6.2 mi offshore, 6.5 to 16.4 ft local relief (141,796 ha).	Broad ridge field (15.5 mi by 31 mi) to north with 6 main downdrift extended fingers, sand flats between ridges. Ridge field 58 mi long, from north to south.	Defined in this work. Occurs on the inner and middle shelf floors.
Edgewater	Ridges 0.3 to 0.75 mi wide, 1.8 mi long, wavelength about 0.3 mi, 40° to 60° azimuth, 3.7 to 6.8 mi offshore (15,979 ha).	Ridge field 25 mi long with 3 main downdrift extended fingers, sand flats between ridges.	Defined in this work. Occurs on the inner shelf floor.
Fort Clinch	Ridges 650 to 1640 ft wide, up to 3 mi long, wavelength about 650 to 1640 ft, 65° to 80° azimuths, 3.7 to9.3 mi offshore, 6.5 to 19 ft local relief (6070 ha).	Broad ridge field (5 mi by 5 mi) to north with 2 main section separated by sand flats between ridges.	Defined in this work. Occurs on the inner shelf floor.
Espanda	Ridges 0.1 to 0.3 mi wide, 1.2 mi long, 15° to 20° azimuth, 6.2 mi offshore, 6.5 to 13 ft local relief (3434 ha).	General north-south ridge field 18 km long, ridges per se traverse NE-SW, wavelengths about 650 to 1300 ft.	Defined in this work. Occurs on the middle shelf floor.
Korona	Ridges 0.1 to 0.3 mi wide, 0.6 to 2.5 mi long, 30° to 40° azimuth, 5 to 7.5 mi offshore, 6.5 to 13 ft local relief (21,479 ha).	Broad ridge field (3.7 by 8.7 mi) to north with 2 main downdrift extended fingers 13 mi long, sand flats between ridges, ridges transverse to the shore.	Defined in this work. Occurs on the inner and middle shelf floors.

Table 3-1.
Submarine physiographic units on the inner continental shelf (extending offshore to the 45-m isobath) along the northeast Florida Atlantic coast.

Physiographic Province	Morphometry[1]	Description	Comments/Source
Sand Flats	Based on examples of: Field & Duane (1974), Meisburger & Field (1975), Knebel (1981), Davis (1994), Warner (1999), Finkl & Khalil (2000), Finkl *et al*. (2003), Finkl & Warner (2004), Fenster (2005), Finkl, Benedet and Andrews (2007), Finkl & Andrews (2007)		
Farmton	Sand flat main trunk about 6 mi, ranges up to 12 mi wide in south, about 140 mi long, some low amplitude ridges 7.5 mi long (201,528 ha).	Extensive shoreface-attached sand sheet from Georgia border in Brevard County. Encroached upon by sand ridges and surrounds shoals on inner shelf floor. Water depth range MLW to65 ft.	Defined in this work. Occurs on the shoreface, inner shelf floor, and shoreward part of the middle shelf floor.
Sand Waves	Based on examples of: Harvey (1966), McCave (1971), Terwindt (1971), Ludwick (1972), Boggs (1974), Fenster *et al*. (1990)		
Flagler	Large shore-normal sand wave 22 mi EW extent by 14 mi NS extent, with long 3-9 mi ridges (85° azimuth) superposed, southern margin of sand body and ridges dissected into smaller ridges, dissected zone about 3 mi wide. Total area is 57,292 ha.	Broad E-W trending sand wave with superposed sand ridges and dissected distal margin. Local relief with-out ridges 6.5 to 13 ft, with ridges 6.5 to 13 ft, in dissection 6.5 to 13 ft. Water depths range from 52.5 ft to 85.3 ft.	Defined in this work. Occurs mostly on middle shelf floor with northeastern segment on the inner part of the outer shelf floor.
Palm Coast	Large shore-normal sand wave18 mi EW extent by 6 mi NS extent, with some long 1-3 mi ridges (85° azimuth) superposed, southern margin of sand body and ridges dissected into smaller ridges, dissected zone 3-5 mi wide. Total area is 25,434 ha.	Broad E-W trending sand wave with some super-posed sand ridges but mostly dissected surface. Local relief without ridges is 6.5 ft, with ridges 6.5-13 ft, in dissection 6.5 to 20 ft. Water depths range from 52.5 to 98.5 ft.	Defined in this work. Occurs on middle shelf floor with northeastern segment on the inner part of the outer shelf floor.
Summer Haven	Large shore-normal sand wave 28.5 mi EW extent by 6 mi NS extent, with some long 1.2 to 3 mi ridges (60°-75° azimuth) super-posed, dissected zone about 2.5 mi wide. Total area is 55,722 ha.	Broad E-W trending sand wave with a few super-posed sand ridges and dissected distal margin. Local relief on wave surface 6.5 to 13 ft., in dissection 6.5 to 19 ft. Water depths range from 52.5 to 92 ft.	Defined in this work. Occurs on inner shelf floor, middle shelf floor, and seaward segment on the inner part of the outer shelf floor.
Shoals	Based on examples of: Purdy (1961), Palmer and Wilson (1978), Penland *et al*. (1989), McBride *et al*. (1999)		
Allandale	Small shoal (1.2 mi wide by 3 mi long) oriented in NS direction, with small ridges (30° and 85° azimuths), 6.5 ft local relief (675 ha).	Shoal area comprised by a series of small isolated sand ridges surrounded by the Farmton Sand Flat. Water depths range from 46 to 52.5 ft.	Defined in this work. Occurs on the inner shelf floor.
Beverly	Small shoal (1.8 mi wide by 3 mi long) oriented in NS direction, with five small ridges (about 350° azimuths), 6.5 ft local relief (1248 ha).	Shoal area comprised by a series of small sand ridges, some of which are subdued extensions of longer ridges in the Farmton Sand Flat. Water depths range from 52.5 to 59 ft.	Defined in this work. Occurs on the inner shelf floor.

Table 3-1.
Submarine physiographic units on the inner continental shelf (extending offshore to the 45-m isobath) along the northeast Florida Atlantic coast.

Physiographic Province	Morphometry[1]	Description	Comments/Source
Oak Hill	Small shoal (1 to 1.2 mi wide by 6 mi long) oriented in NS direction, shoal centered on small ridges (45° and 50° azimuths), 20 ft local relief (1813 ha).	Shoal area comprised by a series of small isolated sand ridges surrounded by the Farmton Sand Flat. Water depths range from 40 to 60 ft.	Defined in this work. Occurs on the inner shelf floor.
Banks	Based on examples of: Agassiz (1802), Illing (1954), Ginsburg and James (1974), Stride *et al*. (1982)		
Nassau	Large NW-SE trending bank, 34 mi long by 7-9 mi wide, with very weak structurally controlled NW-SE trending ridge-and-valley sequences. (55,0000 ha)	Generally subdued surface relief, except long dissected central region and southern margin. Water depths range from 52 ft to 98 ft.	Defined in this work. Occurs mostly on the shoreward parts of the outer shelf floor.
O'Neal	Moderate sized shore-parallel bank with 15 mi E-W extent by 17 mi N-S extent, traversed by low-relief sand ridges, NW part slightly dissected. 13 ft local relief (31,039 ha).	Generally rolling surface but with some areas of ridges in northern part of unit, shoaler than adjoining Nassau Bank. Water depths range from 59 to 92 ft.	Defined in this work. Occurs partly on the seaward part of the inner shelf floor and shoreward part of the middle shelf floor.
Sawgrass	Large shore-normal bank with 39 mi E-W extent by 18 mi N-S extent, traversed by some ridges, some southern areas dissected, 16 ft local relief (86,980 ha).	Generally flat surface but with some areas of hummocky terrain, some ridges, and dissected southern margins. Water depths range from 59 to 111 ft.	Defined in this work. Occurs on the seaward margin of the inner shelf floor, across the middle shelf floor, and onto outer shelf floor.
St. Johns	Large shore-parallel bank about 43.5 mi long by 8.5 mi to 12.5 mi wide, traversed by some widely spaced ridges (40° to 55° azimuth) up to 7.5 mi long throughout, 13 ft local relief (136,962 ha).	Generally flat surface but with some areas of hummocky terrain in the north. Water depths range from 72 ft to 118 ft.	Defined in this work. Occurs on the outer shelf floor.
Volusia	Large shore-parallel bank (6 to 9 mi offshore) about 50 mi long by 6 mi to 15 mi wide, traversed by some widely spaced ridges (50° to 85° azimuth) up to 7.5 mi long throughout, 6.5 to 13 ft local relief (166,917 ha).	Generally flat surface but with scattered areas of hummocky. Shoreward margin is dissected into the Edgewater Ridge Field. Water depths range from 50 to 90 ft.	Defined in this work. Occurs on the middle shelf floor and outer shelf floor.
Ebb-Tidal Deltas	Based on examples of: Dean & Walton (1975), Dean & O'Brien (1987), Finkl (1994), Davis (1997), Powell *et al*. (2006)		
St. Augustine	The ebb-tidal delta extends 2 mi offshore (updrift margin) and 15 mi alongshore, overlaps the Farmton Sand Flat. 45 ft local relief (5680 ha).	Deltaic sands with disrupted bypassing bars and transverse bars down-drift of the inlet. Water depths range from 0 ft to 45 ft.	Defined in this work. Occurs on the shoreface.

Table 3-1.
Submarine physiographic units on the inner continental shelf (extending offshore to the 45-m isobath) along the northeast Florida Atlantic coast.

Physiographic Province	Morphometry[1]	Description	Comments/Source
St. Johns	The ebb-tidal delta extends 1.2 mi offshore (updrift margin) and 5.5 mi alongshore, overlaps the Farmton Sand Flat, cut by navigation channel 9 mi long by about 1300 ft wide. 70 ft local relief (1840 ha).	Deltaic sands with deflected bypassing bars and transverse bars down-drift of the inlet. Water depths range from 0 ft to 32 ft.	Defined in this work. Occurs on the shoreface.
St. Mary's Ebb-Tidal Delta	The ebb-tidal delta extends 3 mi offshore and 8 mi alongshore, overlaps the Farmton Sand Flat, cut by navigation channel 4 mi long by about 750 ft wide. 33 ft local relief (4163 ha).	Deltaic sands with bypassing bars and transverse bars up-and downdrift of the inlet. Water depths range from 0 ft to 20 ft.	Defined in this work. Occurs on the shoreface.
Tisonia – Nassau Sound Ebb-Tidal Delta Complex	The ebb-tidal delta extends 1.2 mi offshore and 4.6 mi alongshore, overlaps the Farmton Sand Flat, well-defined transverse bars. 20 ft local relief (1414 ha).	Deltaic sands with transverse bars (1°-10° azimuth). Water depths range from 0 ft to 20 ft.	Defined in this work. Occurs on the shoreface.
Undifferentiated Seafloor	Based on examples for ridges and banks by: Agassiz (1894), Illing (1954), Ginsburg and James (1974), Stahl *et al*. (1974), Meisburger & Field (1975), Off (1976), Swift & Field (1981), Parker *et al*. (1982), Stride *et al*. (1982), Swift *et al.* (1984), McBride & Moslow (1991), Dyer & Huntley (1999), Snedden & Dalrymple (1999), Freedenberg *et al*. (2000), Finkl & Andrews (2007), Phelps *et al*. (2007)		
With Anastamosing Ridges	Complex deepwater seafloor region (25 mi by 27 mi) with ridges, up to 9 mi long, that separate and reunite, includes small bank areas and undiffer-entiated topography. 20 ft local relief (133,671 ha).	Complex shore-normal deepwater seafloor region (9 mi by 40 mi) with ridges, up to 9 mi long, on the seaward part of the unit. 6 ft to 20 ft local relief.	Defined in this work. Occurs on the outer shelf floor.
With Linear Sand Ridges	Complex shore-normal deepwater seafloor region (13.5 mi by 87 mi) with ridges, 6 mi to 9 mi long, throughout the unit. (174,749 ha).	Complex deepwater seafloor region with large rectilinear and broadly arcuate ridges, up to 13 ft high. 13 ft local relief.	Defined in this work. Occurs on the outer shelf floor.
With Transverse Ridges	Complex shore-normal deepwater seafloor region (9 mi by 40 mi) with ridges, up to 9 mi long, on the seaward part of the unit. 20 ft local relief (101,440 ha).	Contains numerous ridges with dominant 45° to 50° azimuth, dissected small bank areas in shoreward parts, and undifferentiated seafloor flats between ridges. Thicker sediment accumulation along shoreward margins. Water depths range from 60 ft to 120 ft.	Defined in this work. Occurs mostly on the outer shelf floor, but extends across the middle shelf floor onto the seaward-most segment of the outer shelf floor.

[1] Based on interpretation of reformatted NOAA bathymetry, but limited by scalar parameters determined in input of acquisition data that was of variable scales.

Table 3-2. Sand resource potential in Nassau County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which may be less than unity in ridge fields, banks, and ebb-tidal deltas.

Morpho-sedimentary Features	Shelf Area (ha)[1]	% of County Continental Shelf Area[2]	Height of Plane (ft)	Elevation Range[3] (Max to Min Depth) (ft)	% Area Used in Volume Calculations[4]	Sediment Volume (cy)
Amelia Sand Ridge	3,128	2	-54.0	-54.0 to -29.8	75	94,230,464
Duval Ridge Field	22,765	13	-82.68	-82.68 to -41.99	60	1,158,086,485
Farmton Sand Flat A	2	0<1	-58.76	-58.76 to -50.03	100	57,609
Farmton Sand Flat B	59	0<1	-52.10	-52.10 to -48.56	50	125,324
Farmton Sand Flat C	20,814	12	-71.85	-71.85 to 0.33	90	1,658,019,641
Fort Clinch Ridge Field A	5,999	3	-55.12	-55.12 to -25.92	85	230,907,563
Fort Clinch Ridge Field B	71	0<1	-55.35	-55.35 to -44.62	75	1,081,913
Nassau Bank	15,733	9	-88.35	-88.35 to -51.18	85	1,072,344,224
O'Neal Bank	29,162	16	-98.43	-98.43 to -47.24	90	2,914,226,894
St Mary's Ebb-tidal Delta	4,163	2	-64.30	-64.30 to 2.95	100	783,019,736
Talbot Transverse Bar	4,886	3	-44.69	-44.69 to 0.33	80	231,538,881
Tisonia-Nassau Sound Ebb-Tidal Delta	139	0<1	-17.06	-17.06 to -0.79	80	4,046,774
Total	**106,921**	**60**				**8,147,685,507**

Table 3-3. Sand resource potential in Duval County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.

Morpho-sedimentary Features	Shelf Area (ha)[1]	% of County Continental Shelf Area[2]	Height of Plane (ft)	Elevation Range[3] (Max to Min Depth) (ft)	% Area Used in Volume Calculations[4]	Sediment Volume (cy)
Amelia Sand Ridge	1,039	0<1	-49.02	-49.02 to -33.79	75	18,969,512
Duval Ridge Field A	65,666	28	-101.38	-101.38 to -32.48	80	8,253,818,678
Duval Ridge Field B	34	0<1	-52.69	-52.69 to -45.18	95	630,971
Duval Ridge Field C	200	0<1	-52.49	-52.49 to -46.26	70	1,374,238
Farmton Sand Flat A	1,876	1	-65.94	-65.94 to -48.56	100	75,731,840
Farmton Sand Flat B	16,558	7	-82.35	-82.35 to -1.41	100	2,493,129,257
Nassau Bank	46,321	20	-105.64	-105.64 to-58.40	95	4,424,220,406
O'neal Bank	1,876	1	-95.41	-95.41 to -66.90	60	85,147,169
Sawgrass Bank A	425	0<1	-100.72	-100.72 to -84.74	40	4,329,866
Sawgrass Bank B	6,171	3	-97.77	-97.77 to -63.65	75	350,052,874
Sawgrass Bank C	21,730	9	-121.72	-121.72 to -40.68	100	1,549,896,148
St. Johns Ebb-tidal Delta	1,840	1	-78.41	-78.41 to 0.98	65	292,920,217
Talbot Transverse Bar	1,089	0<1	-46.69	-46.69 to -9.51	50	36,044,963
Tisonia – Nassau Sound Ebb-Tidal Delta Complex	1,275	1	-35.10	-35.10 to 2.95	85	122,995,497
Total	**166,102**	**71**				**17,709,261,635**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.

[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.

[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.

[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 3-4. Sand resource potential in St. Johns County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.

Morphosedimentary Features	**Shelf Area (ha)[1]**	**% of County Continental Shelf Area[2]**	**Height of Plane (ft)**	**Elevation Range[3] (Max to Min Depth) (ft)**	**% Area Used in Volume Calculations[4]**	**Sediment Volume (cy)**
Cresent Ridge Field	9,268	2	-71.85	-71.85 to -13.00	80	357,020,073
Duval Ridge Field A	586	0<1	-52.66	-52.66 to -12.70	90	13,185,691
Duval Ridge Field B	52,545	11	-82.35	-82.35 to -1.50	85	4,888,975,292
Espanda Ridge Field	2,109	0<1	-71.85	-71.85 to -15.60	75	63,426,155
Farmton Sand Flat	44,424	9	-140.42	-140.42 to -1.27	100	14,398,452,144
Flagler Sand Wave	82	0<1	-94.49	-94.49 to -25.43	60	868,560
Nassau Bank A	856	0<1	-99.74	-99.74 to -24.70	85	35,783,098
Nassau Bank B	1,707	0<1	-100.07	-100.07 to -22.70	65	56,507,190
Palm Coast Sand Wave	19,656	4	-100.39	-100.39 to -15.50	90	1,773,923,019
Sawgrass Bank	58,653	12	-104.99	-104.99 to -15.20	75	4,843,895,097
St Augustine Eeb-tidal Delta	7,680	2	-51.71	-51.71 to 0.60	70	364,802,151
St Johns Bank	83,966	17	-125.89	-125.89 to -18.50	65	5,811,519,884
Summer Haven Sand Wave	55,722	11	-100.33	-100.33 to -14.80	70	4,111,953,409
Total	**332,253**	**69**				**36720311763**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.
[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.
[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.
[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 3-5. Sand resource potential in Flagler County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.

Morphosedimentary Features	**Shelf Area (ha)[1]**	**% of County Continental Shelf Area[2]**	**Height of Plane (ft)**	**Elevation Range (Max to Min Depth) (ft)**	**% Area Used in Volume Calculations[3]**	**Sediment Volume (cy)**
Beverly Shoal	1,248	1	-64.30	-64.30 to -49.44	85	27,211,953
Bunnel Ridge Field	7,858	4	-76.44	-76.44 to -44.29	45	157,528,249
Espanda Ridge Field	1,325	1	-69.91	-69.91 to -51.84	95	41,304,138
Farmton Sand Flat A	4,163	2	-78.97	-78.97 to -53.48	100	137,021,760
Farmton Sand Flat B	28,764	16	-75.13	-75.13 to -8.60	100	1,751,482,932
Flagler Sand Wave	57,210	31	-98.56	-98.56 to -43.96	95	6,055,565,761
Korona Ridge Field	6,381	3	-81.04	-81.04 to -54.20	80	283,848,808
Palm Coast Sand Wave A	477	0<1	-99.74	-99.74 to -84.74	75	11,279,145
Palm Coast Sand Wave B	5,305	3	-90.45	-90.45 to -49.54	95	514,162,775
St Johns Bank	50,006	27	-111.55	-111.55 to -57.74	50	2,197,992,485
Volusia Bank	12,172	7	-103.67	-103.67 to -63.16	65	598,700,049
Total	**174,911**	**94**				**11,776,098,055**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.

[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.

[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.

[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 3-6. Sand resource potential in Volusia County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.

Morphosedimentary Features	Shelf Area (ha)[1]	% of County Continental Shelf Area[2]	Height of Plane (ft)	Elevation Range[3] (Max to Min Depth) (ft)	% Area Used in Volume Calculations[4]	Sediment Volume (cy)
Allandale Shoal	675	0<1	-59.25	-59.25 to -12.70	75	12,459,973
Bunnel Ridge Field	580	0<1	-67.09	-67.09 to -14.80	30	4,730,003
Canaveral Transverse Bar	929	0<1	-51.71	-51.71 to -2.51	35	17,976,330
Edgewater Ridge Field	15,979	4	-76.12	-76.12 to -12.60	95	943,126,909
Farmton Sand Flat	87,864	23	-78.18	-78.18 to 0	100	6,386,947,776
Korona Ridge Field	15,098	4	-74.25	-74.25 to -10.90	100	910,571,931
Oak Hill Shoal	1,813	0<1	-66.17	-66.17 to -10.00	60	47,892,296
St. Johns Bank	2,990	1	-113.16	-113.16 to -22.10	95	213,500,704
Volusia Bank	154,745	40	-115.81	-115.81 to -14.60	80	19,797,286,537
Total	**280,671**	**72**				**28,334,492,462**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.

[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.

[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.

[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 3-7. Beach nourishment projects along the northeast Florida Atlantic coast in Nassau, Duval, and St. Johns counties in relation to length of county beachfront and percents of total beach length covered.

County	**Beach Restoration Project**	**Beach Front (ft)**[1]	**Project Length (ft)**[1]	**% County Beach Front**[1]	**% Study Area**[1]
Duval	Duval County November 1995 Beach Nourishment	124,914	34,009	27.23	4.42
Nassau	South Amelia Beach Restoration	72,257	19,032	26.34	2.48
Nassau	South Amelia Beach Restoration (Maintenance Dredging)	72,257	4,176	5.78	0.54
Nassau	South Amelia Beach Island Shore Stabilization, Phase 1 - Beach Restoration	72,257	18,631	25.79	2.42
St. John's	St. John's County Shore Protection	217,001	20,219	9.32	2.63
Total			**96,066**		**12.49**

Table 3-8. Explanation of mapping units occuring in state and federal waters based on the 3-mile jurisdictional limit, and showing the breakdown of hectares and percentages by zone of occurence and by unit.

Morphosedimentary Feature	State Shelf Area (ha)	Federal Shelf Area (ha)	Total Shelf Area (ha)	State Area (%)	Federal Area (%)	State % by Unit	Federal % by Unit
Allandale Shoal	183	492	675	0.15	0.04	27.1	72.9
Amelia Sand Ridge	895	3,273	4,168	0.75	0.24	21.47	78.53
Beverly Shoal	321	927	1,248	0.27	0.07	25.72	74.28
Bunnel Ridge Field	0	8,438	8,438	0	0.62	0	100
Canaveral Transverse Bar	929	0	929	0.78	0	100	0
Crescent Ridge Field	0	9,268	9,268	0	0.69	0	100
Duval Ridge Field	2,519	139,278	141,796	2.11	10.31	1.78	98.22
Edgewater Ridge Field	0	15,979	15,979	0	1.18	0	100
Espanda Ridge Field	0	3,434	3,434	0	0.25	0	100
Farmton Sand Flat	93,759	107,750	201,509	78.62	7.97	46.53	53.47
Flagler Sand Wave	0	57,292	57,292	0	4.24	0	100
Fort Clinch Ridge Field	244	5,827	6,071	0.2	0.43	0	100
Korona Ridge Field	0	21,479	21,479	0	1.59	0	100
Nassau Bank	0	64,617	64,617	0	4.78	0	100
Oak Hill Shoal	1,331	481	1,813	1.12	0.04	73.44	26.56
O'Neal Bank	0	31,039	31,039	0	2.3	0	100
Palm Coast Sand Wave	0	25,438	25,438	0	1.88	0	100
Sawgrass Bank	0	86,980	86,980	0	6.44	0	100
St. Augustine Ebb-Tidal Delta	5,680	0	5,680	4.76	0	100	0
St. Johns Bank	0	136,962	136,962	0	10.13	0	100
St. Johns Ebb-Tidal Delta	1,840	0	1,840	1.54	0	100	0
St. Mary's Ebb-Tidal Delta	4,163	0	4,163	3.49	0	100	0
Summer Haven Sand Wave	0	55,722	55,722	0	4.12	0	100
Talbot Transverse Bar	5,972	2	5,974	5.01	0	99.97	0.03
Tisonia – Nassau Sound Ebb-Tidal Delta Complex	1,414	0	1,414	1.19	0	100	0
Undifferentiated Seafloor with Anastomosing Ridges	0	133,671	133,671	0	9.89	0	100
Undifferentiated Seafloor with Linear Sand Ridges	0	174,749	174,749	0	12.93	0	100
Undifferentiated Seafloor with Transverse Ridges	0	101,440	101,440	0	7.51	0	100
Volusia Bank	0	166,907	166,907	0	12.35	0	100
Total	**119,250**	**1,351,444**	**1,470,693**	**100**	**100**	**8.11**	**91.89**

[1] Percentage of total study area under State of Florida jurisdiction, *i.e.* landward of 3-mile limit.
[2] Percentage of total study area under federal jurisdiction, *i.e.* seaward of 3-mile limit.
[3] Percentage of state-controlled continental shelf area comprised by mapping unit, *i.e.* landward of 3-mile limit.
[4] Percentage of federally-controlled continental shelf area comprised by mapping unit, *i.e.* seaward of 3-mile limit.
[5] Percentage of mapping unit under state jurisdiction, *i.e.* landward of 3-mile limit.
[6] Percentage of mapping unit under federal jurisdiction, *i.e.* seaward of 3-mile limit.

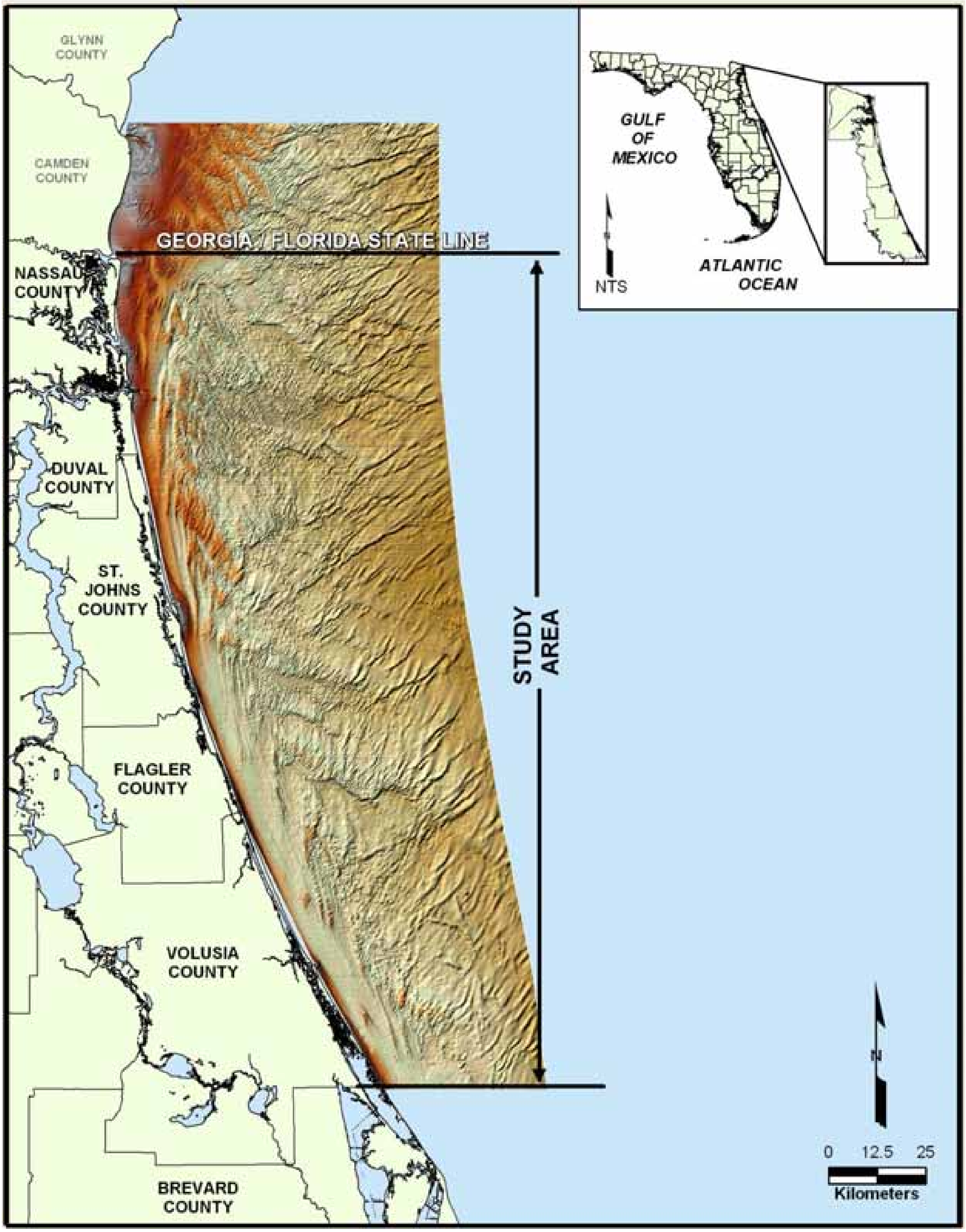
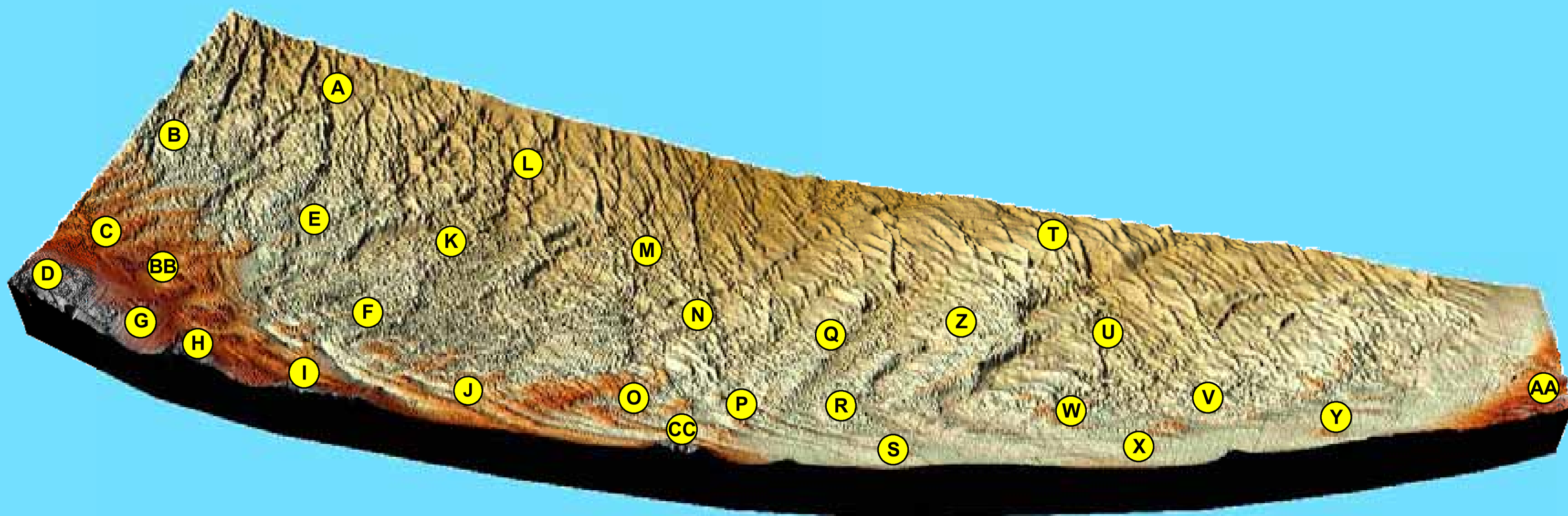


Figure 3-1. Plan view of the study area along the northeast Florida Atlantic continental shelf, covering about 5323 mi^2. The study area is defined by re-formatted NOAA bathymetry in state and federal waters along Nassau, Duval, St. Johns, Flagler, and Volusia counties. The study area extends from the shore to about the 150 ft isobath, which extends up to 45 mi offshore along the Florida-Georgia state line.



LEGEND:

- (A) UNDIFFERENTIATED SEAFLOOR WITH ANASTAMOSING RIDGES
- (B) O'NEAL BANK
- (C) FORT CLINCH RIDGE FIELD
- (D) ST. MARY'S EBB-TIDAL DELTA
- (E) NASSAU BANK
- (F) DUVAL RIDGE FIELD
- (G) TALBOT TRANSVERSE BAR
- (H) TISONIA-NASSAU EBB-TIDAL DELTA
- (I) ST. JOHNS EBB-TIDAL DELTA
- (J) SAWGRASS BANK
- (K) FARMTON SAND FLAT
- (L) UNDIFFERENTIATED SEAFLOOR WITH TRANSVERSE RIDGES
- (M) ST JOHNS BANK
- (N) SUMMER HAVEN SAND WAVE
- (O) CRESCENT RIDGE FIELD
- (P) ESPANDA RIDGE FIELD
- (Q) PALM COAST SAND WAVE
- (R) BUNNEL RIDGE FIELD
- (S) BEVERLY SHOAL
- (T) UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGES
- (U) VOLUSIA BANK
- (V) EDGEWATER RIDGE FIELD
- (W) KORONA RIDGE FIELD
- (X) ALLANDALE SHOAL
- (Y) OAK HILL SHOAL
- (Z) FLAGLER SAND WAVE
- (AA) CANAVERAL TRANSVERSE BAR
- (BB) AMELIA SAND RIDGE
- (CC) ST AUGUSTINE EBB-TIDAL DELTA

TITLE:

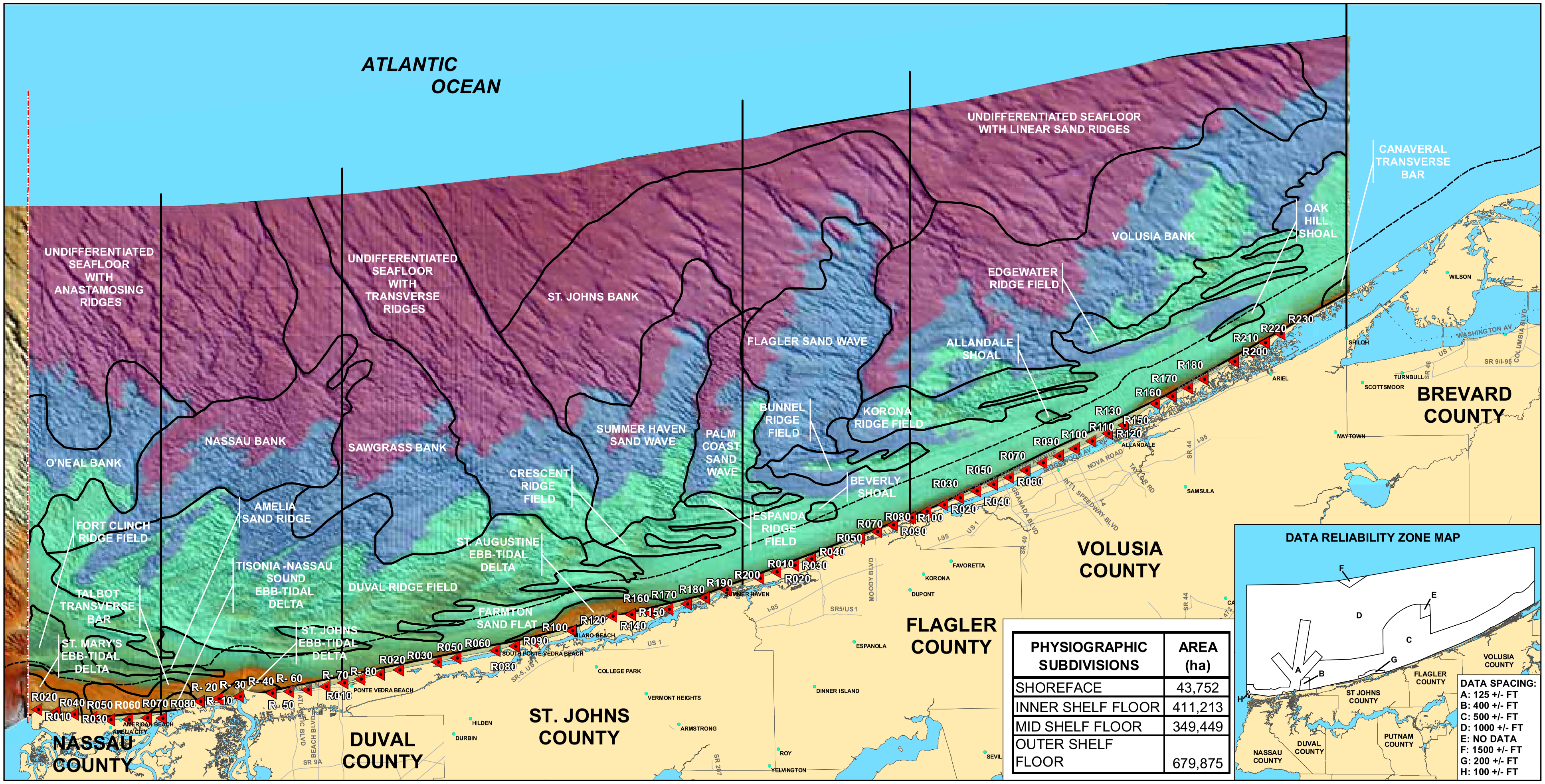
THREE-DIMENSIONAL RENDERING OF OFFSHORE GEOMORPHOLOGY

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 07/27/07	BY: AB/HMV	COMM NO: 7849.29	FIGURE 3-2

G:\DEP-URS\Northeast_Florida_MXD\OBLIQUE_IMAGE.mxd

Figure 3-3. Composite diagram (not to scale) showing the study-area terrain model in relation to cadastral boundaries superimposed on satellite imagery. Near- and offshore sand ridges, bars, banks, shoals, and sand waves are clearly evident in the color-ramped bathymetry. Cape Canaveral is the large salient feature in Brevard County.



PHYSIOGRAPHIC SUBDIVISIONS	AREA (ha)
SHOREFACE	43,752
INNER SHELF FLOOR	411,213
MID SHELF FLOOR	349,449
OUTER SHELF FLOOR	679,875

LEGEND:

- FDEP MONUMENTS
- CITIES
- ROADS
- COUNTY LINES
- GEORGIA / FLORIDA STATE LINE
- FEDERAL / STATE BOUNDARY
- OFFSHORE MORPHOLOGY

PHYSIOGRAPHIC SUBDIVISIONS

- SHOREFACE (MWL TO -12 METERS)
- INNER SHELF FLOOR (-12 METERS TO -20 METERS)
- MID SHELF FLOOR (-20 METERS TO -24 METERS)
- OUTER SHELF FLOOR (-24 METERS TO -70 METERS)

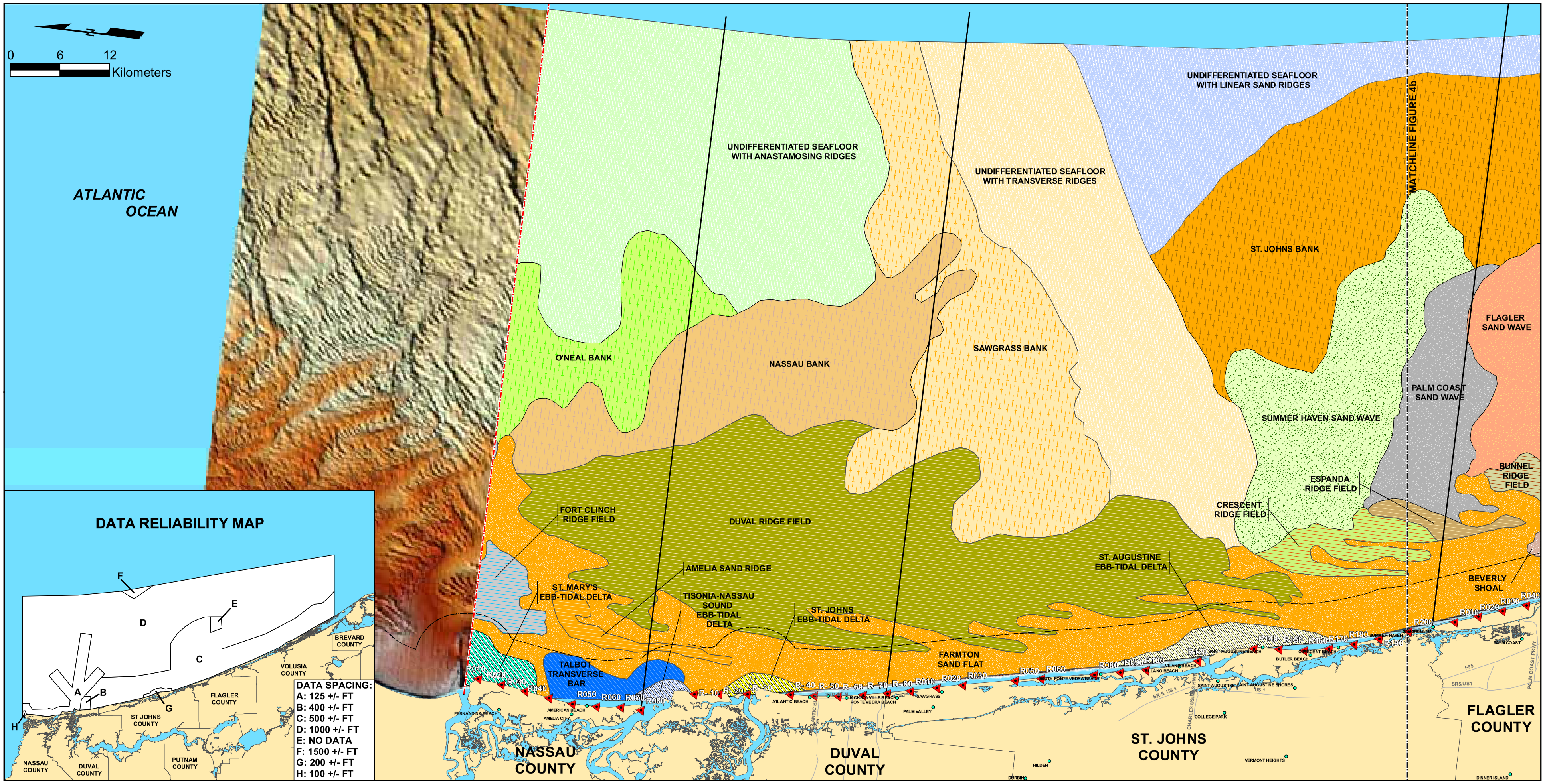
TITLE:

PHYSIOGRAPHIC SUBDIVISIONS OF THE NORTH FLORIDA ATLANTIC CONTINENTAL SHELF

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE:7/27/07 | BY: HMV | COMM NO: 7849.29 | **FIGURE 3-4**

G:\DEP-URS\Northeast_Florida_MXD\Contours.mxd



LEGEND:

- FDEP MONUMENTS
- CITIES
- GEORGIA / FLORIDA STATE LINE
- MATCHLINE
- FEDERAL / STATE BOUNDARY
- COUNTY LINES
- ROADS

GEOMORPHOLOGY
RIDGES
- AMELIA SANDRIDGE
- BUNNEL RIDGE FIELD
- CRESCENT RIDGE FIELD
- DUVAL RIDGE FIELD
- ESPANDA RIDGE FIELD
- FORT CLINCH RIDGE FIELD

SHOALS
- BEVERLY SHOAL

BANKS
- SAWGRASS BANK
- ST. JOHNS BANK
- NASSUA BANK
- O'NEAL BANK

SAND FLAT
- FARMTON SAND FLAT

SAND WAVES
- FLAGLER SAND WAVE
- PALM COAST SAND WAVE
- SUMMER HAVEN SAND WAVE

EBB-TIDAL DELTAS
- ST. AUGUSTINE EBB-TIDAL DELTA
- ST. JOHNS EBB-TIDAL DELTA
- ST. MARY'S EBB-TIDAL DELTA
- TISONIA-NASSAU SOUND EBB-TIDAL DELTA

TRANSVERSE BAR
- TALBOT TRANSVERSE BAR

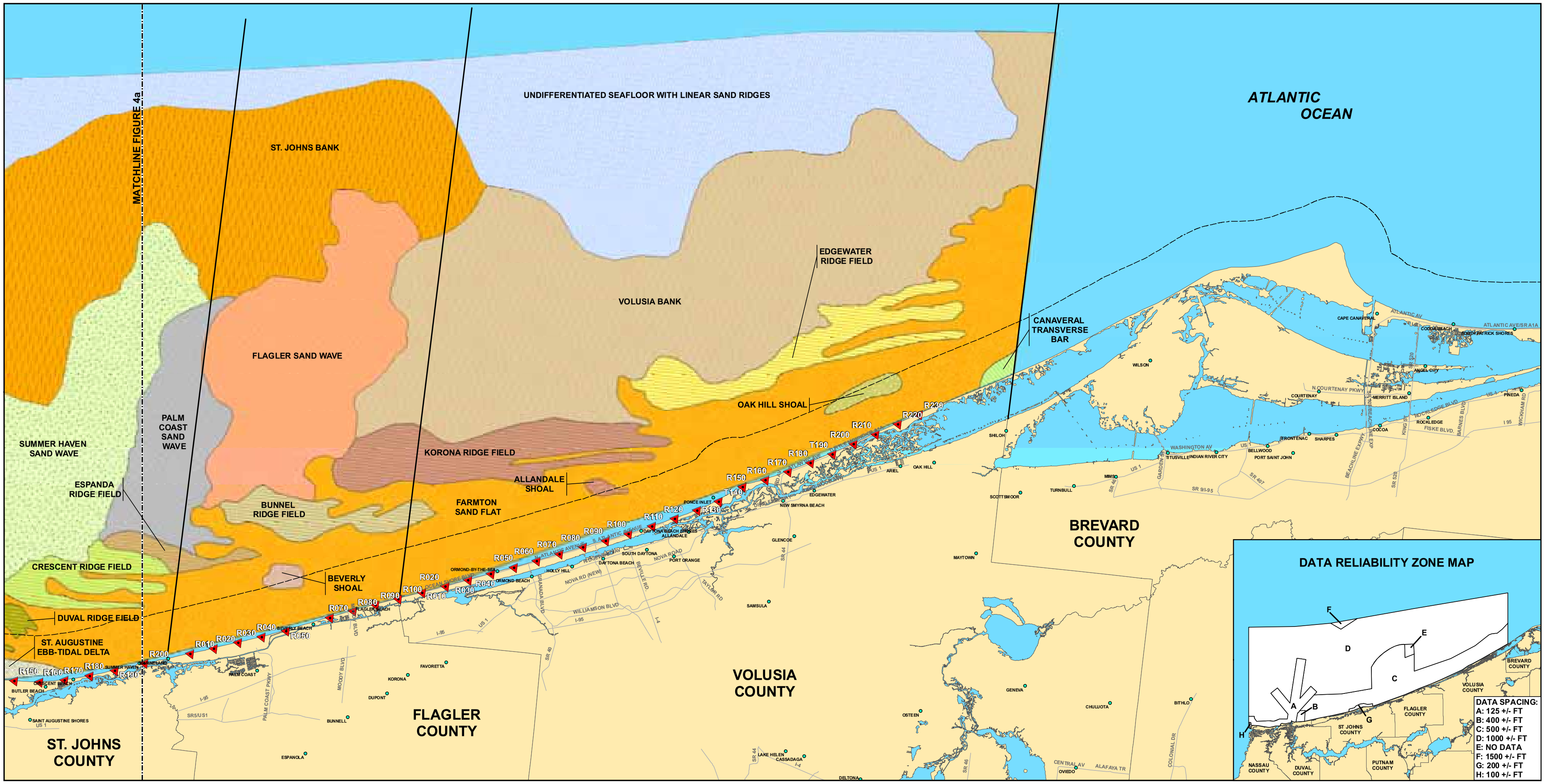
UNDIFFERENTIATED SEAFLOORS
- UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGES
- UNDIFFERENTIATED SEAFLOOR WITH TRANSVERSE RIDGES
- UNDIFFERENTIATED SEAFLOOR WITH ANASTAMOSING RIDGES

TITLE:

SEAFLOOR MAPPING UNITS ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07	BY: HMV	COMM NO: 7849.29	FIGURE 3-5A



LEGEND:

- CITIES
- FDEP MONUMENTS
- ROADS
- COUNTY LINES
- FEDERAL / STATE BOUNDARY
- MATCHLINE

GEOMORPHOLOGY

RIDGES
- BUNNEL RIDGE FIELD
- CRESCENT RIDGE FIELD
- DUVAL RIDGE FIELD
- EDGEWATER RIDGE FIELD
- ESPANDA RIDGE FIELD
- KORONA RIDGE FIELD

SHOALS
- ALLANDALE SHOAL
- BEVERLY SHOAL
- OAK HILL SHOAL

BANKS
- ST. JOHNS BANK
- VOLUSIA BANK

SAND FLAT
- FARMTON SAND FLAT

SAND WAVES
- FLAGLER SAND WAVE
- PALM COAST SAND WAVE
- SUMMER HAVEN SAND WAVE

EBB-TIDAL DELTAS
- ST. AUGUSTINE EBB-TIDAL DELTA

TRANSVERSE BAR
- CANAVERAL TRANSVERSE BAR

UNDIFFERENTIATED SEAFLOORS
- UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGES

TITLE:

SEAFLOOR MAPPING UNITS ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
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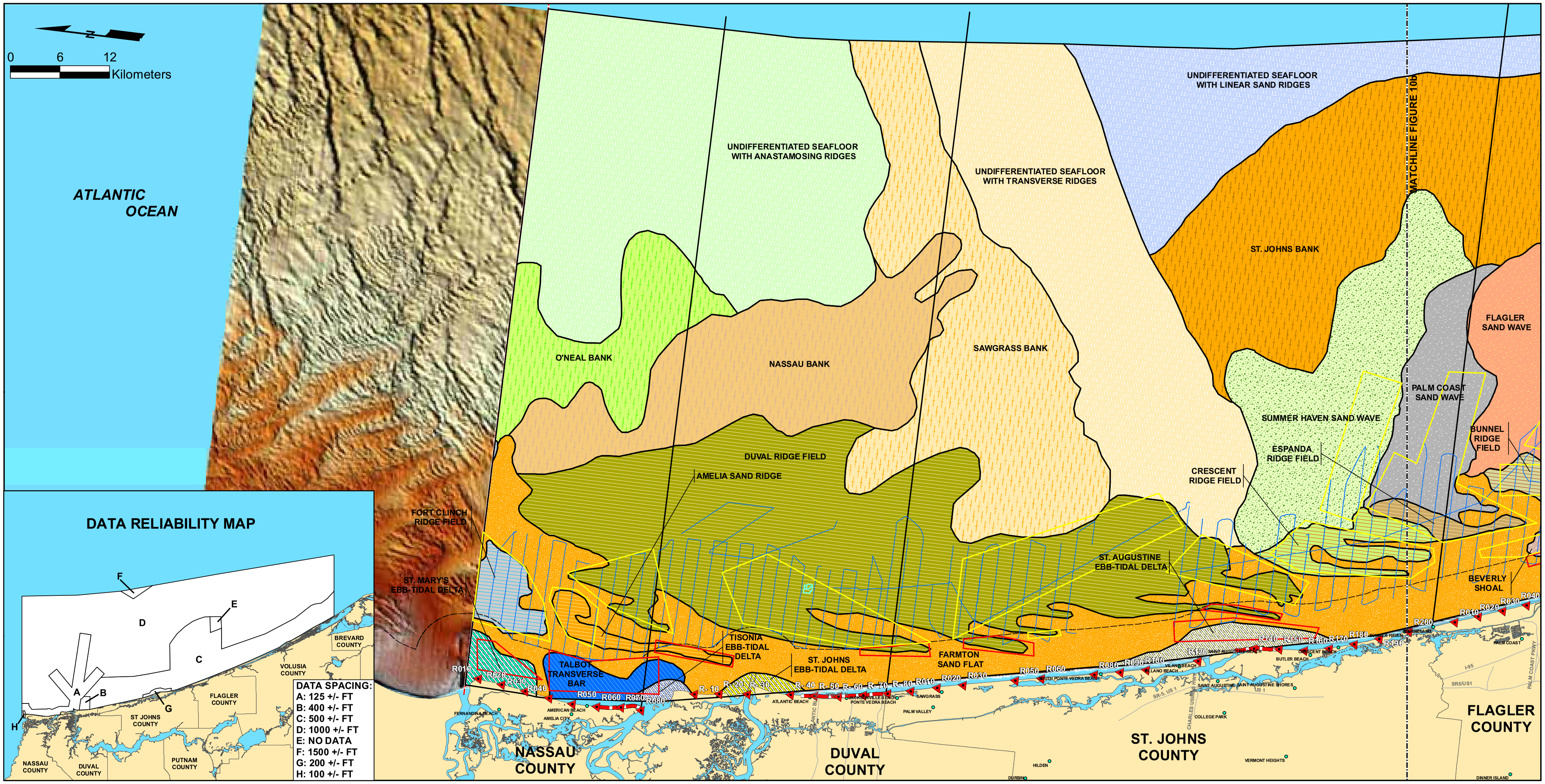
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07 | BY: HMV | COMM NO: 7849.29 | FIGURE 3-5B

G:\DEP-URS\Northeast_Florida_MXD\GEOMORPHOLOGY_SHEET_2.mxd



LEGEND:

- CITIES
- FDEP MONUMENTS
- BEACH RESTORATION PROJECTS
- HISTORICAL SEISMIC TRACKLINES
- GEORGIA / FLORIDA STATE LINE
- MATCHLINE
- FEDERAL / STATE BOUNDARY
- COUNTY LINES
- ROADS
- AREAS OF DETAILED SURVEY
- PRIMARY AREAS TO BE TESTED MORE CAREFULLY
- SECONDARY AREAS TO BE TESTED MORE CAREFULLY
- PREVIOUS DREDGE AREA

GEOMORPHOLOGY
RIDGES
- AMELIA SANDRIDGE
- BUNNEL RIDGE FIELD
- CRESCENT RIDGE FIELD
- DUVAL RIDGE FIELD
- ESPANDA RIDGE FIELD
- FORT CLINCH RIDGE FIELD

SHOALS
- BEVERLY SHOAL

BANKS
- SAWGRASS BANK
- ST. JOHNS BANK
- NASSUA BANK
- O'NEAL BANK

SAND FLAT
- FARMTON SAND FLAT

SAND WAVES
- FLAGLER SAND WAVE
- PALM COAST SAND WAVE
- SUMMER HAVEN SAND WAVE

EBB-TIDAL DELTAS
- ST. AUGUSTINE EBB-TIDAL DELTA
- ST. JOHNS EBB-TIDAL DELTA
- ST. MARY'S EBB-TIDAL DELTA
- TISONIA EBB-TIDAL DELTA

TRANSVERSE BAR
- TALBOT TRANSVERSE BAR

UNDIFFERENTIATED SEAFLOORS
- UNDIFFERENTIATED SEAFLOOR WITH TRANSVERSE RIDGE
- UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGE
- UNDIFFERENTIATED SEAFLOOR WITH ANASTAMOSING RIDGES

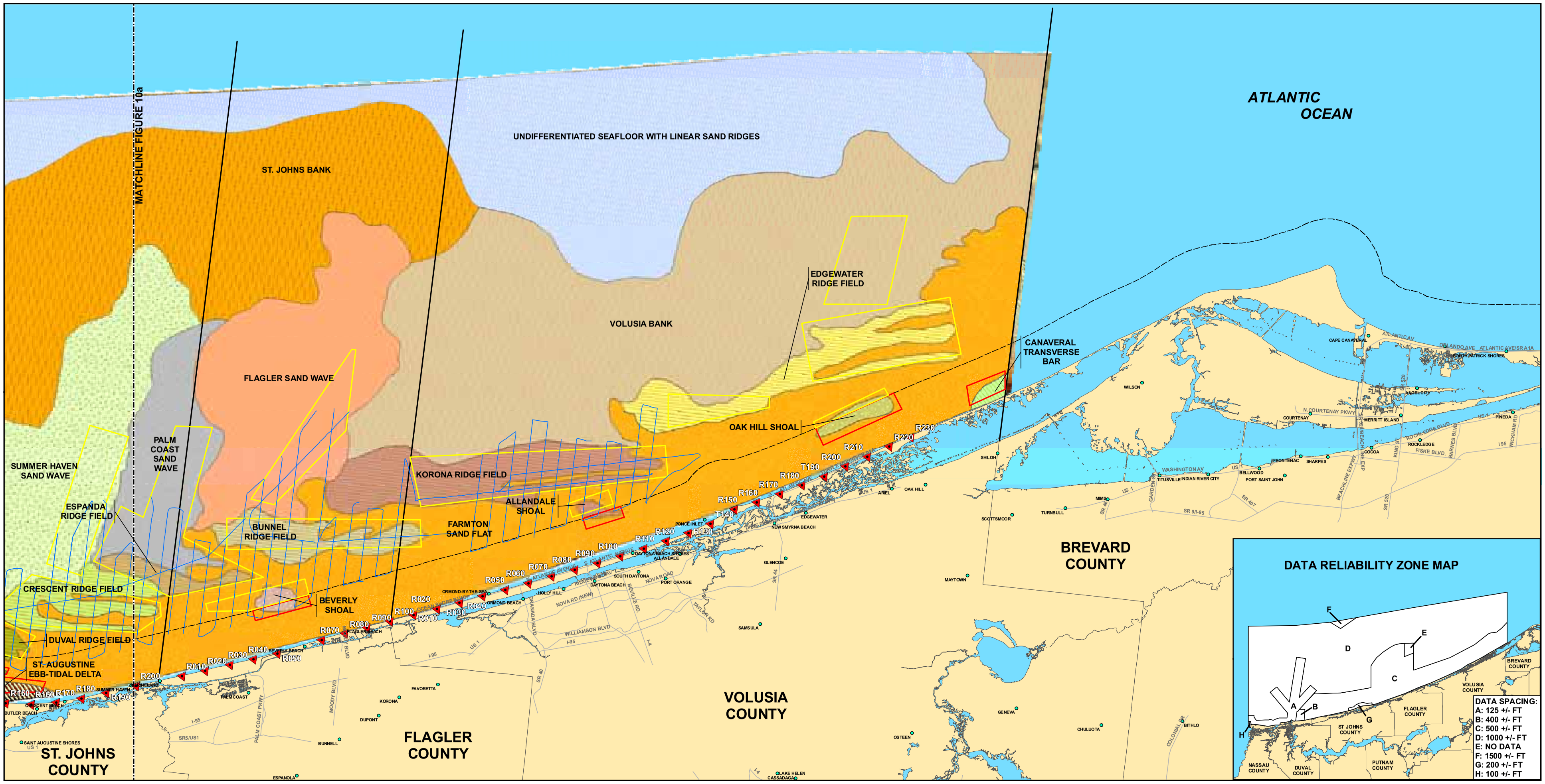
TITLE:

AREAS TO BE TESTED MORE CAREFULLY ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07	BY: HMV	COMM NO: 7849.29	FIGURE 3-6A

G:\DEP-URS\Northeast_Florida_MXD\SEISMIC_REFLECTION_SURVEY_1.mxd



LEGEND:

- CITIES
- FDEP MONUMENTS
- HISTORICAL SEISMIC TRACKLINES
- MATCHLINE
- FEDERAL / STATE BOUNDARY
- COUNTY LINES
- ROADS
- PRIMARY AREAS TO BE TESTED MORE CAREFULLY
- SECONDARYAREAS TO BE TESTED MORE CAREFULLY

GEOMORPHOLOGY

RIDGES
- BUNNEL RIDGE FIELD
- CRESCENT RIDGE FIELD
- DUVAL RIDGE FIELD
- EDGEWATER RIDGE FIELD
- ESPANDA RIDGE FIELD
- KORONA RIDGE FIELD

SHOALS
- ALLANDALE SHOAL
- BEVERLY SHOAL
- OAK HILL SHOAL

BANKS
- ST. JOHNS BANK
- VOLUSIA BANK

SAND FLAT
- FARMTON SAND FLAT

SAND WAVES
- FLAGLER SAND WAVE
- PALM COAST SAND WAVE
- SUMMER HAVEN SAND WAVE

EBB-TIDAL DELTAS
- ST. AUGUSTINE EBB-TIDAL DELTA

TRANSVERSE BAR
- CANAVERAL TRANSVERSE BAR

UNDIFFERENTIATED SEAFLOORS
- UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGES

0 6 12 Kilometers

TITLE:

AREAS TO BE TESTED MORE CAREFULLY ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07	BY: HMV	COMM NO: 7849.29	FIGURE3-6B

G:\DEP-URS\Northeast_Florida_MXD\SEISMIC_REFLECTION_SURVEY_2.mxd

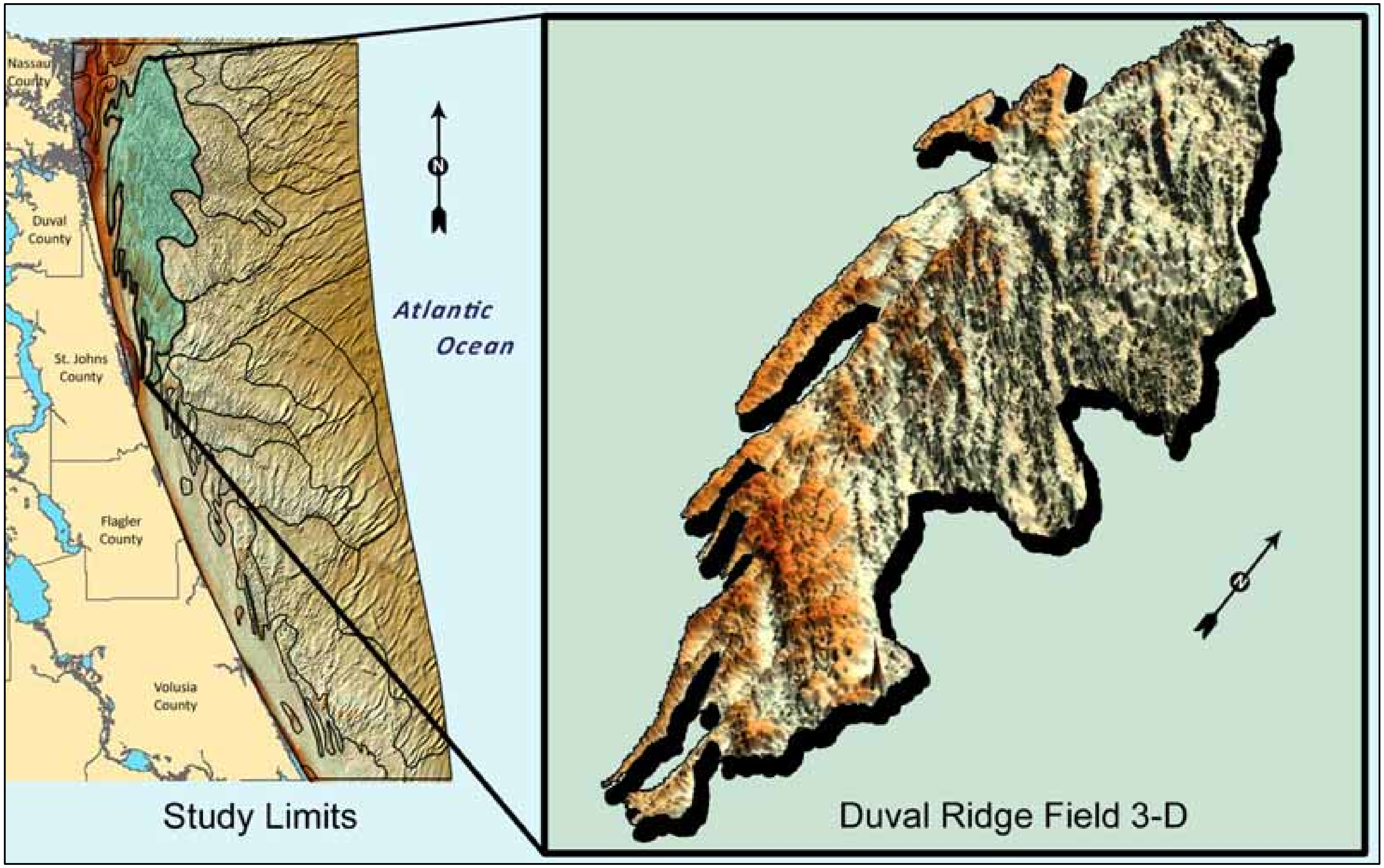


Figure 3-7. Three-dimensional terrain model (not to scale) of the Duval Ridge Field showing ridge sets making up the field and extended downdrift fingers on he shoreward margin of the field. The sand ridge field is flanked seaward by sand banks and shoreward by the Farmton Sand Flat. There is about 6.5 to 16.5 ft of local relief in the ridge field that occupies about 142,000 ha and contains a potential sand volume of about 15.7×10^9 cy.

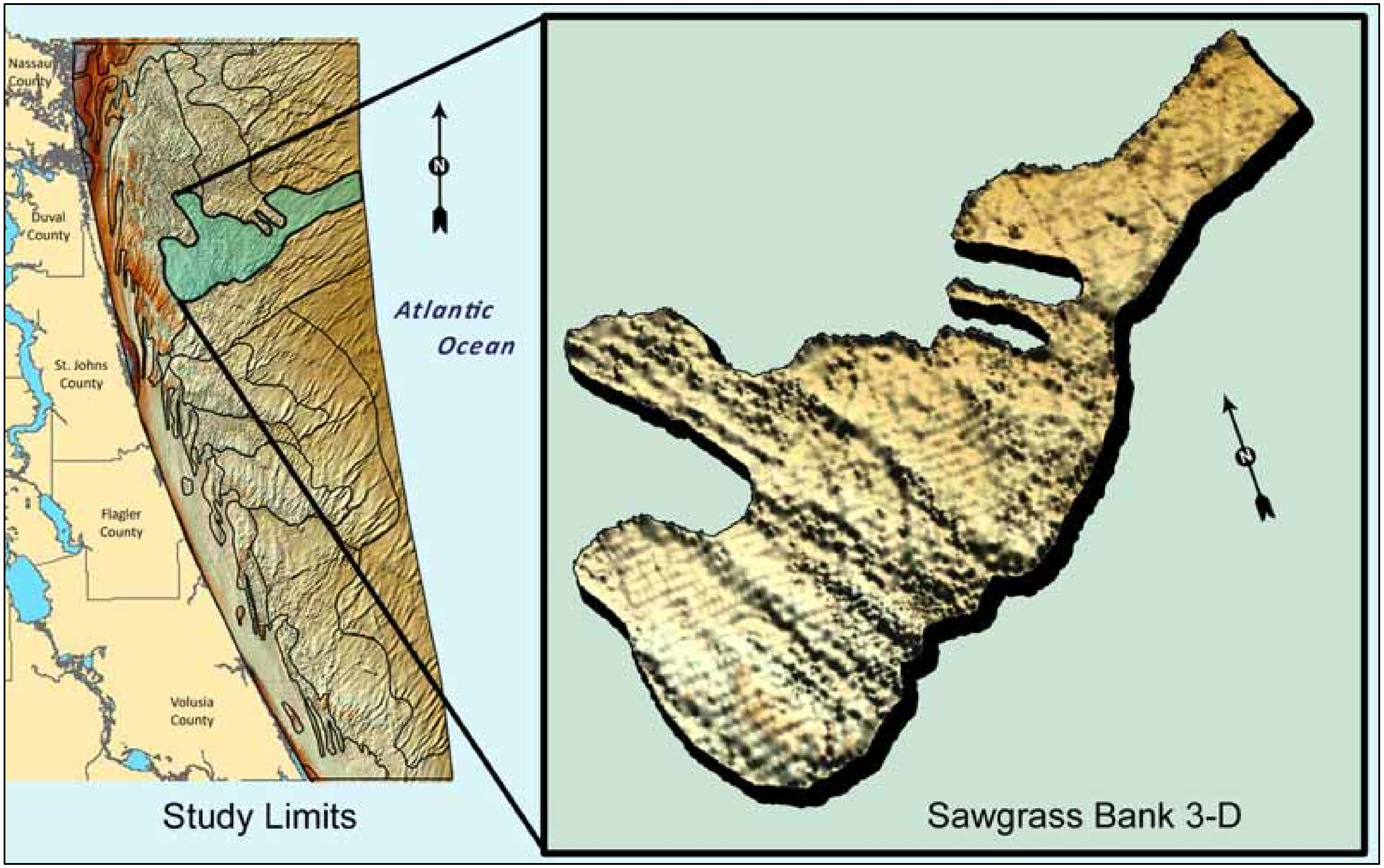


Figure 3-8. Three-dimensional terrain model (not to scale) of the Sawgrass Bank in the northern part of the study shelf area showing the general topography of the bank surface, including sand ridges that surmount the rolling topography of the seafloor. This large sand bank, which occurs mostly on middle and outer shelf floors, merges shoreward with the Farmton Sand Flat and merges north with the Nassau Bank but it otherwise flanked by undifferentiated seafloor mapping units with sand ridges. There is about 16.5 ft of local relief on the bank that occupies about 87,000 ha and contains a potential sand volume of about 6.5×10^9 cy. The parallel lines running through the figure are artifacts for the reformatting process.

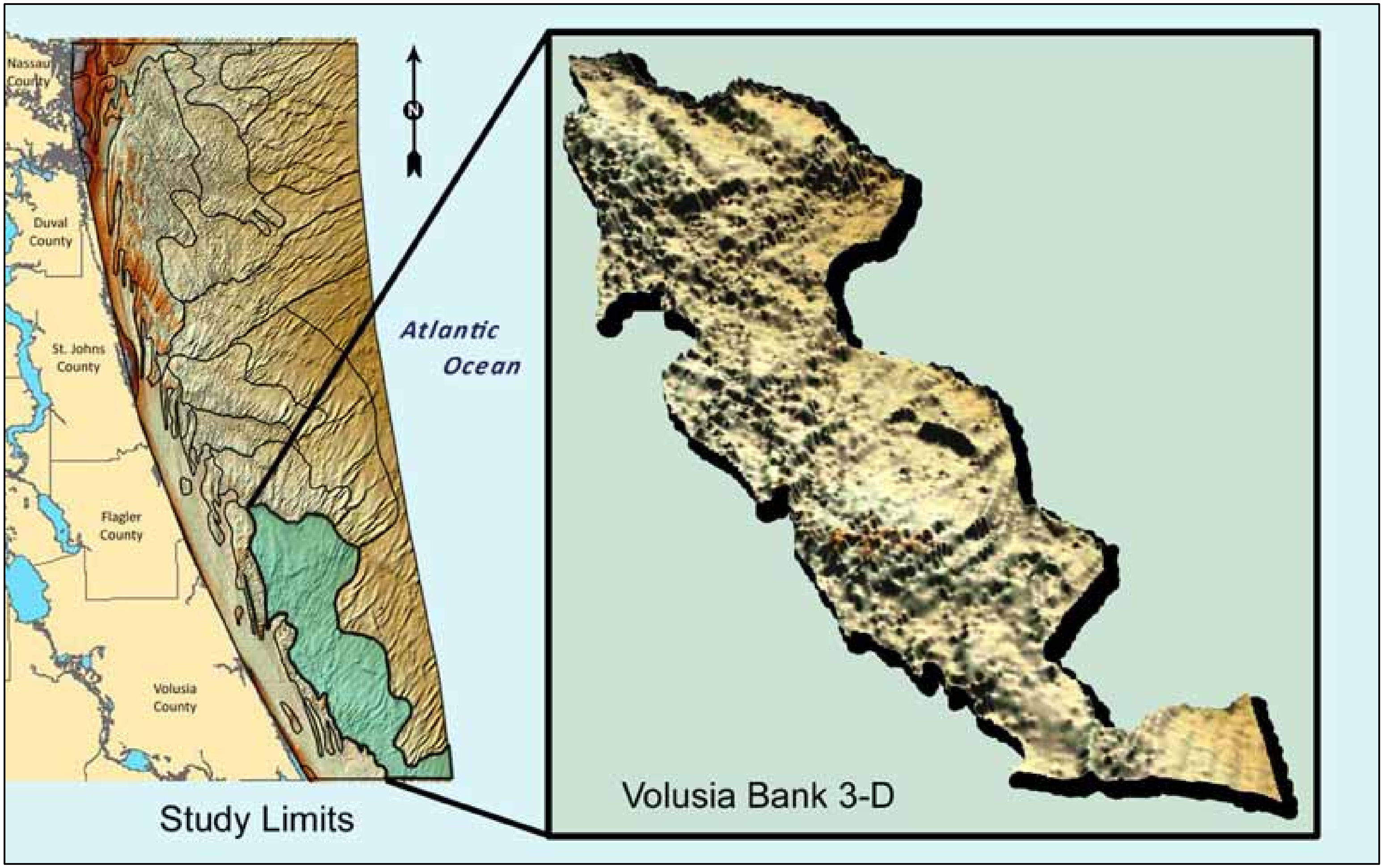


Figure 3-9. Three-dimensional terrain model (not to scale) of the very large Volusia Bank in the southern shelf study area showing the general topography of the bank surface, including sand ridges that surmount the rolling topography of the seafloor. This large sand bank, which occurs on mostly middle and outer shelf floors, merges shoreward with ridge fields but is otherwise flanked by undifferentiated seafloor mapping units with sand ridges. There is about 6.5 to 13 ft of local relief on the bank that occupies about 167,000 ha and contains a potential sand volume of about 20.9 x 10^9 cy.

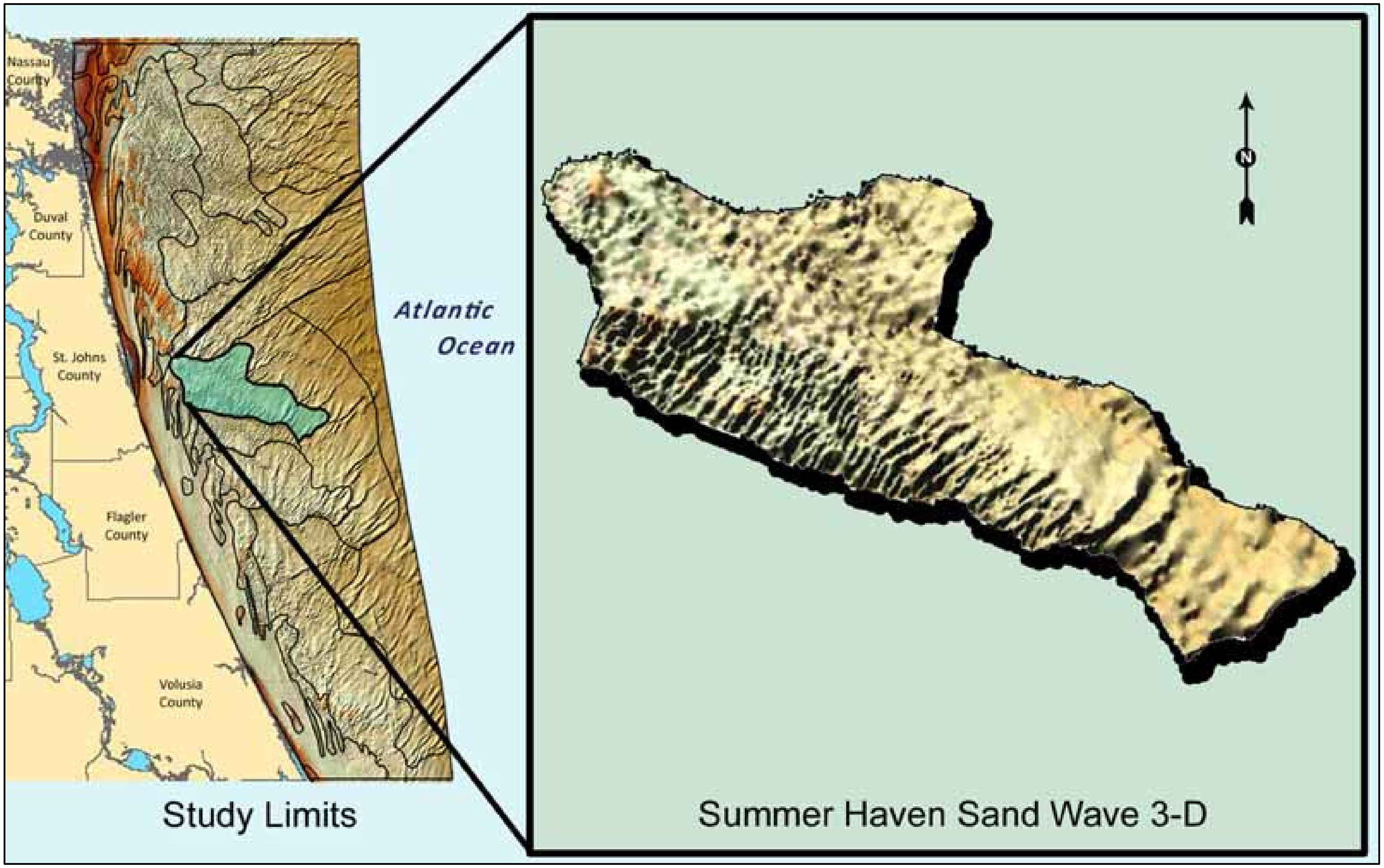


Figure 3-10. Three-dimensional terrain model (not to scale) of the Summer Haven Sand Wave showing the general topography of the sand wave surface, including isolated sand ridges that surmount the undulating topography of the seafloor. This large sand bank, which occurs in a mid-study area location on inner, middle, and outer shelf positions, is flanked shoreward by the Crescent Ridge Field and merges north with undifferentiated seafloor with transverse sand ridges. The Summer Haven Sand Wave is sharply differentiated from the Palm Coast Sand Wave to the south by its strongly dissected southern margin. There is about 20 ft of local relief on the bank that occupies about 56,000 ha and contains a potential sand volume of about 3.9×10^9 cy.

One product of the conceptual geologic model is the identification of potential sand sources for future study. A total of thirty potential sand source areas have been identified in the Phase III northeast region (Figure 4-1). Of this total, 19 are designated as Secondary and are located seaward of the 3 mile federal boundary and 11 designated as Primary, lie within state waters. These 11 include 2 off Nassau, 2 off Duval, 3 off St Johns, 1 off Flagler and 3 off Volusia counties. Each of these areas will be discussed in further detail however only those found within state waters will be analyzed for data content.

As part of the Phase IV Fieldwork portion of the overall Florida Atlantic Coast Sand Search project, approximately 650 line miles of geophysical data has been collected in the form of sub-bottom profiles. This data was collected within the 3 mile state waters limit and has resulted in a reconnaissance level dataset that extends from the Martin – Palm Beach county line, north to the Florida – Georgia border at the St. Mary's River. Along most of this coast, this is the only available geophysical data. For the naming convention of these figures, the first set of numbers is the county code and line number; the second annotation is the direction the line was run and the third annotation is the line segment. Each line was divided into segments due to file size and to increase ease of viewing and downloading from the ROSS ftp site. Figures are organized to show the areas from north to south. Each of these lines has been post-processed so that their orientation is from west on the left to east on the right. As of this date, no additional processing or interpretation has been undertaken on these images. Further interpretation of these figures is scheduled for a future task. This analysis will make use of this geophysical data along with vibracores, jet probes and grab sample information where available. The outcome of this analysis will show all currently available data in the ROSS database regarding the sand resources in each of these areas.

The process for this analysis will be the same for each of the areas selected. This includes using the data and information residing in the ROSS database, by turning on the different Layers on the ArcIMS site, utilizing the images on the associated ftp site and accessing the data in the Oracle database through the Enhanced Query Builder (EQB). This analysis will follow 5 steps by showing; 1) the location of the potential sand source areas, 2) the location of the geophysical tracklines, 3) the geophysical images (from the ftp site), 4) the vibracore and/or jet probe and grab sample locations and 5) the data pertaining to each core layer or sand sample from the Oracle database.

NASSAU COUNTY

The continental shelf survey area in Nassau County, the northernmost county on the northeast Florida Atlantic coast, occupies approximately 177,279 ha and extends from the Georgia State line southwards to Duval County. Shoreline length is about 31 mi, but the survey area extends about 52.8 mi offshore. The largest mapping units in the Nassau County offshore area include all of the O'Neal Bank (about 29,000 ha), most of the Duval Ridge Field (about 23,000 ha), northernmost segment of the Farmton Sand Flat (about 21,000 ha), and the bulk of the Nassau Bank (about 16,000 ha) (Table 4-1). Smaller units include the Amelia Sand Ridge, Fort Clinch Ridge Field, St. Mary's Ebb-Tidal Delta, Talbot Transverse Bar, and the Tisonia - Nassau Sound Ebb-Tidal Delta.

Potential sand resources in the mapped area of the continental shelf off Nassau County amount to something on the order of 19 $x10^6$ cy (6 x 10^9 m^3) of sediment. This sediment volume estimate is based on the thickness of morphosedimentary units such as banks, sand flats, sand ridges, deltas, and transverse bars. Parameters used in the calculations of volume estimates are summarized in Table 4-1 where the range in meters from the height plane is shown for each mapping unit. The percent of area used in the volume calculations is based on a visual estimate of areal coverage in plan view. The largest sediment volume is associated with the O'Neal Bank ($2.9x10^9$ cy), followed by the Farmton Sand Flat $1.7x10^9$ cy) and Duval Ridge Field ($11.6x10^6$ cy) (Table 4-1, Figure 4-2). The O'Neal Bank takes up about 16% of the shelf area whereas the Farmton Sand Flat occupies about 12% and the Duval Ridge Field about 13%. Although taking up only 2% of the shelf area, the Amelia Sand Ridge is an obvious single sediment source. Even though undifferentiated seafloor mapping units, which make up 40% of the shelf area off Nassau County, are not included in calculations of potential sand resources, they should not be ignored because sand ridges occur in these large offshore areas.

Five potential sand source areas have been identified off Nassau County. Two of these, NA-Primary 1 and Primary 2, are in state waters and the other 3, NA-Secondary 1, 2 and 3, reside seaward of the 3 mile federal limit (Figure 4-3). The Primary areas will be discussed below in relation to their proximity on a particular area of a mapping unit. The Secondary areas will be discussed in a regional context.

Nassau Primary

The southern or downdrift part of the St. Marys Ebb-Tidal Delta mapping unit occurs in Nassau County (Figure 4-4). Occupying about 4163 ha (2% of the offshore area, Table 4-1), the delta extends up to 3.5 miles offshore where bypassing bars migrate around the inlet. The delta extends 5.5 miles downcoast from the Florida-Georgia border and maintains a relatively constant width of about 1.5 miles, terminating in about 30 feet water depth where the delta overlies the Farmton Sand Flat. Small transverse bars occur alongshore.

Potential sand resources in the St. Marys Ebb-Tidal Delta are estimated to range on the order of $782 \text{ x}10^6$ cy (Table 4-1, Figure 4-2). Calculations of sediment volume were based on an estimated 100% delta coverage in the mapping unit. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-65 ft) and shallowest isobath (-3 ft) for the unit (Table 4-1). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates. Variation in ebb-tidal delta volume is illustrated by Powell *et al*. (2006) who report $32.7 \text{ x } 10^6$ cy, the difference probably being related to assumptions of sand thickness versus the computerized method employed in our calculations.

Area NA- Primary 1 is located at the Florida – Georgia border and is situated on the St. Mary's ebb-tidal delta (Figure 4-5). Potential volumes have been calculated for NA-Primary 1 using 3, 6 and 9 feet cuts. These volumes are 22,209,954 cy; 44,419,908 cy and 66,629,861 cy respectively (Table 4-2).

Data from the ROSS database lists 51 vibracores collected in this area from 5 separate studies: 1 from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report (Nocita et.al, 1991), 9 from the Nassau County Beach Nourishment (Olsen Associates, 1993), 9 from the Nassau Sound Section 933 Study, Geotechnical Report (Olsen Associates, 1998), 24 from the Nassau Sound Section 933 Study, Geotechnical Report (Olsen Associates, 1992), 4 from the Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Olsen Associates,

1998) and 4 from the Nassau Sound, Section 933 Study, Geotechnical Report (Olsen Associates, 1991). The locations of these vibracores are shown in Figure 4-6. Data associated with these cores is shown in Table 4-3a. The data shows core layer descriptions and color however there is no individual sample granulometry provided. The majority of these layers are described as being comprised mostly of fine sand or clayey sand with trace shell content.

Additionally, 2 grab samples, KBA-31-08 and KBA-22-08 were collected as part of the Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies (ACE, 1995), (Figure 4- 6). Data in ROSS shows a mean grainsize of 0.19 and 0.14 phi respectively (Table 4-3b). This places these surface samples in the medium sand category using the Unified Soils Classification (USC) scheme.

Geophysical Data

The only ROSS source for geophysical data for this area is from the Phase IV Fieldwork portion of this project. During this task 4 tracklines were run across this area (Figure 4-7). The portions of these lines within the potential source area are presented on Figures 4-8 and 4-9. The line images are arranged to present this area of the delta complex from north to south making the first image on Figure 4-8 the northern most line. These images clearly show an increase in thickness of a silty muddy overburden from north to south. The cleaner sand, as evidenced by a lighter washed out pattern between the lower darker reflector and the upper seafloor reflector, becomes more interlayered with darker material suggesting a higher possibly silt or mud content.

Nassau Primary

The Talbot Transverse Bar field (Figure 4-4) occurs downdrift of the St. Mary's Ebb-Tidal Delta and updrift from the Tisonia - Nassau Sound Ebb-Tidal Delta. The bar field, occupying about 4886 ha (3% of the shelf area) along 10 mi of shore, extends up to 3.1 mi offshore onto the Farmton Sand Flat. Some of the longer bars extend up to 1 or 2 miles in length, striking along 55° to 80° azimuths. Individual bar widths range between 600 to 1500 ft. Although wavelengths are about 1300 ft, there are large sand flat areas (up to ½ mi^2) interspersed between bar sets.

Potential sand resources in the Talbot Transverse Bar field are estimated on the order of 2.3×10^8 cy (Table 4-1, Figure 4-2). Calculations of sediment volume were based on an estimated 80% ridge set coverage in the mapping unit. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-45 ft) and shallowest isobath (-0.3 ft) for the unit (Table 4-1). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates.

Area NA-Primary 2 is situated entirely on top of the Talbot Transverse Bar field (Figure 4-10). Calculated volumes for this area for 3, 6 and 9 feet cuts are 66,467,914 cy; 132,935,828 cy and 199,403,742 cy respectively (Table 4-2).

Vibracore and grab sample data from 5 studies that have been conducted in this area are stored in ROSS and locations are shown in Figure 4- 11. The vibracore data includes 1 from Nassau Sound, Section 933 Study, Geotechnical Report (Olsen Associates, 1991), 10 from the Amelia Island Sand Transfer / Sand Search Study (Olsen Associates, 1993), 32 from the South Amelia Island Shoreline Stabilization (Olsen Associates, 2001) and 3 from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the

Georgia Border - Phase II and Final Report (Nocita et.al, 1991). Two grab samples were collected as part of the Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies (ACE, 1995).

Tabular data from the vibracores listed in ROSS is presented in Table 4-4a. Most of the data listed for the cores only contains descriptive information but a number of cores from the South Amelia Island Shoreline Stabilization (Olsen Associates, 2001) study had discrete samples extracted and analyzed resulting in mean grainsize values for these samples. Descriptive information shows most of the core layers are made up of fine quartz sand with some cores fining downward to a higher silt or mud content. The majority of the mean grainsize values range from 0.13 to 1.99 phi placing them within the medium fine USC category. Two outliers of 2.83 and 3.81 phi are from 8 to 10 feet down in cores A-18 and A-20R1 respectively.

Grab sample information shows mean grainsize values of 0.13 and 0.14 phi (Table 4-4b). These values coincide with medium sand using the USC.

Geophysical data from the Phase IV portion of this study is the only seismic data for this area currently in ROSS. Five transects were completed in this area (Figure 4-12). These images are presented in Figures 4- 13, 4-14 and 4-15. By comparing these images to their transect locations on Figure 4- 12, the bar features discussed above are clearly visible.

The Secondary potential sand source areas are those which lie outside of State waters off Nassau county. These are discussed below in relation to the regional setting of the physiographic mapping unit within which they are located.

Fort Clinch Ridge Field and NA Secondary

NA-Secondary 1, located on the Fort Clinch Ridge Field (Figure 4-3), occurs as an enclave within the Farmton Sand Flat on the northern margin of Nassau County (6070 ha, 3% of shelf area). Lying about 3.5 miles offshore at its closest point to the shore, the ridge field extends up to 10 miles offshore. The ridge field, about 5 miles wide by 5 miles long, contains two ridge fields that are separated by a medial valley about 0.62 mi wide. The smaller ridge set is about 1.2 mi wide by about 3.5 miles in length. Ridge crests in the smaller shoreward ridge set average about 50° azimuth where those in the larger seaward set average about 60° to 65° azimuth. The seaward ridges show a wavelength of about 650 ft m to 1600 ft with individual ridges ranging between 300 ft and 1300 ft in width. Shoreward ridges in the southwestern part of the mapping unit tend to be somewhat wider with 1000 ft to 1500 ft widths, but with lower local relief (5-6 ft compared to 15 ft in the seaward extended ridge sets). The ridge field occurs in water depths that range from 30 ft to 50 ft.

Potential sand resources in the Fort Clinch Field are estimated to range on the order of 230.9 10^6 cy in mapping unit ‘A’ (Table 4-1, Figure 4-2) and 1.1 x 10 cy in mapping unit ‘B’ (Table 4-1)). Calculations were based on an estimated 75% and 85% ridge coverage in the ‘A’ (5,999 ha) and ‘B’ (71 ha) mapping units, respectively. Sediment thickness in the ‘A’ mapping unit was calculated from differences in elevation computed between the depth of the deepest isobath (-55 ft) and shallowest isobath (-25 ft) (Table 4-1). The same calculations were made for the ‘B’ mapping unit using the depth range -55 to -45 ft. Variations in thickness throughout the mapping were used as a basis for volume estimates. Volume estimates for NA-Secondary-1 were calculated on 3, 6 and 9 ft cuts. These values are 86,503,143 cy; 173,006,286 cy and 259,509,429 cy respectively (Table 4-2).

Amelia Sand Ridge and NA Secondary

NA-Secondary – 2 is found on the northern segment of the Amelia Sand Ridge morphosedimentary unit (Figure 4-3). As defined here, this segment lies in federal waters offshore Nassau County in water depths ranging from 40 ft to 45 ft (Figure 4-4). Lying about 4 miles offshore, the unit occurs as an enclave within the Farmton Sand Flat. Although the planform of the ridge field runs parallel to the shore, individual ridges making up the field tend to strike normal to the shore at an angle of about 15° along the primary axis of the field. A small ridge set making up the hook on the northern margin of the ridge field, about 7 miles offshore, lies at about a 60° angle from horizontal. This smaller ridge set, comprised by two main ridges, is about 2 miles in length. A topographically subdued extension of this smaller ridge set connects with the southern margin of the Fort Clinch Ridge Field to the north. The ridge field occurs in water depths that range from 40 ft m to 45 ft.

Potential sand resources in the Amelia Sand Ridge are estimated to range on the order of 94 x 10^6 cy (Table 4-2, Figure 4-2). Calculations of sediment volume were based on an estimated 75% ridge coverage in the mapping unit where ridges averaged about <1/2 mile in width. Thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-55 ft) and shallowest isobath (-30 ft) for the unit (Table 4-1). Variations in thickness throughout the mapping unit were a basis for estimating volumes. Volumes for NA-Secondary – 2 have been calculated at 32,695,417 cy for a 3 ft cut, 65,390,834 cy for a 6 ft cut and 98,086,251 cy for a 9 ft cut (Table 4-2).

Duval Ridge Field and NA Secondary

NA-Secondary – 3 lies within the northernmost extension of the Duval Ridge Field (Figure 4-3), As defined here, the Duval Ridge Field occurs mainly on the inner shelf in federal waters off Nassau County. The ridge field occupies about 22,765 ha (13% of the shelf area) and is flanked along its seaward boundary by the Nassau Bank and shoreward by the Farmton Sand Flat (Figure 4-4). The ridge field is about 12 miles long and extends up to 18 miles offshore. Individual ridges trend 290° azimuth, are 1.5 miles in width by up to 6 miles long, and display wavelengths of about 1/2 to 1 mile. Local relief ranges from 6 to 12 ft in water depths ranging from 50 ft to 80 ft. The ridge and valley topography of the mapping unit seems to be structurally controlled by fractures in underlying bedrock sequences. These planes of weakness along faults and fractures appear to be propagated upwards through the surficial sedimentary cover that makes up the seafloor deposits. The ridge field occurs in water depths that range from 50 ft to 80 ft.

Potential sand resources in the Duval Ridge Field are estimated to range on the order of 1.2 x 10^6 cy (Table 4-1, Figure 4-2). Calculations were based on an estimated 60% ridge coverage (13,659 ha) in the mapping unit with a maximum thickness of about 40 ft. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-80 ft) and shallowest isobath (-40 ft) for the unit (Table 4-1). Variations in thickness throughout the mapping unit were used as a basis for volume estimates. Volume calculations for area NA-Secondary – 3 are 77,323,543 cy for a 3 ft cut, 154,647,086 cy for a 6 ft cut and 231,970,629 cy for a 9 ft cut (Table 4-2).

There are several other physiographic mapping units that are potential sand sources on this portion of the continental shelf. These units are found seaward of the 3 mile limit and are discussed below.

Farmton Sand Flat

The northern extension of the Farmton Sand Flat (Figure 4-4), originally defined by Finkl and Andrews (2007) on the central Florida Atlantic coast, extends along the shoreface and shoreward portions of the inner continental shelf floor. The Farmton Sand Flat occupies about 20,875 ha in Nassau County. At its furthest seaward extent, the sand flat lies about 15 miles offshore Nassau County. The sand flat is dissection alongshore by the St. Marys Ebb-Tidal Delta and Talbot Transverse Bar field. Offshore, this morphosedimentary unit is flanked by the Duval Ridge Field. The sand sheet shows about 6 ft of local relief and occurs in water depths that range from 40 ft to 50 ft.

Potential sand resources in the Farmton Sand Flat are estimated to be on the order of 1.7×10^6 cy (Table 4-1, Figure 4-2). This calculation was based on 100% of the 'A' mapping unit being comprised by sand flats but with 50% of the 'B' mapping unit and 90% of the 'C' containing sand flats. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-70 ft) and shallowest isobath (-0.3 ft) for the unit (Table 4-1). Variations in thickness throughout the mapping units (A, B, and C) form a basis for volume estimates.

Nassau Bank

The northern extension of the Nassau Bank (Figure 4-4) lies offshore Nassau County (9% of the shelf area), about 15 miles from shore at its closest point just south of the Georgia border. The bank, about 5 miles wide by 9 miles long, is flanked seaward by the O'Neal Bank and shoreward by the Duval Ridge Field. The bank contains a topographically subdued medial ridge field that is about 5 miles long; individual ridges range from 20° to 60° azimuth with local relief averaging about 6 ft. Ridges in the northeastern part of the bank, taking in about $1 mi^2$, and each about 1/2 mile in width and about 2 miles in length, exhibit average local relief of about 6 ft. The bank occurs in water depths that range from 50 ft to 80 ft.

Potential sand resources in the Nassau Bank are estimated to range on the order of 1.1×10^9 cy (Table 4-1, Figure 4-2). Calculations of sediment volume were based on an estimated 85% bank coverage in the mapping unit where valleys between bank ridges were excluded. Thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-88 ft) and shallowest isobath (-50 ft) for the unit (Table 4-1). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates.

O'Neal Bank

The southern extension of the O'Neal Bank (Figure 4-4) from across the state line in Georgia, occupies about 29,162 ha offshore Nassau County (16% of the shelf area). The bank, about 17 miles long by 12 ½ miles wide, lies about 18 miles offshore and is strongly dissected along the Florida-Georgia border and southwards into the central part of the bank. The bank is flanked seaward by undifferentiated seafloor with anastomosing ridges and shoreward by the Nassau

Bank. Sand ridges surmounting the general level of the bank strike about 50° to 55° azimuth. These ridges, which average about 650 to 1300 ft in width, range up to 2 miles in length.

Local relief on the dissection northern margin of the bank averages about 12 ft whereas on the southern margin it is about 6 m. The bank occurs in water depths that range from 60 ft to 90 ft.

Potential sand resources in the O'Neal Bank are estimated on the order of 2.6 x 10^9 cy (Table 4-1, Figure 4-2). Calculations of sediment volume were based on an estimated 90% bank coverage in the mapping unit where valleys between bank ridges along dissected margins were excluded. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-100 ft) and shallowest isobath (-47 ft) for the unit (Table 4-1). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates.

Tisonia - Nassau Sound Ebb Tidal Delta

The northernmost extension of the Tisonia - Nassau Sound Ebb-Tidal Delta (Figure 4-4) occurs in the nearshore zone of southern Nassau County. This small updrift segment of the delta (139 ha, Table 4-1) extends about 1/2 mile offshore and is about 1 mile long. Some transverse bars, up to 1600 ft in length, from the Talbot Transverse Bar field extend onto deltaic sands and into the mouth of the estuary. The delta merges seaward with the Talbot Transverse Bar system and extends into the main ebb-tidal sand sequence southward in Duval County. The delta occurs in water depths of about 0-26 ft.

Potential sand resources in the Tisonia - Nassau Sound Ebb-Tidal Delta are estimated on the order of 3.9 x 10^6 cy (Table 4-1, Figure 4-2). Calculations of sediment volume were based on an estimated 80% delta coverage in the mapping unit. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-17 ft) and shallowest isobath (-0.79 ft) for the unit (Table 4-1). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates. Variation in ebb-tidal delta volume is illustrated by Powell *et al*. (2006) who report 53.6 x 10^6 cy, the difference probably being related to assumptions of sand thickness versus the computerized method employed in our calculations.

DUVAL COUNTY

The survey area in Duval County occupies approximately 233,677 ha and extends from the Nassau County line to the St. Johns County line, an along-coast distance of about 18 miles. Extending 50 miles offshore, the shelf area is quite diverse being comprised by nearshore bar fields, sand flats, ridge fields, banks, and ebb-tidal deltas.

The main morphological features on the continental shelf include the following mapping units (Figure 4-4), from the shore seaward: the Tisonia - Nassau Sound Ebb-Tidal Delta, St. Johns Ebb-Tidal Delta, Farmton Sand Flat, Amelia Sand Ridge, Duval Ridge Field, Nassau Bank, and undifferentiated seafloor with anastamosing ridges. A small portion of the Sawgrass Bank occurs on the Duval – St. Johns county line, while a portion of the O'Neal Bank falls on the Nassau - Duval county line.

Potential sand resources in the mapped area of the continental shelf in Duval County (166,102 ha) amount to something on the order of 17.7 x 10^9 cy of sediment (Table 4-5). This sediment volume estimate is based on assumptions for average thickness of morphosedimentary units such as bars, ebb-tidal deltas, sand flats, ridge fields, and banks. Parameters used in calculations of volume estimates are summarized in Table 3. The Duval Ridge Field has the largest sediment volume, but the Amelia Sand Ridge Field may offer greater ease of dredging access as the deposits lie closer to shore in state waters. The sand resource potential of each mapping unit is discussed in relation to geographic occurrence, spatial distribution patterns, and morphosedimentary properties, as summarized in Figure 4-2 and Tables 4-1 and 4-5.

Three potential sand source areas have been delineated offshore of Duval County (Figure 4-16). Two of these areas DU-Primary 1 and DU-Primary 2 are within the 3 mile federal marine boundary and the other, DU-Secondary 1 is outside of this boundary. The first two will be discussed in detail using data from ROSS. Other potential offshore sand sources will also be discussed in a regional perspective.

Duval Primary

The southern segment of the Amelia Sand Ridge morphosedimentary unit (Figure 4-4) as defined here, lies mostly in state waters offshore Duval County in water depths ranging from 40 to 45 ft. Lying about 2 ½ miles offshore, the 6 mile long unit occurs as an enclave within the Farmton Sand Flat. Although the planform of the ridge field runs parallel to the shore, individual ridges making up the field tend to strike normal to the shore at an angle of about 15° along the primary axis of the field. The ridge field occurs in water depths that range from 40 to 45 ft.

Potential sand resources in the Amelia Sand Ridge are estimated to range on the order of 18.3 x 10^6 cy (Table 4-5, Figure 4-2). Calculations were based on an estimated 75% ridge coverage (1039 ha) in the mapping unit with a maximum thickness of about 18 ft. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-49 ft) and shallowest isobath (-33.4 ft) for the unit (Table 3). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Area DU-Primary 1 is located on the extreme southern end of the Amelia Sand Ridge between range monuments DU-001 and DU-026 (Figure 4-17). Potential sand volumes from this area have been calculated on a 3, 6 and 9 feet cut and are presented in Table 4-2. These volumes are 16,228,176 cy, 32,456,352 cy and 48,684,527 cy respectively.

To date the only data in ROSS for this area is 1 vibracore from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report (Nocita et.al, 1991) and 1 vibracore from the FGS/MMS “A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two” (FGS/MMS, 2003-2004) (Figure 4- 18). There is no grab sample data currently in the database. The vibracore data is presented in Table 4-6. A review of this data shows that both cores have descriptive information but only from the FGS/MMS core were samples taken for analysis. The descriptions show the core layers are made up of mostly sand with trace amounts of shell and clay. Samples taken from the FGS/MMS core list mean grainsize values between 1.95 and 2.79 phi placing these samples within the fine classification using the USC.

Two studies have produced geophysical data, in the form of sub-bottom profiles, over this area (Figure 4-19). One trackline from the FGS/MMS “A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two” (FGS/MMS, 2003-2004) (Figure 4-20) and 6 tracklines from the Phase IV portion of this project. Four of these lines are shown in Figures 4-21 and 4-22. Each of these images shows there is a potential for large volumes of sand located in this area.

Duval Primary

The northern extension of the Duval Ridge Field (Figure 4-4), as defined here, occurs mainly on the inner shelf in federal waters off Nassau County but extends onto the middle shelf near its seaward margin. The ridge field occupies about 65,900 ha (28% of the shelf area) and is flanked along its seaward boundary by the Nassau Bank and shoreward by the Farmton Sand Flat. Because the ridge field is dissected by offshore extension of county boundaries, the unit is divided into three segments (Table 4-5, Figure 4-2): (A) bulk of the unit (65,666 ha), (B) a small sliver on the Nassau-Duval county line, and (C) a small part of the ridge field recurving southward into Duval County from Nassau County. The main ridge field segment is about 17 miles long by 20 miles wide and extends up to 18 miles offshore. Individual ridges trend 290 degrees azimuth, are 1.8 miles in width by up to 9 miles long, and display wavelengths of about 0.6 to 1.2 miles. Local relief ranges from 6.5 to 13 ft in water depths ranging from 45 to 78 ft. The ridge and valley topography of the mapping unit seems to be structurally controlled by fractures in underlying bedrock sequences. These planes of weakness along faults and fractures appear to be propagated upwards through the surficial sedimentary cover that makes up the seafloor deposits. The ridge field occurs in water depths that range from 45 to 78 ft.

Potential sand resources in the Duval Ridge Field segments (A, B, and C) are estimated to range on the order of 8.2×10^9 cy (Table 4-5, Figure 4-2). Calculations were based on an estimated 80%, 95%, and 70% ridge coverage (65,900 ha) in A, B, and C segments, respectively, with a maximum thickness of about 65 ft occurring in segment A. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-101 ft) and shallowest isobath (-32.5 ft) for the unit, but varied by spatial unit (Segments A, B, and C in Table 4-5). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

DU Primary 2 straddles the Duval – St Johns county line just inside the 3 mile federal limit (Figure 4- 23). This area is located on a southern trending arm of the Duval Ridge Field between Duval county range monument DU-067 and St. Johns county range monument SJ-016. Potential volumes calculated for 3, 6 and 9 feet depths for this area are found in Table 4-2. These volumes are 12,675,611 cy, 25,351,223 cy and 38,026,834 cy respectively.

Data collection efforts for ROSS have not turned up any core or grab sample datasets associated with this location (Figure 4-24). However, during Phase IV of this project, this portion of the Duval Ridge Field was targeted by personnel of the BBCS for geophysical data collection. The result is that 4 tracklines, DU09a_N_000, DU10_E_001, SJ01_NW_000 and SJ02_E_000 were run over this area (Figure 4-25).

Figures 4- 26 and 4-27 show these line images. Each of these images reveals this area to have upwards of 50 feet thickness of potentially usable sand overtopped by small thicknesses of overburden. Another interesting feature seen on both images on Figure 4- 26 is the location of 3 paleo channels, circled in red. Paleo channels are valuable as sources of organic materials that may be used for age dating these features.

The Secondary potential sand source areas are those which lie outside of State waters off Duval County. These are discussed below in relation to the regional setting of the physiographic mapping unit within which they are located.

Farmton Sand Flat and DU Secondary 1

The northern extension of the Farmton Sand Flat (Figure 4-4), originally defined by Finkl and Andrews (2007) on the central Florida Atlantic coast, extends along the shoreface and shoreward portions of the inner continental shelf floor in Duval County. The Farmton Sand Flat occupies about 18,434 ha in Duval County. At its furthest seaward extent, the sand flat lies about 7.5 miles offshore. The sand flat is overlapped alongshore by the Tisonia - Nassau Sound and St. Johns ebb-tidal deltas and Talbot Transverse Bar field. Offshore, this morphosedimentary unit is flanked by the Duval Ridge Field. The sand sheet shows about 8 m of local relief and occurs in water depths that range from 26 to 52 ft.

Potential sand resources in the Farmton Sand Flat are estimated to be on the order of 2.6 x 10^9 cy (Table 4-5, Figure 4-2). This calculation was based on 100% of the ‘A’ and ‘B’ mapping units being comprised by sand flats. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-82.3 ft) and shallowest isobath (-1.4 ft) for the unit (Table 4-5). Variations in thickness throughout the mapping units (A and B) were used as a basis for volume estimates.

DU Secondary 1 is found seaward of the 3 mile limit in an area that is comprised of both the Duval Ridge Field (discussed above) and the Farmton Sand Flat mapping zones (Figure 4-16). This area makes up the fourth largest potential sand source mapped as part of this project. Volumes for this area are 161,921,874 cy for a 3 ft cut, 323,843,748 cy for a 6 ft cut and 485,765,622 cy for a 9 ft cut (Table 4-2).

There are six other physiographic mapping units that are potential sand sources on this portion of the continental shelf. These units are found seaward of the 3 mile limit and are discussed below.

Nassau Bank

The bulk of the Nassau Bank, defined here, occurs in Duval County (Figure 4-4). Lying about 18.6 miles offshore, the bank is 17.4 miles long by 8.7 miles wide. It is flanked seaward by undifferentiated seafloor with anastamosing ridges, to the south by the Sawgrass Bank and shoreward by the Duval Ridge Field. Occupying about 20% (46,321 ha) of the offshore area, the mapping unit makes up a significant block of landform assemblages. Most of the unit contains low-relief seafloor units, except in area “A” of the data reliability map (Figure 4-4) where more detailed bathymetry was acquired along the approachway to the St. Johns River system. The detailed bathymetry here shows dissected seafloor units with about 13.12 ft of local relief whereas bathymetric variance on the northern and southern margins of the bank average about 2 m.

Potential sand resources in the Nassau Bank are estimated to range on the order of 3.9 x 10^9 cy (Table 4-5, Figure 4-2). Calculations of sediment volume were based on an estimated 95% bank coverage in the mapping unit where valleys between bank ridges along dissected margins were excluded. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-105.6 ft) and shallowest isobath (-58.4 ft) for the unit (Table 4-

5). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates.

O'Neal Bank

A small segment of the southernmost extension of the O'Neal Bank, as defined here, (Figure 4-4) extends across the northern offshore border of Duval County. This segment, occupying about 1876 ha (1% of offshore county shelf area), lies about 28 miles offshore from the mouth of the St. Johns River estuary. The bank contains a few small sand ridges between .6 to 1.8 miles in length and ranging from 1000 to 1900 ft in width. The bank is flanked shoreward by the Nassau Bank and seaward by undifferentiated seafloor with anastamosing ridges. The bank occurs in water depths that range from 60 to 90 ft.

Potential sand resources in the O'Neal Bank are estimated to range on the order of 8.5 x 10^6 cy (Table 4-5, Figure 4-2). Calculations of sediment volume were based on an estimated 60% bank coverage in the mapping unit where valleys between bank ridges along dissected margins were excluded. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-66.9 ft) and shallowest isobath (-95.4 ft) for the unit (Table 4-5). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates.

Sawgrass Bank

Extensions of the Sawgrass Bank (Figure 4-4), as defined here, occur along the southern offshore boundary of Duval County about 15.5 miles (Segment B), 30 miles (Segment A), and 34.8 miles (Segment C) from shore. These segments of the bank, all lying on the outer shelf floor, respectively occupy 425 ha, 6171 ha, and 21,730 ha of the shelf. These units are bounded seaward by the Nassau Bank and shoreward by the Duval Ridge Field. Topographic relief of the bank stands in marked contrast to the structurally controlled ridges of the Duval Ridge Field and sedimentary plateaus of the Nassau Bank. Prominent sand ridges are associated with Segment A whereas segments B and C generally lack ridges. Local relief in all three segments averages about 3 m. The bank occurs in water depths that range from 72 ft to 118 ft.

Potential sand resources in the Sawgrass Bank are estimated on the order of 1.6 x 10^9 cy in Segment C, about 3.5 x 10^6 cy in Segment B and 4.3 x 10^6 cy in Segment A (Table 4-5, Figure 4-2). Calculations of sediment volume were based on an estimated 40% bank coverage in Segment A, 75% bank coverage in Segment B, and 100% bank coverage in Segment C. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-121.7 ft) in Segment C and shallowest isobath (-63.6 ft) in Segment B (Table 4-5). Variations in thickness throughout the mapping units were used as a basis for these volume estimates.

St Johns Ebb Tidal Delta

The St. Johns Ebb-Tidal Delta (Figure 4-4) occurs at the mouth of the St. John River from about R020 to R050 in Duval County. Occupying an area of about 1840 ha (Table 4-5), the delta stretches alongshore for a distance of about 5.6 miles and extends offshore about 1.2 miles from the updrift margin. The distal margins of the delta merge with the Farmton Sand Flat.

The delta sediment volume amounts to something on the order of 2.9 x 10^6 cy (Table 4-5, Figure 4-2). Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-78.4 ft) and shallowest isobath (-0.98 ft) (Table 4-5). Variations in thickness throughout the mapping units were used as a basis for these volume estimates. Powell *et al*. (2006) combined the St. John and Ft. George ebb-tidal deltas to get an estimated volume of about 170 x 10^6 cy. The larger volume obtained by Powell *et al.* (2006), compared to that derived in this report, may be due to perceived differences in sediment thickness.

Talbot Transverse Bar

The southern extension of the Talbot Transverse Bar field (Figure 4-4), as defined here, occurs on the northwestern boundary of the shelf area on the shoreface. Here, the bar field is about 2.9 miles in length by about 1.6 miles in width at it widest point. The bar field, superposed on top of the Farmton Sand Flat, merges shoreward with the Tisonia - Nassau Sound Ebb-Tidal Delta. Bars nearly 1.8 miles long lie at a high angle to the coast (75° to 80° azimuth) but bend shoreward near the outer boundary of the delta to merge with shore-normal bars on the delta platform.

Potential sand resources in the Talbot Transverse Bar field are estimated on the order of 35.3 x 10^6 cy (Table 4-5, Figure 4-2). Calculations of sediment volume were based on an estimated 50% bar coverage in the mapping unit. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-46.7 ft) and shallowest isobath (-9.5 ft) for the unit (Table 4-5). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates.

Tisonia - Nassau Sound Ebb-Tidal Delta

Most of the Tisonia - Nassau Sound Ebb-Tidal Delta (Figure 4-4), as defined here, occurs in the Duval County shelf area. The delta extends alongshore for about 3.7 miles and extends offshore for a distance of about 1.6 miles. The delta is built out over the Farmton Sand Flat on the shoreface and merges seaward with the Talbot Transverse Bar field. Occurring in about 6 m water depth, local relief averages about 4 m.

Occupying an area of about 1275 ha (1% of the shelf area), the delta is estimated to contain about 122.9 x 10^6 cy of sand (Table 4-5, Figure 4-2). Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-35.1 ft) and shallowest isobath (-2.95 ft) for the unit (Table 4-5). Variations in thickness throughout the mapping unit were used as a basis for these volume estimates. Powell *et al*. (2006) estimate volume at 53.6 x 10^6 cy.

ST. JOHNS COUNTY

The survey area in St. Johns County, the largest offshore county shelf area from Brevard County to the Georgia state line, occupies approximately 484,542 ha and extends from the Duval County line to the Flagler County line, an along-coast distance of about 41 miles. Extending 46 miles offshore, the shelf area is quite diverse being comprised by sand flats, ridge fields, banks, sand waves, and ebb-tidal deltas. These seafloor features account for about 69% of the total shelf area (Table 4-7), the remained being taken up by undifferentiated seafloor with transverse ridges.

The main morphological seafloor features on the continental shelf include the following mapping units (Figure 4-4), from the shore seaward: the St. Augustine Ebb-Tidal Delta, Farmton Sand Flat, Duval Ridge Field, Espanda Ridge Field, Sawgrass Bank, Summerhaven Sand Wave, St. Johns Bank, Crescent Ridge Field, Palm Coast Sand Wave and undifferentiated seafloor with transverse ridges. A small portion of the Nassau Bank occurs on the Duval – St. Johns county line.

Potential sand resources in the mapped area of the continental shelf in St. Johns County (332,253 ha) amount to something on the order of 3.7 x 10^9 cy of sediment (Table 4-7). This estimate of sediment volume is based on assumptions for average thickness of morphosedimentary units such as ebb-tidal deltas, sand flats, ridge fields, sand waves, and banks. Parameters used in calculations of volume estimates are summarized in Table 4-7. The Farmton Sand Flat has the largest potential sediment volume, followed by the Duval Ridge Field, Palm Coast Sand Wave, Sawgrass Bank, St. Johns Bank, and the Summer Haven Sand Wave. The sand resource potential of each mapping unit is discussed in relation to geographic occurrence, spatial distribution patterns, and morphosedimentary properties, as summarized in Figures 4-2 and 4-4 and Table 4-7.

Potential sand source areas off St. Johns County are concentrated within the major ridge fields. Nine potential areas have been designated as part of this report. SJ Primary 1, SJ Primary 2 and SJ Primary 3 all lie within the state 3 mile limit while SJ Secondary 1, SJ Secondary 2, SJ Secondary 3, SJ Secondary 4, SJ Secondary 5 and SJ Secondary 6 are found seaward of the 3 mile limit (Figure 4-28). Primary areas will be discussed in relation to data in ROSS while secondary areas will be described in a regional sense.

St Johns Primary

The Duval Ridge Field (Figure 4-4), as defined here, extends through the central part of the inner shelf floor from Duval County to the south-central part of the continental shelf off St. Johns County. Due to shoreward downdrift extending fingers of the ridge field, a small section of the shoreward-most finger (Segment A) extends from Duval County into St. Johns County. The main body of the ridge field is denoted as Segment B for computational purposes when calculating areas and potential sediment volumes. Taking in the larger area, Segment B occupies about 52,545 ha (11% of the county continental shelf area) (Table 4-7). The much smaller Segment A occupies about 586 ha.

The ridge field shoreward overlaps the Farmton Sand Flat and is bordered on its seaward margins by the Sawgrass Bank and undifferentiated seafloor with transverse ridges. Some of the downdrift extending fingers show subdued continuation of low-relief ridges onto the Farmton Sand Flat, for example, the shoreward-most sediment tail being 12.4 miles in length and merging with the St. Augustine Ebb-Tidal Delta. Structural control of the ridge field is evident in the northern part of the shelf area but becomes less clear with distance south. Local relief (about 6.5 to 13 ft) is most pronounced where the ridge field begins to fragment into downdrift fingers along a 20 mile long diagonal extending from Segment A to a point about 10 miles offshore. The ridges occur in water depths that range from 40 to 78 ft.

Potential sand resources in the Duval Ridge Field are estimated to range on the order of 4.8 x 10^9 cy (3,737,889,865 m^3) in Segment B and about 13.1 x 10^6 cy in Segment A (Table 4-7, Figure 4-2). Calculations were based on an estimated 90% ridge coverage in Segment A with a maximum thickness of about 11 ft and an estimated 85% ridge coverage in Segment B with a maximum thickness range of about 80 ft. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-82.3 ft) and shallowest isobath (-4.9 ft) for both units combined. Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

SJ Primary 1 is located in the nearshore waters off St. Johns County between range monuments SJ-067 and SJ- 016 and sits on one of the larger southward extending fingers of the region designated as Duval Ridge Field B (Figure 4-29). Potential sand volumes for this area are presented in Table 4-2. These volumes have been calculated using a 3, 6 and 9 feet depth and are 16,780,854 cy, 33,561,708 cy and 50,342,562 cy respectively (Table 4-2).

The ROSS database lists 1 vibracore collected as part of the "Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report (Nocita et.al, 1991) (Figure 4-30). This core was divided into three layers. Descriptive information for these layers shows the sediment to be mostly quartz sand ranging from fine to medium grainsize. There are no mean grainsize values presented suggesting no individual samples were extracted.

Geophysical data was collected in this area as part of the Phase IV portion of this project. Four tracklines traverse the main feature associated with this area (Figure 4-31). These are lines SJ03_W_000, SJ04_NE_000, SJ05_NW_000 and SJ06_E_000 which are presented as Figure 4-32 and Figure 4-33. These images show the extent which potential sand lie below the surface. There is between approximately 40-50 feet of compatible sand under only a few feet of overburden. Further data collection on this ridge is needed to verify this estimate

St. Johns Primary

The St. Augustine Ebb-Tidal Delta (Figure 4-4) occurs mostly on the shoreface but its distal surface surmounts the inner shelf floor. Sediment is contributed to the delta from sand ridges that extend southwards from depositional fingers of the Duval Ridge Field. Some of these sand ridges originate about 12 miles to the north, eventually merging with the delta with feeder sand. One large sand ridge lies about 2600 ft offshore the deltafront. Local relief averages about 32 ft on the delta swash platform. The sand bank occurs in water depths that range from 0 ft to 32 ft.

Potential sand resources in the St. Augustine Ebb-Tidal Delta are estimated to be on the order of 363 x 10^6 cy (Table 4-7, Figure 4-2). This calculation was based on 70% of the mapping unit being comprised by deltaic sand units. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-51.7 ft) and shallowest isobath (-1.97 ft) for a maximum sediment thickness range of about 50 ft in the unit (Table 4-7). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

The potential sand source area SJ Primary 2 lies on top of this ebb tidal delta between range monuments SJ-111 and SJ- 165 (Figure 4-34). Sand volumes for this area, calculated using 3, 6 and 9 feet cuts are 46,041,954 cy; 92,083,908 cy and 138,125,862 cy respectively (Table 4-2).

Data found in ROSS lists 11 vibracores from two studies have been entered into the database for this area. Their locations are shown on Figure 4-35. These include 5 vibracores from the St. John's Vibracore 1998 (Taylor Engineering Inc., 1998) and 6 from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the

Georgia Border - Phase II and Final Report (Nocita et.al, 1991). Associated data for these cores lists core layer descriptions (Table 4-9) that show sediment types are made up of fine sand with some layers showing trace amounts of organics and or shell fragments. In core 848 from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report (Nocita et.al, 1991) two samples were extracted and returned mean grainsizes value 2.74 phi and 2.98 phi, placing them well within the fine sand category of the USC.

Figure 4-36 shows that geophysical data collected during Phase IV of this project consists of 4 tracklines, SJ14_NW_000, SJ15_E_000, SJ15a_NW_000 and SJ16_E_000. Images of these lines are seen in Figures 4-37, 4-38 and 4-39. These images show this ebb tidal delta increasing in depth from north to south with the thickness of potential sand increasing seaward.

St Johns Primary

SU Primary 3 is also located in the Duval Ridge Field physiographic province (discussed in 4.3.1) between range monuments SJ-120 and SJ- 149. Situated on top of a distinguishable ridge (Figure 4-40), this area shows only 1 vibracore from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report (Nocita et.al, 1991) on the extreme eastern edge (Figure 4-41). This core appears to actually be in the Farmton Sand Flat region and not on the ridge itself. Data from this core (Table 4-10) lists core layers as having a mostly silty, shelly composition.

Geophysical data crossing this feature includes 4 tracklines from the Phase IV portion of this project and 1 trackline from the FGS/MMS Year 2 study (FGS/MMS, 2003-2004) (Figure 4-42). The Phase IV Images of these tracklines (Figures 4-43 and 4-44) clearly show the ridge feature. The FGS/MMS line (Figure 4-45) traverses the ridge longitudinally so the vertical aspect of the ridge is not as apparent. Each of these images does show there is a potential for large quantities of sand to be found not only in the ridge itself but also a few feet below the seafloor.

St Johns Secondary and

Each of these areas lies seaward of the 3 mile state waters limit within the Duval Ridge Field mapping unit (discussed in 4.3.1) (Figure 4-28). Volume calculations for each of these areas have been determined using 3, 6 and 9 ft cuts (Table 4-2). This table shows the potential for 50,342,562 cy, 138,125,862 cy and 29,901,438 cy (based on 9 ft cut) in each of these areas respectively.

Crescent Ridge Field and SJ Secondary

Occupying about 9268 ha (2% of the mapped shelf area), the Crescent Ridge Field (Figure 4-4), as defined here, occurs on the inner shelf floor in the southwestern part of the offshore shelf area. Shoreward the ridge field overlaps the Farmton Sand Flat mapping unit and is flanked on its seaward margin by the Summer Haven Sand Wave and Palm Coast Sand Wave. The ridge field is about 3 miles wide at its widest extent in the north where it merges with the Summer Haven Sand Wave. About 3 ½ miles south of its northern apex, the ridge field trifurcates into three southward extending fingers, the longest set of which is about 8 miles in length. The sand ridges sets average about 0.3 to .6 miles in width and the extended fingers respectively range up to 7, 8 and 9 miles in length in the shoreward, middle, and seaward arms. Occurring 4.5 to 6 miles offshore, the ridges trend along 90° to 100° azimuths. Greatest local relief (about 13 ft) occurs at the northern end of the middle extended ridge set. The ridges occur in water depths that range from 52 ft to 65 ft.

Potential sand resources in the Crescent Ridge Field are estimated to range on the order of 355.8 x 10^6 cy (Table 4-7, Figure 4-2). Calculations were based on an estimated 80% ridge coverage with a maximum thickness of about 30 ft. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-71.8 ft) and shallowest isobath (-42.6 ft) for the unit. Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

SJ Secondary 4 is located in an area that is comprised of portions of the Crescent Ridge Field and the Farmton Sand Flats mapping units (Figure 4-28). The volumes of sand for this area are based on what is potentially available in the ridges. Based on 3, 6 and 9 ft cuts, these volumes are 105,301,915 cy, 210,603,831 cy and 315,905,746 cy respectively (Table 4-2).

Summer Haven Sand Wave and SJ Secondary 5

The Summer Haven Sand Wave (Figure 4-4) occupies about 55,722 ha (11% of the county continental shelf area) (Table 4-7) and lies about 7.5 miles offshore on the middle shelf floor. The mapping unit extends another 25 miles seaward to where it imperceptibly merges with the St. Johns Bank on the outer shelf floor. The sand wave is bounded to the north by the St. Johns Bank and undifferentiated seafloor with transverse ridges. The shoreward margin on the inner shelf floor breaks down into the Crescent Ridge Field, which represents degradation of the sand wave into large downdrift ridge segments. The southern 1 to 2.5 mile wide dissected margin of the sand wave terminates at the updrift margin of the Palm Coast Sand Wave. Some large sand ridges, 1.2 to 3 miles long (60°-75° azimuth) surmount the general level of the sand wave surface. The sand wave occurs in water depths that range from 50 ft to 90 ft.

Potential sand resources in the Summer Haven Sand Wave are estimated to be on the order of 3.9 x 10^9 cy (Table 4-7, Figure 4-2). This calculation was based on 70% of the mapping unit being comprised by sand wave units, except along dissected margins. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-100 ft) and shallowest isobath (-48.5 ft) for a maximum sediment thickness range of 51.8 ft in the unit, valley in dissected margin to ridge crest on top of sand wave surface. Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

SJ Secondary 5 is located within the Summer Haven Sand Wave mapping unit where this unit and the Palm Coast Sand Wave merge (Figure 4-28). The area encompassed by SJ Secondary 5 is made up largely of sand ridges. The volume of SJ Secondary 5 is based on these ridges and show for a 3 ft cut there is an estimated 98,209,718 cy, for a 6 ft cut there is an estimated 196,419,435 cy and for a 9 ft cut there is an estimated 294,629,153 cy (Table 4-2).

Palm Coast Sand Wave, Espanda Ridge Field and SJ Secondary 6

Comprising 19,656 ha (4% of the shelf area), the bulk of the Palm Coast Sand Wave (Figure 4-4), as defined here, occurs in St. Johns County. The sand wave occurs mostly on the middle shelf floor but extends 28 miles seaward onto the outer shelf floor. The northern flank of the sand wave is bordered by the dissected southern downdrift margin of the Summer Haven Sand Wave, which also wraps around the seaward end of the sand wave. The Espanda Ridge Field marks the dissected shoreward margin. The southern downdrift margin of the sand bank is characterized by a 1 to 3 mile wide dissected zone with numerous ridges. The sand wave occurs in water depths that range from 78 to 110 ft.

Potential sand resources in the Palm Coast Wave are estimated to be on the order of 1.8 x 10^9 cy (Table 4-7, Figure 4-2). This calculation was based on 90% of the mapping unit being comprised by sand wave units. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-100 f.) and shallowest isobath (-50.8 ft) for a maximum sediment thickness range of 50 ft in the unit (Table 4-7). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Espanda Ridge Field

The northern extension of the Espanda Ridge Field, as defined here, occurs along the border with Flagler County about 6 miles offshore from R190 (Figure 4-4). The ridge field extends northwards about 6 miles on the middle shelf floor into the southern part of the offshore St. Johns County continental shelf. The ridge field is flanked on its shoreward margin by the Crescent Ridge Field and on its seaward margin by the Palm Coast Sand Wave. The ridge field terminates northward on the dissected southern boundary of the Summer Haven Sand Wave. Individual ridges average about 0.3 to 0.6 miles in width and range up to 1.2 miles in length, trending on azimuths of about 15° to 20°. The ridges occur in water depths that range from 59 to 65 ft.

Potential sand resources in the Espanda Ridge Field are estimated to range on the order of 62.8 x 10^6 cy (Table 4-7, Figure 4-2). Calculations were based on an estimated 75% ridge coverage with a maximum thickness range of about 20.6 ft. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-71.8 ft) and shallowest isobath (-51.2 ft) for both units combined. Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

SJ Secondary 6 is situated primarily on the southern downdrift margin of the Palm Coast Sand Wave mapping unit with a smaller western portion made up of the Espanda Ridge Field mapping unit (Figure 4-28). In both of these mapping units the targeted sand sources reside in the ridges. Combined volumes for SJ Secondary 6 from each of these mapping units are presented here and are shown in Table 4-2. Volume calculated for a 3 ft cut is 201,155,198 cy, a 6 ft cut is 402,310,396 cy and a 9 ft cut is 603,465,595 cy.

Five other physiographic mapping units that are not located within the 3 mile boundary are also considered potential sand sources off St Johns County. These are discussed below.

Farmton Sand Flat

The Farmton Sand Flat (Figure 4-4), as defined by Finkl and Andrews (2006), occurs all along the inner shelf floor in St. Johns County, a distance of about 40 miles. The sand flats are flanked on seaward margins by the Duval and Crescent ridge fields. These sand flats extend up to 7 ½ miles offshore but are partly surmounted by sand ridges that come within 1.2 miles of shore. This shoreface attached sand sheet displays a generally subdued relief that is only broken by low sand ridges extending downdrift from shoreward-aligning fingers of the Duval Ridge Field. The sand sheet is also overlain by the St. Augustine Ebb-Tidal Delta from R080 to R170. The sand flats occur in water depths that range from 6.4 ft to m to 65.5 ft.

Potential sand resources in the Farmton Sand Flat are estimated to be on the order of 14.4 x 10^9 cy (Table 4-7, Figure 4-2). This calculation was based on 100% of the mapping unit being comprised by sand flats as including subdued sand ridge extensions from the Duval Ridge Field. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-140.4 ft) and shallowest isobath (-4.17 ft) for the unit (Table 4-7). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Flagler Sand Wave

A small sliver of the Flagler Sand Wave (an area of about 82 ha) (Figure 4-4), occurs on the border with Flagler County about 22 miles offshore from R200. This small unit is flanked to the north by the dissected margin of the Palm Coast Sand Wave. Sand accumulating on the northern margin of the Flagler Sand wave present a strikingly smooth seafloor compared to the dissection that occurs on the southern downdrift margins of the updrift sand wave. The sand wave occurs in water depths that range from 85 to 92 ft.

Potential sand resources in the Flagler Sand Wave are estimated to be on the order of 868 x 10^3 cy (Table 4-7, Figure 4-2). This calculation was based on 60% of the mapping unit being comprised by sand wave units. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-94.5 ft) and shallowest isobath (-83.43 ft) for the unit (Table 4-7). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Nassau Bank

Two small southern-most extensions of the Nassau Bank (Figure 4-4), as defined here, occur on the shelf offshore St. Johns County. Segments A and B respectively lie about 28 miles and 32 miles offshore R070. These southern extensions of the Nassau Bank protrude into the mapping unit identified as Undifferentiated Seafloor with Transverse Ridges. Segment A takes in 856 ha and Segment B occupies 1707 ha. The southwestern flanks of the banks are marginally dissected. Local relief on these segments averages about 10 ft. The sand bank occurs in water depths that range from 78 to 100 ft.

Potential sand resources in these small extensions of the Nassau Bank are estimated to be on the order of 35.3 x 10^6 cy in Segment A and about 56.2 x 10^6 cy in Segment B (Table 4-7, Figure 4-2). This calculation was based on 85% of Segment A being comprised by sand wave units and 65% of Segment B containing sand wave units. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-100 ft) and shallowest isobath (-74.5 ft) between both units (Table 4). Variations in thickness throughout the mapping unit were used as a basis for volume estimates. The sand bank occurs in water depths that range from 78 to 98 ft.

Sawgrass Bank

The large segment (58,653 ha, 12% of the shelf area) of the Sawgrass Bank (Figure 4-4) occurring in St. Johns County lies along the northern border with Duval County. Here, the bank lies about 10 miles offshore on the middle shelf floor but extends seaward onto the outer shelf floor. The bank is flanked on its shoreward margin by the Duval Ridge Field and seaward by undifferentiated seafloor with transverse ridges. Local relief on the bank averages about 16 ft, except along the southern dissected margin that lies about 18 miles from shore. Some sand ridges surmount the bank surface, especially on the middle shelf floor on shoreward margins of the outer shelf floor. The sand bank occurs in water depths that range from 52 to 92 ft.

Potential sand resources in the Sawgrass Bank are estimated to be on the order of 4.8×10^9 cy (Table 4-7, Figure 4-2). This calculation was based on 75% of the mapping unit being comprised by sand wave units, except along dissected margins. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-105 ft) and shallowest isobath (-49.8 ft) for a maximum sediment thickness range of 55.1 ft in the unit (Table 4-7). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

St. Johns Bank

The St. Johns Bank (Figure 4-4) is a large sand bank that occupies about 83,966 ha (about 17% of the county continental shelf area) (Table 4-7) about 21.7 mi offshore on the outer shelf floor. This sand bank extends about 40 miles offshore in the central and southern parts of the survey area. It merges seaward with undifferentiated seafloor with sand ridges and is bounded shoreward by the Summer Haven and Palm Coast sand waves. Some areas of hummocky terrain occur near the central part of the sand bank about 25 miles offshore from R150 to R170. Some large sand ridges surmount the general level of the bank and extend in a general northeast-southwest direction (40° to 55° azimuth) for about 6 to 7.5 miles. Local relief on the bank surface averages about 13 ft, except in the vicinity of sand ridges. The sand bank occurs in water depths that range from 79 to 112 ft.

Potential sand resources in the St. Johns Bank are estimated to be on the order of 5.8×10^9 cy (Table 4-7, Figure 4-2). This calculation was based on 65% of the mapping unit being comprised by sand wave units, except along dissected margins. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-125.9 ft) and shallowest isobath (-60.7 ft) for a maximum sediment thickness range of 65.3 ft in the unit, valley to ridge crest (Table 4-7). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

FLAGLER COUNTY

The survey area in Flagler County, the second smallest offshore county shelf area (185,321 ha) after Nassau County, extends from St. Johns County to Volusia County for an along-coast distance of about 17 miles. Extending about 43 miles offshore, the shelf area is quite diverse being comprised by sand flats, ridge fields, sand waves, and banks. These seafloor features account for about 94% of the total mapped shelf area (Table 4-11), the small remainder being taken up by undifferentiated seafloor with transverse ridges.

The main morphological seafloor features on the continental shelf include the following mapping units (Figure 4-46), from the shore seaward: the Farmton Sand Flat, Beverly Shoal, Bunnel Ridge Field, Korona Ridge Field, Espanda Ridge Field, Flagler Sand Wave, Palm Coast sand Wave, Volusia Bank and the St. Johns Bank. Mapping units taking up the most area include the Flagler Sand Wave, St. Johns Bank, and Farmton Sand Flat.

Potential sand resources in the mapped area of the continental shelf in Flagler County (174,911 ha) amount to 12.5 x 10^9 cy of sediment. This sediment volume estimate is based on assumptions for average thickness of morphosedimentary units such as, sand flats, ridge fields, sand waves, shoals, and banks. Parameters used in calculations of volume estimates are summarized in Table 4-11. The Flagler Sand Wave has the largest potential sediment volume, followed by the St. Johns Sand Bank and the Farmton Sand Flat. The sand resource potential of each mapping unit is discussed in relation to geographic occurrence, spatial distribution patterns, and morphosedimentary properties, as summarized in Figure 4-47 and Table 4-11.

Potential sand source areas off Flagler County are found primarily in the sand wave and sand flat areas described above. Out of four potential sand source areas identified, only 1, FL_Primary 1, lies within state waters (Figure 4-48). This area will be discussed in relation to data contained in ROSS where the other 3 will be discussed in a more regional context.

Flagler Primary

FL Primary 1 is located on top of the portion of the Beverly Shoal that lies within state waters (Figure 4-49) between range monuments FL-038 and FL-065. This shoal is found about 2.8 miles offshore R040, the Beverly Shoal (Figure 4-46) and occurs as an enclave within the Farmton Sand Flat. The shoal is about 1.7 miles wide by 2.8 miles long, taking in about 1248 ha (1% of the county continental shelf area) (Table 4-11). It contains the distal margins of subdued shoals (350° azimuths) extending downdrift (southwards) from the Crescent Ridge Field, about 6.8 mi updrift (northwards). Smaller subdued ridge extensions from the Espanda Ridge Field mark the seaward flank of the shoal.

Potential sand resources in the Beverly Shoal are estimated to be on the order of 26.2 x 10^6 cy (Table 4-11, Figure 4-47). This calculation was based on 85% of the mapping unit being comprised by sand ridge units that make up the shoal area. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-64.3 ft) and shallowest isobath (-49.4 ft) for a maximum sediment thickness range of 14.7 ft in the unit (Table 4-11). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Data in ROSS from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report (Nocita et.al, 1991) shows 1 vibracore was taken near the shoal within the area (Figure 4-50). Data from this core residing in ROSS lists no descriptive information however there were 3 samples taken from this core upon which mean grainsize values were determined. These values are 2.3, 2.5 and 2.7 phi (Table 4-12) placing these sediments well within the fine sand classification using the USC. Volume calculations for this based on 3, 6 and 9 feet cuts are 10,648,973 cy, 21,297,946 cy and 31,946,920 cy respectively (Table 4-2).

Geophysical data for this area was again part of both the Phase IV of this study and the FGS/MMS Year 2 study (FGS/MMS, 2003-2004). Locations of the tracklines is shown in Figure 4-51. The line images from both cruises, Figures 4-52 and 4-53, show potential sand thicknesses of up to 50 feet over this shoal.

Flagler Secondary 1 is also located on the Beverly Shoal however it is located seaward of the 3 mile state limit (Figure 4-48). This area occupies the majority of the shoal and as such makes it an important candidate for future more detailed studies. Volume estimates for this area are presented for a 3 ft cut, 26,947,976 cy a 6 ft cut, 53,895,952 cy and a 9 ft cut 80,843,927 cy (Table 4-2).

Bunnel Ridge Field and Flagler Secondary 2

The Bunnel Ridge Field (Figure 4-46) encompasses about 7858 ha (4% of county continental shelf area) (Table 4-11). The shoreward margins of the Bunnel Ridge Field lie about 6 miles offshore R020 to R100. The ridge field, lying on the middle shelf floor, is about 15.5 miles long by 3 miles wide at it widest point offshore R030. The seaward margin of the main ridge field is flanked by the Flagler Sand Wave whereas the downdrift southern extended fingers are surrounded by Farmton Sand Flats. Surmounting the Farmton Sand Flat, the ridge field extends southwards into Volusia County. Individual ridges range from 1/2 to 3 miles in width and strike about 90° to 100° azimuths. Ridges in downdrift-extending fingers of the main ridge field are narrower (980 ft to 2600 ft) and shorter (1.8 to 3.7 miles). The ridges occur in water depths that range from 52.5 to 72 ft.

Potential sand resources in the Bunnel Ridge Field (Figure 4-46) are estimated to range on the order of 157 x 10^6 cy (Table 4-11, Figure 4-47). Calculations were based on an estimated 45% ridge coverage (the remainder of the mapping unit being dissected ridge margins and slopes to sand flats) with a maximum thickness range of about 35.4 ft. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-76.4 ft) and shallowest isobath (-44.3 ft) (Table 4-11). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Flagler Secondary 2 occupies the entire Bunnel Ridge Field. Total estimated volume for this area has been presented above. Estimated volumes based on 3, 6 and 9 ft cuts are 99,394,685 cy, 198,789,369 cy and 298,184,054 cy respectively and are presented in Table 2.

Flagler Sand Wave and Flagler Secondary 3

The Flagler Sand Wave (Figure 4-46) lies wholly in Flagler County, except for a small sliver in St. Johns County. The mapping unit takes in 57,210 ha (31% of the county continental shelf area) (Table 4-11). The unit is the southernmost sand wave in the Summer Haven – Palm Coast – Flagler sand-wave triumvirate. The Bunnel Ridge Field represents the dissected shoreward margin of the sand wave where sediments are transported downdrift in long fingers. The mapping unit is bounded seaward by the St. Johns Bank. The Volusia Bank occurs to the south where the dissected southern margin of the Flagler Sand Wave dissipates into a smoothly flowing bathymetry. Lying 10 to 30 miles offshore, this large shore-normal sand wave is about 22 miles wide in east-west extent by about 14 miles long in a north-south extent, with long 3-9 mile ridges (85° azimuth) superimposed. The northern undissected zones range up to 7.5 miles in north-south extent before breaking up into the 3 mile wide southern dissected zone.

Potential sand resources in the Flagler Sand Wave are estimated to be on the order of 6.0 x 10^9 cy (Table 4-11, Figure 4-47). This calculation was based on 95% of the mapping unit being comprised by northern sand wave surface and ridge units, as occur along the southern dissected margin. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-98.5 ft) and shallowest isobath (-43.9 ft) for a maximum sediment thickness range of 54.5 ft in the unit, valley in dissected margin to ridge crest on top of sand wave surface (Table 4-11). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Flagler Secondary 3 is located in the ridge units within the southern dissected margin (Figure 4 – 48). This area has calculated volumes of 85,771,617 cy for a 3 ft cut, 171,543,234 cy for a 6 ft cut and 257,314,851 cy for a 9 ft cut.

Six other physiographic zones are also potential sand sources for offshore Flagler County. These are found seaward of state waters and will be discussed in a regional context below.

Espanda Ridge Field

The southern part of the Espanda Ridge Field (Figure 4-46), lying about 6 miles offshore on the middle shelf floor, extends about 6 miles into Flagler County from St. Johns County. This southern extension of the ridge field (1325 ha, 1% of the county continental shelf area) (Table 4-11), which is about 1.8 miles wide along the southern border of St. John County and which narrows to less than .6 miles in width at its distal point, is surrounded by Farmton Sand Flats. Individual ridges that make up the ridge field average about 300 to 1600 ft in width, are about 1.2 miles long, and lie on 15° to 20° azimuths. Subdued ridges extend downdrift from the ridge field onto the Farmton Sand Flat.

Potential sand resources in the Espanda Ridge Field are estimated to range on the order of 40.5 x 10^6 cy (Table 4-11, Figure 4-47). Calculations were based on an estimated 95% ridge coverage with a maximum thickness range of about 18 ft. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-69.9 ft) and shallowest isobath (-51.8 ft) (Table 4-11). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Farmton Sand Flat

The Farmton Sand Flat (Figure 4-46) is a shoreface-connected sand sheet that generally extends about 6 miles offshore on the inner shelf floor and shoreward part of the middle shelf floor, but extension sand ridges may extend up to 12 miles offshore. For computational purposes, the sand flats have been divided into two segments, A and B. Segment A lies seaward, being cut off from the main body of sand flats by the Bunnel Ridge Field. Segment A, the smaller of the two parts, takes in about 4163 ha (2% of the county continental shelf area) (Table 4-11). Segment B, the larger of the two parts, lies alongshore and takes in about 28,764 ha (16% of the county continental shelf area) (Table 4-11). These extensive sand sheets show low local relief (about 6.5 to 13 ft) and occur in water depths of about 6.5 to 72 ft.

Potential sand resources in the Farmton Sand Flat are estimated to be on the order of 130.8 x 10^6 cy in Segment A and about 1.8 x 10^9 cy in Segment B (Table 4-11, Figure 4-47). This calculation was based on 100% of the 'A' and 'B' mapping units being comprised by sand flats. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-78.9 ft) (Segment B) and shallowest isobath (-8.6 ft) (Segment A) for both units (Table 4-11). Variations in thickness throughout the mapping units (A and B) were used as a basis for volume estimates.

Korona Ridge Field

The northern extension of the Korona Ridge Field (Figure 4-46), lying about 8 miles offshore on the inner and middle shelf floor, extends about 6 miles into Flagler County from Volusia County. This northern extension of the ridge field (6381 ha, 3% of the county continental shelf area) (Table 4-11), which is about 4 miles wide along the northern border of Volusia County, is flanked shoreward by the Farmton Sand Flat. The seaward margin of the ridge field is flanked by the Volusia Bank. Individual ridges making the ridge field average about 650 to 1600 ft wide by .6 to 2.5 miles long along 30° to 40° azimuths. Compared to the southern part of the Korona Ridge Field in Volusia County, the northern extension show weaker ridge development and stronger expression of broad merged ridges.

Potential sand resources in the Korona Ridge Field are estimated to range on the order of 283.8 x 10^6 cy (Table 4-11, Figure 4-47). Calculations were based on an estimated 80% ridge coverage with a maximum thickness range of about 26 ft. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-81 ft) and shallowest isobath (-54.2 ft) (Table 4-11). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Palm Coast Sand Wave

The southern dissected margins of the Palm Coast Sand Wave (Figure 4-46) lie partly in Flagler County, extending 1.8 to 3 miles across the seaward extended border from St. Johns County into Flagler County. The mapping unit is divided into two part for computation purposes, A and B. Part A is the smaller shoreward part of the sand wave that takes in 477 ha and part B, the larger seaward part, takes in 5305 ha (3% of the county continental shelf area) (Table 4-11). These two segments are the middle sand wave in the Summer Haven – Palm Coast – Flagler sand-wave triumvirate. The mapping unit is bounded seaward by the Summer Haven Sand Wave and St. Johns Bank. This dissected southern flank of the Palm Coast Bank dissipates into a smoothly flowing bathymetry on the Flagler Sand Wave. Lying 7.5 to 18 miles offshore, this part of the large shore-normal sand wave is about 12 miles wide in east-west extent by about 1.8 miles long in a north-south extent, with some ridges (85° azimuth) superposed. The sand wave has a local relief of about 6.5 to 13 ft and occurs in water depths that range from 60 to 70 ft.

Potential sand resources in the Palm Coast Sand Wave are estimated to be on the order of 10.5 x 10^6 cy (Table 4-11, Figure 4-47). This calculation was based on 75% of the mapping unit being comprised by sand wave surface and ridge units, as occur along the southern dissected margin. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-99.7 ft) and shallowest isobath (-84.7 ft) for a maximum sediment thickness range of 4.6 m in the unit, from the valleys in the dissected margin to ridge crests on top of sand wave surface (Table 4-11). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

St. Johns Bank

Occurring 26 to 38 miles offshore, the St. Johns Bank (Figure 4-46) takes up about 50,000 ha (Table 4-11) on the outer shelf floor from the offshore extension of the St. Johns County line to the Volusia County line, a distance of about 16 miles. The bank grades shoreward into the Flagler Sand Wave and the Volusia Bank. It is bounded seaward by undifferentiated seafloor with transverse ridges. Although the bank displays a generally flat surface with some areas of hummocky terrain in the north, it is surmounted by some widely spaced (1 to 3 miles apart) sand ridges (40° to 55° azimuths) up to 7.5 miles long throughout the mapping unit. This large shore-parallel bank extends up to 40 miles offshore into water depths that average about 88 ft. Local relief on the bank surface *per se* is about 6.5 ft but is greater (up to 20 ft) in the vicinity of surmounted sand ridges.

Potential sand resources in the St. Johns Bank are estimated to be on the order of 2.2 x 10^9 cy (Table 4-11, Figure 4-47). This calculation was based on 50% of the mapping unit being comprised by sand bank units (smooth seafloor mapped from reformatted NOAA data in Zone D), except along dissected margins. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-111 ft) and shallowest isobath (-57.7 ft) for a maximum sediment thickness range of 53.8 ft in the unit, from valley to ridge crest (Table 4-11). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Volusia Bank

The northern extension of the Volusia Bank (Figure 4-46) occurs on the offshore extension of the Flagler-Volusia county line. Here, the bank lies about 12 to 26 miles offshore and is bounded seaward by the St. Johns Bank and shoreward by the northern part of the Korona Ridge Field. The bank is separated from the dissected margin of the Flagler Sand Wave to the north. This distinct boundary is characterized by a rapid change from dissected terrain on the southern flanks of the sand wave to generally flat seafloor of the bank that is occasionally punctuated by low-relief (4 m) sand ridges. The bank has a local relief of about 6.5 to 13 ft and occurs in water depths that range from 78 to 98 ft.

Potential sand resources in the Volusia Bank are estimated to be on the order of 597.7 x 10^6 cy (Table 4-11, Figure 4-47). This calculation was based on 65% of the mapping unit being comprised by sand bank units (smooth seafloor mapped from reformatted NOAA data in Zone D), except along dissected margins. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-103.6 ft) and shallowest isobath (-63.2 ft) for a maximum sediment thickness range of 40 .6 ft in the unit, valley to ridge crest (Table 4-11). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

VOLUSIA COUNTY

The survey area in Volusia County, the second largest offshore county shelf area (389,900 ha) after St. Johns County, extends from Flagler County to Brevard County for an along-coast distance of about 50 miles. Extending about 40 miles offshore, the shelf area is quite diverse being comprised by sand flats, ridge fields, shoals, bars, and banks. These seafloor features account for about 72% of the total mapped shelf area (Table 4-13), the remainder being taken up by undifferentiated seafloor with transverse ridges.

The main morphological seafloor features on the continental shelf include the following mapping units (Figure 4-46), from the shore seaward: the Farmton Sand Flat, Allandale Shoal, Oak Hill Shoal, Korona Ridge Field, Edgewater Ridge Field, and the Volusia Bank. Mapping units taking up the most area include the Farmton Sand Flat, Volusia Bank, Korona Ridge Field, and the Edgewater Ridge Field.

Potential sand resources in the mapped area of the continental shelf in Volusia County (280,671 ha) amount to something on the order of 28.3 x 10^9 cy of sediment. This sediment volume estimate is based on assumptions for average thickness of morphosedimentary units such as sand flats, bars, ridge fields, shoals, and banks. Parameters used in calculations of volume estimates are summarized in Table 4-13. The Volusia Bank has the largest potential sediment volume, followed by the Farmton Sand Flat and the Korona Ridge Field. The sand resource potential of each mapping unit is discussed in relation to geographic occurrence, spatial distribution patterns, and morphosedimentary properties, as summarized in Figure 4-47 and Table 4-13.

Potential sand source areas off Volusia County are found primarily on the Korona and Edgewater ridge fields, the Allandale and Oak Hill shoals and the Canaveral Transverse Bar physiographic zones. Nine potential sand source areas have been identified for Volusia County (Figure 4-54) with 3 of these, VO Primary 1, VO Primary 2 and VO Primary 3 located within state waters and 6, VO Secondary 1, VO Secondary 2, VO Secondary 3, VO Secondary 4, VO Secondary 5, VO Secondary 6, located seaward of the 3 mile limit. The primary areas will be discussed in relation to data contained in ROSS where the other 6 will be discussed in a more regional context.

Volusia Primary

The Allandale Shoal (Figure 4-46) lies about 3 miles offshore R100 in about 50 ft water depth. The shoal is an enclave within the Farmton Sand Flat mapping unit. The small shoal takes up about 675 ha and is comprised by sand ridges (30° and 85° azimuths) with updrift linkages to the Bunnel Ridge Field. The shoal, 1.2 miles wide by 3 miles long, is oriented in NS direction, lies about 1 mile shoreward of the Korona Ridge Field. The shoal occurs in water depths that range from 52 to 59 ft.

Potential sand resources in the Allandale Shoal are estimated to be on the order of 11.8 x 10^6 cy (Table 4-13, Figure 4-47). This calculation was based on 75% of the mapping unit being comprised by sand ridge units that make up the shoal area. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-59.25 ft) and shallowest isobath (-41.67 ft) for a maximum sediment thickness range of about 20 ft in the unit (Table 4-13). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

VO Primary 1 is located between range monuments R082 and R101 in the nearshore waters off Volusia County (Figure 4-55). This area is situated on the southward extending finger of the Allandale Shoal. Volumes for this area calculated using 3, 6 and 9 feet cuts (7,819,416 cy; 15,638,831 cy and 23,458,247 cy respectively) are presented in Table 4-2. Data in ROSS for this area consists of 1 vibracore, Core B 10-3, from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border -

Phase II and Final Report (Nocita et.al, 1991) (Figure 4-56). Data in Table 4-14 includes no descriptive information but shows there were 3 samples taken from this core and analyzed for mean grainsize. Values returned are 2.27, 2.06 and 3.16 phi which correspond to the fine sand category using the USC.

Geophysical data includes line 05b28 from the FGS/MMS study (FGS/MMS, 2003-2004) and lines VO08_W_000 and VO09_E_001 from the Phase IV portion of this project (Figure 4-57). The images of these tracklines are presented as Figures 4-58 and 4-59. Each figure shows evidence of a sand ridge. Paleo channels are circled in blue.

Volusia Primary

Located about 1.8 miles offshore on the inner shelf floor, the small Oak Hill Shoal (Figure 4-46) occurs as an enclave within the Farmton Sand Flat. The shoal, about 1 to 1.2 miles wide by 6 miles long, is oriented in a north-south direction and centers on small transverse ridges that strike along 45° and 50° azimuths. Topographically subdued sand ridges extending 13 miles downdrift from the Korona Ridge Field feed into the Oak Hill Shoal. The shoal shows a local relief of about 4 m and occurs in water depths that range from 45 to 60 ft.

Potential sand resources in the Oak Hill Shoal are estimated to be on the order of 47.1 x 10^6 cy (Table 4-13, Figure 4-47). This calculation was based on 60% of the mapping unit being comprised by sand ridges (ridge and valley topography mapped from reformatted NOAA data in Zone C). Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-66.17 ft) and shallowest isobath (-32.81 ft) for a maximum sediment thickness range of about 32 ft in the unit, deepest trough to highest ridge crest (Table 4-13). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

VO Primary 2 takes up almost the entire Oak Hill Shoal extending from range monument R191 south to R228 and seaward to the 3 mile federal limit (Figure 4-60). Volume calculations run on 3, 6 and 9 feet cuts (27,671,781 cy; 55,343,562 cy and 83,015,343 cy respectively) are presented in Table 4-2. The ROSS database includes vibracore data from two surveys conducted in this area. Five cores from the Volusia County Reconnaissance (Coastal Technology Corp., 2004) and 1 core from the Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report (Nocita et.al, 1991). Core locations are shown in Figure 4-61. Data from these cores is presented in Table 4-15. Descriptive data shows that fine grained coarse sand and shell comprises most of the sediments in the cores. Twenty four individual samples were taken from the Volusia County Reconnaissance cores and the mean grainsize values are shown in the table. Most of the samples have a mean grain size range from1.66 to 2.64 phi with 4 samples outside of this range at 1.13, -0.53, 0.64 and 0.64 phi. This places the majority of these samples in the fine sand category using the USC with the 4 outliers falling into the medium sand category.

Two geophysical tracklines from the Phase IV portion of this study cross over the main ridge within this area (Figure 4-62). Figure 4-63 shows the images from these lines. The lower image is oriented west to east. The upper image is oriented southeast to northeast and shows the ridges on the right. In both of these images the potential sand is visible as the washed out zone between the two darker bands. Estimated thickness of this sand unit is approximately 50 feet.

Volusia Primary

The northern extension of the Canaveral Transverse Bar field (Figure 4-46), previously described by Finkl and Andrews (2007), occurs alongshore on the shoreface and inner shelf floor on the Volusia-Brevard county line. Here, the ridge field extends about 2.5 miles alongshore and about 1.5 miles offshore. The bar field occupies about 929 ha with individual bars 650 to 1600 ft wide, striking along 55 to 80° azimuths. The bar field, which tapers off seaward to the Farmton Sand Flat, has a local relief of about 13 ft and occurs in water depths of about 65 ft.

Potential sand resources in the Canaveral Transverse Bar field are estimated to be on the order of 17 x 10^6 cy (Table 4-13, Figure 4-47). This calculation was based on 35% of the mapping unit being comprised by transverse bars (bar and trough seafloor mapped from reformatted NOAA data in Zone C). Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-51.71 ft) and shallowest isobath (-8.23 ft) for a maximum sediment thickness range of 42 ft in the unit, deepest trough to highest bar crest (Table 4-13). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

VO Primary 3 is located on the northern end of the Canaveral Transverse Bar physiographic zone (Figure 4-64) between range monuments V022 and V037. Currently there is no data in ROSS for this area. Unfortunately this area was not designated as a target during the Phase IV geophysical data collection effort for this project.

Other areas offshore of Volusia County have the potential for being future sand source areas. These areas are discussed below in a regional context.

Allandale Shoal and Volusia Secondary

The Volusia Secondary 1 area is located on the seaward side of the 3 mile state limit on the Allandale Shoal (discussed in 4.5.1) (Figure 4-54). This shoal has a total estimated volume of 12,459,972 cy. Using a 3, 6 and 9 ft cut, estimated volumes for this area are 10,964,492 cy, 21,928,984 cy and 32,893,477 cy respectively (Table 4-2).

Korona Ridge Field and Volusia Secondary

The southern extension of the Korona Ridge Field (Figure 4-46) occurs south of the Flagler-Volusia county border, extending about 18 miles southward into the offshore region of Volusia County. Lying 5 to 7.5 miles offshore, the ridge field abruptly terminates shoreward at the Farmton Sand Flat. The mapping unit represents 2.5 mile wide dissected shoreward margin of the Volusia Bank. Individual ridges, about 650 to 1600 ft wide by .5 to 2.5 mile long, strike along 30° to 40° azimuths. This broad ridge field (3 mile wide) has two main downdrift extended fingers that are about 13.5 mile long with sand flats between the ridges. Individual subridges lie transverse to the shore. The ridge field shows a local relief of about 13 ft and occurs in water depths that range from 45 to 72 ft.

Potential sand resources in the Korona Ridge Field are estimated to be on the order of 9.2 x 10^6 cy (Table 4-13, Figure 4-47). This calculation was based on 100% of the mapping unit being comprised by sand ridges (ridge and valley topography mapped from reformatted NOAA data in Zones C and D). Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-74.25 ft) and shallowest isobath (-35.76 ft) for a maximum sediment thickness range of 34.5 ft in the unit, deepest trough to highest ridge crest (Table 4-13). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Volusia Secondary 2 is located on the southern extension of this feature (Figure 4-54). Refined volume calculations have yielded 179,203,917 cy for a 3 ft cut, 358,407,833 cy for a 6 ft cut and 537,611,750 cy for a 9 ft cut (Table 4-2).

Edgewater Ridge Field and Volusia Secondary and Secondary

The Edgewater Ridge Field (Figure 4-46) only occurs in Volusia County, about 3 to 7 miles offshore on the middle shelf floor. The ridge field marks the seaward extent of the Farmton Sand Flat and is characterized by an abrupt transition from flat seafloor to ridge and valley topography. The mapping unit represents the shoreward dissected margin of the Volusia Bank. Individual ridges making up the ridge field are about 0.3 to 0.7 miles wide and about 1.8 miles long (along 40° to 60° azimuths) with wavelengths about 1600 ft. There are three large downdrift extended fingers of the ridge field that average about 5 to 7.5 miles in length. The ridge field shows a local relief of about 20 ft and occurs in water depths that range from 45 to 65 ft.

Potential sand resources in the Edgewater Ridge Field are estimated to be on the order of 943 x 10^6 cy (Table 4-13, Figure 4-47). This calculation was based on 95% of the mapping unit being comprised by sand ridges (ridge and valley topography mapped from reformatted NOAA data in Zones C and D). Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-76.12 ft) and shallowest isobath (-41.34 ft) for a maximum sediment thickness range of 34.5 ft in the unit, from the deepest trough to the highest ridge crest. Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Volusia Secondary 3 and Secondary 5 are both located on the more ridge dominated sections of this mapping unit (Figure 4-54). Volume calculations for Volusia Secondary 3 are 39,392,793 cy for a 3 ft cut, 78,785,585 cy for a 6 ft cut and 118,178,378 cy for a 9 ft cut. Volumes for Volusia Secondary 5 are 154,170,536 cy for 3 ft 308,341,072 cy for 6 ft and 462,511,608 cy for 9 ft cuts.

Volusia Secondary 4 is located seaward of the 3 mile state limit, adjacent to Volusia Primary 2 on the Oak Hill Shoal mapping unit (Section 4.5.2) (Figure 4-54). This area makes up only a small percent of the total shoal but since it is seaward of the 3 mile limit it is listed as a separate potential sand source area. Volumes calculated for this portion of the shoal are 10,084,179 cy for a 3 ft cut, 20,168,359 cy for a 6 ft cut and 30,252,538 cy fro a 9 ft cut (Table 4-2).

Volusia Bank and Volusia Secondary

The Volusia Bank (Figure 4-46) is a large shore-parallel offshore bank that is about 47 miles long by about 7 to 18 miles wide. The bank occurs on the middle and outer shelf floors. Dissected shoreward margins of the bank are identified as the Korona and Edgewater ridge fields. The bank is flanked seaward by undifferentiated seafloor with transverse ridges. The bank surface is characterized by scattered pockets of hummocky terrain amid a generally flat seafloor surface that is surmounted by widely spaced ridges, up to 40 miles long, which strike along 50°

to 85° azimuths. These sand ridges continue onto the bank from farther offshore, but are less prominent and topographically subdued compared to their deepwater occurrence.

Potential sand resources in the Volusia Bank are estimated to be on the order of 19.6 x 10^9cy (Table 4-13, Figure 4-47). This calculation was based on 80% of the mapping unit being comprised by bank surfaces and some sand ridges (ridge and valley topography mapped from reformatted NOAA data in Zone D). Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-115.8 ft) and shallowest isobath (-47.9 ft) for a maximum sediment thickness range of about 67.9 ft in the unit, deepest trough to highest ridge crest (Table 4-13). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

Volusia Secondary 6 is located in and portion of the Volusia Bank that is made up of scattered pockets of hummocky terrain (Figure 4-54). These hummocks, or mounds, are estimated to hold enough potentially usable sand sources to be of interest in future targeted studies. Volumes calculated for this area are; 91,629,665 cy for a 3 ft cut, 183,259,329 cy for a 6 ft cut and 274,888,994 cy for a 9 ft cut (Table 4-2).

Two additional physiographic zones are also potential sand sources for offshore Volusia County. These are found seaward of 3 mile state waters limit and will be discussed in a regional context below.

Farmton Sand Flat

The largest single mapping unit in offshore Volusia County, the Farmton Sand Flat (Figure 4-46) occupies 87,864 ha on the shoreface, inner shelf floor, and shoreward-most margin of the middle shelf floor. The sand flats are bounded seaward by the Korona Ridge Field, Edgewater Ridge Field, and the Volusia Bank. The morphological transition from sand flat to seaward morphosedimentary units is abrupt, except in the southern part of the county offshore zone where the sand flats merge with the Volusia Bank. The Allandale and Oak Hill shoals occur within the Farmton Sand Flat as enclaves. The sand flats show a local relief of about 6.5 to 13 ft and occurs in water depths that range from 6.5 to 65 ft.

Potential sand resources in the Farmton Sand Flat are estimated to be on the order of 6.4 x 10^9 cy (Table 4-13, Figure 4-47). This calculation was based on 100% of the mapping unit being comprised by sand flats. Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-78.18 ft) and shallowest isobath (-0 ft) (Table 4-13). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

St. Johns Bank

A small segment of the southernmost extension of the St. Johns Bank (Figure 4-46) occurs along the Flagler-Volusia county line. The bank is about 7.7 miles wide along the county line and extends 2.4 miles into Volusia County. The bank is adjacent shoreward with the Volusia Bank and seawards with undifferentiated seafloor with transverse ridges. Distal portions of some sand ridges occur within the mapping unit. The shoal shows a local relief of about 20 ft and occurs in water depths that range from 78 to 98 ft.

Potential sand resources in the St. Johns Bank are estimated to be on the order of 213.2 x 10^6 cy (Table 4-13, Figure 4-47). This calculation was based on 95% of the mapping unit being comprised by bank surfaces and some sand ridges (ridge and valley topography mapped from reformatted NOAA data in Zone D). Sediment thickness was calculated from differences in elevation computed between the depth of the deepest isobath (-113.2 ft) and shallowest isobath (-72.51 ft) for a maximum sediment thickness range of about 41 ft in the unit, from the deepest trough to the highest ridge crest (Table 4-13). Variations in thickness throughout the mapping unit were used as a basis for volume estimates.

SUMMARY OF POTENTIAL SAND RESOURCES ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

The preceding analysis reported on the kind and sequence of seabed topography in relation to sedimentary bodies. This information was communicated by county, but this summary reports total occurrence of morphosedimentary features for the whole study area on the continental shelf off the northeast Florida Atlantic coast (Table 4-16). Based on this reconnaissance survey, the total estimated volume of potential sand resources on the continental shelf amounts to something on the order of 102.7 x 10^9 cy (102 billion cubic yards). This estimate is based on areal distribution patterns and conservative deposit thicknesses that were derived from local relief on sand ridges, sand flats, transverse bars, sand waves, banks, shoals, and ebb-tidal deltas.

This section of the western North Atlantic Shelf along the northeast Florida shore contains abundant sediments that have accumulated in a range of deposits. These unconsolidated surficial seafloor materials are prominent on the shoreface, inner shelf floor, middle shelf floor and outer shelf floor. The largest potential sand resources occur in St. Johns County (36.6 x 10^9 cy), followed by Volusia County (28.3 x 10^9 cy), which together take in about 612,924 ha of seafloor. Significant potential sand resources are also associated with Duval County (17.7 x 10^9 cy), Flagler County (11.8 x 10^9 cy), and Nassau County (8.1 x 10^9 cy) (see Tables 4-1, 4-5, 4-7, 4-11 and 4-13).

Of primary interest to the State of Florida is the volume of potential sand resources that occur in state waters, that is, shoreward of the so-called 3-mile offshore limit. One way to assess the sand resource potential in state waters is to determine the areas of specific morphosedimentary features that occur shoreward of the 3-mile limit, as shown in Table 4-16. With such a wide shelf area extending to the 150 ft isobath, only a small percentage of the mapped morphosedimentary units occurs within state jurisdiction. Conversely, on broad shallow shelf areas such as occur offshore the northeast coast of Florida, most of the sand resources fall under the jurisdiction of the federal government. The largest potential sand resource area in state waters is associated with the Farmton Sand Flat (93,759 ha). The Talbot Transverse Bar field occupies about 5972 ha, followed by the St. Augustine Ebb-Tidal Delta that takes in 5680 ha and the St. Johns and Tisonia – Nassau Sound ebb-tidal deltas that respectively include about 1840 ha and 1414 ha. The part of the Duval Ridge Field occurring in state waters includes about 2519 ha. Along with lesser areas of ridges and shoals, state waters include 119,250 ha overall (Table 4-16). Ebb-tidal deltas have been a traditional sand source and consequently areas associated with ridges, bars, and shoals constitute new locations with potential as sand resource areas.

The Farmton Sand Flat is a significant potential sand resource for the state because it makes up about 79% of the seafloor area under state jurisdiction with nearly half (47%) of the morphosedimentary units occurring shoreward of the 3-mile limit (Table 4-16). The Talbot Transverse Bar field makes up about 5% of the area under state control, as does the St. Augustine Ebb-Tidal Delta followed by about 3.5% for the St. Mary's Ebb-Tidal Delta. Areas of all other morphosedimentary features within the 3-mile limit make minor (<3%) contribution to state-controlled seafloor. Another way to look at the sand resource base is to consider the area percent of the morphosedimentary units under state jurisdiction. In the case of the Farmton Sand Flat, for example, about 47% of this morphosedimentary unit falls under state jurisdiction. For state percent by area by morphosedimentary unit, total amount to about 27% and 26% percent respectively for the Allandale and Beverly shoals; about three-quarters (73%) of the Oak Hill Shoal area comes under state hegemony (Table 4-16). What all this means is that the Farmton Sand Flat is the largest single potential sand source in state waters for the northeast Florida Atlantic continental shelf.

In federal waters, the Volusia Bank, St. Johns Bank, Sawgrass Bank, Farmton Sand Flat, and Duval Ridge Field make up the largest areas with potential sand resources (Table 4-16). These morphosedimentary units respectively make up the following areal percents under federal jurisdiction: 12%, 10%, 6%, 8%, and 10%. These mapping units collectively make up nearly half (46%) of the shelf area under federal control. Undifferentiated seafloor with sand ridges makes up an additional 30% of seafloor area under federal jurisdiction. Although these morphological mapping units account for a majority of the shelf area mapped, the spatial extent is not the complete answer for sand resource investigations. Sediment volume needs to be considered as well and in this respect, sand waves should be considered even though their percentage areal distributions are relatively small (Summer Haven Sand Wave, 4%; Palm Coast Sand Wave, 1.88%; Flagler Sand Wave, 4%) (Table 4-16).

Table 4-1: *Sand resource potential in Nassau County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which may be less than unity in ridge fields, banks, and ebb-tidal deltas.*

Morpho-sedimentary Features	Shelf Area (ha)[1]	% of County Continental Shelf Area[2]	Height of Plane (ft)	Elevation Range[3] (Max to Min Depth) (ft)	% Area Used in Volume Calculations[4]	Sediment Volume (cy)
Amelia Sand Ridge	3,128	2	-54.0	-54.0 to -29.86	75	94,230,464
Duval Ridge Field	22,765	13	-82.68	-82.68 to -41.99	60	1,158,086,485
Farmton Sand Flat A	2	0<1	-58.76	-58.76 to -50.03	100	57,609
Farmton Sand Flat B	59	0<1	-52.10	-52.10 to -48.56	50	125,324
Farmton Sand Flat C	20,814	12	-71.85	-71.85 to 0.33	90	1,658,019,641
Fort Clinch Ridge Field A	5,999	3	-55.20	-55.12 to -25.92	85	230,907,563
Fort Clinch Ridge Field B	71	0<1	-55.35	-55.35 to -44.62	75	1,081,913
Nassau Bank	15,733	9	-88.35	-88.35 to -51.18	85	1,072,344,224
O'Neal Bank	29,162	16	-98.43	-98.43 to -47.24	90	2,914,226,894
St Mary's Ebb-tidal Delta	4,163	2	-64.30	-64.30 to -2.95	100	783,019,736
Talbot Transverse Bar	4,886	3	-44.69	-44.69 to 0.33	80	231,538,881
Tisonia-Nassau Sound Ebb-Tidal Delta	139	0<1	-17.06	-17.06 to -0.79	80	4,046,774
Total	**106,921**	**60**				**8,147,685,508**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.
[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.
[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.
[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 4-2: *Northeast Promising Areas not Previously Identified.*

Area ID	Areal Extent (sq.ft)	Areal Extent (acres)	Total Volume (yd^3) (3 ft cut)	Total Volume (yd^3) (6 ft cut)	Total Volume (yd^3) (9 ft cut)
DU-PRIMARY-1	146053582	3353	16228176	32456352	48684527
DU-PRIMARY-2	114080502	2619	12675611	25351223	38026834
DU-SECONDARY-1	1457296866	33455	161921874	323843748	485765622
FL-PRIMARY-1	95840759	2200	10648973	21297946	31946920
FL-SECONDARY-1	242531782	5568	26947976	53895952	80843927
FL-SECONDARY-2	894552161	20536	99394685	198789369	298184054
FL-SECONDARY-3	771944554	17721	85771617	171543234	257314851
NA-PRIMARY-1	199889584	4589	22209954	44419908	66629861
NA-PRIMARY-2	598211225	13733	66467914	132935828	199403742
NA-SECONDARY-1	778528288	17873	86503143	173006286	259509429
NA-SECONDARY-2	294258753	6755	32695417	65390834	98086251
NA-SECONDARY-3	695911887	15976	77323543	154647086	231970629
SJ-PRIMARY-1	151027686	3467	16780854	33561708	50342562
SJ-PRIMARY-2	414377586	9513	46041954	92083908	138125862
SJ-PRIMARY-3	89704313	2059	9967146	19934292	29901438
SJ-SECONDARY-1	29289377	672	3254375	6508750	9763126
SJ-SECONDARY-2	2005443154	46039	222827017	445654034	668481051
SJ-SECONDARY-3	717437961	16470	79715329	159430658	239145987
SJ-SECONDARY-4	947717238	21757	105301915	210603831	315905746
SJ-SECONDARY-5	883887459	20291	98209718	196419435	294629153
SJ-SECONDARY-6	1810396784	41561	201155198	402310396	603465595
VO-PRIMARY-1	70374741	1616	7819416	15638831	23458247
VO-PRIMARY-2	249046028	5717	27671781	55343562	83015343
VO-PRIMARY-3	114666372	2632	12740708	25481416	38222124
VO-SECONDARY-1	98680430	2265	10964492	21928984	32893477
VO-SECONDARY-2	1612835249	37026	179203917	358407833	537611750
VO-SECONDARY-3	354535133	8139	39392793	78785585	118178378
VO-SECONDARY-4	90757614	2084	10084179	20168359	30252538
VO-SECONDARY-5	1387534824	31853	154170536	308341072	462511608
VO-SECONDARY-6	824666981	18932	91629665	183259329	274888994

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-2	-21	2a	0	2	GRAY	mostly Fine To Medium Shelly Quartz Sand				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-2	-21	2b	2	5		mostly Fine Sand; trace Shell				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-2	-21	2c	5	8	GRAY	mostly Silty Sand; trace Shell				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-2	-21	2d	8	15	GRAY	mostly Sandy Clay				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-4	-16.9	4a	0	9	GRAY	mostly Fine Quartz Sand; trace Shell				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-4	-16.9	4b	9	14	GRAY	mostly Fine Silty Quartz Sand; trace Shell				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-4	-16.9	4c	14	21	GRAY	mostly Fine Quartz Sand				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-4	-16.9	4d	21	22	GRAY	mostly Clayey Sand				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-4	-16.9	4e	22	29	GRAY	mostly Clay; trace Sand				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-5	-16.7	5a	0	10	GRAY	mostly Fine To Medium Shelly Quartz Sand; trace Shell				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-5	-16.7	5b	10	28	GRAY	mostly Fine Quartz Sand				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-5	-16.7	5c	28	30		mostly Clayey Sand				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-5	-16.7	5d	30	34	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-6	-12.4	6a	0	0.5	GRAY	mostly Sandy Clay; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-6	-12.4	6b	0.5	3	GRAYISH TAN	mostly Fine To Medium Shelly Sand				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-6	-12.4	6c	3	18	GRAY	mostly Fine Quartz Sand; trace Shell				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-6	-12.4	6d	18	21	GRAY	mostly Sandy Clay				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-15	-22.3	15a	0	2.1		mostly Fine To Coarse Sand				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-15	-22.3	15b	2.1	15.6	LIGHT GRAYISH	mostly Fine Sand; trace Clay; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-15	-22.3	15c	15.6	19.8	DARK GRAYISH	mostly Clay; trace Sand				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-16	-20.9	16a	0	3.1		mostly Fine Sand; trace Clay				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-16	-20.9	16b	3.1	4.9	LIGHT GRAYISH	mostly Fine Sand; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-16	-20.9	16c	4.9	8.5	LIGHT BROWNISH	mostly Fine Sand; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-16	-20.9	16d	8.5	14.5	LIGHT GRAYISH	mostly Fine Sand; trace Clay; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-16	-20.9	16e	14.5	17.3	LIGHT GRAYISH	mostly Fine Sand; trace Clay				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-16	-20.9	16f	17.3	18.1	DARK GRAYISH	mostly Clay; trace Sand				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-16	-20.9	16g	18.1	19.7	GRAY	mostly Fine To Medium Sand; trace Clay				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19a	0	1.4	LIGHT BROWNISH	mostly Fine To Medium Sand				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19b	1.4	2.7		mostly Medium Sand				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19c	2.7	4.8	GRAY	mostly Fine To Medium Sand; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19d	4.8	7.8	LIGHT BROWNISH	mostly Fine Sand; trace Clay; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19e	7.8	9.2	GRAY	mostly Fine Sand; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19f	9.2	10.6	LIGHT BROWNISH	mostly Fine Sand; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19g	10.6	14.8	GRAY	mostly Fine Sand; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19h	14.8	16.2	BROWN	mostly Fine Sand; trace Clay				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-19	-19.5	19i	16.2	19.7	GRAY	mostly Fine Sand; trace Clay				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-22	-22	22a	0	2	GRAY	mostly Fine To Medium Sand				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-22	-22	22b	2	2.8	LIGHT BROWNISH	mostly Fine Sand; trace Shell; trace Clay				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-22	-22	22c	2.8	4.7	GRAY	mostly Fine Sand; trace Clayey Sand				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-22	-22	22d	4.7	7.3	LIGHT BROWNISH	mostly Fine Sand; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-22	-22	22e	7.3	9	GRAY	mostly Fine Sand				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-22	-22	22f	9	12.6	LIGHT BROWNISH	mostly Fine Sand; trace Shell				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-22	-22	22g	12.6	18	GRAY	mostly Fine Sand; trace Clay				
Nassau County Shore Protection Project, Borrow Site and Geotechnical Data (Response to RAI #2)	CB-NAS98-22	-22	22h	18	19.8	DARK GRAYISH	mostly Clay; trace Sand				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-1A	-18.8	1Aa	0	7	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-1A	-18.8	1Ab	7	9	DARK GRAYISH	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-1A	-18.8	1Ac	9	11	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-1A	-18.8	1Ad	11	13	GRAY	mostly Fine To Medium Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-1A	-18.8	1Ae	13	15		mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-1A	-18.8	1Af	15	18	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-1A	-18.8	1Ag	18	20	GRAY	mostly Clay				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Aa	0	4		mostly Fine To Medium Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Ab	4	5	GRAY	mostly Sandy Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Ac	5	6		mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Ad	6	7	GRAY	mostly Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Ae	7	9	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Af	9	10	GRAY	mostly Sandy Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Ag	10	11	GRAY	mostly Fine To Medium Quartz Sand				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Ah	11	13	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2A	-19.6	2Ai	13	15	GRAY	mostly Fine To Medium Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-3A	-19.8	3Aa	0	4	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-3A	-19.8	3Ab	4	6		mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-3A	-19.8	3Ac	6	7	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-3A	-19.8	3Ad	7	9	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-3A	-19.8	3Ae	9	10	GRAY	mostly Fine To Medium Quartz Sand				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-3A	-19.8	3Af	10	15	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC-92-1	-18.5	1a	0	9	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC-92-1	-18.5	1b	9	15		mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2	-19.5	2a	0	2	GRAY	mostly Fine To Medium Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2	-19.5	2b	2	6	BROWN	mostly Fine Shelly Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2	-19.5	2c	6	7	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-2	-19.5	2d	7	15	DARK GRAYISH	mostly Fine To Medium Quartz Sand				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-3	-19.6	3a	0	5	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-3	-19.6	3b	5	15	DARK GRAYISH	mostly Fine To Medium Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-5	-18.5	5a	0	5	TAN	mostly Fine To Medium Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-5	-18.5	5b	5	10	DARK GRAYISH	mostly Fine Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-5	-18.5	5c	10	15	DARK GRAYISH	mostly Sandy Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-6	-18.8	6a	0	3	GRAY	mostly Fine To Medium Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-6	-18.8	6b	3	13	DARK GRAYISH	mostly Fine Clayey Quartz Sand; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-6	-18.8	6c	13	15	LIGHT GRAYISH	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-7	-19	7a	0	4	GRAYISH TAN	mostly Fine To Medium Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-7	-19	7b	4	15.5	DARK GRAYISH	mostly Fine Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-7	-19	7c	15.5	20	BLUEISH GRAY	mostly Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-8	-17.2	8a	0	5	TANISH GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-8	-17.2	8b	5	10	GRAY	mostly Fine Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-8	-17.2	8c	10	14	DARK GRAYISH	mostly Clay; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-8	-17.2	8d	14	15		mostly Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-9	-17.3	9a	0	5.5	LIGHT GRAYISH	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-9	-17.3	9b	5.5	15	GRAY	mostly Fine Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-10	-18.5	10a	0	7	TAN	mostly Fine To Medium Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-10	-18.5	10b	7	11	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-10	-18.5	10c	11	15		mostly Clay; trace Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-11	-17.4	11a	0	13.5	LIGHT GRAYISH	mostly Fine To Medium Quartz Sand; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-11	-17.4	11b	13.5	20	GRAY	mostly Fine Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-12	-16.5	12a	0	10	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-12	-16.5	12b	10	10.5		mostly Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-12	-16.5	12c	10.5	15	GRAY	mostly Clay; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-13	-16.6	13a	0	2	TAN	mostly Medium Quartz Sand; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-13	-16.6	13b	2	3	GRAY	mostly Fine To Medium Shelly Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-13	-16.6	13c	3	10	GRAY	mostly Fine Silty Quartz Sand; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-14	-17.5	14a	0	1	GRAY	mostly Medium Shelly Quartz Sand; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-14	-17.5	14b	1	7	GRAY	mostly Fine To Medium Quartz Sand; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-14	-17.5	14c	7	10	GRAY	mostly Fine To Medium Silty Quartz Sand; trace Clay; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-15	-17.7	15a	0	1	TAN	mostly Fine To Medium Quartz Sand; trace Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-15	-17.7	15b	1	8	GRAY	mostly Fine To Medium Shelly Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-15	-17.7	15c	8	10	GRAY	mostly Fine Silty Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-17	-16.3	17a	0	8	TAN	mostly Fine To Medium Quartz Sand; trace Silt				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-17	-16.3	17b	8	10	GRAY	mostly Fine Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-17	-16.3	17c	10	15	LIGHT GRAYISH	mostly Fine Quartz Sand; trace Silt; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-17	-16.3	17d	15	18	GRAY	mostly Sandy Clay; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-17	-16.3	17e	18	20	GRAY	mostly Fine To Medium Clayey Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-18	-17.1	18a	0	8	TAN	mostly Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-18	-17.1	18b	8	11	GRAY	mostly Fine To Medium Quartz Sand; trace Shell; trace Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-18	-17.1	18c	11	15	GRAY	mostly Fine Quartz Sand				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-19	-19.6	19a	0	6	TAN	mostly Fine To Medium Quartz Sand; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-19	-19.6	19b	6	7	GRAY	mostly Fine To Medium Quartz Sand; trace Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-19	-19.6	19c	7	8	GRAY	mostly Sandy Clay; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-19	-19.6	19d	8	10	GRAY	mostly Fine To Medium Clayey Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-20	-19.6	20a	0	1	TAN	mostly Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-20	-19.6	20b	1	9	GRAY	mostly Fine Quartz Sand; trace Shell; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-20	-19.6	20c	9	11	GRAY	mostly Fine To Medium Quartz Sand; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-20	-19.6	20d	11	12	GRAY	mostly Medium Quartz Sand; trace Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-20	-19.6	20e	12	15	GRAY	mostly Fine To Medium Clayey Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-21	-18.4	21a	0	5	TAN	mostly Fine Quartz Sand; trace Silt; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-21	-18.4	21b	5	10	GRAY	mostly Fine Quartz Sand; trace Silt; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-21	-18.4	21c	10	12	GRAY	mostly Fine To Medium Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-21	-18.4	21d	12	15	GRAY	mostly Sandy Clay				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-22	-22.2	22a	0	7	GRAY	mostly Fine To Medium Quartz Sand; trace Silt; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-22	-22.2	22b	7	10	GRAY	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-4	-18.9	4a	0	9	GRAYISH TAN	mostly Fine To Medium Quartz Sand				
Nassau Sound Section 933 Study, Geotechnical Report (September 1992)	CB-NC92-4	-18.9	4b	9	15	DARK GRAYISH	mostly Fine Quartz Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2a	0	2.4	GRAY	mostly Fine Sand	2S1	0	1	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2b	2.4	7	GRAY	mostly Fine Sand; trace Shell	2S3	5.5	6	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2b	2.4	7	GRAY	mostly Fine Sand; trace Shell	2S4	7	7.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2b	2.4	7	GRAY	mostly Fine Sand; trace Shell	2S2	3	3.5	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2c	7	7.4	GRAY	mostly Fine Silty Sand	2S4	7	7.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2d	7.4	9	DARK GRAYISH	mostly Clay	2S4	7	7.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2e	9	10	GRAY	mostly Fine Silty Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2f	10	14.5	DARK GRAYISH	mostly Clay				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2g	14.5	17.5	DARK GRAYISH	mostly Fine Silty Sand; trace Clay				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2i	17.5	19	DARK GRAY	mostly Fine Clayey Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS-98-2	-17.4	2h	19	19.7	GRAY	mostly Fine Sand; trace Silt; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4a	0	2.8	GRAY	mostly Fine Sand; trace Shell	4S1	0	0.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4a	0	2.8	GRAY	mostly Fine Sand; trace Shell	4S2	2.5	3	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4b	2.8	3.7	DARK GRAYISH	mostly Clay; trace Sand	4S2	2.5	3	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4c	3.7	6.4	DARK GRAYISH	mostly Fine Silty Sand	4S3	4	4.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4c	3.7	6.4	DARK GRAYISH	mostly Fine Silty Sand	4S4	6	6.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4d	6.4	12.3	DARK GRAYISH	mostly Clay; trace Shell	4S4	6	6.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4e	12.3	13	GRAY	mostly Fine Sand; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4f	13	16.3	DARK GRAYISH	mostly Clay; trace Shell; trace Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-4	-21.8	4g	16.3	19.6	LIGHT GRAYISH	mostly Fine Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6a	0	0.7		mostly Fine To Coarse Sand; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6b	0.7	10.6	LIGHT GRAYISH	mostly Fine Sand; trace Shell; trace Clay	6S1	1	1.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6b	0.7	10.6	LIGHT GRAYISH	mostly Fine Sand; trace Shell; trace Clay	6S2	3	3.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6b	0.7	10.6	LIGHT GRAYISH	mostly Fine Sand; trace Shell; trace Clay	6S3	5.5	6	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6b	0.7	10.6	LIGHT GRAYISH	mostly Fine Sand; trace Shell; trace Clay	6S4	8.5	9	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6c	10.6	11.4	DARK GRAYISH	mostly Clay				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6d	11.4	12.3	GRAY	mostly Fine Silty Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6e	12.3	16.2	DARK GRAYISH	mostly Clay; trace Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6f	16.2	18.8	DARK GRAYISH	mostly Fine Silty Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-6	-16.2	6g	18.8	19.7	DARK GRAYISH	mostly Clay; trace Silt; trace Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7a	0	2	LIGHT BROWNISH	mostly Fine Sand	7S1	1	1.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7b	2	4.9	GRAY	mostly Fine Sand	7S2	4	4.5	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7c	4.9	6.8	GRAY	mostly Fine Sand; trace Shell	7S3	5.5	6	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7d	6.8	7.7	DARK GRAYISH	mostly Clay; trace Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7e	7.7	8.9	GRAY	mostly Fine Sand; trace Shell	7S4	8	8.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7f	8.9	12.8	DARK GRAYISH	mostly Clay; trace Shell; trace Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7g	12.8	14.1	DARK GRAYISH	mostly Fine Silty Sand; trace Shell; trace Clay				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7h	14.1	19.5	DARK GRAYISH	mostly Clay				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-7	-18	7i	19.5	19.8	GRAY	mostly Fine To Medium Sand; trace Clay; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-8	-25.6	8a	0	3.7	GRAY	mostly Fine Sand	8S1	1	1.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-8	-25.6	8a	0	3.7	GRAY	mostly Fine Sand	8S2	3	3.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-8	-25.6	8b	3.7	10.3	DARK GRAYISH	mostly Clay; trace Sand; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-8	-25.6	8c	10.3	14.3	DARK GRAYISH	mostly Fine Clayey Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-8	-25.6	8d	14.3	14.9	DARK GRAYISH	mostly Clay; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-8	-25.6	8e	14.9	19.8	GRAY	mostly Fine Clayey Sand; trace Shell; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9a	0	2.5	LIGHT BROWNISH	mostly Fine Sand; trace Shell	9S1	1.5	2	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9b	2.5	4.5	GRAY	mostly Fine Sand	9S2	3.5	4	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9c	4.5	6.7	LIGHT BROWNISH	mostly Sand	9S3	5.5	6	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9d	6.7	10.9	GRAY	mostly Fine Sand; trace Clay; trace Shell	9S5	10.5	11	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9d	6.7	10.9	GRAY	mostly Fine Sand; trace Clay; trace Shell	9S4	8	8.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9e	10.9	16.7	DARK GRAYISH	mostly Clay; trace Silty Sand; trace Sand	9S5	10.5	11	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9f	16.7	17.6	DARK GRAYISH	mostly Fine Clayey Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9g	17.6	18.6	DARK GRAYISH	mostly Clay; trace Sand; trace Silt				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9h	18.6	19.5	DARK GRAYISH	mostly Fine Clayey Sand; trace Shell; trace Silt				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-9	-19.5	9i	19.5	19.8	DARK GRAYISH	mostly Fine To Medium Clayey Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-10	-16.7	10a	0	3.2	LIGHT BROWNISH	mostly Fine To Coarse Sand	10S1	1	1.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-10	-16.7	10b	3.2	4.8	LIGHT GRAYISH	mostly Fine To Coarse Sand	10S2	3.5	4	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-10	-16.7	10c	4.8	7.5		mostly Fine Sand; trace Shell	10S3	6	6.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-10	-16.7	10d	7.5	14.4	GRAY	mostly Fine Sand; trace Clay; trace Shell	10S4	8.5	9	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-10	-16.7	10d	7.5	14.4	GRAY	mostly Fine Sand; trace Clay; trace Shell	10S5	11.5	12	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-10	-16.7	10e	14.4	19.8	DARK GRAYISH	mostly Clay; trace Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11a	0	2.9	LIGHT BROWNISH	mostly Fine Sand; trace Shell	11S1	1.5	2	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11b	2.9	7.5	GRAY	mostly Fine Sand; trace Shell	11S3	5.5	6	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11b	2.9	7.5	GRAY	mostly Fine Sand; trace Shell	11S4	7	7.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11b	2.9	7.5	GRAY	mostly Fine Sand; trace Shell	11S2	3.5	4	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11c	7.5	13.1	DARK GRAYISH	mostly Clay; trace Sand	11S4	7	7.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11d	13.1	14.7		mostly Fine Clayey Sand; trace Shell; trace Silt				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11e	14.7	15.9	DARK GRAYISH	mostly Clay; trace Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11f	15.9	16.7	DARK GRAYISH	mostly Fine To Coarse Silty Sand; trace Clay				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11g	16.7	17.5	DARK GRAYISH	mostly Clay				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11h	17.5	18.3	GREEN	mostly Fine Clayey Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-11	-23.9	11i	18.3	19.3		mostly Fine To Coarse Clayey Sand				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12a	0	2.8	LIGHT GRAYISH	mostly Fine Sand; trace Shell	12S1	1	1.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12b	2.8	4.6	GRAY	mostly Fine Sand	12S2	3.5	4	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12c	4.6	7.2	LIGHT GRAYISH	mostly Fine Sand; trace Shell	12S3	6	6.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12d	7.2	12.9		mostly Fine Sand; trace Clay	12S5	11	11.5	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12d	7.2	12.9		mostly Fine Sand; trace Clay	12S4	8.5	9	
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12e	12.9	16	DARK GRAYISH	mostly Clay; trace Sand; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12f	16	16.9	DARK GRAYISH	mostly Fine Clayey Sand; trace Silt; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12g	16.9	18.8	DARK GRAYISH	mostly Clay; trace Shell				
Nassau Sound Section 933 Study, Geotechnical Report (1998)	CB-NAS98-12	-20	12h	18.8	19.8	GRAY	mostly Fine Sand; trace Shell				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau County Beach Nourishment (1993)	CB-NC93-23	-21.7	23-A	0	15	GRAY	mostly Fine To Medium Shelly Sand	CB-NC93-23-1	0	2	
Nassau County Beach Nourishment (1993)	CB-NC93-23	-21.7	23-A	0	15	GRAY	mostly Fine To Medium Shelly Sand	CB-NC93-23-5	10	15	
Nassau County Beach Nourishment (1993)	CB-NC93-23	-21.7	23-B	15	17.3	DARK GRAY	mostly Clay	CB-NC93-23-5	10	15	
Nassau County Beach Nourishment (1993)	CB-NC93-23	-21.7	23-C	17.3	20	DARK GRAY	mostly Fine To Medium Clayey Sand; trace Shell Fragments				
Nassau County Beach Nourishment (1993)	CB-NC93-24	-28.9	24-A	0	5	GRAY	mostly Fine Sand	CB-NC93-24-1	0	5	
Nassau County Beach Nourishment (1993)	CB-NC93-24	-28.9	24-B	5	8	DARK GRAY	mostly Clay; trace Fine Sand	CB-NC93-24-1	0	5	
Nassau County Beach Nourishment (1993)	CB-NC93-24	-28.9	24-C	8	10	DARK GRAY	mostly Fine To Medium Clayey Sand; trace Shell Fragments				
Nassau County Beach Nourishment (1993)	CB-NC93-25	-21.2	25-A	0	20	GRAY	mostly Fine To Medium Sand; trace Shell	CB-NC93-25-1	0	2	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
							Fragments				
Nassau County Beach Nourishment (1993)	CB-NC93-25	-21.2	25-A	0	20	GRAY	mostly Fine To Medium Sand; trace Shell Fragments	CB-NC93-25-4	7	10	
Nassau County Beach Nourishment (1993)	CB-NC93-25	-21.2	25-A	0	20	GRAY	mostly Fine To Medium Sand; trace Shell Fragments	CB-NC93-25-7	15	20	
Nassau County Beach Nourishment (1993)	CB-NC93-25	-21.2	25-B	20	20.7	DARK GRAY	mostly Clay	CB-NC93-25-7	15	20	
Nassau County Beach Nourishment (1993)	CB-NC93-25	-21.2	25-C	20.7	21	DARK GRAY	mostly Fine To Medium Sand				
Nassau County Beach Nourishment (1993)	CB-NC93-25	-21.2	25-D	21	26.2	DARK GRAY	mostly Clay				
Nassau County Beach Nourishment (1993)	CB-NC93-27	-17.2	27-A	0	10	GRAY	mostly Fine Sand	CB-NC93-27-1	0	5	
Nassau County Beach Nourishment (1993)	CB-NC93-27	-17.2	27-A	0	10	GRAY	mostly Fine Sand	CB-NC93-27-2	5	8.6	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau County Beach Nourishment (1993)	CB-NC93-27	-17.2	27-B	10	15		mostly Medium To Coarse Silty Sand				
Nassau County Beach Nourishment (1993)	CB-NC93-27	-17.2	27-C	15	20	DARK GRAY	mostly Fine To Medium Clayey Sand				
Nassau County Beach Nourishment (1993)	CB-NC93-28	-15.7	28-A	0	17.9	GRAY	mostly Fine Sand; trace Shell Fragments	CB-NC93-28-1	0	5	
Nassau County Beach Nourishment (1993)	CB-NC93-28	-15.7	28-A	0	17.9	GRAY	mostly Fine Sand; trace Shell Fragments	CB-NC93-28-5	12	15	
Nassau County Beach Nourishment (1993)	CB-NC93-28	-15.7	28-B	17.9	20	GRAY	mostly Fine Sand; trace Shell				
Nassau County Beach Nourishment (1993)	CB-NC93-28	-15.7	28-C	20	25.7	DARK GRAY	mostly Clay; trace Fine Sand				
Nassau County Beach Nourishment (1993)	CB-NC93-29	-14.8	29-A	0	12.4	GRAY	mostly Fine To Medium Sand; trace Shell Fragments	CB-NC93-29-2	2.5	5	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau County Beach Nourishment (1993)	CB-NC93-29	-14.8	29-A	0	12.4	GRAY	mostly Fine To Medium Sand; trace Shell Fragments	CB-NC93-29-5	10	11.5	
Nassau County Beach Nourishment (1993)	CB-NC93-29	-14.8	29-B	12.4	15	GRAY	mostly Fine To Medium Silty Sand; trace Shell Fragments				
Nassau County Beach Nourishment (1993)	CB-NC93-29	-14.8	29-C	15	20	GRAY	mostly Medium To Coarse Sand				
Nassau County Beach Nourishment (1993)	CB-NC93-29	-14.8	29-D	20	25	DARK GRAY	mostly Clay; trace Fine Sand; trace Silt				
Nassau County Beach Nourishment (1993)	CB-NC93-30	-15.8	30-A	0	15	GRAY	mostly Fine To Medium Sand; trace Shell Fragments	CB-NC93-30-1	0	2	
Nassau County Beach Nourishment (1993)	CB-NC93-30	-15.8	30-A	0	15	GRAY	mostly Fine To Medium Sand; trace Shell Fragments	CB-NC93-30-4	6.5	10	
Nassau County Beach Nourishment (1993)	CB-NC93-30	-15.8	30-A	0	15	GRAY	mostly Fine To Medium Sand; trace	CB-NC93-30-7	15	17	

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
							Shell Fragments				
Nassau County Beach Nourishment (1993)	CB-NC93-30	-15.8	30-B	15	17	DARK GRAY	mostly Fine To Medium Clayey Sand	CB-NC93-30-7	15	17	
Nassau County Beach Nourishment (1993)	CB-NC93-30	-15.8	30-C	17	20	GRAY	mostly Fine To Medium Sand; trace Shell Fragments	CB-NC93-30-7	15	17	
Nassau County Beach Nourishment (1993)	CB-NC93-30	-15.8	30-D	20	25	DARK GRAY	mostly Fine Clayey Sand; trace Shell Fragments				
Nassau County Beach Nourishment (1993)	CB-NC93-31	-17.6	31-A	0	10.7	GRAYISH BROWN	mostly Medium To Coarse Shelly Sand	CB-NC93-31-1	1	3	
Nassau County Beach Nourishment (1993)	CB-NC93-31	-17.6	31-A	0	10.7	GRAYISH BROWN	mostly Medium To Coarse Shelly Sand	CB-NC93-31-3	5	10	
Nassau County Beach Nourishment (1993)	CB-NC93-31	-17.6	31-B	10.7	15	DARK GRAY	mostly Fine To Medium Clayey Sand; trace Shell Fragments				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau County Beach Nourishment (1993)	CB-NC93-32	-16.1	32-A	0	6.8	GRAY	mostly Fine To Medium Sand	CB-NC93-32-1	0	2.1	
Nassau County Beach Nourishment (1993)	CB-NC93-32	-16.1	32-A	0	6.8	GRAY	mostly Fine To Medium Sand	CB-NC93-32-4	6.8	10	
Nassau County Beach Nourishment (1993)	CB-NC93-32	-16.1	32-B	6.8	15	DARK GRAY	mostly Fine Silty Sand; trace Clay	CB-NC93-32-4	6.8	10	
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	821	9999	821-1	0	57	LIGHT TANISH	mostly Quartz Sand; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	821	9999	821-2	57	124	LIGHT TANISH	mostly Quartz Sand; some Shell Fragments				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	821	9999	821-3	124	162	MEDIUM GRAYISH	mostly Quartz Silt; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	821	9999	821-4	162	216	MEDIUM GRAYISH	mostly Quartz Silt; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	821	9999	821-5	216	297	MEDIUM GRAYISH	mostly Quartz Silt; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	821	9999	821-6	297	327	MEDIUM GRAYISH	mostly Quartz Silt; trace Shell Fragments				

Table 4-3a: *Nassau Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	821	9999	821-7	327	358	MEDIUM GRAYISH	mostly Quartz Silt; trace Shell Fragments				

Table 4-3b: *Nassau Primary 1 Grab Sample Query*.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Bottom of Layer Interval	Top of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies								KBA-31-08	0	0.1	0.19
Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies								KBA-22-08	0	0.1	0.14

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-11	-25.5	11a	0	9	DARK GRAY	mostly Fine Shelly Quartz Sand				
Nassau Sound, Section 933 Study, Geotechnical Report (1991)	CB-NC-11	-25.5	11b	9	15	GRAY	mostly Sandy Clay				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-1	-8	1a	0	16.4	LIGHT GRAY	mostly Medium Quartz Sand; trace Shell Fragments; trace Mud				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-2	-13.6	2a	0	2.8	LIGHT TAN	mostly Medium Quartz Sand; trace Shell Fragments				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-2	-13.6	2b	2.8	8.3	LIGHT GRAY	mostly Fine Quartz Sand; trace Shell				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-2	-13.6	2c	8.3	15.1		mostly Poorly Sorted Coarse Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-3	-11.3	3a	0	7.5	LIGHT GRAY	mostly Medium Quartz Sand; trace Small Shell Fragments				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-3	-11.3	3b	7.5	13.5		mostly Quartz Sand				
Amelia Island Sand Transfer / Sand Search	NCCB-3	-11.3	3c	13.5	15	DARK GRAY	mostly Poorly Sorted Coarse				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Study (1993)							Shelly Sand; trace Shell				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-4	-13.8	4a	0	6.3	LIGHT GRAY	mostly Medium Quartz Sand; trace Shell				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-4	-13.8	4b	6.3	11.1	MEDIU M GRAY	mostly Medium Shelly Quartz Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-9	-25.6	9a	0	1.7		mostly Medium Quartz Sand; trace Shell; isolated Mud				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-9	-25.6	9b	1.7	9	LIGHT GRAY	mostly Medium Quartz Sand; trace Shell				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-9	-25.6	9c	9	13	MEDIU M GRAY	mostly Poorly Sorted Coarse Shelly Quartz Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-9	-25.6	9d	13	15.5	DARK GRAY	mostly Mud; trace Shell				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-9	-25.6	9e	15.5	17.4	DARK GRAY	mostly Quartz Sand; trace Shell				
Amelia Island Sand Transfer / Sand Search	NCCB-14	-28.3	14a	0	0.7	BLACK	mostly Muddy Clay				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Study (1993)											
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-14	-28.3	14b	0.7	1.4		mostly Coarse Sand; trace Shell Fragments				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-14	-28.3	14c	1.4	13	LIGHT GRAY	mostly Medium Quartz Sand; trace Clay; trace Shell Fragments				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-14	-28.3	14d	13	15.5	DARK GRAY	mostly Coarse Shelly Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-14	-28.3	14e	15.5	16.5	LIGHT GRAY	mostly Fine Quartz Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-15	-33.8	15a	0	0.6	DARK GREENISH GRAY	mostly Clay				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-15	-33.8	15b	0.5	5.5	GRAY	mostly Rock; trace Shell Fragments				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-15	-33.8	15c	5.5	7	GRAY	mostly Medium Quartz Sand; trace Shell Fragments				
Amelia Island Sand Transfer / Sand Search	NCCB-15	-33.8	15d	7	9.2	DARK GREE	mostly Sandy Clay; trace				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Study (1993)						N	Shell Fragments				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-15	-33.8	15e	9.2	10.5	DARK GREEN	mostly Fine Clayey Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-15	-33.8	15f	10.5	13.5	GRAY	mostly Medium To Fine Quartz Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-15	-33.8	15g	13.5	14.9	WHITE	mostly Medium To Fine Quartz Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-34	22	34a	0	3.5	DARK GRAY	mostly Very Poorly Sorted Coarse Shelly Quartz Sand; isolated Mud				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-34	22	34b	3.5	5.5	MEDIUM GRAY	mostly Medium Quartz Sand; trace Shell				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-34	22	34c	5.5	9.7	LIGHT GRAY	mostly Medium Quartz Sand; isolated Mud				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-34	22	34d	9.7	12.7		mostly Poorly Sorted Medium Quartz Sand				
Amelia Island Sand	NCCB-	22	34e	12.7	15.3	LIGHT	mostly				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Transfer / Sand Search Study (1993)	34					GRAY	Medium Quartz Sand; isolated Mud				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-34	22	34f	15.3	16.2		mostly Medium To Fine Quartz Sand; isolated Peat				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-35	-35.9	35a	0	0.4	DARK GRAY	mostly Coarse To Fine Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-35	-35.9	35b	0.4	1	GRAY	mostly Fine Sandy Silt; trace Shell Fragments				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-35	-35.9	35c	1	1.5	DARK GRAY	mostly Coarse To Medium Sand				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-35	-35.9	35d	1.5	6.9	DARK GRAY	mostly Gravely Clay				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-35	-35.9	35e	6.9	14.1	DARK GREE N	mostly Clay				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-35	-35.9	35f	14.1	14.5		mostly Fine Sandy Mud				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-37	-34.8	37a	0	0.4	DARK GRAY	mostly Mud; trace Shell				
Amelia Island Sand	NCCB-	-34.8	37b	0.4	2.6		mostly Fine To				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Transfer / Sand Search Study (1993)	37						Very Fine Quartz Sand; trace Shell				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-37	-34.8	37c	2.6	9.9	DARK GRAY	mostly Mud				
Amelia Island Sand Transfer / Sand Search Study (1993)	NCCB-37	-34.8	37d	9.9	18.5	DARK GRAY	mostly Mud; trace Shell				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-A	0	3.6	10YR 8/2	mostly Fine Quartz Sand	A-2-1	0	1	0.45
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-A	0	3.6	10YR 8/2	mostly Fine Quartz Sand	A-2-2	3.5	4.5	0.14
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-B	3.6	7.8	10YR 7.5/1	mostly Fine Quartz Sand; trace Carbonate; trace Silt; trace Organics	A-2-2	3.5	4.5	0.14
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-C	7.8	8	10YR 7.5/1	mostly Coarse Shell				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-D	8	8.2	10YR 5/1	mostly Mud				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-E	8.2	8.5		mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-F	8.5	8.7	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-G	8.7	8.9	10YR 7/2	mostly Silty Sand				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-H	8.9	9.1		mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-I	9.1	11.2	10YR 7/2	mostly Fine Quartz Sand; trace Mud; trace Silt				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-J	11.2	15.6	10YR 7/3	mostly Silty Sand; trace Mud				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-K	15.6	18.8	10YR 7.5/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-2	-13.2	A-2-L	18.8	20.3	10YR 7/2	mostly Silty Sand; trace Mud				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-20R1	-13.1	A-20R1-A	0	2.8	10YR 8/0	mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell				
South Amelia Island Shoreline Stabilization (2001)	A-20R1	-13.1	A-20R1-B	2.8	5.7	10YR 7.5/0	mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments	A-20R1-1	4.5	5.5	0.15
South Amelia Island Shoreline Stabilization (2001)	A-20R1	-13.1	A-20R1-C	5.7	10.4	10YR 7/0	mostly Fine Quartz Sand	A-20R1-2	7.5	8.5	3.81
South Amelia Island Shoreline Stabilization (2001)	A-20R1	-13.1	A-20R1-D	10.4	11.7	10YR 7/0	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-20R1	-13.1	A-20R1-E	11.7	13.5	10YR 7/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-20R1	-13.1	A-20R1-F	13.5	13.9	10YR 7.5/0	mostly Fine Sand				
South Amelia Island Shoreline Stabilization (2001)	A-20R2	-12.8	A-20R2-B	8.7	14.8	10YR 6/2	mostly Medium To Fine Quartz Sand	A-20R2_1	11.5	12.5	1.21
South Amelia Island Shoreline Stabilization (2001)	A-20R2	-12.8	A-20R2-C	14.8	16	10YR 6/0	mostly Medium Sand				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-20R2	-12.8	A-20R2-D	16	17.5	10YR 6/0	mostly Fine Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-20R2	-12.8	A-20R2-E	17.5	17.9	10YR 6/0	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-20R2	-12.8	A-20R2-F	17.9	18.6	10YR 6/0	mostly Fine Sand; trace Mud				
South Amelia Island Shoreline Stabilization (2001)	A-8	-16.7	A-8-A	0	4.5		mostly Fine Quartz Sand; trace Silt	A-8-1	2.3	3.5	0.24
South Amelia Island Shoreline Stabilization (2001)	A-8	-16.7	A-8-B	4.5	5.1		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-8	-16.7	A-8-C	5.1	10.4		mostly Fine Quartz Sand	A-8-2	8.5	9.5	0.48
South Amelia Island Shoreline Stabilization (2001)	A-8	-16.7	A-8-D	10.4	15		mostly Shell Fragments	A-8-3	11.5	12.5	0.64
South Amelia Island Shoreline Stabilization (2001)	A-8	-16.7	A-8-E	15	18.8		mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-12R1	-11	A-12R1-A	0	2.6		mostly Fine Quartz Sand; trace Large Shell Fragments				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-12R1	-11	A-12R1-B	2.6	4		mostly Fine Quartz Sand; trace Mud				
South Amelia Island Shoreline Stabilization (2001)	A-12R1	-11	A-12R1-C	4	8.6		mostly Fine Quartz Sand; trace Mud	A-12R1-1	4.5	5.5	0.17
South Amelia Island Shoreline Stabilization (2001)	A-12R1	-11	A-12R1-D	8.6	10.2		mostly Fine Quartz Sand	A-12R1-2	9	10	0.67
South Amelia Island Shoreline Stabilization (2001)	A-12R1	-11	A-12R1-E	10.2	14.1	10YR 6.5/2					
South Amelia Island Shoreline Stabilization (2001)	A-12R2	-11	A-12R2-A	9.7	14.7	10YR 6.5/2	mostly Medium To Coarse Sand	A-12R2-1	14.5	15.5	1.99
South Amelia Island Shoreline Stabilization (2001)	A-12R2	-11	A-12R2-B	14.7	19.2	10YR 6.5/2	mostly Medium To Coarse Sand	A-12R2-1	14.5	15.5	1.99
South Amelia Island Shoreline Stabilization (2001)	A-12R2	-11	A-12R2-C	19.2	20	10YR 6.5/2	mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-A	0	1	10YR 7.5/2	mostly Medium Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-B	1	1.3	10YR 7/1	mostly Shell Fragments; trace Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-C	1.3	1.7	10YR 5/1	mostly Mud; trace Silt; trace Sand				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-D	1.7	4.8		mostly Shell Fragments; trace Large Whole Shell; trace Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-E	4.8	7.1		mostly Fine Quartz Sand; trace Shell Fragments	A-13R1-1	5.5	6.5	0.28
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-F	7.1	10.9		mostly Fine Quartz Sand; trace Organics	A-13R1-2	9.5	10.5	0.2
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-G	10.9	11.5		mostly Fine Quartz Sand; trace Organics; trace Whole Shell				
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-H	11.5	13.9		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13R1-I	13.9	15.5		mostly Fine Quartz Sand; trace Organics; trace Shell Fragments	A-13R1-3	15.5	16.5	0.21

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-13R1	-14.7	A-13-R1-J	15.5	17.2		mostly Fine Quartz Sand; trace Organics	A-13R1-3	15.5	16.5	0.21
South Amelia Island Shoreline Stabilization (2001)	A-13R2	-34.5	A-13R2-A	10.7	12.5		mostly Fine Quartz Sand; trace Heavy Minerals				
South Amelia Island Shoreline Stabilization (2001)	A-13R2	-34.5	A-13R2-B	12.5	15.1	10YR 7.5/1	mostly Fine Quartz Sand; trace Organics	A-13R2-1	13.5	14.5	0.2
South Amelia Island Shoreline Stabilization (2001)	A-13R2	-34.5	A-13R2-C	15.1	15.8		mostly Fine Quartz Sand; trace Organics; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-13R2	-34.5	A-13R2-D	15.8	17.6		mostly Medium To Fine Quartz Sand; trace Organics				
South Amelia Island Shoreline Stabilization (2001)	A-13R2	-34.5	A-13R2-E	17.6	19.5		mostly Medium To Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-13R2	-34.5	A-13R2-F	19.5	20.1		mostly Fine Quartz Sand; trace Organics				
South Amelia Island Shoreline Stabilization (2001)	A-14	-18.8	A-14-A	0	1.3	10YR 7.5/1	mostly Fine Quartz Sand	A-14-1	0	1	0.54

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-14	-18.8	A-14-B	1.3	12.8		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments	A-14-2	2.5	3.5	0.16
South Amelia Island Shoreline Stabilization (2001)	A-14	-18.8	A-14-B	1.3	12.8		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments	A-14-3	8.5	9.5	0.18
South Amelia Island Shoreline Stabilization (2001)	A-14	-18.8	A-14-C	12.8	13.4		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-14	-18.8	A-14-D	13.4	15.4		mostly Silty Mud; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-14	-18.8	A-14-E	15.4	18.1		mostly Quartz Silt				
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-A	0	0.3	10YR 7.5/1	mostly Fine Quartz Sand; trace Mud				
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-B	0.3	0.4	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-C	0.4	0.6	10YR 7.5/1	mostly Fine Quartz Sand				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-D	0.6	0.8	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-E	0.8	1.9	10YR 7.5/1	mostly Fine Quartz Sand	A-15-1	1	2	0.78
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-F	1.9	2.8	10YR 5/1	mostly Mud; trace Fine Quartz Sand	A-15-1	1	2	0.78
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-G	2.8	3.5	10YR 7.5/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-H	3.5	15.4		mostly Fine Quartz Sand; trace Mud; trace Shell Fragments	A-15-2	9.5	10.5	0.19
South Amelia Island Shoreline Stabilization (2001)	A-15	-18.7	A-15-I	15.4	20.2	10YR 7.5/2	mostly Silty Mud; trace Mud				
South Amelia Island Shoreline Stabilization (2001)	A-16	-11	A-16-A	0	5.3	10YR 8/2	mostly Fine Quartz Sand	A-16-1	2.5	3.5	0.24
South Amelia Island Shoreline Stabilization (2001)	A-16	-11	A-16-B	5.3	12.2		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments	A-16-2	6.5	7.5	0.18

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-16	-11	A-16-C	12.2	15.2		trace Shell Fragments	A-16-3	12.5	13.5	0.81
South Amelia Island Shoreline Stabilization (2001)	A-16	-11	A-16-D	15.2	16.3		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-A	0	4.5		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-B	4.5	4.8	10YR 8/2	mostly Medium To Fine Sand				
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-C	4.8	6.7	10YR 7.5/1	mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-D	6.7	7.7	10YR 7.5/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-E	7.7	10.1		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments	A-17-1	8.5	9.5	0.19

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-F	10.1	10.5	10YR 7.5/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-G	10.5	11.4	10YR 7.5/1	mostly Fine Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-H	11.4	12.8	10YR 7.5/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-17	-7.4	A-17-I	12.8	19.2		mostly Fine Quartz Sand; trace Organics; isolated Shell Fragments	A-17-2	15.5	16.5	0.17
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-A	0	1.6	10YR 9/1	mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell				
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-B	1.6	5.9		mostly Fine Quartz Sand; trace Organics	A-18-1	5.5	6.5	0.17
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-C	5.9	7.5		mostly Fine Quartz Sand	A-18-1	5.5	6.5	0.17
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-D	7.5	10.8		mostly Fine Quartz Sand	A-18-2	8.5	9.5	2.83

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-E	10.8	16		mostly Fine Quartz Sand; trace Mud; trace Organics	A-18-3	12.5	13.5	0.16
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-F	16	16.7		mostly Fine Quartz Sand; trace Mud; trace Organics				
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-G	16.7	19.5		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-H	19.5	19.6	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-18	-7.2	A-18-I	19.6	20.2		mostly Shell Fragments; trace Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-19R1	-10.1	A-19R1-A	0	2.2		mostly Fine Quartz Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-19R1	-10.1	A-19R1-B	2.2	4.7	10YR 7.5/1	mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-19R1	-10.1	A-19R1-C	4.7	5.6		mostly Fine Quartz Sand; trace Organics				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-19R1	-10.1	A-19R1-D	5.6	5.7	10YR 6/2	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-19R1	-10.1	A-19R1-E	5.7	7.6		mostly Fine Quartz Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-19R1	-10.1	A-19R1-F	7.6	9.9		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-19R1	-10.1	A-19R1-G	9.9	13.2		mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-19R1	-10.1	A-19R1-H	13.2	13.5	10YR 7.5/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-19R2	-10.3	A-19R2-A	6	6.2	10YR 6/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-19R2	-10.3	A-19R2-B	6.2	9.5	10YR 8/1	mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell	A-19R2-1	6.5	7.5	0.5
South Amelia Island Shoreline Stabilization (2001)	A-19R2	-10.3	A-19R2-C	9.5	11		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-19R2	-10.3	A-19R2-D	11	14.8		mostly Whole Shell	A-19R2-2	12.5	13.5	1.51

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-19R2	-10.3	A-19R2-E	14.8	18.3	10YR 7.5/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-19R2	-10.3	A-19R2-F	18.3	18.7		mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-19R2	-10.3	A-19R2-G	18.7	19.9		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-21	-16.6	A-21-A	0	2.1	10YR 8/2	mostly Fine Quartz Sand; trace Silt; trace Shell Fragments	A-21-1	1.5	2.5	0.13
South Amelia Island Shoreline Stabilization (2001)	A-21	-16.6	A-21-B	2.1	5.4		mostly Fine Quartz Sand	A-21-1	1.5	2.5	0.13
South Amelia Island Shoreline Stabilization (2001)	A-21	-16.6	A-21-C	5.4	5.7	10YR 7.5/2	mostly Fine Quartz Sand; trace Mud				
South Amelia Island Shoreline Stabilization (2001)	A-21	-16.6	A-21-D	5.7	11.8		mostly Fine Quartz Sand	A-21-2	9.5	10.5	0.94
South Amelia Island Shoreline Stabilization (2001)	A-21	-16.6	A-21-E	11.8	20.4		mostly Silt; trace Mud; trace Shell Fragments; trace Whole Shell				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-23R1	-10.8	A-23R1-A	0	2.6		mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell	A-23R1-1	1.5	2.5	0.15
South Amelia Island Shoreline Stabilization (2001)	A-23R1	-10.8	A-23R1-B	2.6	3.8		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-23R1	-10.8	A-23R1-C	3.8	5		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-23R1	-10.8	A-23R1-D	5	5.6		mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-23R1	-10.8	A-23R1-E	5.6	6.7		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-23R1	-10.8	A-23R1-F	6.7	13.3		mostly Quartz Sand	A-23R1-2	11.5	12.5	0.63
South Amelia Island Shoreline Stabilization (2001)	A-23R2	-10.3	A-23R2-A	10.5	15		mostly Fine Quartz Sand	A-23R2-1	12.5	13.5	1.11
South Amelia Island Shoreline Stabilization (2001)	A-23R2	-10.3	A-23R2-B	15	18.3		mostly Medium Quartz Sand	A-23R2-2	15.5	16.5	0.71

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-23R2	-10.3	A-23R2-C	18.3	19.8		mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-A	0	0.7	10YR 8.5/0	mostly Very Fine Quartz Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-B	0.7	5.4		mostly Fine Quartz Sand; trace Shell Fragments	A-24-1	2.5	3.5	0.18
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-C	5.4	6.6		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-D	6.6	8.6		mostly Fine Quartz Sand	A-24-2	8.5	9.5	0.21
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-E	8.6	9.9		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments	A-24-2	8.5	9.5	0.21
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-F	9.9	10.3	10YR 7.5/1	mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-G	10.3	10.6	10YR 7.5/2	mostly Fine Quartz Sand; trace Small Shell Fragments				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-H	10.6	10.9		mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-I	10.9	16.2		mostly Fine Quartz Sand; trace Shell Fragments	A-24-3	12.5	13.5	0.18
South Amelia Island Shoreline Stabilization (2001)	A-24	-5.8	A-24-J	16.2	16.8		mostly Fine Quartz Sand; trace Mud				
South Amelia Island Shoreline Stabilization (2001)	A-25	-6.1	A-25-A	0	1.3		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-25	-6.1	A-25-B	1.3	3.1		mostly Fine Quartz Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-25	-6.1	A-25-C	3.1	14.1		mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell	A-25-1	5.5	6.5	0.19
South Amelia Island Shoreline Stabilization (2001)	A-25	-6.1	A-25-C	3.1	14.1		mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell	A-25-2	13.5	14.5	0.2

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-25	-6.1	A-25-D	14.1	19.8		mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell	A-25-2	13.5	14.5	0.2
South Amelia Island Shoreline Stabilization (2001)	A-26R1	-10.1	A-26R1-A	0	1.9	10YR 7.5/1	mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-26R1	-10.1	A-26R1-B	1.9	2.9		mostly Fine Quartz Sand	A-26R1-1	2.5	3.5	0.25
South Amelia Island Shoreline Stabilization (2001)	A-26R1	-10.1	A-26R1-C	2.9	5	10YR 7.5/1	mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments	A-26R1-1	2.5	3.5	0.25
South Amelia Island Shoreline Stabilization (2001)	A-26R1	-10.1	A-26R1-D	5	5.4	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-26R1	-10.1	A-26R1-E	5.4	8.7	10YR 8/1	mostly Fine Quartz Sand	A-26R1-2	5.5	6.5	0.56

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-26R1	-10.1	A-26R1-F	8.7	9.7		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-26R1	-10.1	A-26R1-G	9.7	13.7	10YR 7.5/1	mostly Medium To Fine Quartz Sand	A-26R1-3	11.5	12.5	1.06
South Amelia Island Shoreline Stabilization (2001)	A-26R1	-10.1	A-26R1-H	13.7	14.8	10YR 6/3	mostly Silty Sand				
South Amelia Island Shoreline Stabilization (2001)	A-26R2	-9.8	A-26R2-A	8	12.7		mostly Fine Quartz Sand	A-26R2-2	10.5	11.5	0.81
South Amelia Island Shoreline Stabilization (2001)	A-26R2	-9.8	A-26R2-B	12.7	13.1	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-26R2	-9.8	A-26R2-C	13.1	14.6		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-26R2	-9.8	A-26R2-D	14.6	18	10YR 6/3	mostly Silty Sand; trace Whole Shell; trace Shell Fragments				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-A	0	1.3		mostly Medium To Very Fine Quartz Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-B	1.3	2.2	10YR 7.5/1	mostly Medium Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-C	2.2	2.7	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-D	2.7	4.1	10YR 7/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-E	4.1	4.8		mostly Fine Quartz Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-F	4.8	5.3	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-G	5.3	6.4		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-H	6.4	10.1		mostly Medium To Fine Quartz Sand	A-27R1-1	8.5	9.5	1.42

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-27R1	-14.2	A-27R1-I	10.1	14.8	10YR 8/1	mostly Fine Quartz Sand; trace Shell Fragments	A-27R1-2	11.5	12.5	0.15
South Amelia Island Shoreline Stabilization (2001)	A-27R2	-14	A-27R2-A	10.4	12		mostly Fine Quartz Sand; trace Shell Fragments	A-27R2-1	10.5	11.5	0.16
South Amelia Island Shoreline Stabilization (2001)	A-27R2	-14	A-27R2-B	12	20.1		mostly Fine Quartz Sand; trace Shell Fragments	A-27R2-2	13.5	14.5	0.15
South Amelia Island Shoreline Stabilization (2001)	A-28	-2.2	A-28-A	0	1.9		mostly Fine Quartz Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-28	-2.2	A-28-B	1.9	3.1		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-28	-2.2	A-28-C	3.1	5.8		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments; trace Mud	A-28-1	5.5	6.5	0.16
South Amelia Island Shoreline Stabilization (2001)	A-28	-2.2	A-28-D	5.8	7.9		mostly Fine Quartz Sand; trace Shell Fragments	A-28-1	5.5	6.5	0.16

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-28	-2.2	A-28-E	7.9	9.5		mostly Fine Quartz Sand	A-28-2	8.5	9.5	0.58
South Amelia Island Shoreline Stabilization (2001)	A-28	-2.2	A-28-F	9.5	12.4		mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell; trace Mud	A-28-2	8.5	9.5	0.58
South Amelia Island Shoreline Stabilization (2001)	A-28	-2.2	A-28-G	12.4	12.9		mostly Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-28	-2.2	A-28-H	12.9	17.8		mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell	A-28-3	14.5	15.5	0.21
South Amelia Island Shoreline Stabilization (2001)	A-29	-15.7	A-29-A	0	7.3		mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell	A-29-1	2.5	3.5	0.13
South Amelia Island Shoreline Stabilization (2001)	A-29	-15.7	A-29-B	7.3	8.3		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-29	-15.7	A-29-C	8.3	8.7	10YR 7.5/3	mostly Mud				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-29	-15.7	A-29-D	8.7	9.5		mostly Fine Quartz Sand; trace Silt				
South Amelia Island Shoreline Stabilization (2001)	A-29	-15.7	A-29-E	9.5	12.5		mostly Fine Silty Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-29	-15.7	A-29-F	12.5	20.5		mostly Quartz Silt; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-30R1	-10	A-30R1-A	0	5.1		mostly Fine Quartz Sand; trace Shell Fragments	A-30R1-1	2.5	3.5	0.16
South Amelia Island Shoreline Stabilization (2001)	A-30R1	-10	A-30R1-B	5.1	15	10YR 8/1	mostly Fine Quartz Sand; trace Shell Fragments	A-30R1-2	9.5	10.5	0.14
South Amelia Island Shoreline Stabilization (2001)	A-30R1	-10	A-30R1-C	15	15.8		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-30R2	-8.9	A-30R2-A	10.2	11.1		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-30R2	-8.9	A-30R2-B	11.1	14.4	10YR 8/1	mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell	A-30R2-1	12.5	13.5	0.14

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-30R2	-8.9	A-30R2-C	14.4	16	10YR 8/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-30R2	-8.9	A-30R2-D	16	16.3	10YR 5/1	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-30R2	-8.9	A-30R2-E	16.3	17.1		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-30R2	-8.9	A-30R2-F	17.1	20.1		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-31R1	-4.5	A-31R1-A	0	0.5		mostly Fine Quartz Sand; trace Organics; isolated Carbonate				
South Amelia Island Shoreline Stabilization (2001)	A-31R1	-4.5	A-31-R1-B	0.5	5.2	10YR 8.5/0	mostly Fine Quartz Sand; trace Shell Fragments	A-31R1-1	4.5	5.5	0.14
South Amelia Island Shoreline Stabilization (2001)	A-31R1	-4.5	A-31R1-C	5.2	7.5		mostly Fine Quartz Sand; trace Organics; trace Shell Fragments	A-31R1-1	4.5	5.5	0.14

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-31R1	-4.5	A-31R1-C	5.2	7.5		mostly Fine Quartz Sand; trace Organics; trace Shell Fragments	A-31R1-2	7.5	8.5	0.59
South Amelia Island Shoreline Stabilization (2001)	A-31R1	-4.5	A-31R1-D	7.5	10.3		mostly Fine Quartz Sand; trace Large Shell Fragments	A-31R1-2	7.5	8.5	0.59
South Amelia Island Shoreline Stabilization (2001)	A-31R1	-4.5	A-31R1-E	10.3	12.4		mostly Fine Quartz Sand; trace Organics				
South Amelia Island Shoreline Stabilization (2001)	A-31R2	-4.6	A-31R2-A	9	10.1	10YR 8/2	mostly Medium To Fine Quartz Sand	A-31R2-1	9.5	10.5	1.47
South Amelia Island Shoreline Stabilization (2001)	A-31R2	-4.6	A-31R2-B	10.1	13.5		mostly Fine Quartz Sand	A-31R2-1	9.5	10.5	1.47
South Amelia Island Shoreline Stabilization (2001)	A-31R2	-4.6	A-31R2-C	13.5	14.5		mostly Fine Quartz Sand; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-31R2	-4.6	A-31R2-D	14.8	15.4		mostly Fine Quartz Sand; trace Organics				
South Amelia Island Shoreline Stabilization (2001)	A-31R2	-4.6	A-31R2-E	15.4	16		mostly Fine Quartz Sand; trace Mud	A-21R2-2	15.5	16.5	0.16

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-31R2	-4.6	A-31R2-F	16	20.2		mostly Fine Quartz Sand; trace Shell Fragments	A-21R2-2	15.5	16.5	0.16
South Amelia Island Shoreline Stabilization (2001)	A-32	-1.6	A-32-A	0	2.6		mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-32	-1.6	A-32-B	2.6	5.4		mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-32	-1.6	A-32-C	5.4	13.4		mostly Fine Quartz Sand; trace Shell Fragments	A-32-1	5.5	6.5	0.18
South Amelia Island Shoreline Stabilization (2001)	A-32	-1.6	A-32-C	5.4	13.4		mostly Fine Quartz Sand; trace Shell Fragments	A-32-3	11.5	12.5	1.67
South Amelia Island Shoreline Stabilization (2001)	A-32	-1.6	A-32-D	13.4	14.9		mostly Fine Quartz Sand; trace Coral				
South Amelia Island Shoreline Stabilization (2001)	A-32	-1.6	A-32-E	14.9	15.5		mostly Mud; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-32	-1.6	A-32-F	15.5	18.4	10YR 8/0	mostly Fine Quartz Sand; trace Mud; trace Silt	A-32-2	16.5	17.5	0.16

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-33	-14	A-33-A	0	2.1	10YR 8/0	mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell				
South Amelia Island Shoreline Stabilization (2001)	A-33	-14	A-33-B	2.1	4.5	10YR 7.5/0	mostly Fine Quartz Sand; trace Whole Shell; trace Shell Fragments				
South Amelia Island Shoreline Stabilization (2001)	A-33	-14	A-33-C	4.5	9.6	10YR 8/0	mostly Fine Quartz Sand; trace Shell Fragments; trace Whole Shell				
South Amelia Island Shoreline Stabilization (2001)	A-33	-14	A-33-D	9.6	9.9	10YR 5/2	mostly Mud				
South Amelia Island Shoreline Stabilization (2001)	A-33	-14	A-33-E	9.9	12.7	10YR 7.5/0	mostly Large Shell Fragments	A-33-1	11.5	12.5	1.67
South Amelia Island Shoreline Stabilization (2001)	A-33	-14	A-33-F	12.7	13.8	10YR 7.5/1	mostly Fine Quartz Sand; trace Mud				
	A-33	-14	A-33-G	13.8	15.1	10YR 6/2	mostly Fine Quartz Sand; trace Mud				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
South Amelia Island Shoreline Stabilization (2001)	A-33	-14	A-33-H	15.1	15.7	10YR 7/1	mostly Fine Quartz Sand				
South Amelia Island Shoreline Stabilization (2001)	A-33	-14	A-33-I	15.7	19.3	10YR 6/1	mostly Mud				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	928		928-1	0	42	LIGHT GRAYISH	mostly Fine Quartz Sand; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	928		928-2	42	56	LIGHT GRAYISH	mostly Quartz Silt; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	928		928-3	56	75	LIGHT GRAYISH	mostly Clay; trace Shell Fragments				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	928		928-4	75	139	LIGHT GRAYISH	mostly Quartz Silt; some Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929A		929A-1	0	41	MEDIUM GRAYISH	mostly Silty Quartz Sand; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929A		929A-2	41	62	MEDIUM GRAYISH	mostly Silty Quartz Sand; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929A		929A-3	62	83	MEDIUM GRAYISH	mostly Silty Quartz Sand; trace Shell				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929A		929A-4	83	102	DARK GRAYISH	mostly Silty Clay; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929A		929A-5	102	198	DARK GRAYISH	mostly				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929A		929A-6	198	230	DARK GRAYISH	mostly				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929A		929A-7	230	292	TAN	mostly; some Carbonate				

Table 4-4a. *Nassau Primary 2 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929A		929A-8	292	318	LIGHT GRAYISH	mostly Quartz Silt; some Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	929		929-1	0	149	MEDIUM GRAYISH	mostly Quartz Silt; trace Shell Fragments				

Table 4-4b: *Nassau Primary 2 Grab Sample Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Bottom of Layer Interval	Top of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies								KBA-76-04	0	0.1	0.13
Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies								KBA-76-08	0	0.1	0.14

Table 4-5: *Sand resource potential in Duval County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.*

Morpho-sedimentary Features	**Shelf Area (ha)[1]**	**% of County Continental Shelf Area[2]**	**Height of Plane (ft)**	**Elevation Range[3] (Max to Min Depth) (ft)**	**% Area Used in Volume Calculations[4]**	**Sediment Volume (cy)**
Amelia Sand Ridge	1,039	0<1	-49.02	-49.02 to -33.79	75	18,969,512
Duval Ridge Field A	65,666	28	-101.38	-101.38 to -32.48	80	8,253,818,678
Duval Ridge Field B	34	0<1	-52.69	-52.69 to -45.18	95	630,971
Duval Ridge Field C	200	0<1	-52.49	-52.49 to -46.26	70	1,374,238
Farmton Sand Flat A	1,876	1	-65.94	-65.94 to -48.56	100	75,731,840
Farmton Sand Flat B	16,558	7	-82.35	-82.35 to -1.41	100	2,493,129,257
Nassau Bank	46,321	20	-105.64	-105.64 to-58.40	95	4,424,220,406
O'Neal Bank	1,876	1	-95.41	-95.41 to -66.90	60	85,147,169
Sawgrass Bank A	425	0<1	-100.72	-100.72 to -84.74	40	4,329,866
Sawgrass Bank B	6,171	3	-97.77	-97.77 to -63.65	75	350,052,874
Sawgrass Bank C	21,730	9	-121.72	-121.72 to -40.68	100	1,549,896,148
St. Johns Ebb-Tidal Delta	1,840	1	-78.41	-78.41 to -0.98	65	292,920,217
Talbot Transverse Bar	1,089	0<1	-46.69	-46.69 to -9.51	50	36,044,963
Tisonia – Nassau Sound Ebb-Tidal Delta Complex	1,275	1	-35.10	-35.10 to -2.95	85	122,995,497
Total	**166,102**	**71**				**17,709,261,636**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.
[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.
[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.
[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 4-6: *Duval Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	925		925-1	0	33	DARK GRAYISH	mostly Quartz Silt; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	925		925-2	33	68	LIGHT GRAYISH	mostly Clay; little Quartz Clay; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	925		925-3	68	84	MEDIUM TANISH	mostly Quartz Silt; trace Shell Fragments				
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-1	0	2	LIGHT OLIVEISH GRAY	mostly Sand; trace Heavy Minerals; trace Shell; trace Clay	VDU10-1	0	2	2.47
A Geological	VDU-10	48	VDU10-	0	2	LIGHT	mostly Sand;	VDU10-2	2	4	2.79

Table 4-6: *Duval Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two			1			OLIVEISH GRAY	trace Heavy Minerals; trace Shell; trace Clay				
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-2	2	4	LIGHT OLIVEISH GRAY	mostly Fine To Coarse Sand; trace Shell; trace Clay; isolated Heavy Minerals	VDU10-1	0	2	2.47
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-2	2	4	LIGHT OLIVEISH GRAY	mostly Fine To Coarse Sand; trace Shell; trace Clay; isolated Heavy Minerals	VDU10-3	4	6	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-2	2	4	LIGHT OLIVEISH GRAY	mostly Fine To Coarse Sand; trace Shell; trace Clay; isolated Heavy Minerals	VDU10-2	2	4	2.79
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-3	4	6	LIGHT OLIVEISH GRAY	mostly Sand; trace Clay; trace Shell; isolated Heavy Minerals	VDU10-3	4	6	
A Geological	VDU-10	48	VDU10-	4	6	LIGHT	mostly Sand;	VDU10-4	6	8	

Table 4-6: *Duval Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two			3			OLIVEISH GRAY	trace Clay; trace Shell; isolated Heavy Minerals				
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-3	4	6	LIGHT OLIVEISH GRAY	mostly Sand; trace Clay; trace Shell; isolated Heavy Minerals	VDU10-2	2	4	2.79
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-4	6	8	LIGHT OLIVEISH GRAY	mostly Sand; little Clay; trace Shell	VDU10-3	4	6	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-4	6	8	LIGHT OLIVEISH GRAY	mostly Sand; little Clay; trace Shell	VDU10-4	6	8	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-4	6	8	LIGHT OLIVEISH GRAY	mostly Sand; little Clay; trace Shell	VDU10-5	8	10	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-5	8	10	OLIVEISH GRAY	mostly Clay; some Quartz Sand; trace Shell	VDU10-6	10	12	

Table 4-6: *Duval Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-5	8	10	OLIVEISH GRAY	mostly Clay; some Quartz Sand; trace Shell	VDU10-4	6	8	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-5	8	10	OLIVEISH GRAY	mostly Clay; some Quartz Sand; trace Shell	VDU10-5	8	10	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-6	10	12	MEDIUM GRAY	mostly Sand; little Silt; little Clay; trace Limestone; trace Shell	VDU10-7	12	14	2.48
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-6	10	12	MEDIUM GRAY	mostly Sand; little Silt; little Clay; trace Limestone; trace Shell	VDU10-6	10	12	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-6	10	12	MEDIUM GRAY	mostly Sand; little Silt; little Clay; trace Limestone; trace Shell	VDU10-5	8	10	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-7	12	14	OLIVEISH GRAY	mostly Sand; little Limestone	VDU10-7	12	14	2.48

Table 4-6: *Duval Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-7	12	14	OLIVEISH GRAY	mostly Sand; little Limestone	VDU10-8	14	16	2.57
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-7	12	14	OLIVEISH GRAY	mostly Sand; little Limestone	VDU10-6	10	12	
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-8	14	16	LIGHT OLIVEISH GRAY	mostly Sand; trace Heavy Minerals	VDU10-7	12	14	2.48
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-8	14	16	LIGHT OLIVEISH GRAY	mostly Sand; trace Heavy Minerals	VDU10-8	14	16	2.57
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-8	14	16	LIGHT OLIVEISH GRAY	mostly Sand; trace Heavy Minerals	VDU10-9	16	18	2.29
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-9	16	18	YELLOWISH GRAY	mostly Fine To Coarse Sand; isolated Heavy Minerals	VDU10-10	18	19	1.95

Table 4-6: *Duval Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-9	16	18	YELLOWISH GRAY	mostly Fine To Coarse Sand; isolated Heavy Minerals	VDU10-8	14	16	2.57
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-9	16	18	YELLOWISH GRAY	mostly Fine To Coarse Sand; isolated Heavy Minerals	VDU10-9	16	18	2.29
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-10	18	19	YELLOWISH GRAY	mostly Sand; trace Clay; isolated Heavy Minerals	VDU10-10	18	19	1.95
A Geological Investigation of the Offshore Area Along Florida's Northeast Coast - Year Two	VDU-10	48	VDU10-10	18	19	YELLOWISH GRAY	mostly Sand; trace Clay; isolated Heavy Minerals	VDU10-9	16	18	2.29

Table 4-7: *Sand resource potential in St. Johns County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.*

Morphosedimentary Features	Shelf Area (ha)[1]	% of County Continental Shelf Area[2]	Height of Plane (ft.)	Elevation Range[3] (Max to Min Depth) (ft.)	% Area Used in Volume Calculations[4]	Sediment Volume (cy)
Cresent Ridge Field	9,268	2	-71.85	-71.85 to -42.65	80	357,020,073
Duval Ridge Field A	586	0<1	-52.66	-52.66 to -41.67	90	13,185,691
Duval Ridge Field B	52,545	11	-82.35	-82.35 to -4.92	85	4,888,975,292
Espanda Ridge Field	2,109	0<1	-71.85	-71.85 to -51.18	75	63,426,155
Farmton Sand Flat	44,424	9	-140.42	-140.42 to -4.17	100	14,398,452,144
Flagler Sand Wave	82	0<1	-94.49	-94.49 to -83.43	60	868,560
Nassau Bank A	856	0<1	-99.74	-99.74 to -81.04	85	35,783,098
Nassau Bank B	1,707	0<1	-100.07	-100.07 to -74.48	65	56,507,190
Palm Coast Sand Wave	19,656	4	-100.39	-100.39 to -50.85	90	1,773,923,019
Sawgrass Bank	58,653	12	-104.99	-104.99 to -49.87	75	4,843,895,097
St Augustine Eeb-tidal Delta	7,680	2	-51.71	-51.71 to -1.97	70	364,802,151
St Johns Bank	83,966	17	-125.89	-125.89 to -60.70	65	5,811,519,884
Summer Haven Sand Wave	55,722	11	-100.33	-100.33 to -48.56	70	4,111,953,409
Total	**332,253**	**69**				**36,720,311,763**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.
[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.
[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.
[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 4-8: *St. Johns Primary 1 Vibracore Query.*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	858		858-1	0	40	LIGHT TANISH	mostly Medium To Fine Quartz Sand; trace Whole Shell				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	858		858-3	85	95	LIGHT GRAYISH	mostly Fine Quartz Sand				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	858		858-2	40	85	MEDIUM GRAYISH	mostly Quartz Sand; trace Shell Fragments				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-4	-22.3	CB-SJ98-4 A	0	1.2	LIGHT GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-4	-22.3	CB-SJ98-4 B	1.2	8	GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-4	-22.3	CB-SJ98-4 C	8	11.6	GRAY	mostly Fine Sand; trace Shell				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-4	-22.3	CB-SJ98-4 D	11.6	19.6	GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-5	-24.9	CB-SJ98-5 A	0	1.6	GRAY	mostly Fine Sand; trace Shell				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-5	-24.9	CB-SJ98-5 B	1.6	9.5	GRAY	mostly Fine Sand; trace Shell; trace Clay				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-5	-24.9	CB-SJ98-5 C	9.5	12.5	DARK GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-5	-24.9	CB-SJ98-5 D	12.5	19.5	DARK GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-5	-24.9	CB-SJ98-5 E	19.5	19.8	DARK GRAY	mostly Clay				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-6	-18.1	CB-SJ98-6 A	0	2.3		mostly Fine Sand				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-6	-18.1	CB-SJ98-6 B	2.3	12.3	GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-6	-18.1	CB-SJ98-6 C	12.3	17.8	GRAY	mostly Fine Sand; trace Shell				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-6	-18.1	CB-SJ98-6 D	17.8	19.8	GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-8	-16.3	CB-SJ98-8 A	0	2	LIGHT GRAY	mostly Fine Sand; trace Shell				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-8	-16.3	CB-SJ98-8 B	2	4.8	GRAY	mostly Fine Sand; trace Shell				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-8	-16.3	CB-SJ98-8 C	4.8	7	LIGHT GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-8	-16.3	CB-SJ98-8 D	7	17.9	GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-8	-16.3	CB-SJ98-8 E	17.9	19.8	GRAY	mostly Fine Sand; trace Shell				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-9	-24.4	CB-SJ98-9 A	0	3.1	DARK GRAY	mostly Fine Sand; trace Shell				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-9	-24.4	CB-SJ98-9 B	3.1	5.2	GRAY	mostly Fine Sand				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-9	-24.4	CB-SJ98-9 C	5.2	8.5	DARK GRAY	mostly Fine Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-9	-24.4	CB-SJ98-9 D	8.5	15.8	DARK GRAY	mostly Fine Silty Sand; trace Shell				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-9	-24.4	CB-SJ98-9 E	15.8	17.7	GRAY	mostly Fine Silty Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-9	-24.4	CB-SJ98-9 F	17.7	19	DARK GRAY	mostly Clay; trace Sand				
St. John's Vibracore 1998 (provided on logs)	CB-SJ98-9	-24.4	CB-SJ98-9 G	19	19.8		mostly Fine Sand				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	845		845-1	0	20	LIGHT GRAYISH	mostly Quartz Sand; trace Shell Fragments				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	845		845-2	20	42	MEDIUM GRAYISH	mostly Quartz Silt; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	845		845-3	42	72	LIGHT GRAYISH	mostly Quartz Sand; little Shell				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border -	845		845-4	72	104	LIGHT TANISH	mostly Carbonate; trace Shell Fragments				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Phase II and Final Report											
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	845		845-5	104	149	WHITE	mostly Carbonate; little Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	845		845-6	149	209	LIGHT TANISH	mostly Carbonate; trace Shell Fragments				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	846		846-1	0	110	MEDIUM GRAYISH	mostly Quartz Sand; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	846		846-2	110	187	MEDIUM GRAYISH	mostly Quartz Sand; some Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border -	846		846-3	187	280	LIGHT GRAYISH	mostly Carbonate; little Quartz Sand; trace Shell Fragments				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Phase II and Final Report											
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	846		846-4	280	307	VERY LIGHT TANISH	mostly Carbonate; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	848			0				848-1			2.98

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	848			0				848-2			2.74
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	849B		849-1	0	106	LIGHT GRAYIS H	mostly Quartz Sand; trace Shell				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border -	849B		849-2	106	151	MEDIU M GRAYIS H					

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Phase II and Final Report											
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	849B		849-3	151	171	MEDIUM GRAYISH	mostly Quartz Sand; trace Shell				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	962		962-1	0	174	MEDIUM GRAYISH	mostly Clayey Quartz Silt; trace Shell Fragments				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	962		962-2	174	205	BLACK	mostly Organics				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	962		962-3	205	230	MEDIUM GRAYISH	mostly Shell; some Quartz Silt				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border -	963		963-1	0	74	WHITE	mostly Fine Carbonate Sand; trace Shell Fragments				

Table 4-9: *St. Johns Primary 2 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Phase II and Final Report											
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	963		963-2	74	103	WHITE	mostly Fine Carbonate Sand; little Shell Fragments				

Table 4-10: *St. Johns Primary 3 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	834		834-1	0	69	DARK GRAYISH	mostly Quartz Silt; trace Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	834		834-2	69	130	DARK GRAYISH	mostly Quartz Silt; little Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	834		834-3	130	160	MEDIUM GRAYISH	mostly Quartz Silt; little Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	834		834-4	160	410	WHITE	mostly Carbonate; some Quartz Sand; trace Shell Fragments				

Table 4-11: *Sand resource potential in Flagler County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.*

Morphosedimentary Features	**Shelf Area (ha)[1]**	**% of County Continental Shelf Area[2]**	**Height of Plane (ft.)**	**Elevation Range (Max to Min Depth) (ft.)**	**% Area Used in Volume Calculations[3]**	**Sediment Volume (cy)**
Beverly Shoal	1,248	1	-64.30	-64.30 to -49.44	85	27,211,953
Bunnel Ridge Field	7,858	4	-76.44	-76.44 to -44.29	45	157,528,249
Espanda Ridge Field	1,325	1	-69.91	-69.91 to -51.84	95	41,304,138
Farmton Sand Flat A	4,163	2	-78.97	-78.97 to -53.48	100	137,021,760
Farmton Sand Flat B	28,764	16	-75.13	-75.13 to -8.60	100	1,751,482,932
Flagler Sand Wave	57,210	31	-98.56	-98.56 to -43.96	95	6,055,565,761
Korona Ridge Field	6,381	3	-81.04	-81.04 to -54.20	80	283,848,808
Palm Coast Sand Wave A	477	0<1	-99.74	-99.74 to -84.74	75	11,279,145
Palm Coast Sand Wave B	5,305	3	-90.45	-90.45 to -49.54	95	514,162,775
St Johns Bank	50,006	27	-111.55	-111.55 to -57.74	50	2,197,992,485
Volusia Bank	12,172	7	-103.67	-103.67 to -63.16	65	598,700,049
Total	**174,911**	**94**				**11,776,098,055**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.
[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.
[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.
[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 4-12: Flagler Primary 1 Vibracore Query

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Bottom of Layer Interval	Top of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	946				0			946-1			2.7
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	946				0			946-2			2.5
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	946				0			946-3			2.3

Table 4-13: *Sand resource potential in Volusia County by morphosedimentary units where volume calculations are based on percent areal coverage in the mapping unit, which is less than unity for bars and ridge fields.*

Morphosedimentary Features	Shelf Area (ha)[1]	% of County Continental Shelf Area[2]	Height of Plane (ft.)	Elevation Range[3] (Max to Min Depth) (ft.)	% Area Used in Volume Calculations[4]	Sediment Volume (cy)
Allandale Shoal	675	0<1	-59.25	-59.25 to -41.67	75	12,459,973
Bunnel Ridge Field	580	0<1	-67.09	-67.09 to -48.56	30	4,730,003
Canaveral Transverse Bar	929	0<1	-51.71	-51.71 to -8.23	35	17,976,330
Edgewater Ridge Field	15,979	4	-76.12	-76.12 to -41.34	95	943,126,909
Farmton Sand Flat	87,864	23	-78.18	-78.18 to 0	100	6,386,947,776
Korona Ridge Field	15,098	4	-74.25	-74.25 to -35.76	100	910,571,931
Oak Hill Shoal	1,813	0<1	-66.17	-66.17 to -32.81	60	47,892,296
St. Johns Bank	2,990	1	-113.16	-113.16 to -72.51	95	213,500,704
Volusia Bank	154,745	40	-115.81	-115.81 to -47.90	80	19,797,286,537
Total	**280,671**	**72**				**28,334,492,459**

[1] For conversion of hectares (ha) to square kilometers (100 ha = 1 km^2), move decimal point two digits to the left.
[2] Refers to continental shelf area offshore from county lines for ease of reference. State waters lie shoreward of the 3-mile and federal waters are seaward.
[3] Based on measurement of local relief from the reformatted NOAA bathymetry. These measurements are limited by the grid scale of the NOAA bathymetric data. Sediment volume was calculated from a TIN data structure using the maximum and minimum elevations within the mapping unit.
[4] Some mapping units embrace larger areas than sand ridges *per se*, for example, to simplify mapping. Areas thus designated as ridge fields contains sand ridges plus intervening swales and sand plain units.

Table 4-14: *Volusia Primary 1 Vibracore Query*

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Volusia County Reconnaissance	B10-3	-55.4	29	0	0.8	10YR 6/2	Muddy, quartz, SAND, abrupt contact				
Volusia County Reconnaissance	B10-3	-55.4	30	0.8	7.5	10YR 4/1	Muddy and shelly (8-15%), quartz, SAND, common articulation of bivalves, mud and shell content increases towards base, layer of rounded rock cobbles and claystone at base (6.0' to 7.5', abrupt contact	B10-3 #1	1	1.3	2.27
Volusia County Reconnaissance	B10-3	-55.4	30	0.8	7.5	10YR 4/1	Muddy and shelly (8-15%), quartz, SAND, common articulation of bivalves, mud and shell content increases towards base, layer of rounded rock cobbles and claystone at base (6.0' to 7.5', abrupt contact	B10-3 #2	7	7.3	2.27
Volusia County Reconnaissance	B10-3	-55.4	31	7.5	11.1	10YR 7/2	Fine grained, quartz SAND, shells (20%) abundant at 9.5', contact abrupt with erosional shell lag	B10-3 #3	8	8.3	2.06
Volusia County Reconnaissance	B10-3	-55.4	32	11.1	14.8	7.5YR 4/1	Muddy and shelly, fine grained, quartz, SAND, very large bivalves (Mercinaria sp.) 10 cm width, shell (~20%) and clay content increases to base, clay intraclasts at base, abrupt contact	B10-3 #4	12	12.3	3.16
Volusia County Reconnaissance	B10-3	-55.4	33	14.8	15.6	7.5YR 5/1	CLAY, burrows (1 cm diameter) with shell infill at top				

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Volusia County Reconnaissance	B14-1	-56.9	75	0	0.3	10YR 7/1	Muddy, quartz-rich, course grained, skelletal, SAND, abrupt contact				
Volusia County Reconnaissance	B14-1	-56.9	76	0.3	4.2	7.5YR 5/1	Muddy, shelly(~10%), SAND, grading down to shelly, sandy, clay, abrupt contact	B14-1 #1	1	1.3	2.5
Volusia County Reconnaissance	B14-1	-56.9	76	0.3	4.2	7.5YR 5/1	Muddy, shelly(~10%), SAND, grading down to shelly, sandy, clay, abrupt contact	B14-1 #2	3.5	3.8	2.51
Volusia County Reconnaissance	B14-1	-56.9	77	4.2	5.7	10YR 5/2	Clayey, SAND grading down to fine grained, quartz sand, abrupt contact				
Volusia County Reconnaissance	B14-1	-56.9	78	5.7	7.8	10YR 8/3	course grained, quartz-rich, skelletal, SAND, possibly weathered limestone broken by vibracoring	B14-1 #3	6.5	6.8	1.66
Volusia County Reconnaissance	B14-2	-45.7	70	0	5.9	10YR 7/1	Fine grained, quartz, SAND, trace shell, thin layers of blackened grains at 5.0' to 5.9', gradational contact, white (10YR 8/1) to	B14-2 #1	0.5	0.8	2.09

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Volusia County Reconnaissance	B14-2	-45.7	70	0	5.9	10YR 7/1	Fine grained, quartz, SAND, trace shell, thin layers of blackened grains at 5.0' to 5.9', gradational contact, white (10YR 8/1) to	B14-2 #2	4.7	5	2.22
Volusia County Reconnaissance	B14-2	-45.7	71	5.9	7.1	10YR 6/1	Muddy, fine grained, quartz, SAND, some shell (14%), mottled (burrows and lamina), sharp contact	B14-2 #3	6.5	6.8	2.27
Volusia County Reconnaissance	B14-2	-45.7	72	7.1	10	10YR 5/1	Muddy, fine grained, quartz, SAND, vertical burrow (1-5 mm diameter) and trace large bivalves, contact obscured by cut	B14-2 #4	8.5	8.8	2.64
Volusia County Reconnaissance	B14-2	-45.7	73	10	15	10YR 4/1	Muddy, shelly, fine grained, quartz, SAND, abrupt contact	B14-2 #6	14.5	14.8	1.82
Volusia County Reconnaissance	B14-2	-45.7	73	10	15	10YR 4/1	Muddy, shelly, fine grained, quartz, SAND, abrupt contact	B14-2 #5	11	11.3	2.26
Volusia County Reconnaissance	B14-2	-45.7	74	15	16.7		CLAY, with sandy peat intraclasts (~5 cm diameter) in top 1', gray (2.5y /7-6)				

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Volusia County Reconnaissance	B14-3	-39.9	59	0	10.7	10YR 8/1	Fine grained, quartz, SAND, trace to common (10%) blackened grains (shell) scattered throughout and as thin (4mm) laminar sets, shell content increases to base of unit (18%), coarse sand to gravel sized shell layer at 9.9'-10.7' (gray 10YR 5/1)	B14-3 #1	0	0.3	2.2
Volusia County Reconnaissance	B14-3	-39.9	59	0	10.7	10YR 8/1	Fine grained, quartz, SAND, trace to common (10%) blackened grains (shell) scattered throughout and as thin (4mm) laminar sets, shell content increases to base of unit (18%), coarse sand to gravel sized shell layer at 9.9'-10.7' (gray 10YR 5/1)	B14-3 #3	9	9.3	1.69

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Volusia County Reconnaissance	B14-3	-39.9	59	0	10.7	10YR 8/1	Fine grained, quartz, SAND, trace to common (10%) blackened grains (shell) scattered throughout and as thin (4mm) laminar sets, shell content increases to base of unit (18%), coarse sand to gravel sized shell layer at 9.9'-10.7' (gray 10YR 5/1)	B14-3 #4	9.7	10	1.13
Volusia County Reconnaissance	B14-3	-39.9	59	0	10.7	10YR 8/1	Fine grained, quartz, SAND, trace to common (10%) blackened grains (shell) scattered throughout and as thin (4mm) laminar sets, shell content increases to base of unit (18%), coarse sand to gravel sized shell layer at 9.9'-10.7' (gray 10YR 5/1)	B14-3 #2	3	3.3	2.29
Volusia County Reconnaissance	B14-3	-39.9	60	10.7	16.2	10YR 7/1	Fine grained, quartz, SAND, blackened grains, two layer of clay and coarse grained shell (OH) (gray (10YR 7/1) to dk gray (10YR 5/1)) at 12.1' to 12.7' and	B14-3 #7	14.5	14.8	1.95

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
							13.2' to 13.8', gradational contact				
Volusia County Reconnaissance	B14-3	-39.9	60	10.7	16.2	10YR 7/1	Fine grained, quartz, SAND, blackened grains, two layer of clay and coarse grained shell (OH) (gray (10YR 7/1) to dk gray (10YR 5/1)) at 12.1' to 12.7' and 13.2' to 13.8', gradational contact	B14-3 #6	12.3	12.6	2.24
Volusia County Reconnaissance	B14-3	-39.9	60	10.7	16.2	10YR 7/1	Fine grained, quartz, SAND, blackened grains, two layer of clay and coarse grained shell (OH) (gray (10YR 7/1) to dk gray (10YR 5/1)) at 12.1' to 12.7' and 13.2' to 13.8', gradational contact	B14-3 #5	11	11.3	2.07

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Volusia County Reconnaissance	B14-3	-39.9	61	16.2	20	10YR 4/1	Muddy, shelly, fine grained, quartz, SAND, one articulated bivalve at 17.2', sand filled vertical burrows (1 to 3 mm) at top, shell content increases towards base (as much as 38%) , long (~6 in) narrow (~ 3 mm) vertical sand filled lamina and burrows	B14-3 #9	19.5	19.8	2.49
Volusia County Reconnaissance	B14-3	-39.9	61	16.2	20	10YR 4/1	Muddy, shelly, fine grained, quartz, SAND, one articulated bivalve at 17.2', sand filled vertical burrows (1 to 3 mm) at top, shell content increases towards base (as much as 38%) , long (~6 in) narrow (~ 3 mm) vertical sand filled lamina and burrows	B14-3 #8	16.5	16.8	2.27
Volusia County Reconnaissance	B14-3 r-2	-41.1		0							

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Volusia County Reconnaissance	B14-4	-52.4	90	0	2.5	10YR 7/1	Fine grained, quartz, SAND, trace blackened grains, mud layers at -1.7' (1 cm) and 2.2'-2.5', contact abrupt	B14-4 #1	0	0.3	1.74
Volusia County Reconnaissance	B14-4	-52.4	91	2.5	5	10YR 4/1	Muddy, quartz, SAND bioturbated with clean, quartz, sand infill, trace shell, contact obsured by cut	B14-4 #2	3	3.3	2.65
Volusia County Reconnaissance	B14-4	-52.4	92	5	8	10YR 4/1	Muddy, quartz, SAND with large articulated bivalves and clay, contact gradational	B14-4 #3	6	6.3	2.02
Volusia County Reconnaissance	B14-4	-52.4	93	8	8.8	10YR 6/1	Clayey, quartz, SAND, limestone clasts at base, contact abrupt	B14-4 #4	8.5	8.8	0.64
Volusia County Reconnaissance	B14-4	-52.4	94	8.8	11.5	10YR 6/1	Course shell hash in weathered LIMESTONE, limestone clast throughout, gradational contact	B14-4 #4	8.5	8.8	0.64
Volusia County Reconnaissance	B14-4	-52.4	94	8.8	11.5	10YR 6/1	Course shell hash in weathered LIMESTONE, limestone clast throughout, gradational contact	B14-4 #5	9.5	9.8	-0.53

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Volusia County Reconnaissance	B14-4	-52.4	95	11.5	12.3	10YR 7/1	Fine grained, quartz, SAND	B14-4 #6	12	12.3	2.29
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	105		105-2	12	33	LIGHT GRAYISH	mostly Fine Quartz Sand; little Shell Fragments				
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	105		105-3	33	189	MEDIUM GRAYISH	mostly Quartz Sand; trace Shell Fragments				

Table 4-15: Volusia Primary 2 Vibracore Query.

Sand Query Results Project Name	Core Identifier	Core Top Elevation	Core Layer Identifier	Top of Layer Interval	Bottom of Layer Interval	Core Layer Color	Core Layer Qualifiers	Sample Identifier	Top Of Sample Interval	Bottom Of Sample Interval	Mean
Sand, Gravel and Heavy-Mineral Resource Potential of Holocene Sediments Offshore of Florida, Cape Canaveral to the Georgia Border - Phase II and Final Report	105		105-4	189	224	MEDIUM GRAYISH	mostly; trace Shell				

Table 4-16: Explanation of mapping units occurring in state and federal waters, based on the 3-mile jurisdictional limit, and showing the breakdown of hectares and percentages by zone of occurrence and by unit.

Morphosedimentary Feature	State Shelf Area (ha)	Federal Shelf Area (ha)	Total Shelf Area (ha)	State Area (%)	Federal Area (%)	State % by Unit	Federal % by Unit
Allandale Shoal	183	492	675	0.15	0.04	27.10	72.90
Amelia Sand Ridge	895	3,273	4,168	0.75	0.24	21.47	78.53
Beverly Shoal	321	927	1,248	0.27	0.07	25.72	74.28
Bunnel Ridge Field	0	8,438	8,438	0.00	0.62	0.00	100.00
Canaveral Transverse Bar	929	0	929	0.78	0.00	100.00	0.00
Crescent Ridge Field	0	9,268	9,268	0.00	0.69	0.00	100.00
Duval Ridge Field	2,519	139,278	141,796	2.11	10.31	1.78	98.22
Edgewater Ridge Field	0	15,979	15,979	0.00	1.18	0.00	100.00
Espanda Ridge Field	0	3,434	3,434	0.00	0.25	0.00	100.00
Farmton Sand Flat	93,759	107,750	201,509	78.62	7.97	46.53	53.47
Flagler Sand Wave	0	57,292	57,292	0.00	4.24	0.00	100.00
Fort Clinch Ridge Field	244	5,827	6,071	0.20	0.43	0.00	100.00
Korona Ridge Field	0	21,479	21,479	0.00	1.59	0.00	100.00
Nassau Bank	0	64,617	64,617	0.00	4.78	0.00	100.00
Oak Hill Shoal	1,331	481	1,813	1.12	0.04	73.44	26.56
O'Neal Bank	0	31,039	31,039	0.00	2.30	0.00	100.00
Palm Coast Sand Wave	0	25,438	25,438	0.00	1.88	0.00	100.00
Sawgrass Bank	0	86,980	86,980	0.00	6.44	0.00	100.00
St. Augustine Ebb-Tidal Delta	5,680	0	5,680	4.76	0.00	100.00	0.00
St. Johns Bank	0	136,962	136,962	0.00	10.13	0.00	100.00
St. Johns Ebb-Tidal Delta	1,840	0	1,840	1.54	0.00	100.00	0.00
St. Mary's Ebb-Tidal Delta	4,163	0	4,163	3.49	0.00	100.00	0.00

Table 4-16: Explanation of mapping units occurring in state and federal waters, based on the 3-mile jurisdictional limit, and showing the breakdown of hectares and percentages by zone of occurrence and by unit.

Morphosedimentary Feature	State Shelf Area (ha)	Federal Shelf Area (ha)	Total Shelf Area (ha)	State Area (%)	Federal Area (%)	State % by Unit	Federal % by Unit
Summer Haven Sand Wave	0	55,722	55,722	0.00	4.12	0.00	100.00
Talbot Transverse Bar	5,972	2	5,974	5.01	0.00	99.97	0.03
Tisonia – Nassau Sound Ebb-Tidal Delta Complex	1,414	0	1,414	1.19	0.00	100.00	0.00
Undifferentiated Seafloor with Anastomosing Ridges	0	133,671	133,671	0.00	9.89	0.00	100.00
Undifferentiated Seafloor with Linear Sand Ridges	0	174,749	174,749	0.00	12.93	0.00	100.00
Undifferentiated Seafloor with Transverse Ridges	0	101,440	101,440	0.00	7.51	0.00	100.00
Volusia Bank	0	166,907	166,907	0.00	12.35	0.00	100.00
Total	**119,250**	**1,351,444**	**1,470,693**	**100.00**	**100.00**	**8.11**	**91.89**

[1] Percentage of total study area under State of Florida jurisdiction, *i.e.* landward of 3-mile limit.
[2] Percentage of total study area under federal jurisdiction, *i.e.* seaward of 3-mile limit.
[3] Percentage of state-controlled continental shelf area comprised by mapping unit, *i.e.* landward of 3-mile limit.
[4] Percentage of federally-controlled continental shelf area comprised by mapping unit, *i.e.* seaward of 3-mile limit.
[5] Percentage of mapping unit under state jurisdiction, *i.e.* landward of 3-mile limit.
[6] Percentage of mapping unit under federal jurisdiction, *i.e.* seaward of 3-mile limit.

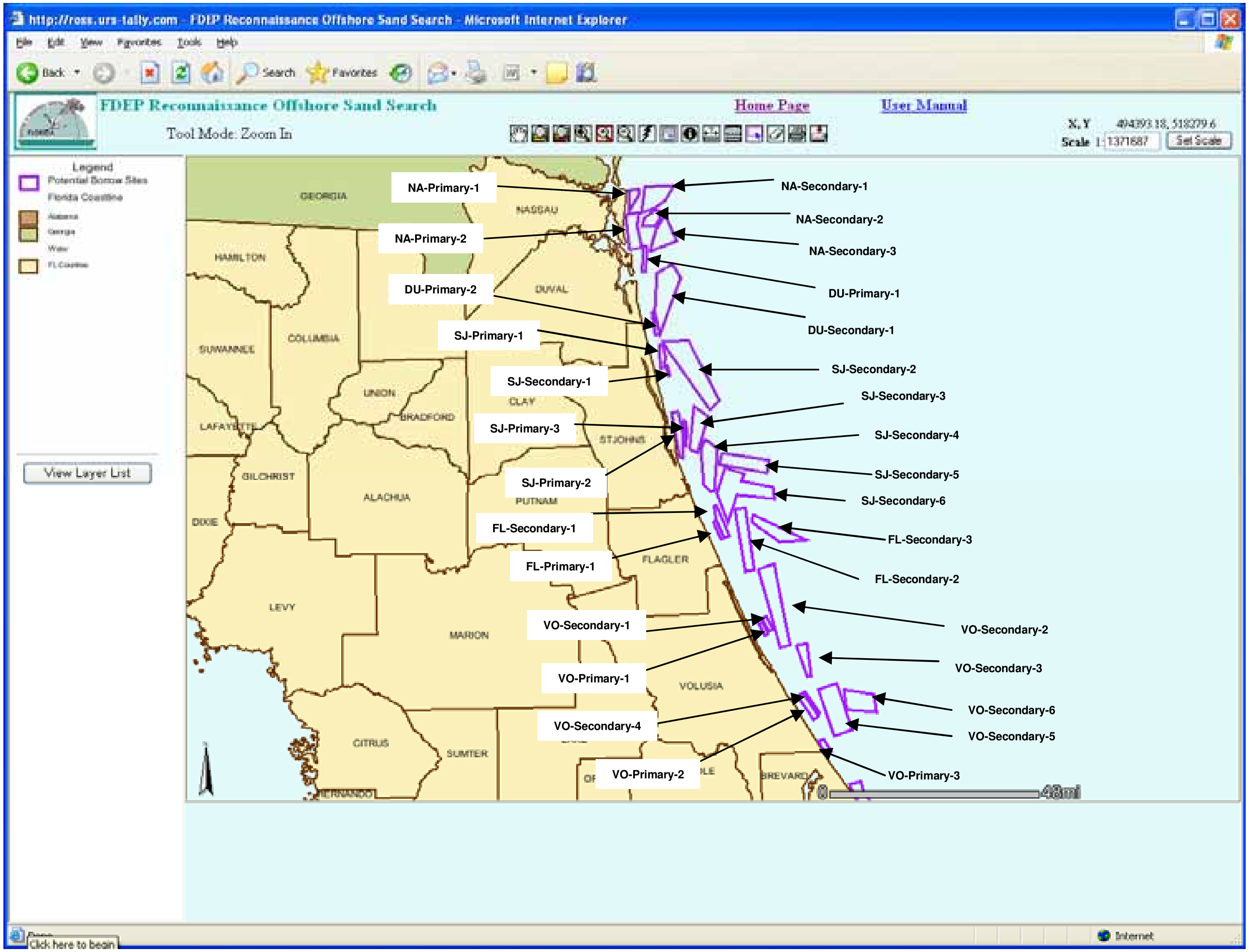


Figure 4-1. Potential Sand Source Areas for Northeast Phase III region.

NASSAU COUNTY

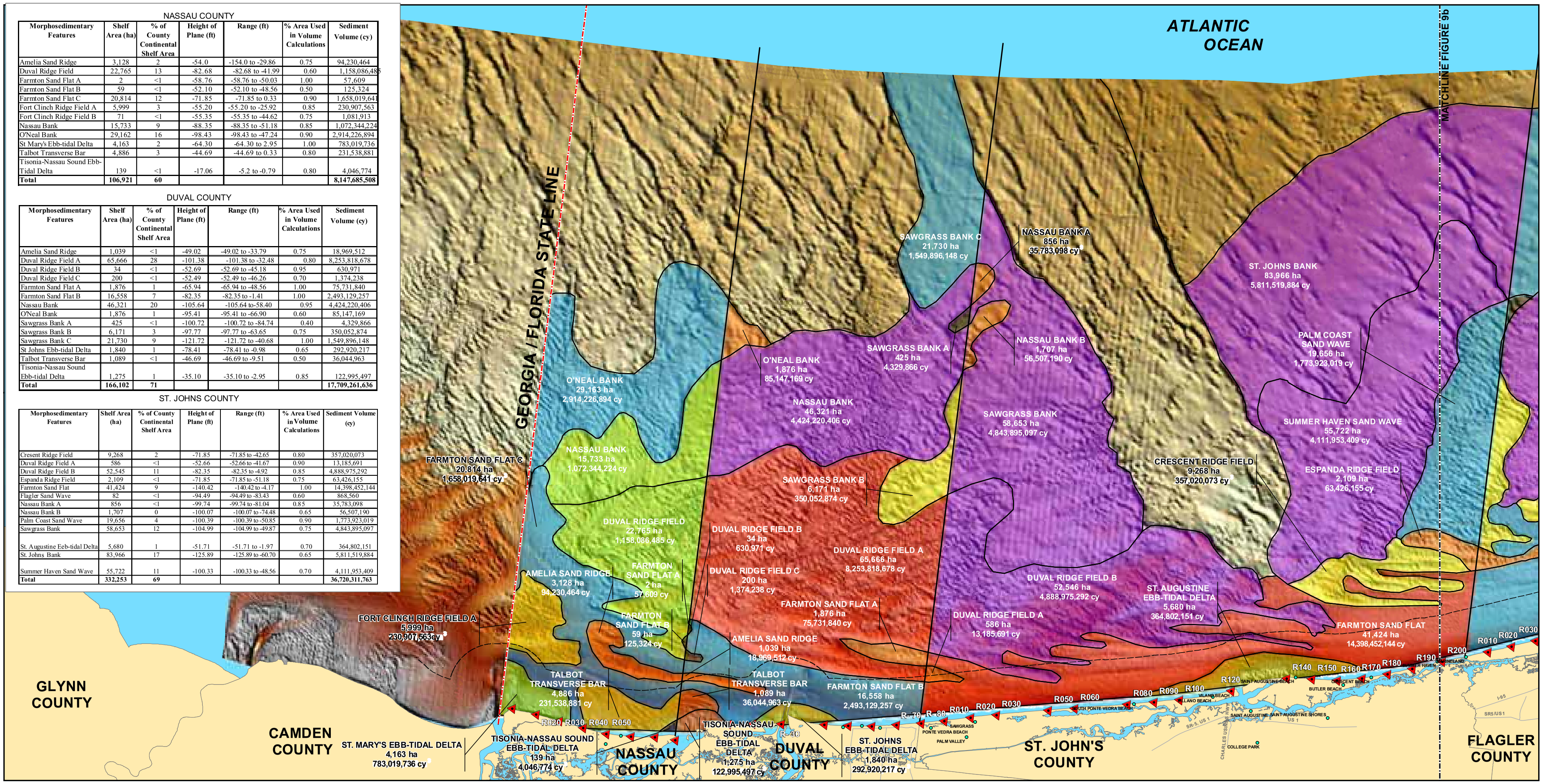
Morphosedimentary Features	Shelf Area (ha)	% of County Continental Shelf Area	Height of Plane (ft)	Range (ft)	% Area Used in Volume Calculations	Sediment Volume (cy)
Amelia Sand Ridge	3,128	2	-54.0	-154.0 to -29.86	0.75	94,230,464
Duval Ridge Field	22,765	13	-82.68	-82.68 to -41.99	0.60	1,158,086,485
Farmton Sand Flat A	2	<1	-58.76	-58.76 to -50.03	1.00	57,609
Farmton Sand Flat B	59	<1	-52.10	-52.10 to -48.56	0.50	125,324
Farmton Sand Flat C	20,814	12	-71.85	-71.85 to 0.33	0.90	1,658,019,641
Fort Clinch Ridge Field A	5,999	3	-55.20	-55.20 to -25.92	0.85	230,907,563
Fort Clinch Ridge Field B	71	<1	-55.35	-55.35 to -44.62	0.75	1,081,913
Nassau Bank	15,733	9	-88.35	-88.35 to -51.18	0.85	1,072,344,224
O'Neal Bank	29,162	16	-98.43	-98.43 to -47.24	0.90	2,914,226,894
St Mary's Ebb-tidal Delta	4,163	2	-64.30	-64.30 to 2.95	1.00	783,019,736
Talbot Transverse Bar	4,886	3	-44.69	-44.69 to 0.33	0.80	231,538,881
Tisonia-Nassau Sound Ebb-Tidal Delta	139	<1	-17.06	-5.2 to -0.79	0.80	4,046,774
Total	**106,921**	**60**				**8,147,685,508**

DUVAL COUNTY

Morphosedimentary Features	Shelf Area (ha)	% of County Continental Shelf Area	Height of Plane (ft)	Range (ft)	% Area Used in Volume Calculations	Sediment Volume (cy)
Amelia Sand Ridge	1,039	<1	-49.02	-49.02 to -33.79	0.75	18,969,512
Duval Ridge Field A	65,666	28	-101.38	-101.38 to -32.48	0.80	8,253,818,678
Duval Ridge Field B	34	<1	-52.69	-52.69 to -45.18	0.95	630,971
Duval Ridge Field C	200	<1	-52.49	-52.49 to -46.26	0.70	1,374,238
Farmton Sand Flat A	1,876	1	-65.94	-65.94 to -48.56	1.00	75,731,840
Farmton Sand Flat B	16,558	7	-82.35	-82.35 to -1.41	1.00	2,493,129,257
Nassau Bank	46,321	20	-105.64	-105.64 to-58.40	0.95	4,424,220,406
O'Neal Bank	1,876	1	-95.41	-95.41 to -66.90	0.60	85,147,169
Sawgrass Bank A	425	<1	-100.72	-100.72 to -84.74	0.40	4,329,866
Sawgrass Bank B	6,171	3	-97.77	-97.77 to -63.65	0.75	350,052,874
Sawgrass Bank C	21,730	9	-121.72	-121.72 to -40.68	1.00	1,549,896,148
St Johns Ebb-tidal Delta	1,840	1	-78.41	-78.41 to -0.98	0.65	292,920,217
Talbot Transverse Bar	1,089	<1	-46.69	-46.69 to -9.51	0.50	36,044,963
Tisonia-Nassau Sound Ebb-tidal Delta	1,275	1	-35.10	-35.10 to -2.95	0.85	122,995,497
Total	**166,102**	**71**				**17,709,261,636**

ST. JOHNS COUNTY

Morphosedimentary Features	Shelf Area (ha)	% of County Continental Shelf Area	Height of Plane (ft)	Range (ft)	% Area Used in Volume Calculations	Sediment Volume (cy)
Cresent Ridge Field	9,268	2	-71.85	-71.85 to -42.65	0.80	357,020,073
Duval Ridge Field A	586	<1	-52.66	-52.66 to -41.67	0.90	13,185,691
Duval Ridge Field B	52,545	11	-82.35	-82.35 to -4.92	0.85	4,888,975,292
Espanda Ridge Field	2,109	<1	-71.85	-71.85 to -51.18	0.75	63,426,155
Farmton Sand Flat	41,424	9	-140.42	-140.42 to -4.17	1.00	14,398,452,144
Flagler Sand Wave	82	<1	-94.49	-94.49 to -83.43	0.60	868,560
Nassau Bank A	856	<1	-99.74	-99.74 to -81.04	0.85	35,783,098
Nassau Bank B	1,707	0	-100.07	-100.07 to -74.48	0.65	56,507,190
Palm Coast Sand Wave	19,656	4	-100.39	-100.39 to -50.85	0.90	1,773,923,019
Sawgrass Bank	58,653	12	-104.99	-104.99 to -49.87	0.75	4,843,895,097
St. Augustine Eeb-tidal Delta	5,680	1	-51.71	-51.71 to -1.97	0.70	364,802,151
St. Johns Bank	83,966	17	-125.89	-125.89 to -60.70	0.65	5,811,519,884
Summer Haven Sand Wave	55,722	11	-100.33	-100.33 to -48.56	0.70	4,111,953,409
Total	**332,253**	**69**				**36,720,311,763**



LEGEND:

- CITIES
- FDEP MONUMENTS
- ROADS
- COUNTY LINES
- FEDERAL / STATE BOUNDARY
- GEORGIA / FLORIDA STATE LINE
- MATCHLINE

OFFSHORE MORPHOLOGY VOLUME IN CUBIC YARDS:

- 57,609 - 13,000,000
- 13,000,000 - 130,000,000
- 130,000,000 - 650,000,000
- 650,000,000 - 1,300,000,000
- 1,300,000,000 - 4,000,000,000
- 4,000,000,000 - 7,800,000,000
- 7,800,000,000 - 14,000,000,000

N

0 6 12 Kilometers

TITLE:

POTENTIAL SAND RESOURCES ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

CPE
COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07	BY: HMV	COMM NO: 7849.29	FIGURE 4-2

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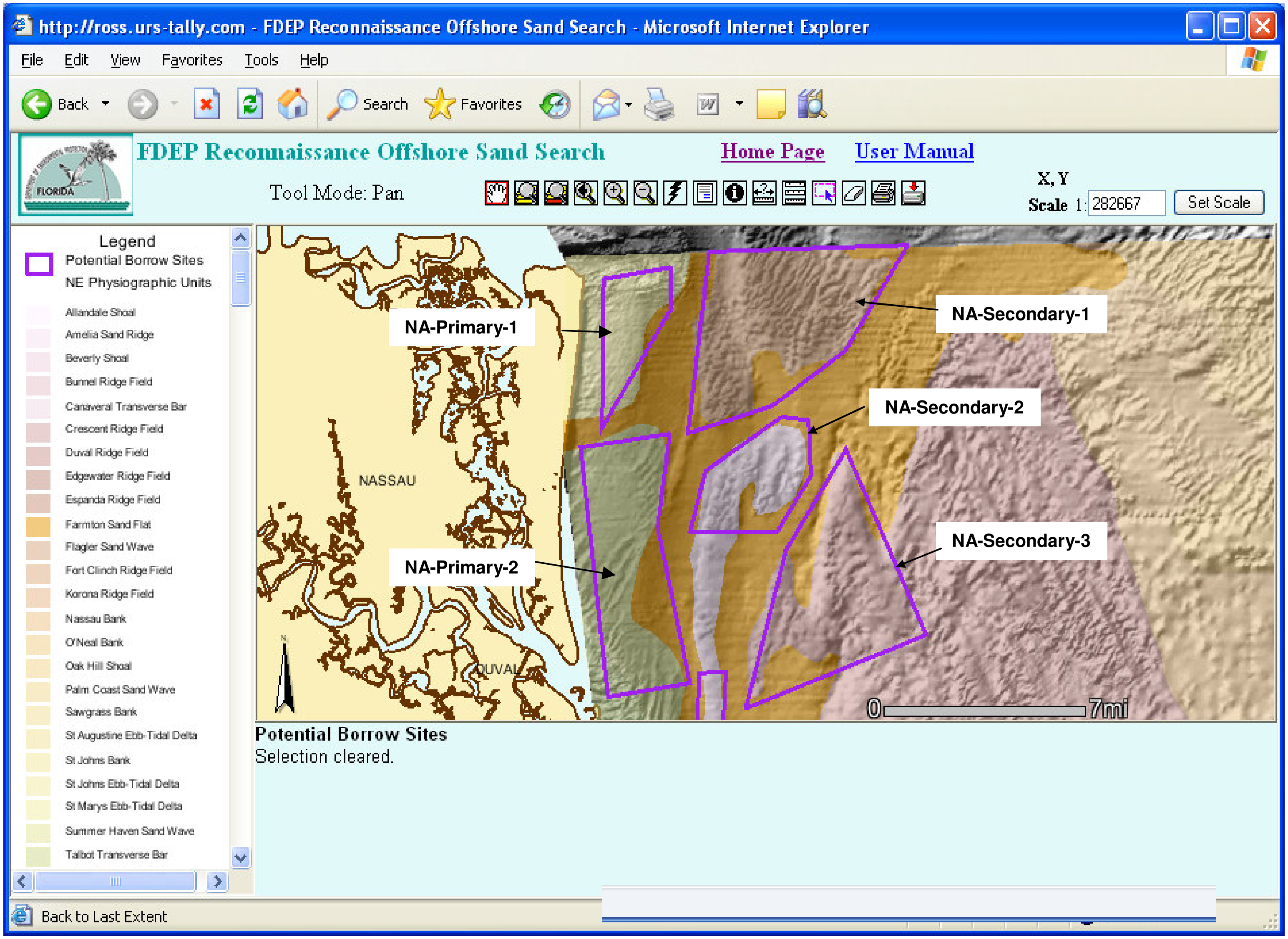
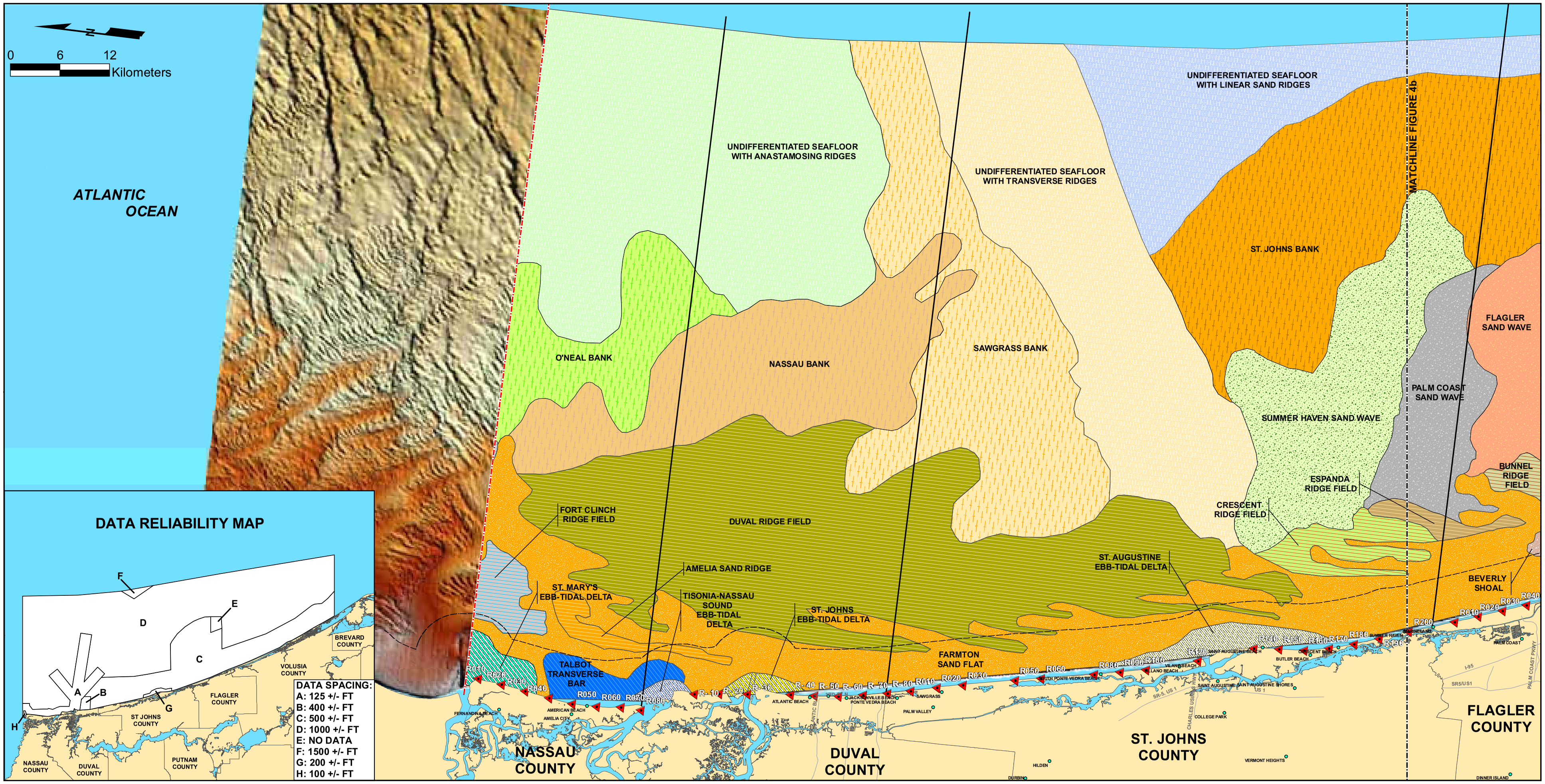


Figure 4-3. Nassau County Area showing nearshore potential borrow areas and physiographic zones.



LEGEND:

- FDEP MONUMENTS
- CITIES
- GEORGIA / FLORIDA STATE LINE
- MATCHLINE
- FEDERAL / STATE BOUNDARY
- COUNTY LINES
- ROADS

GEOMORPHOLOGY

RIDGES
- AMELIA SANDRIDGE
- BUNNEL RIDGE FIELD
- CRESCENT RIDGE FIELD
- DUVAL RIDGE FIELD
- ESPANDA RIDGE FIELD
- FORT CLINCH RIDGE FIELD

SHOALS
- BEVERLY SHOAL

BANKS
- SAWGRASS BANK
- ST. JOHNS BANK
- NASSUA BANK
- O'NEAL BANK

SAND FLAT
- FARMTON SAND FLAT

SAND WAVES
- FLAGLER SAND WAVE
- PALM COAST SAND WAVE
- SUMMER HAVEN SAND WAVE

EBB-TIDAL DELTAS
- ST. AUGUSTINE EBB-TIDAL DELTA
- ST. JOHNS EBB-TIDAL DELTA
- ST. MARY'S EBB-TIDAL DELTA
- TISONIA-NASSAU SOUND EBB-TIDAL DELTA

TRANSVERSE BAR
- TALBOT TRANSVERSE BAR

UNDIFFERENTIATED SEAFLOORS
- UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGES
- UNDIFFERENTIATED SEAFLOOR WITH TRANSVERSE RIDGES
- UNDIFFERENTIATED SEAFLOOR WITH ANASTAMOSING RIDGES

TITLE:

SEAFLOOR MAPPING UNITS ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07 | BY: HMV | COMM NO: 7849.29 | **FIGURE 4-4**

G:\DEP-URS\Northeast_Florida_MXD\GEOMORPHOLOGY_SHEET_1.mxd

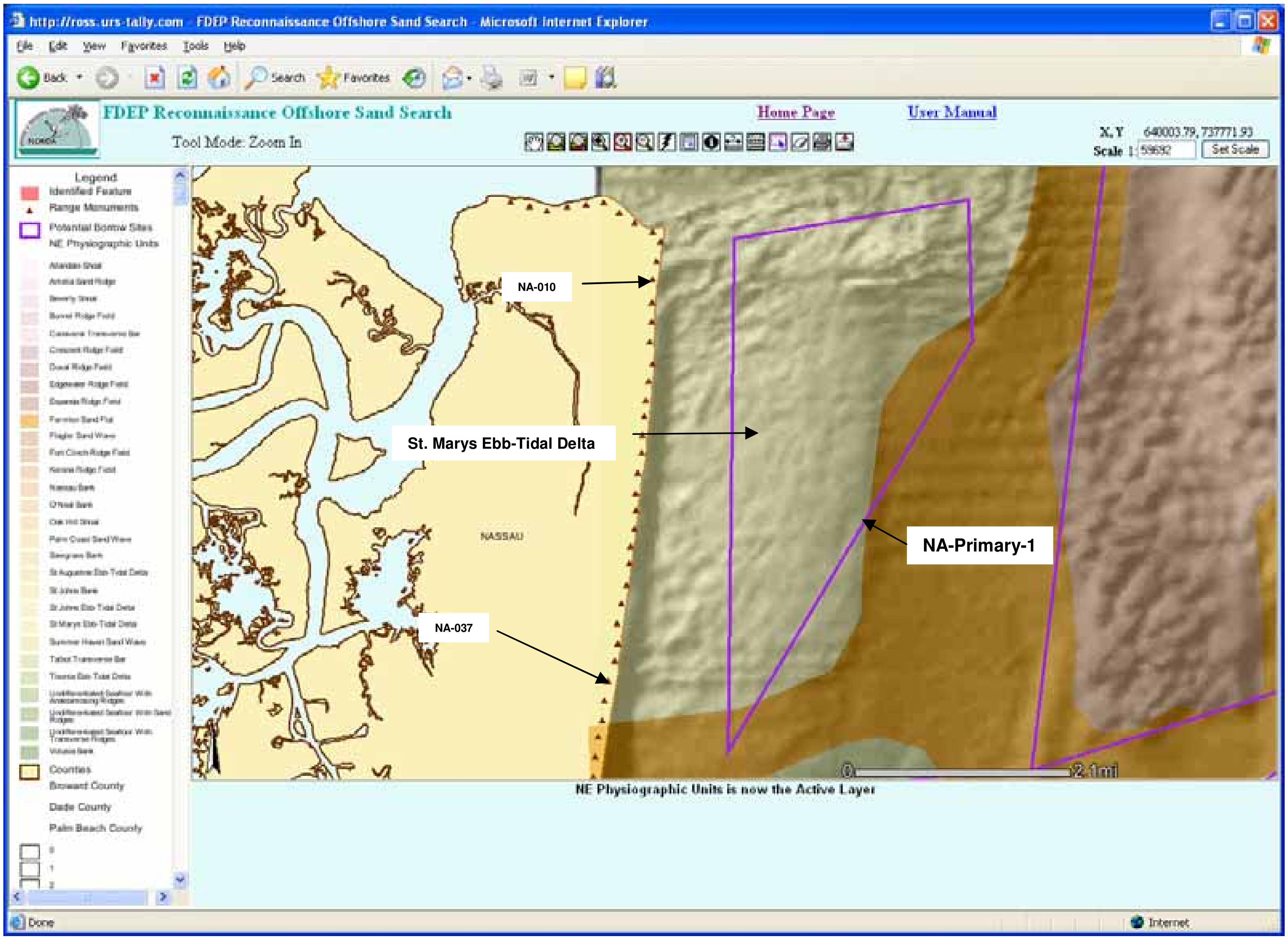


Figure 4-5. Nassau County Area NA-Primary-1 showing physiographic zones overlaying the gray scale image.

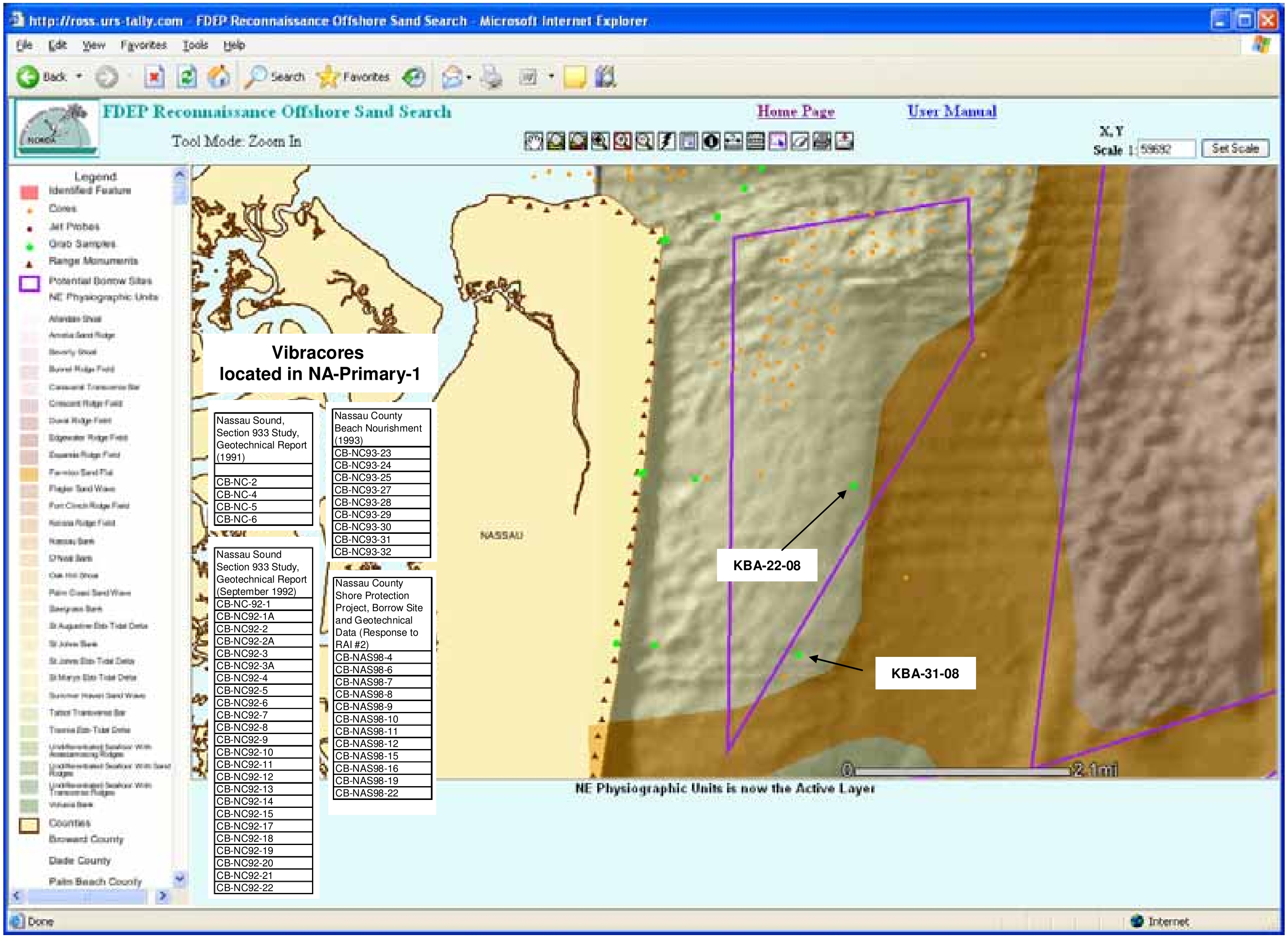


Figure 4-6. Nassau County Area NA-Primary-1 showing Vibracore and Grab Sample locations.

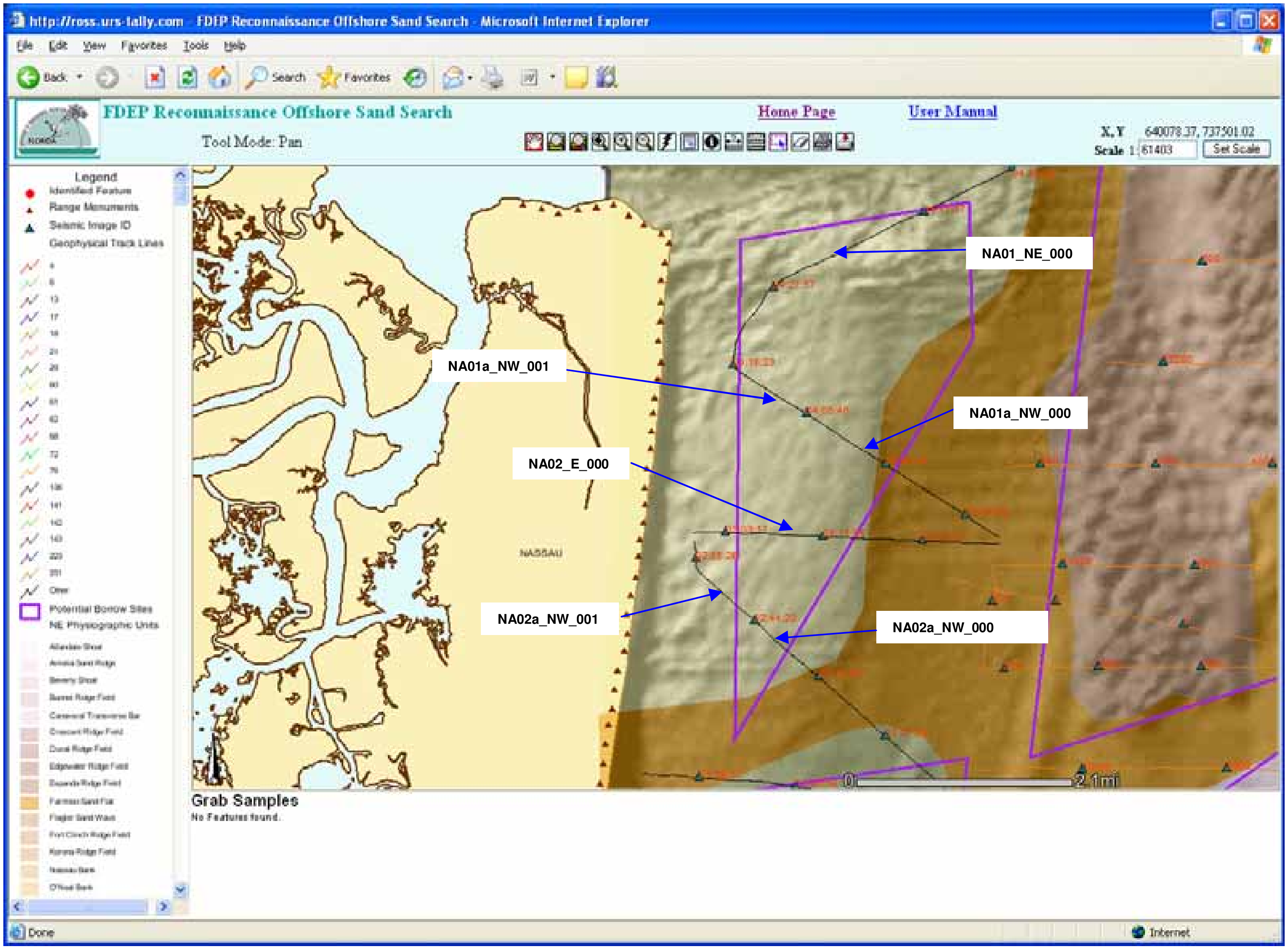


Figure 4-7. Nassau County Area NA-Primary-1 showing geophysical trackline locations.

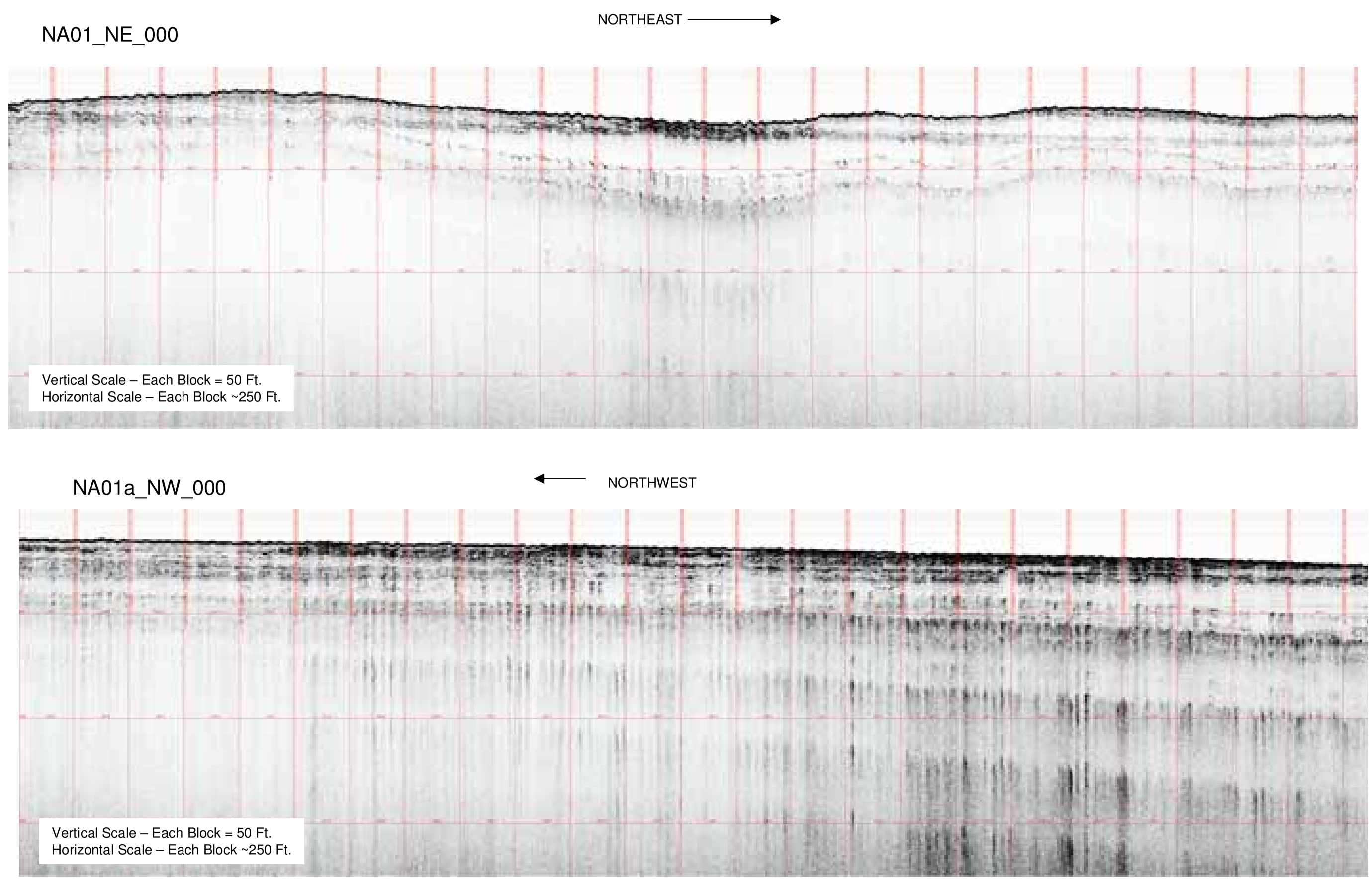


Figure 4-8. Nassau County Area NA-Primary 1. Portions of lines NA01_NE (above) and NA01a_NW_000 (below).

NA02_E_000

EAST →

NA02a_NW_001

← NORTHWEST

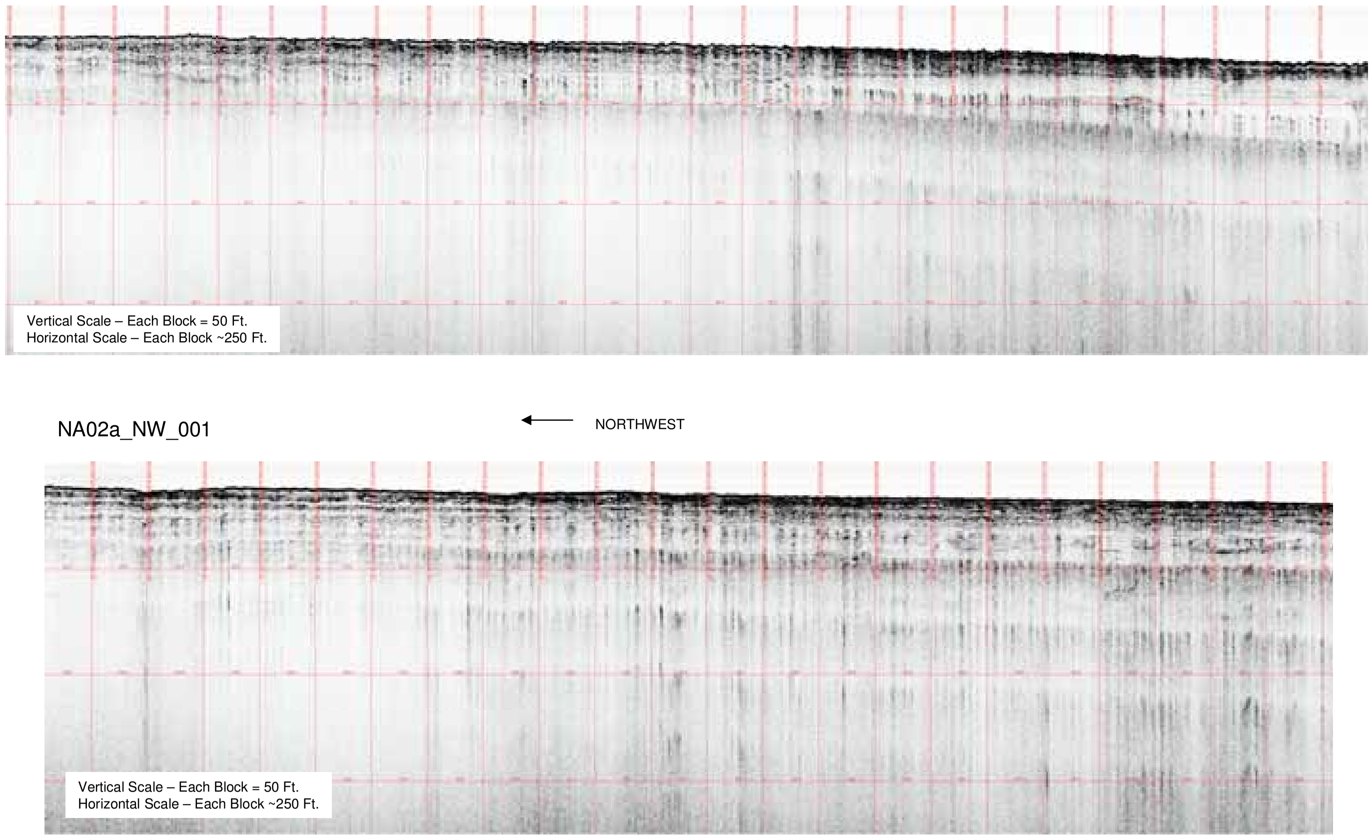


Figure 4-9. Nassau County Area NA-Primary 1. Portions of lines NA02_E_000 (above) and NA02a_NW_001 (below).

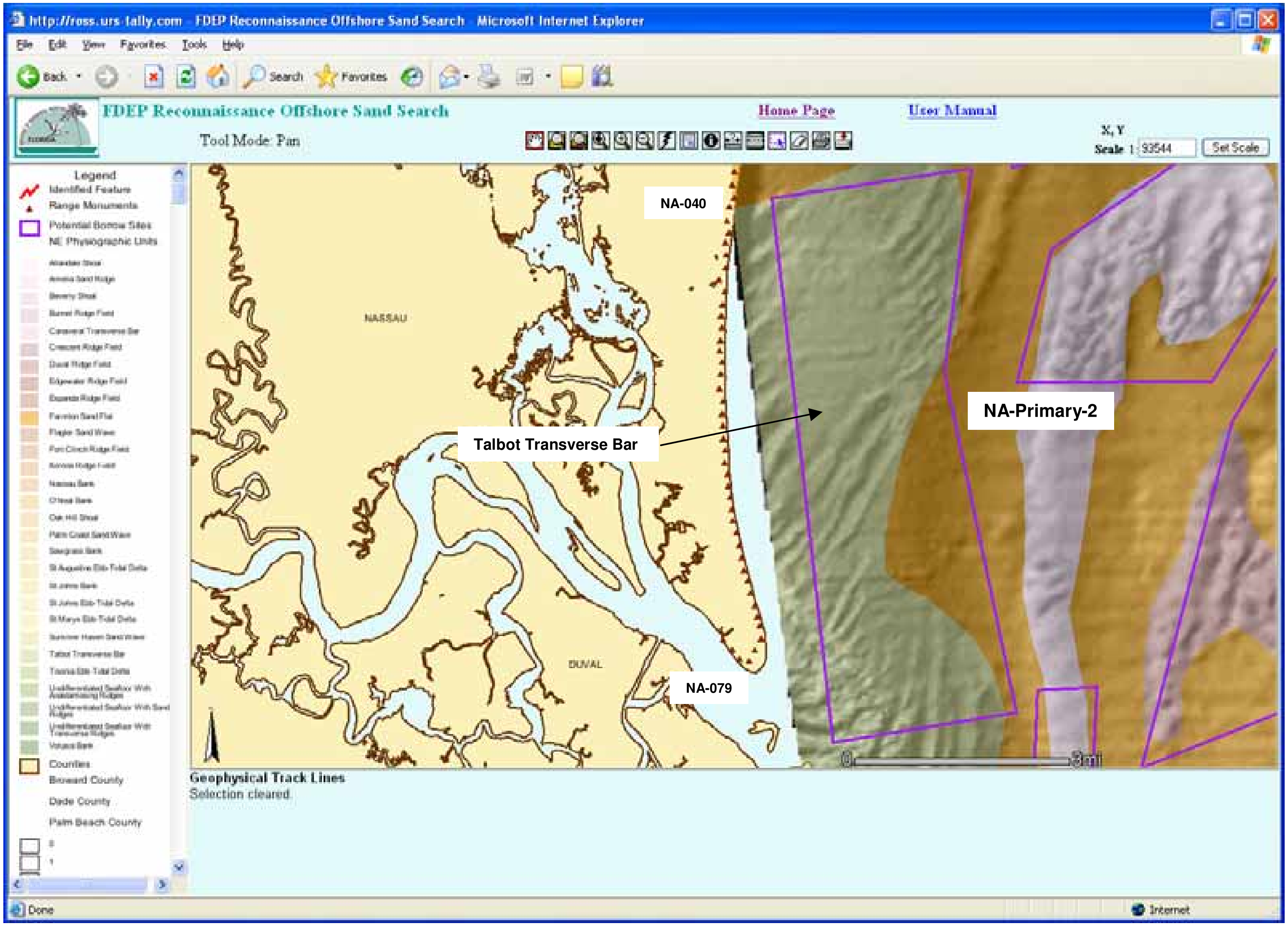


Figure 4-10. Nassau County Area NA-Primary-2 showing physiographic zones overlaying the gray scale image.

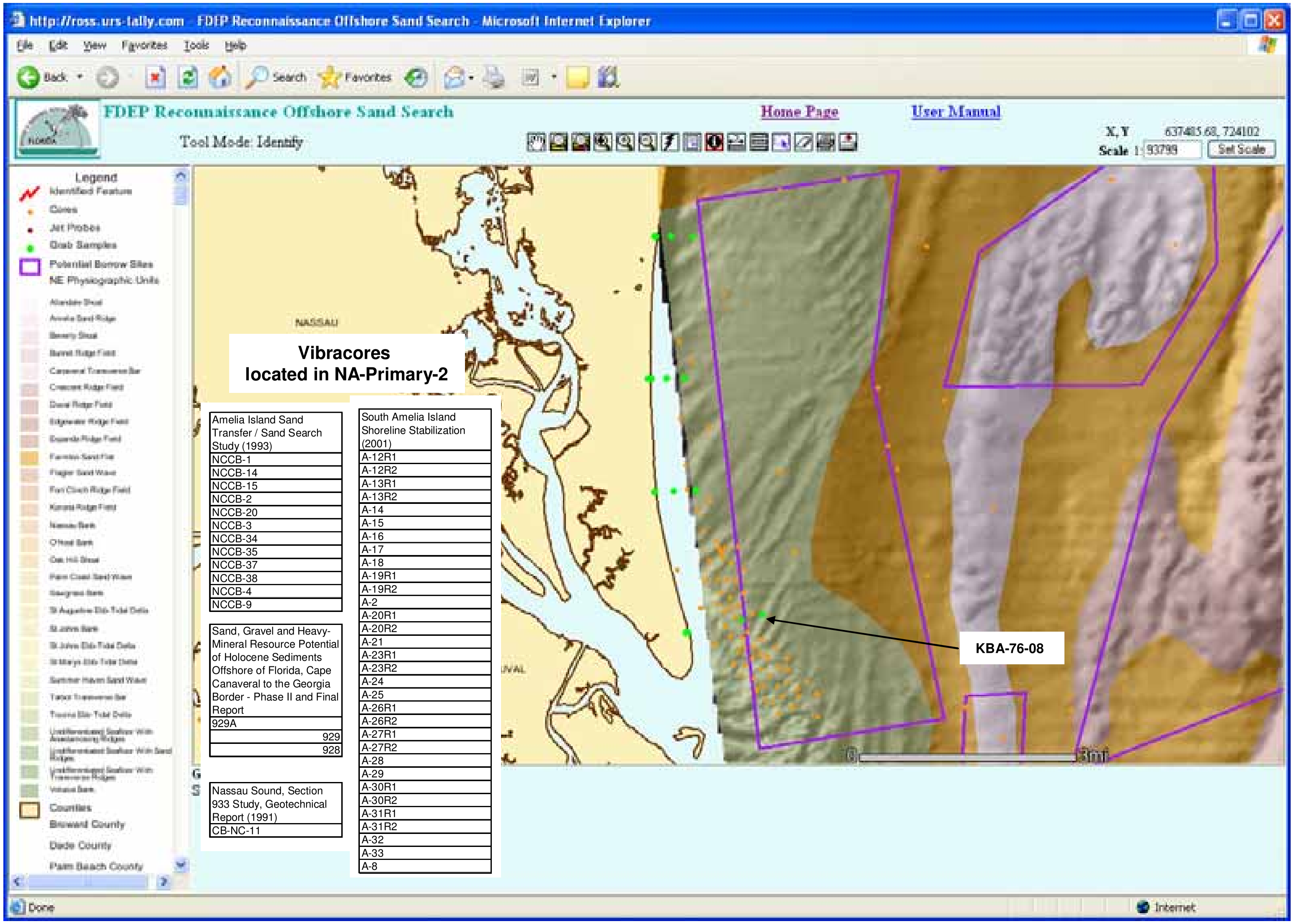


Figure 4-11. Nassau County Area NA-Primary-2 showing Vibracore and Grab Sample locations.

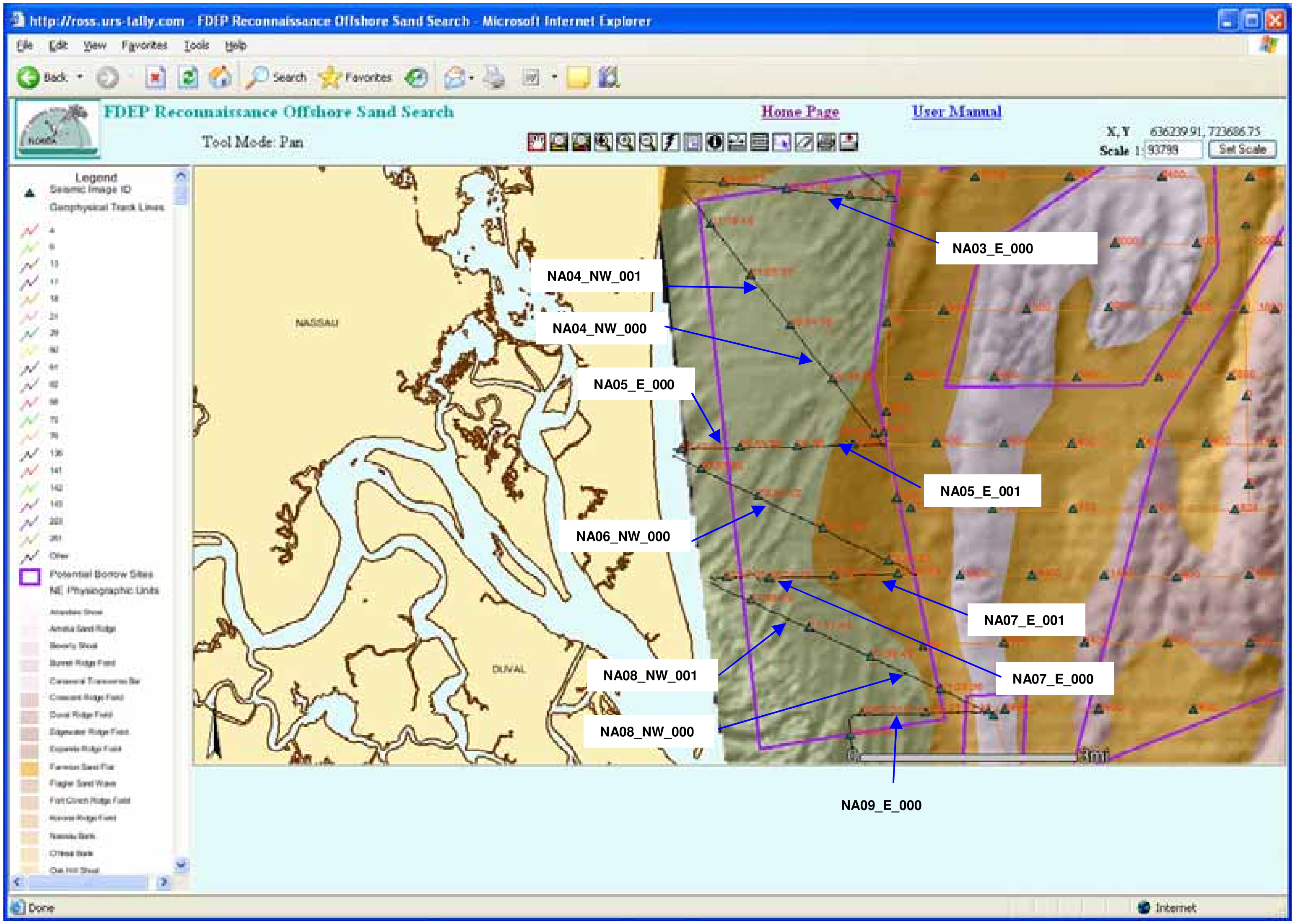


Figure 4-12. Nassau County Area NA-Primary-2 showing geophysical trackline locations and timestamps.

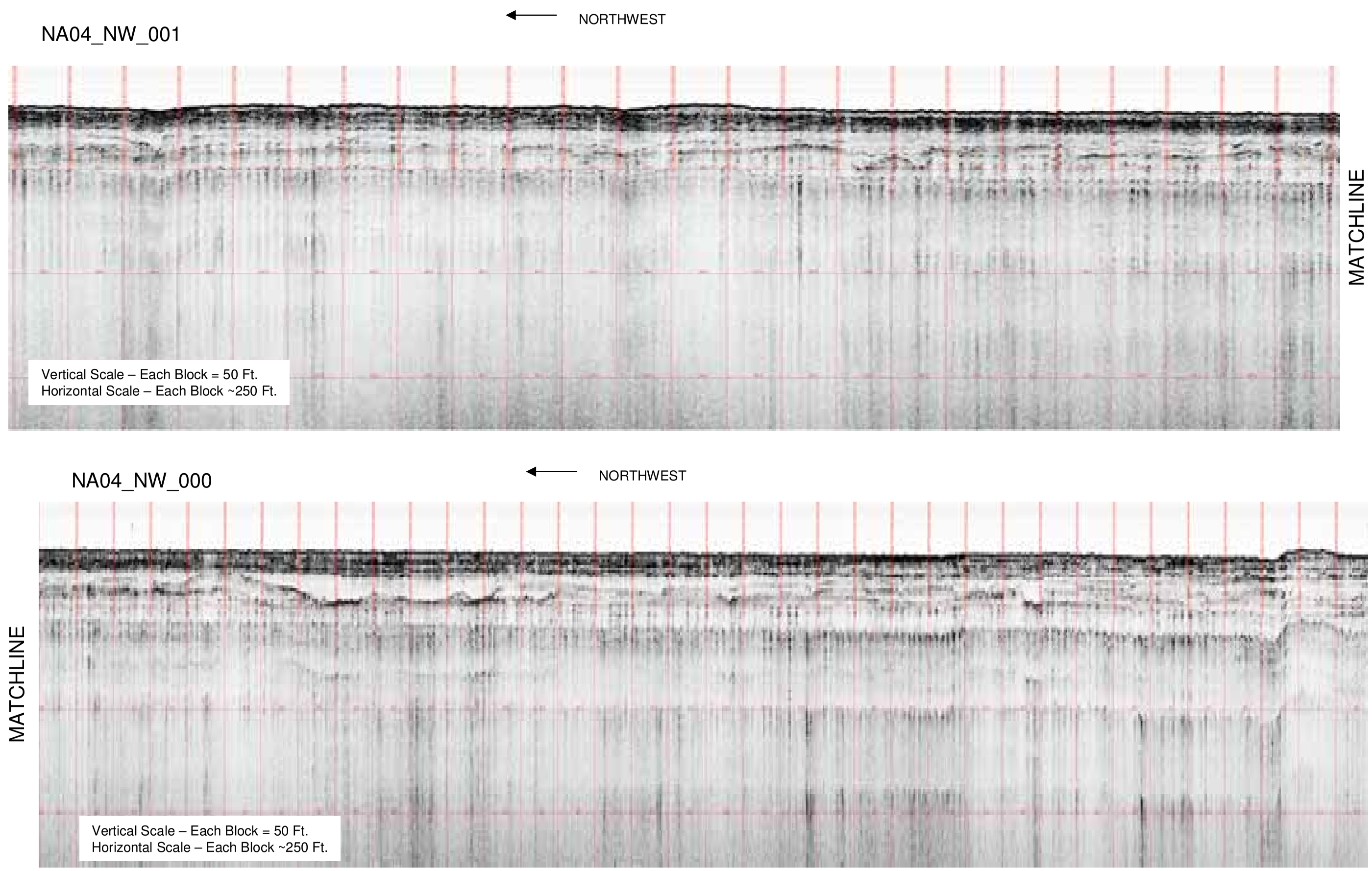


Figure 4-13. Nassau County Area NA-Primary 2. Portions of lines NA04_NW_001 (above) and NA04_NW_000 (below).

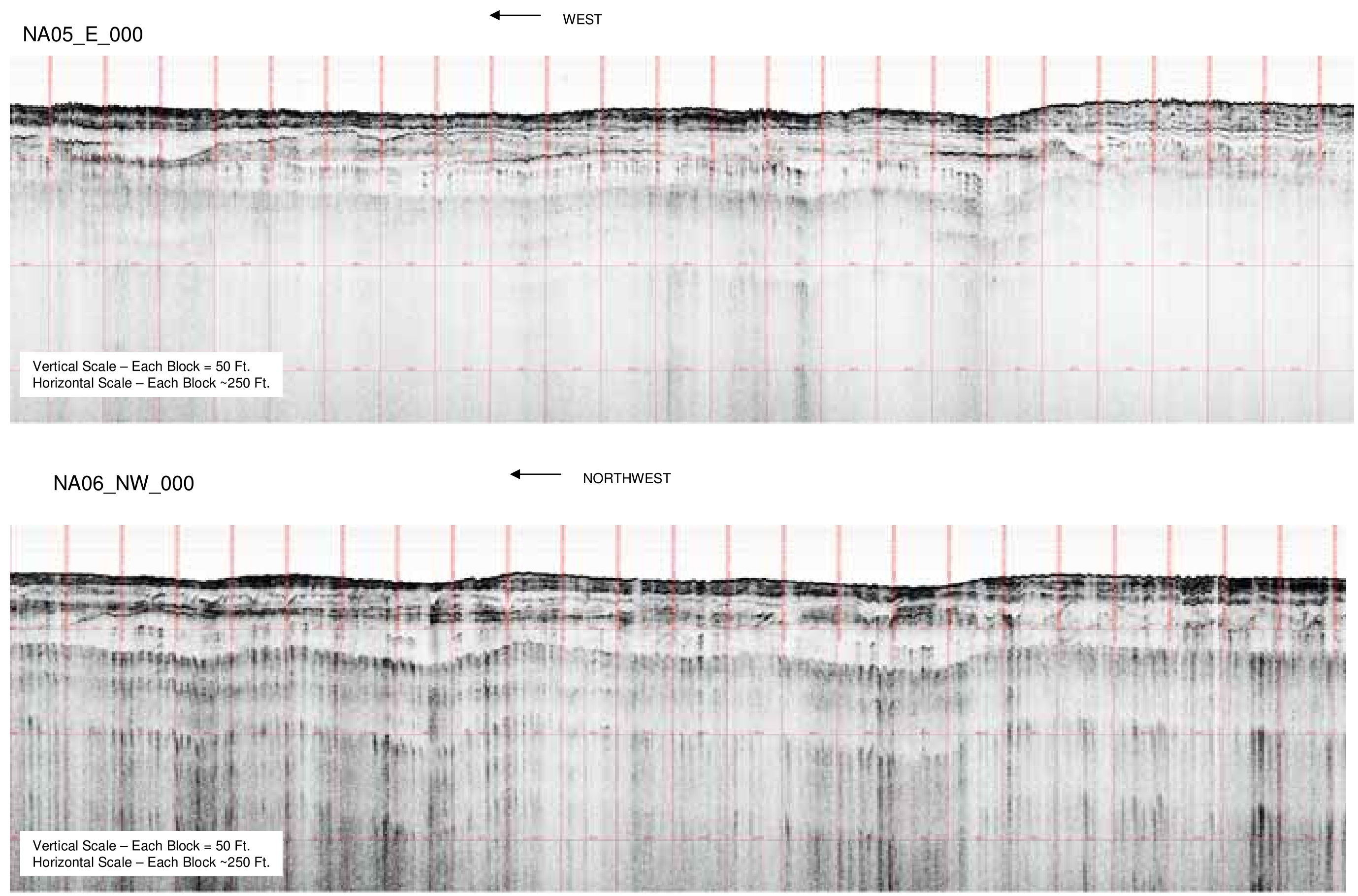


Figure 4-14. Nassau County Area NA-Primary 2. Portions of lines NA05_E_000 (above) and NA06_NW_000 (below).

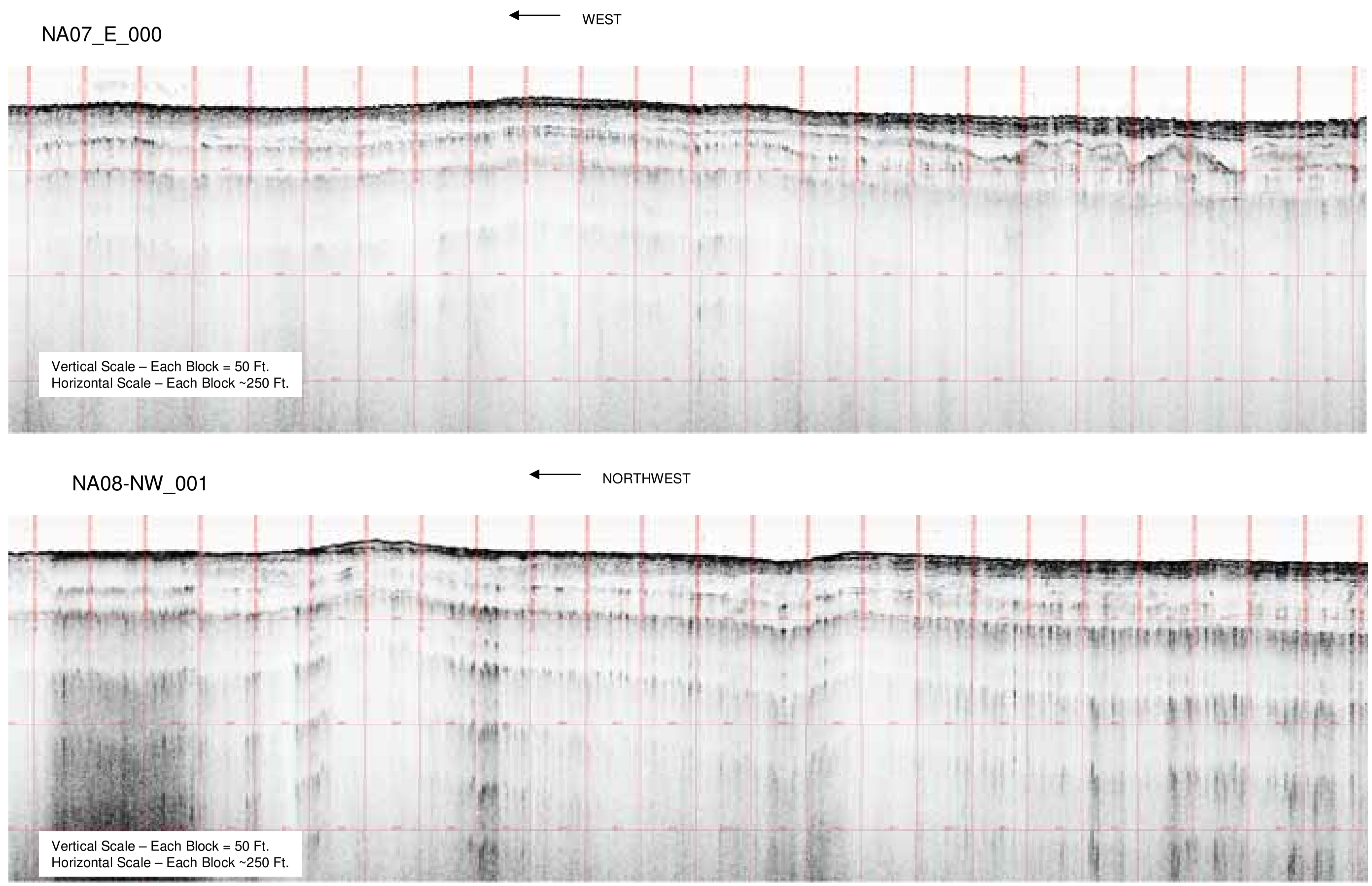


Figure 4-15. Nassau County Area NA-Primary 2. Portions of lines NA07_E_000 (above) and NA08_NW_001 (below).

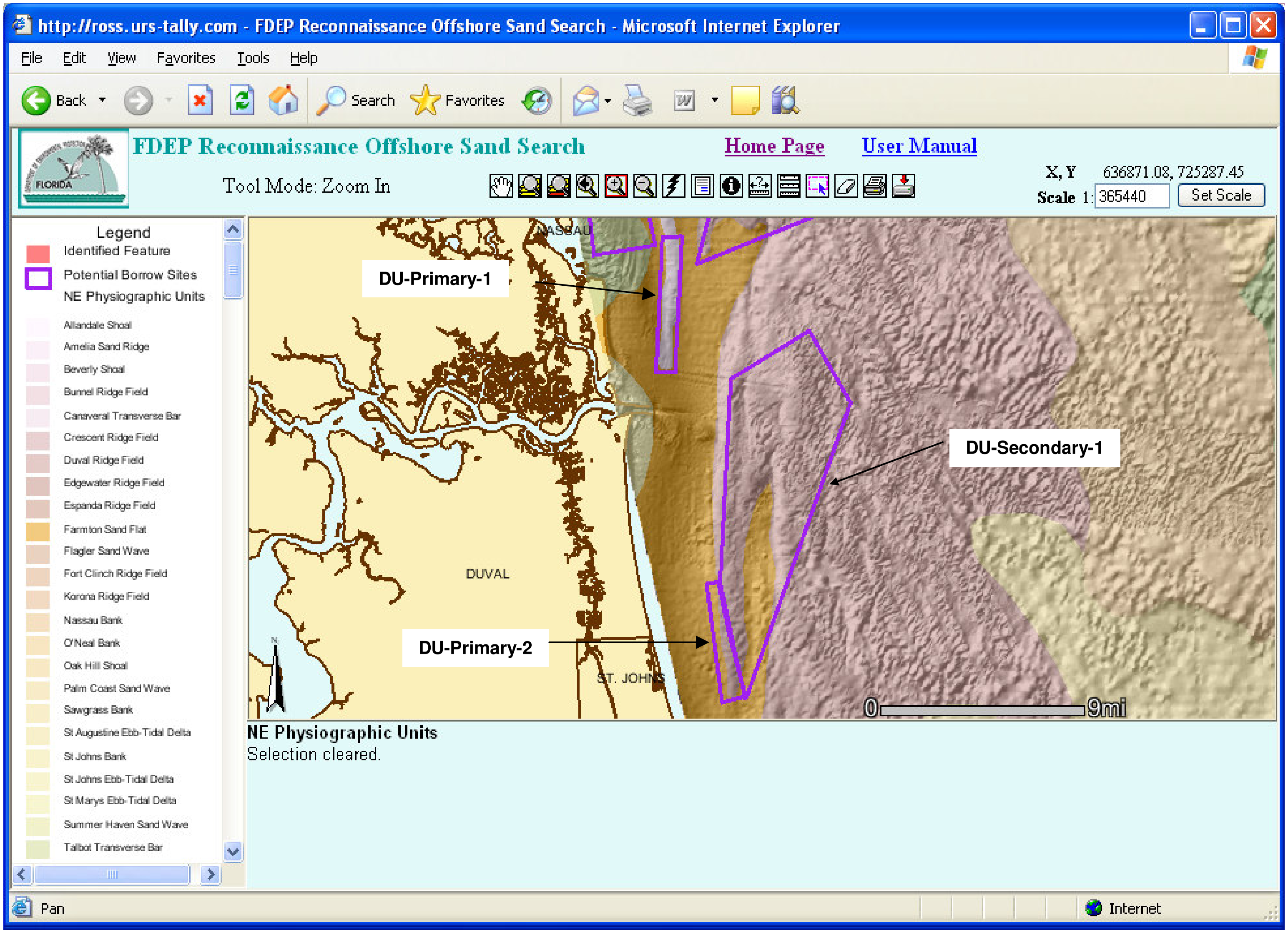


Figure 4-16. Duval County Area showing nearshore Potential Borrow Areas and physiographic zones.

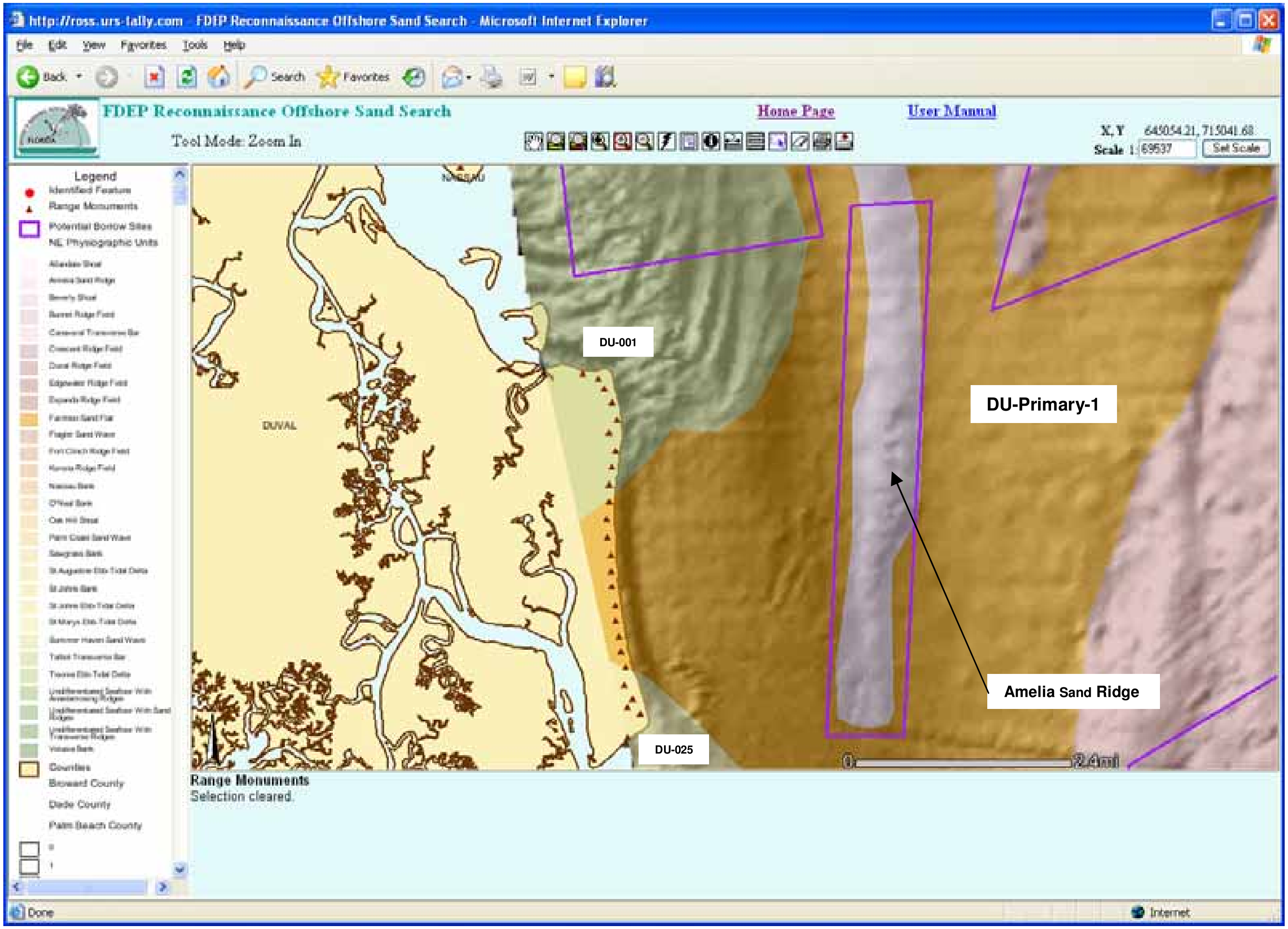


Figure 4-17. Duval County Area DU-Primary-1 showing physiographic zones overlaying the gray scale image.

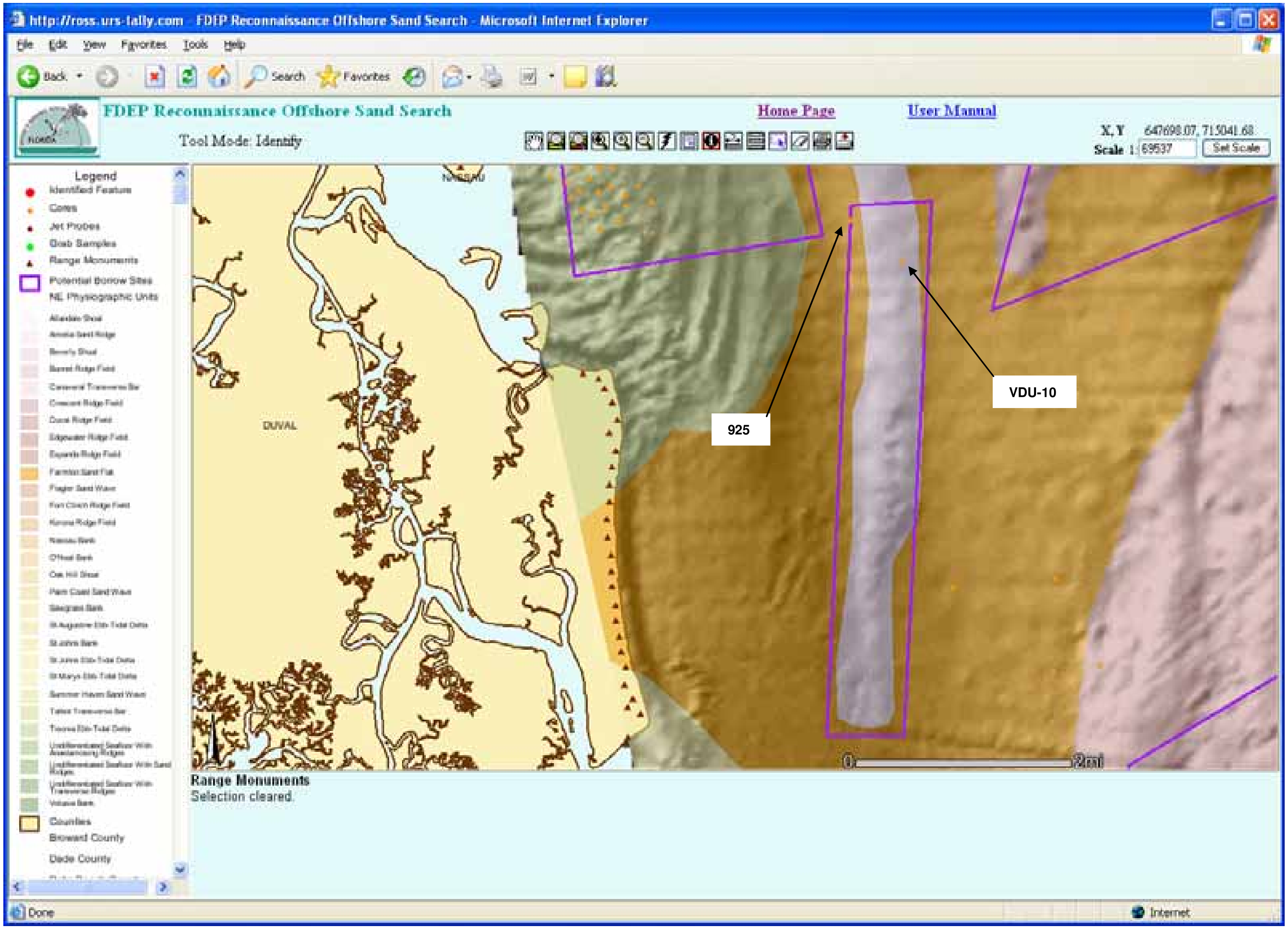


Figure 4-18. Duval County Area DU-Primary-1 showing Vibracore locations.

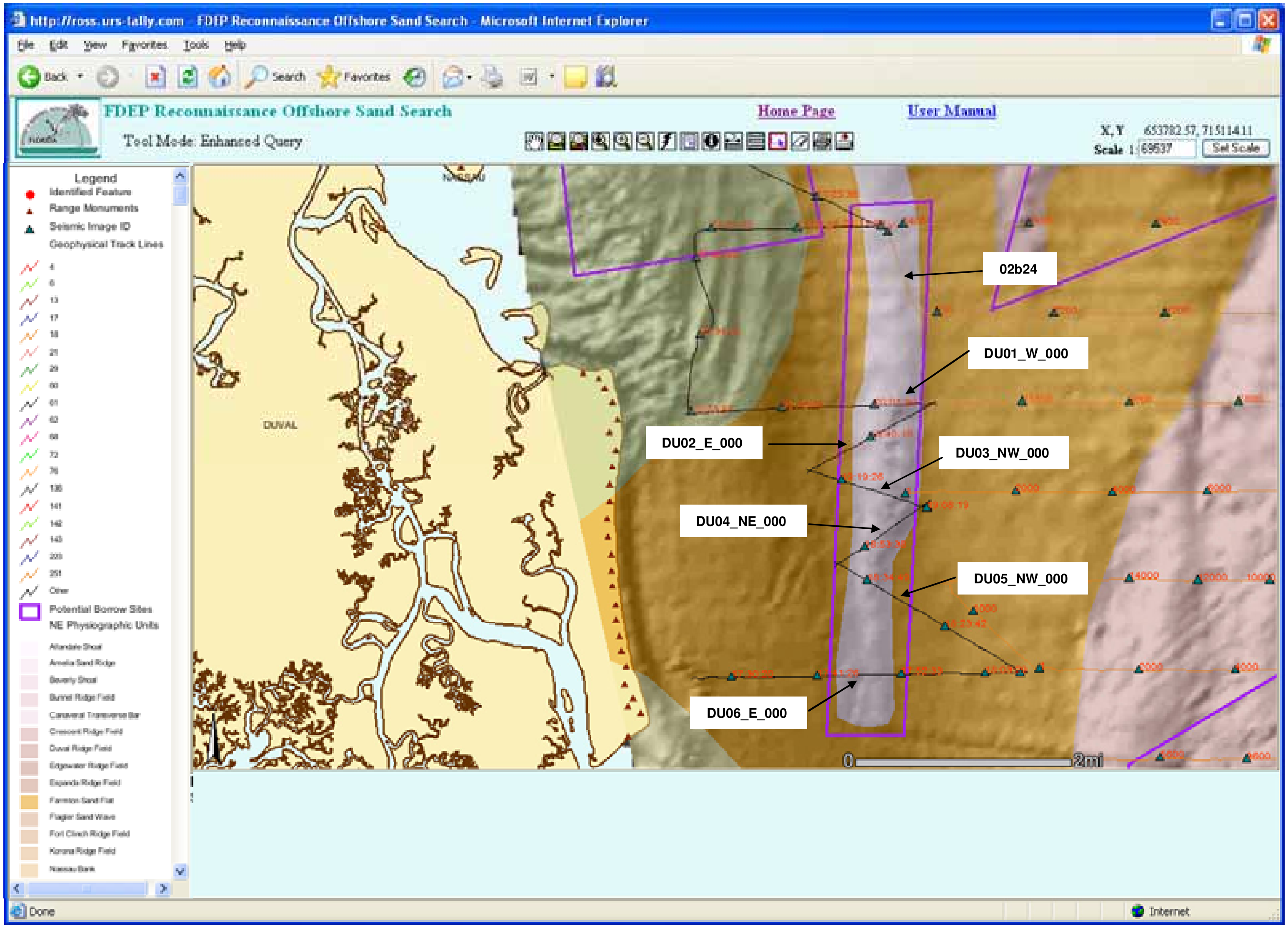


Figure 4-19. Duval County Area DU-Primary-1 showing geophysical trackline locations and timestamps.

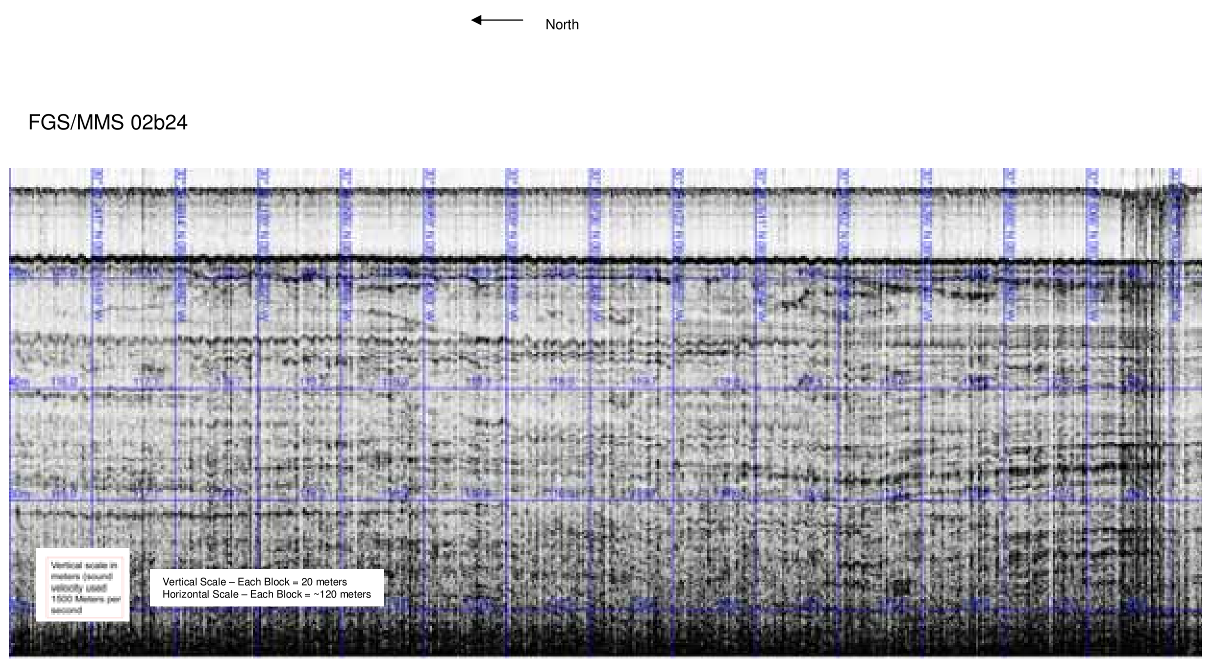


Figure 4-20. Duval County Area DU Primary 1. FGS/MMS line 02b24.

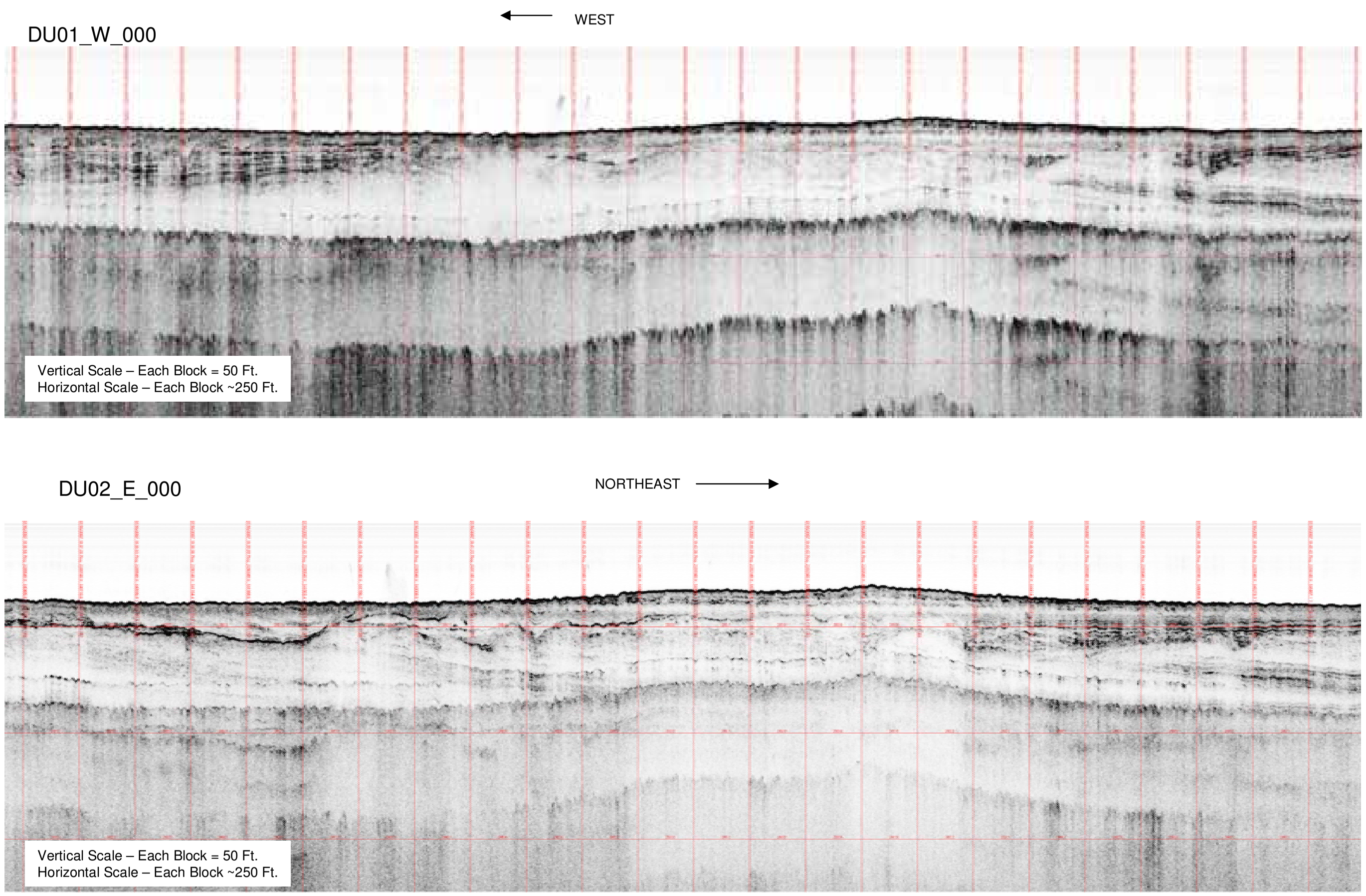


Figure 4-21. Duval County Area DU Primary 1. Portions of lines DU01_W_000 (above) and DU02_E_000 (below).

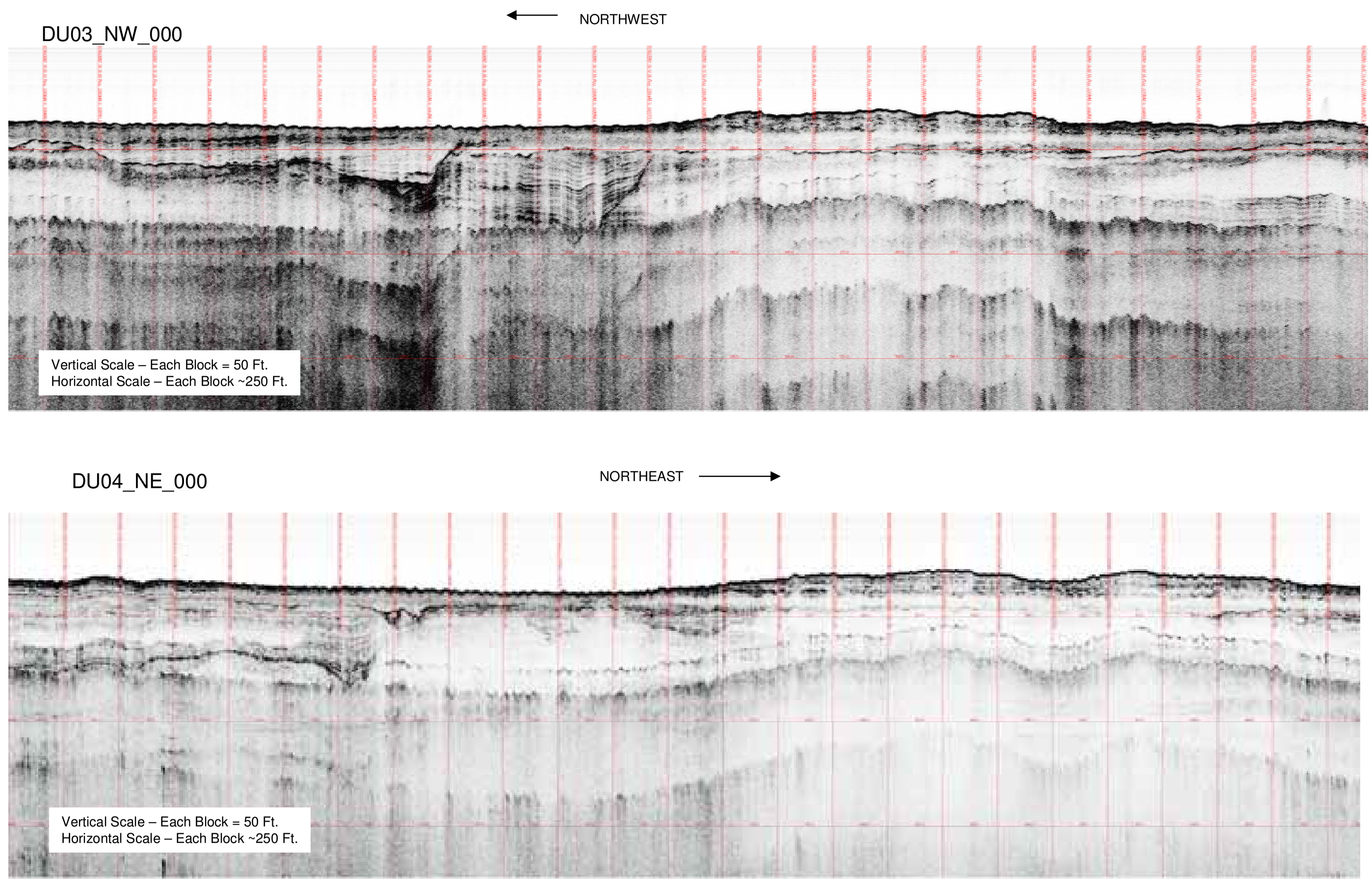


Figure 4-22. Duval County Area DU Primary 1. Portions of lines DU03_NW_000 (above) and DU04_NE_000 (below).

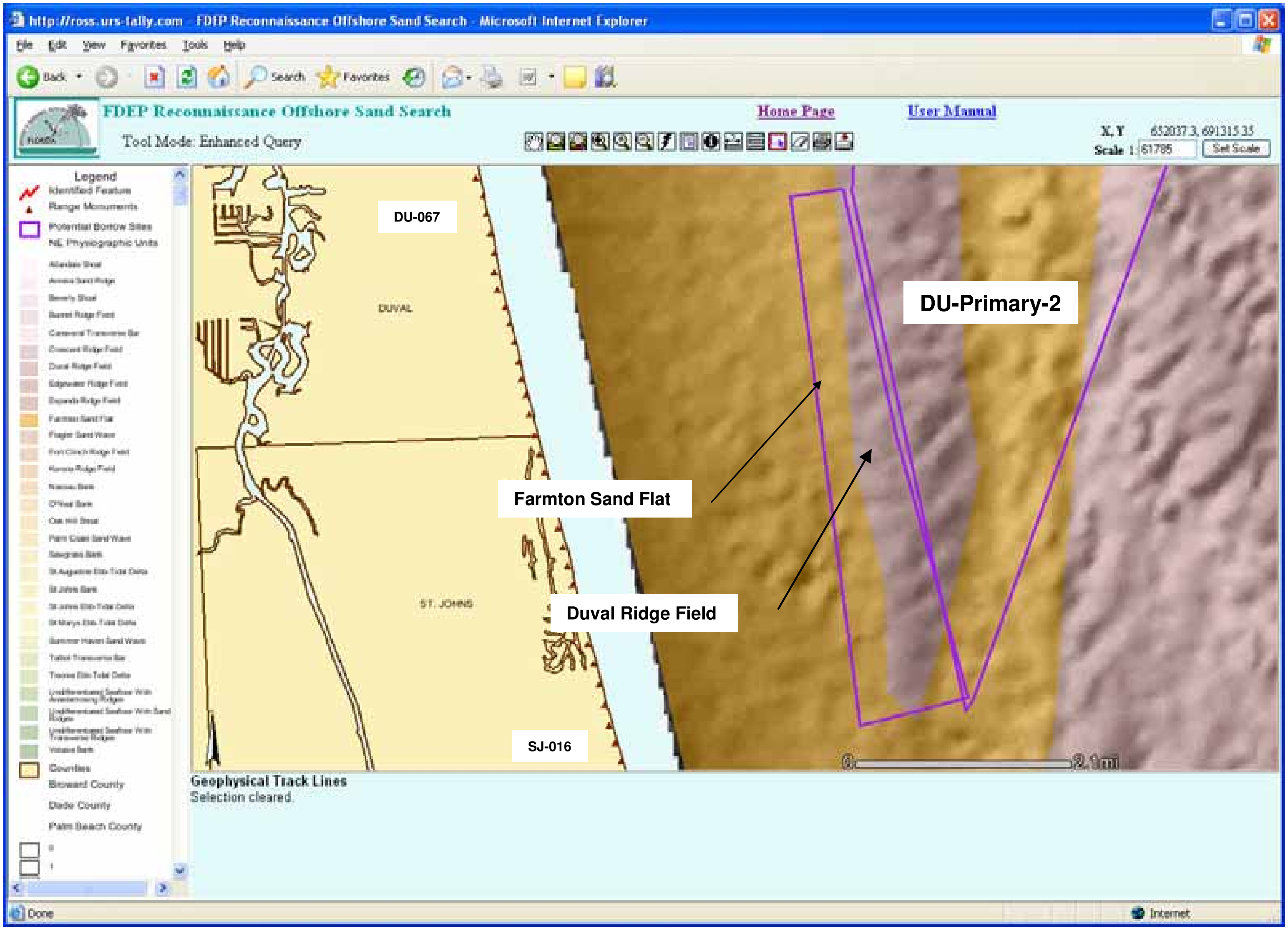


Figure 4-23. Duval County Area DU-Primary-2 showing physiographic zones overlaying the gray scale image.

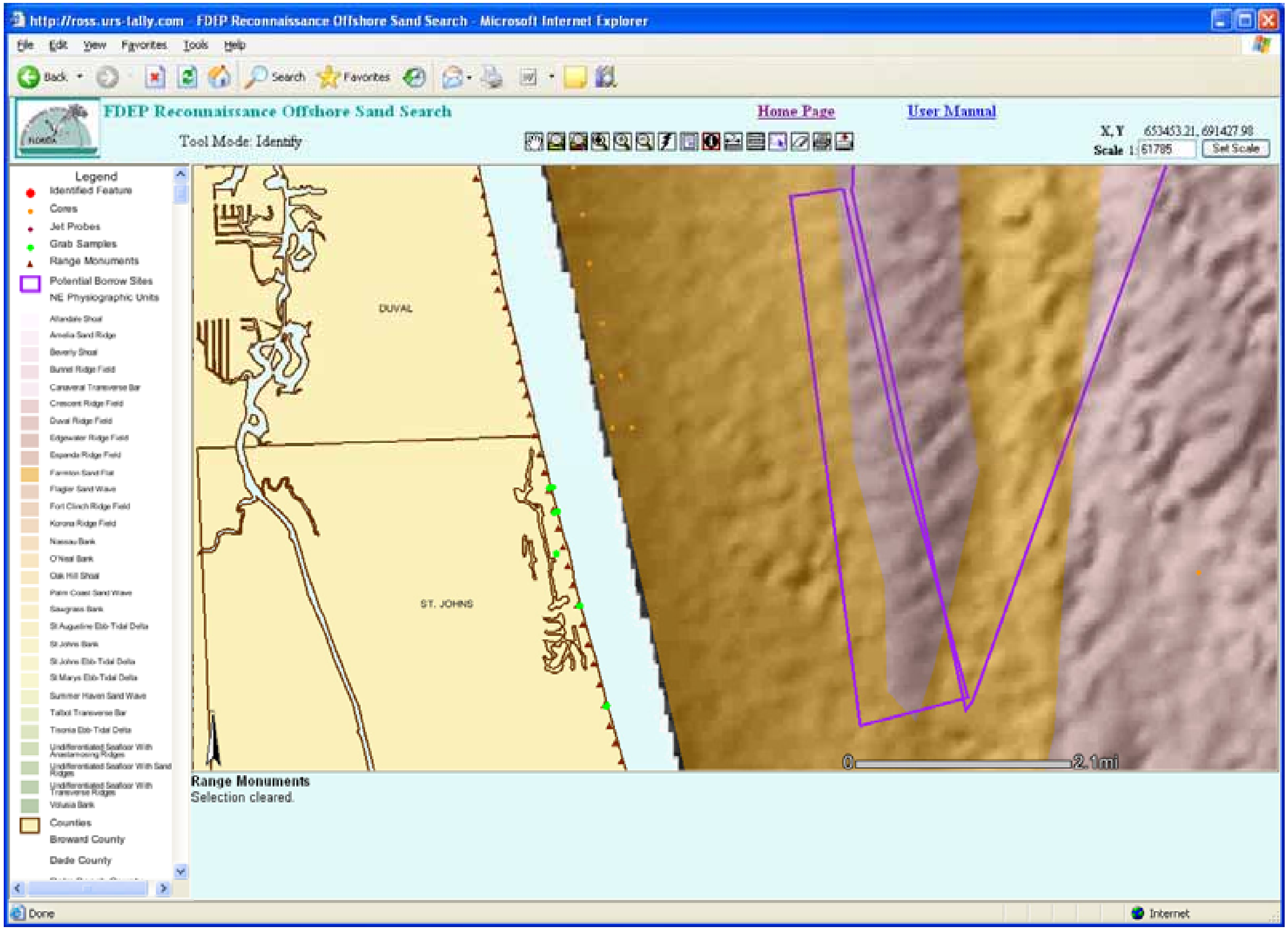


Figure 4-24. Duval County Area DU-Primary-2 showing the absence of Vibracore and Grab Sample locations.

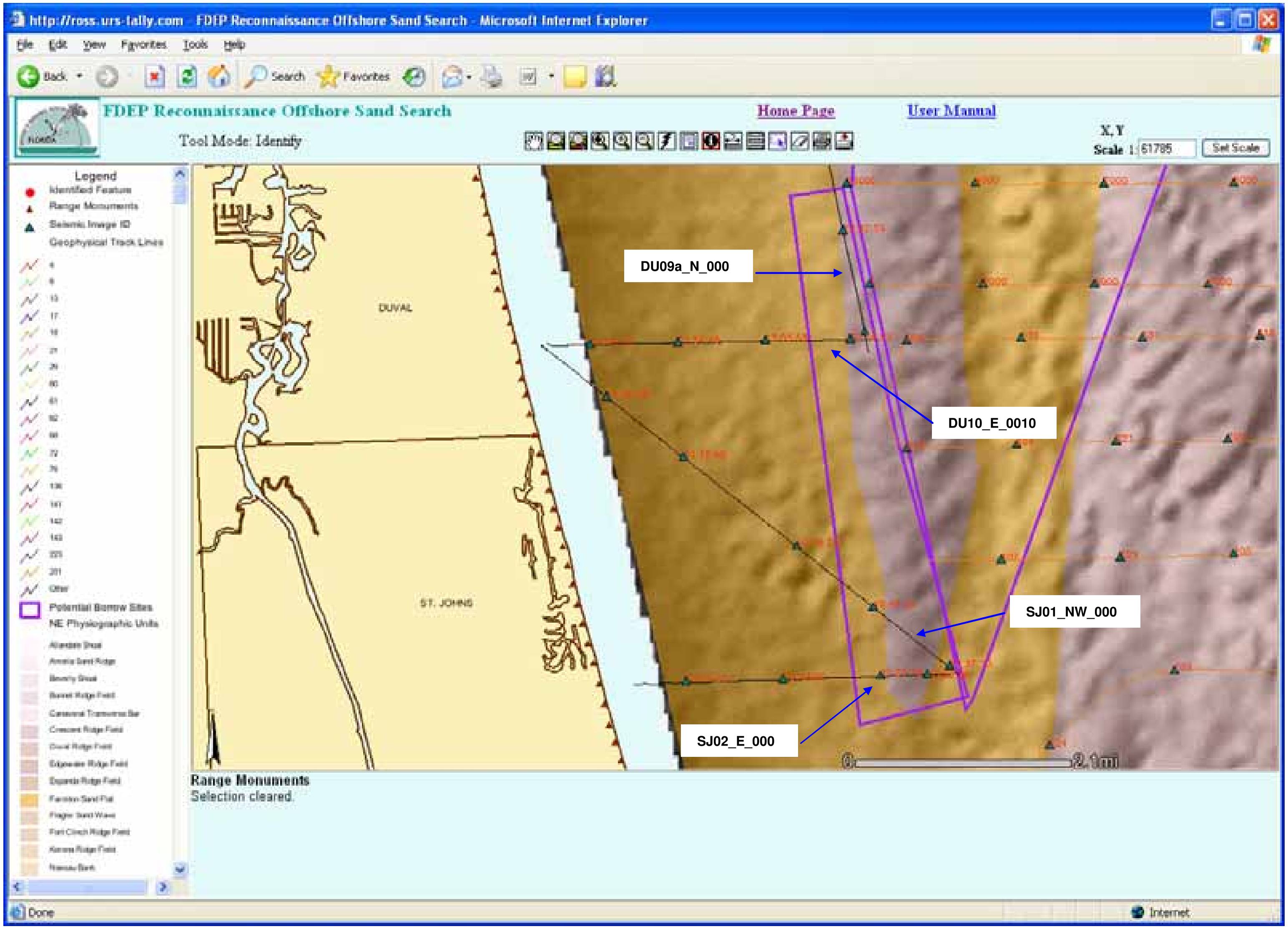


Figure 4-25. Duval County Area DU-Primary-2 showing geophysical trackline locations and timestamps.

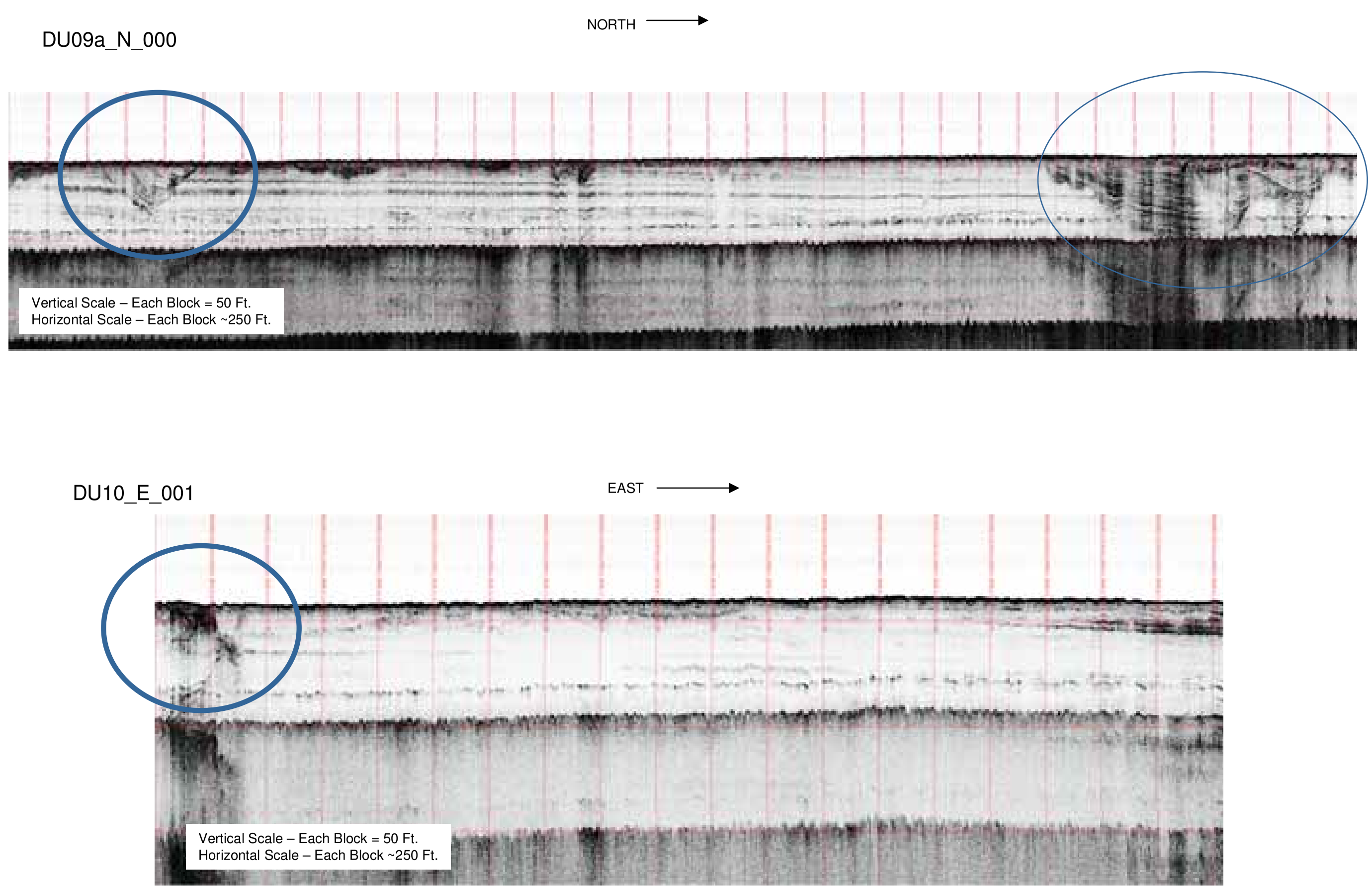
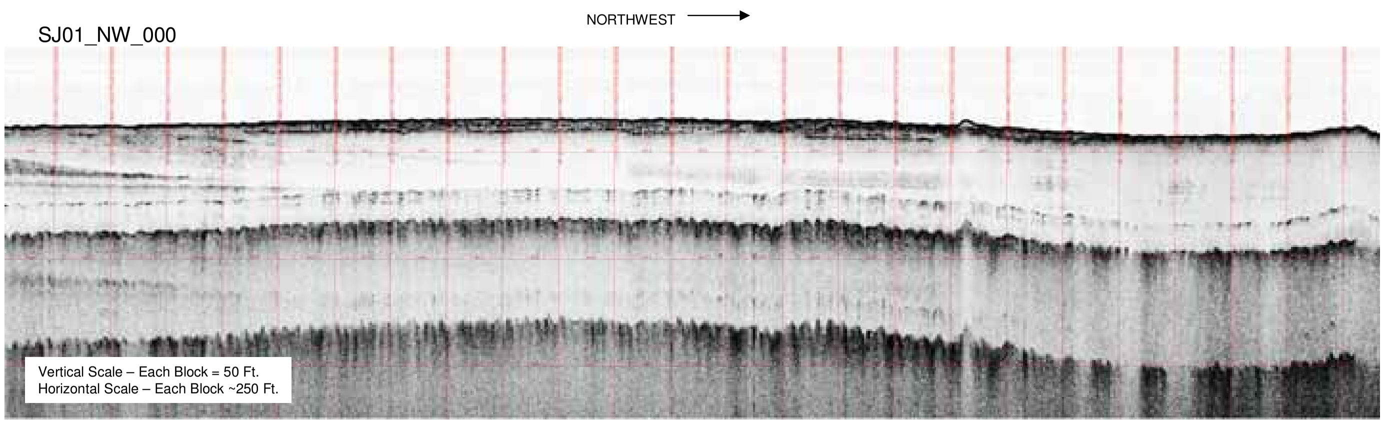


Figure 4-26. Duval County Area DU Primary 2. Portions of lines DU09a_N_000 (above) and DU10_E_001 (below). Paleo channels are circled in blue.



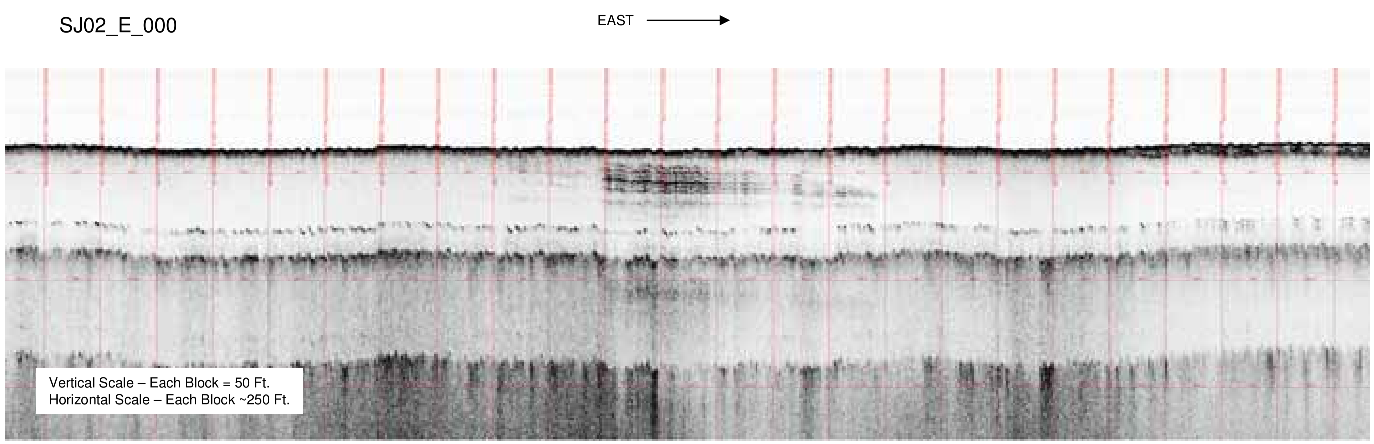


Figure 4-27. Duval County Area DU Primary 2. Portions of lines SJ01_NW_000 (above) and SJ02_E_000 (below).

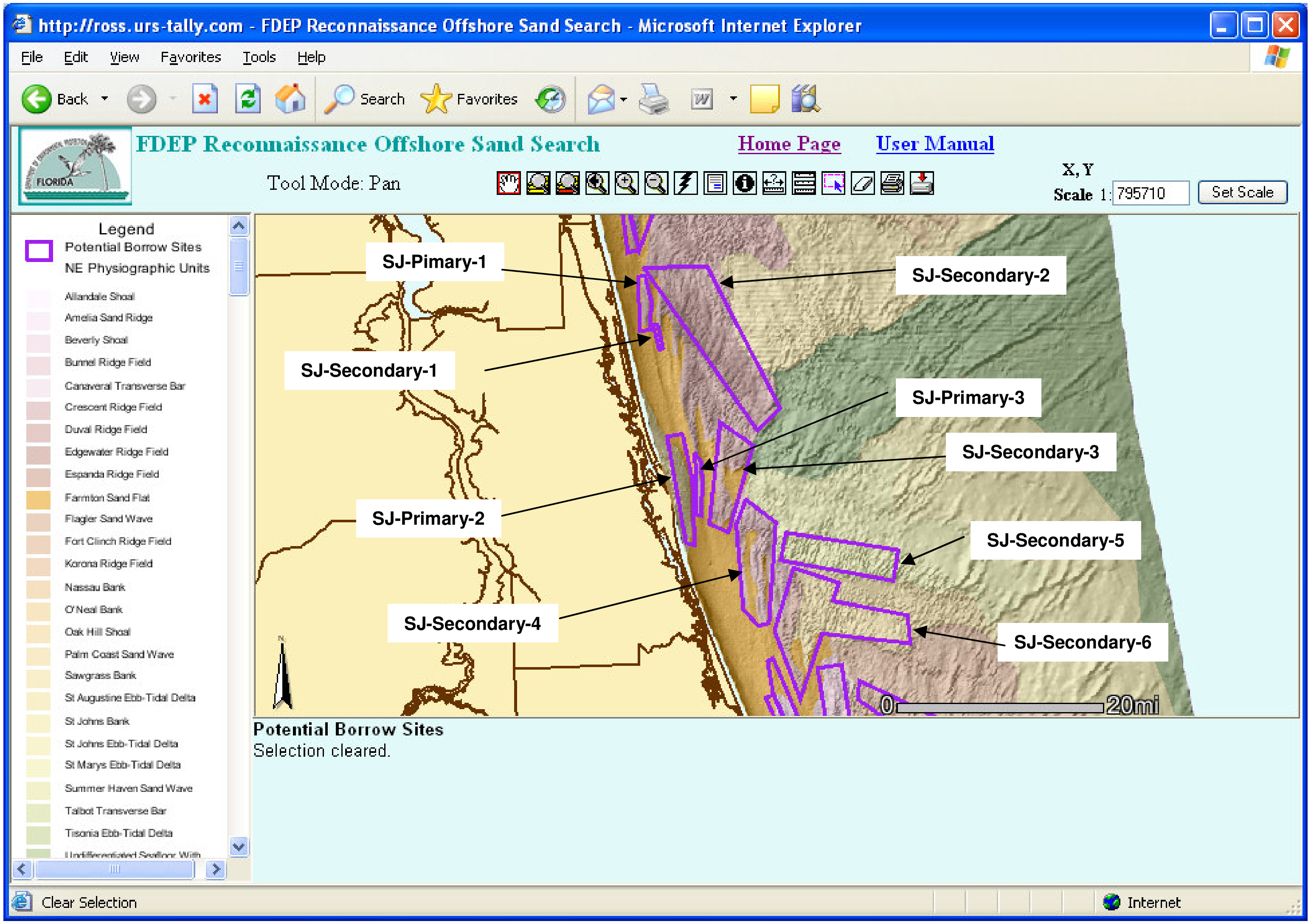


Figure 4-28. St. Johns County showing nearshore Potential Borrow Areas and physiographic zones.

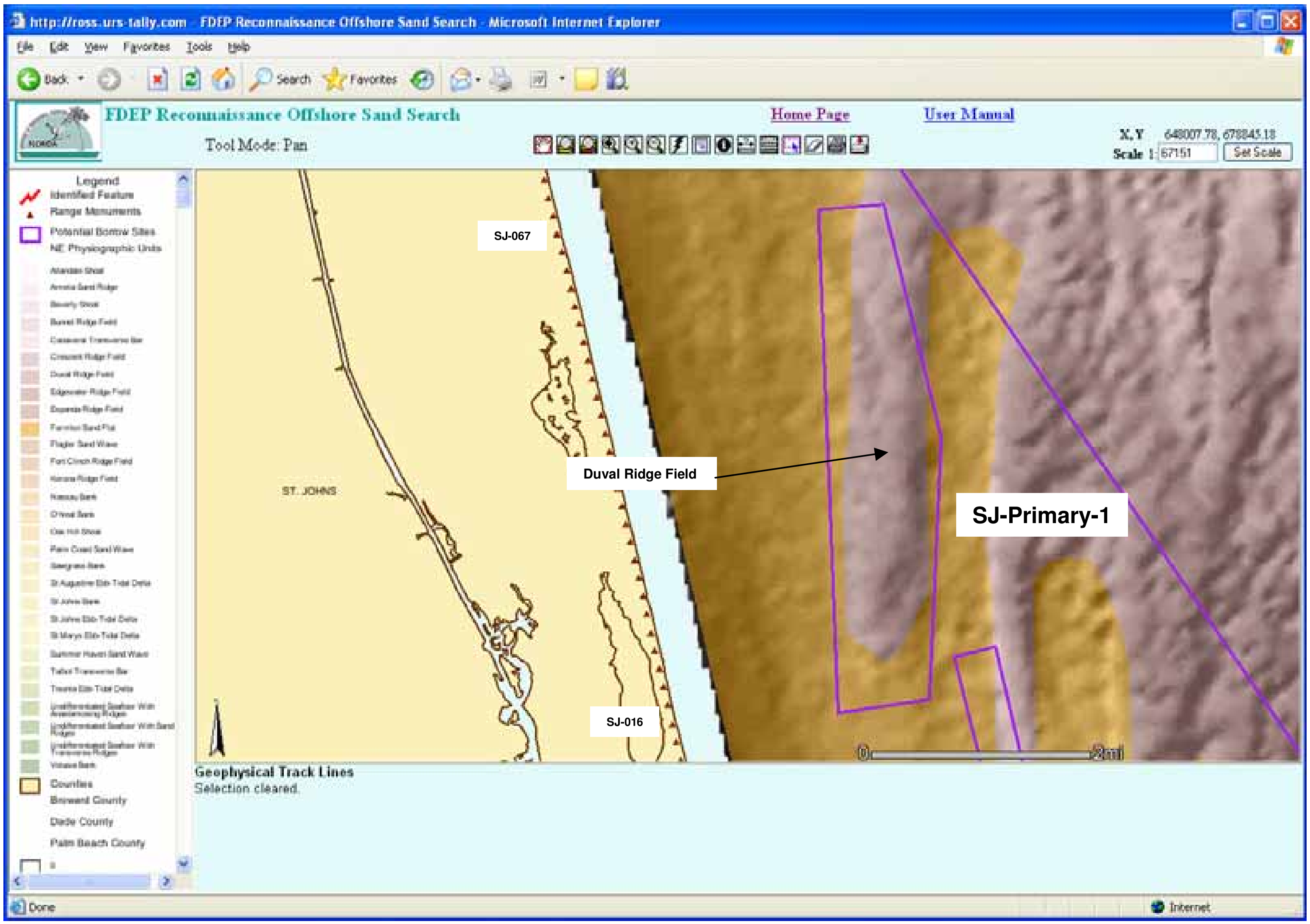


Figure 4-29. St. Johns County Area SJ-Primary-1 showing physiographic zones overlaying the gray scale image.

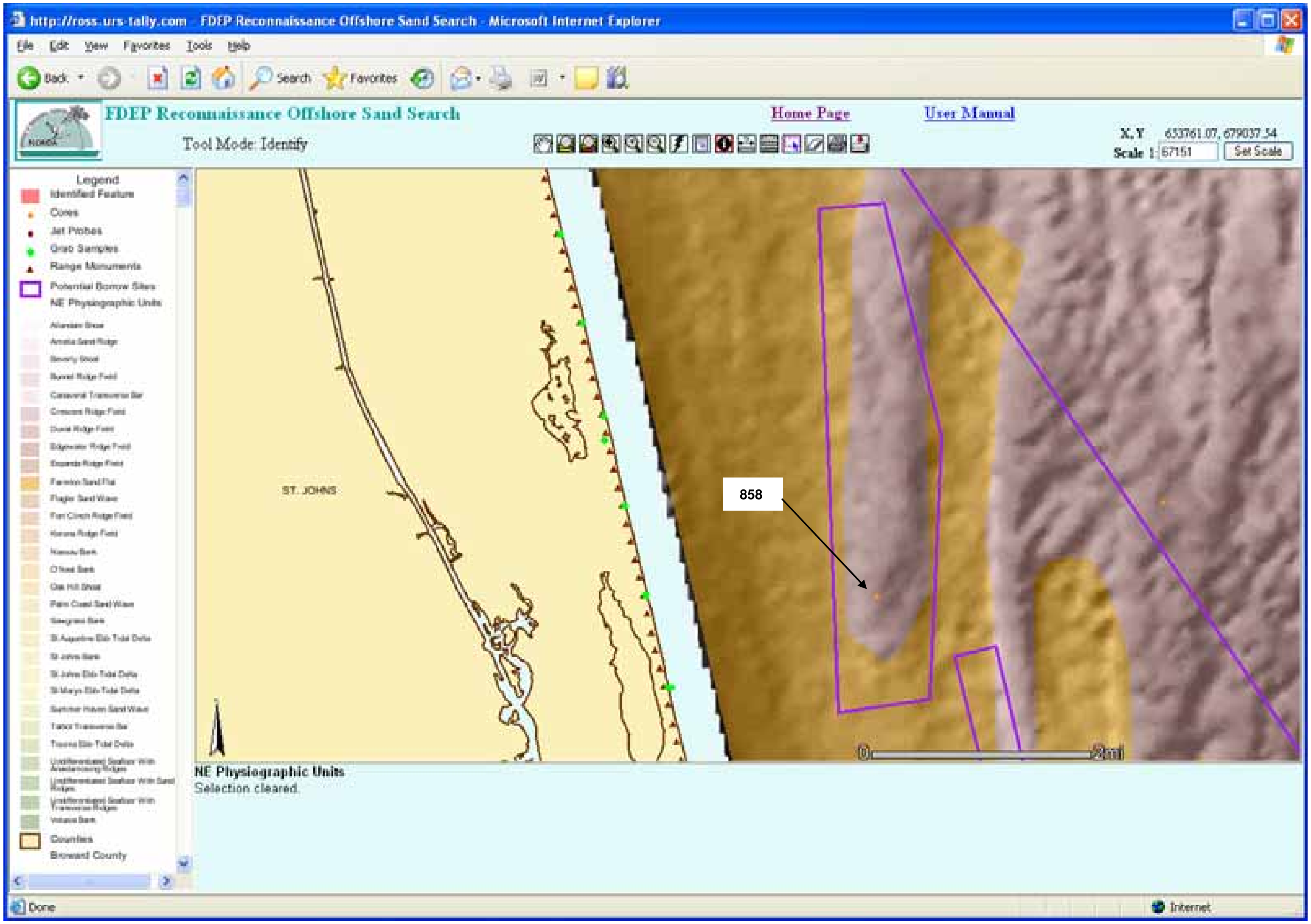


Figure 4-30. St. Johns County Area SJ-Primary-1 showing Vibracore location.

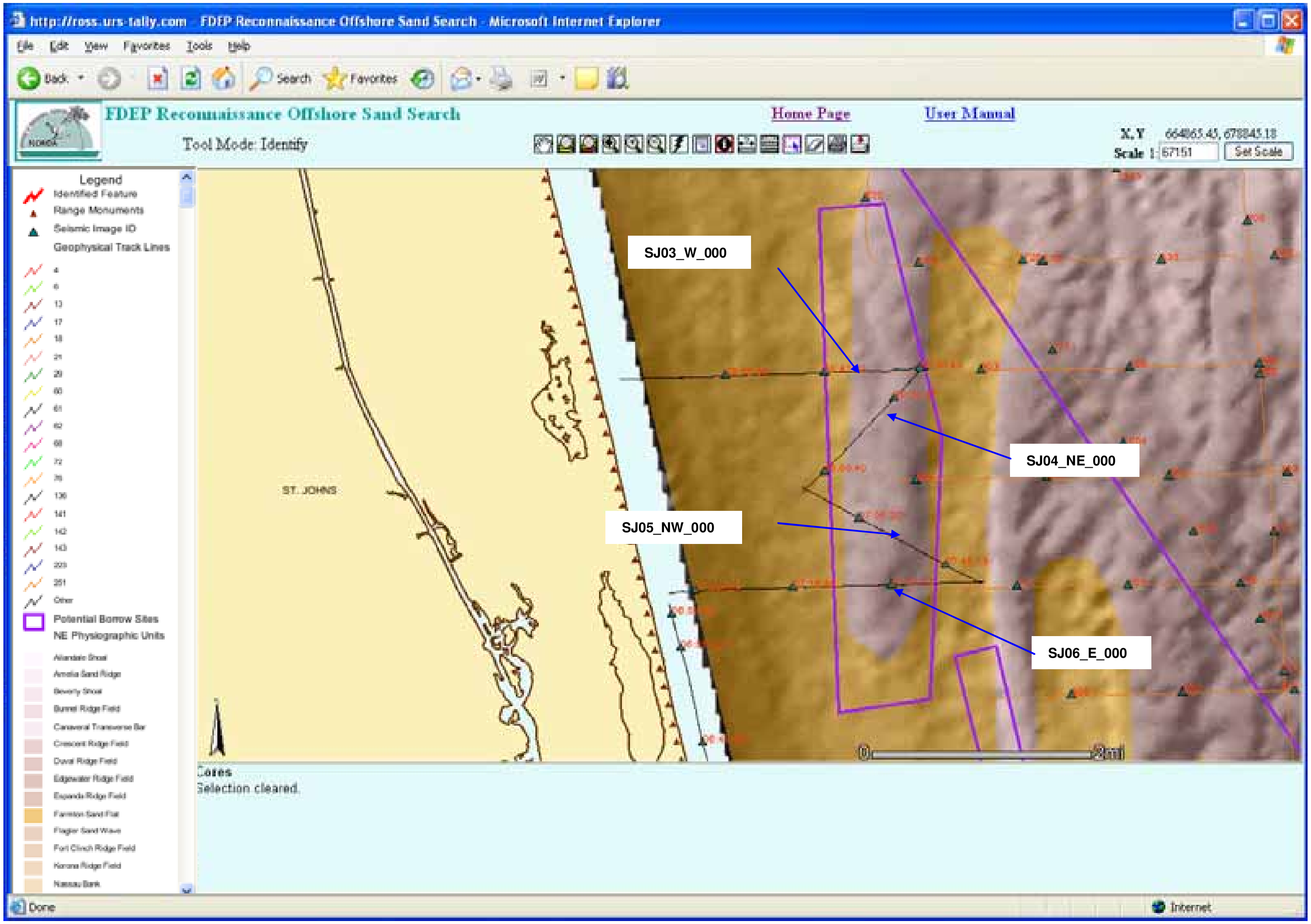
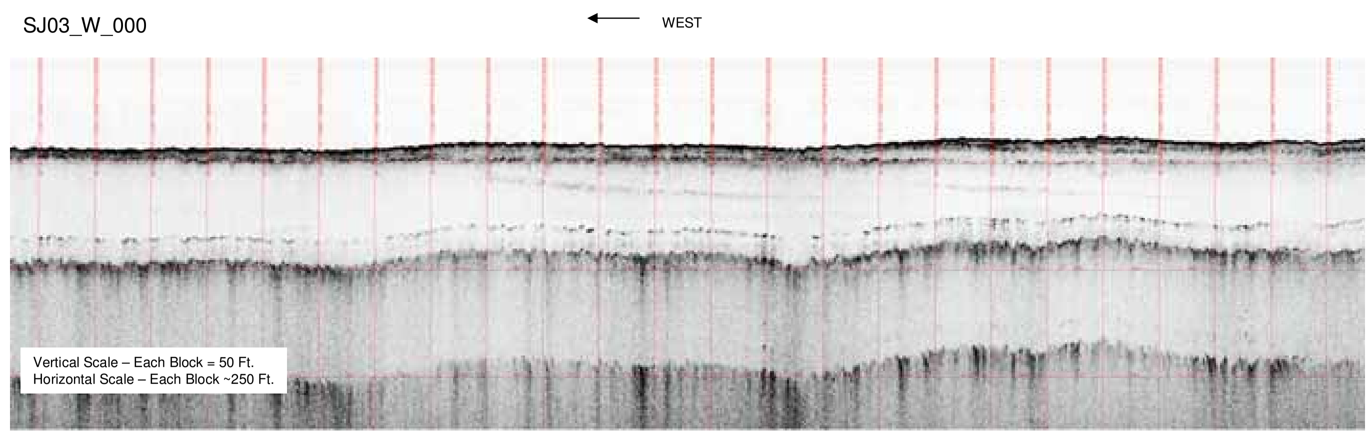


Figure 4-31. St. Johns County Area SJ-Primary-1 showing geophysical trackline locations and timestamps.



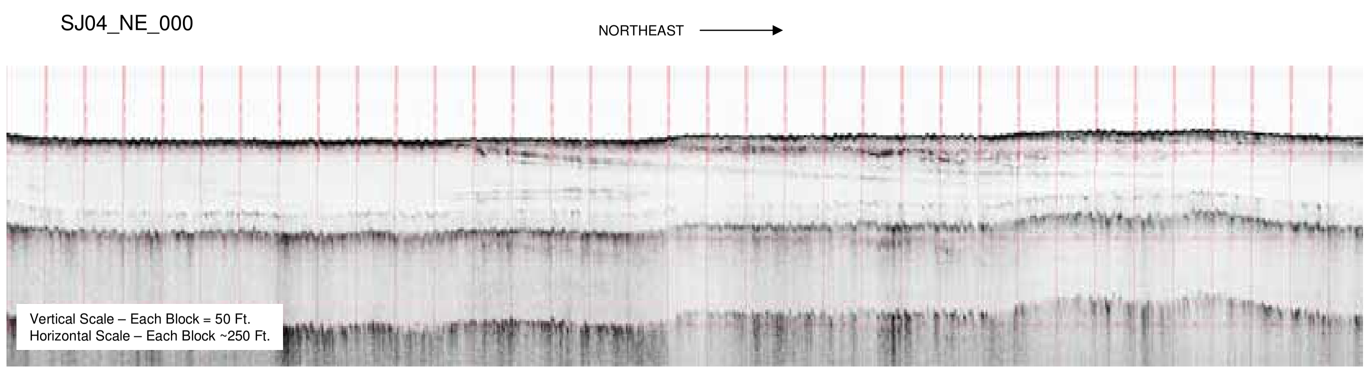


Figure 4-32. St Johns County Area SJ Primary 1 Portions of lines SJ03_w_000 (above) and SJ04_NE_000 (below).

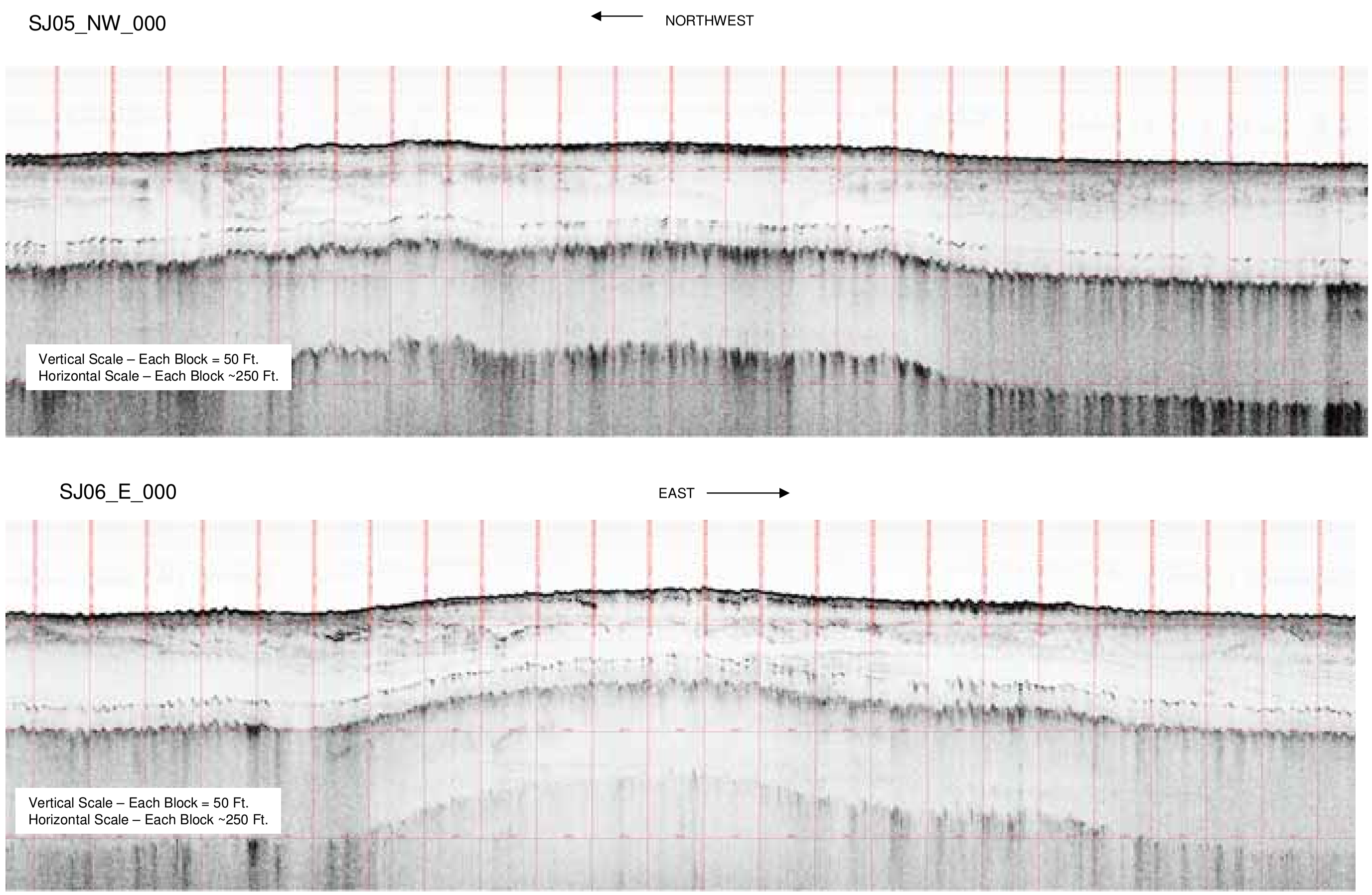


Figure 4-33. St Johns County Area SJ Primary 1 Portions of linesSJ05_NW_000 (above) and SJ06_E_000 (below).

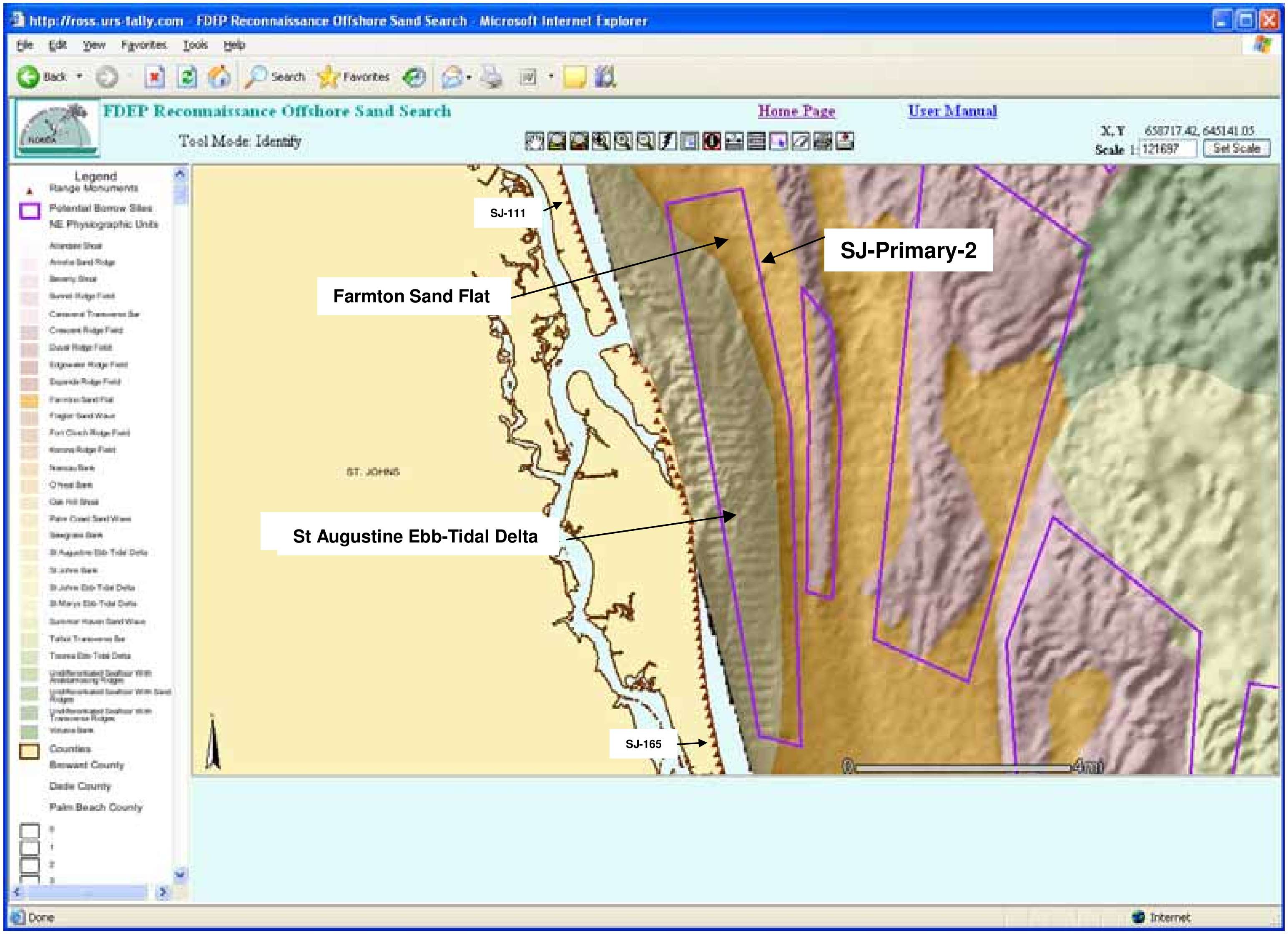


Figure 4-34. St. Johns County Area SJ-Primary-2 showing physiographic zones overlaying the gray scale image.

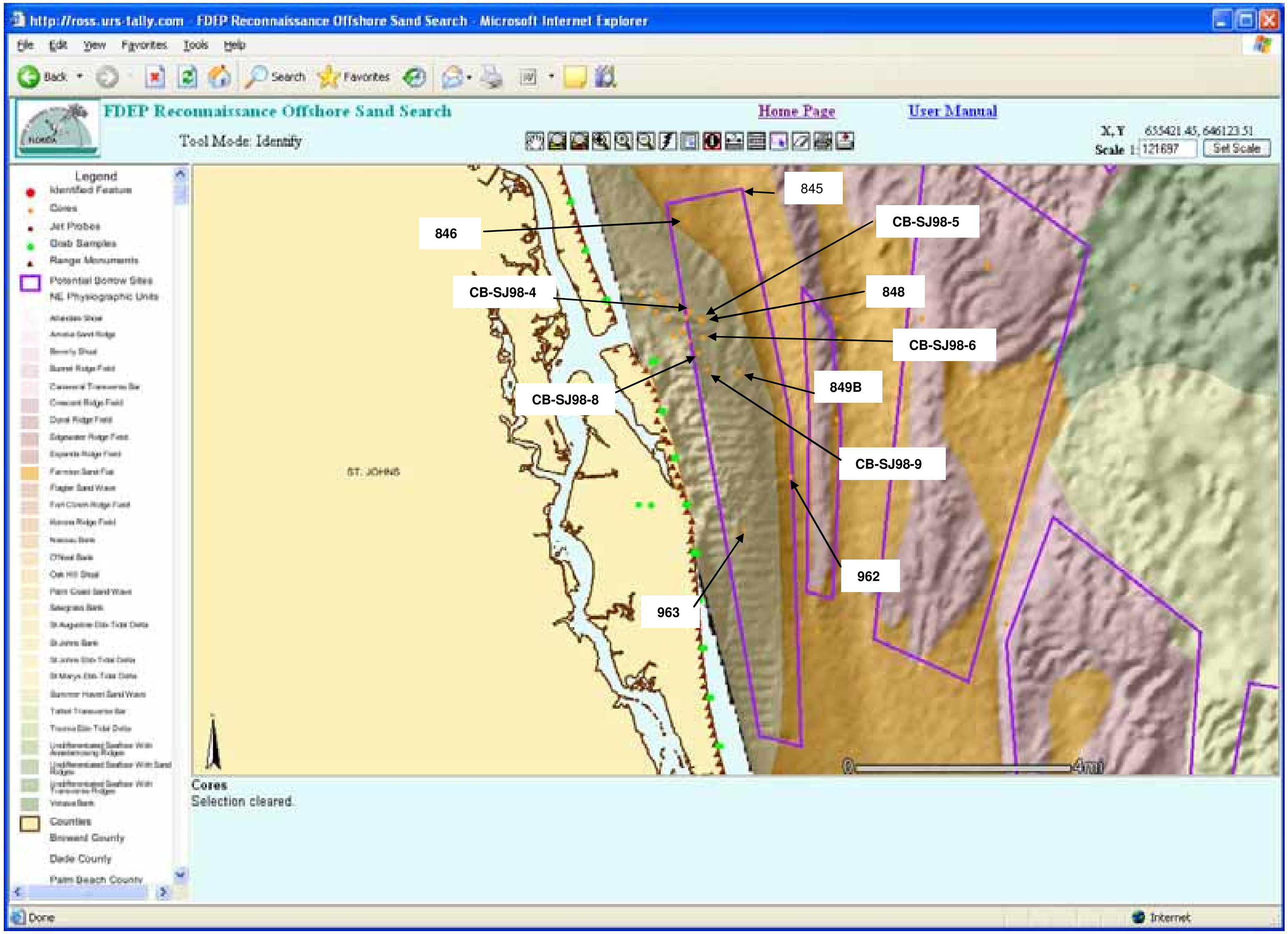


Figure 4-35. St. Johns County Area SJ-Primary-2 showing Vibracore and Grab Sample locations.

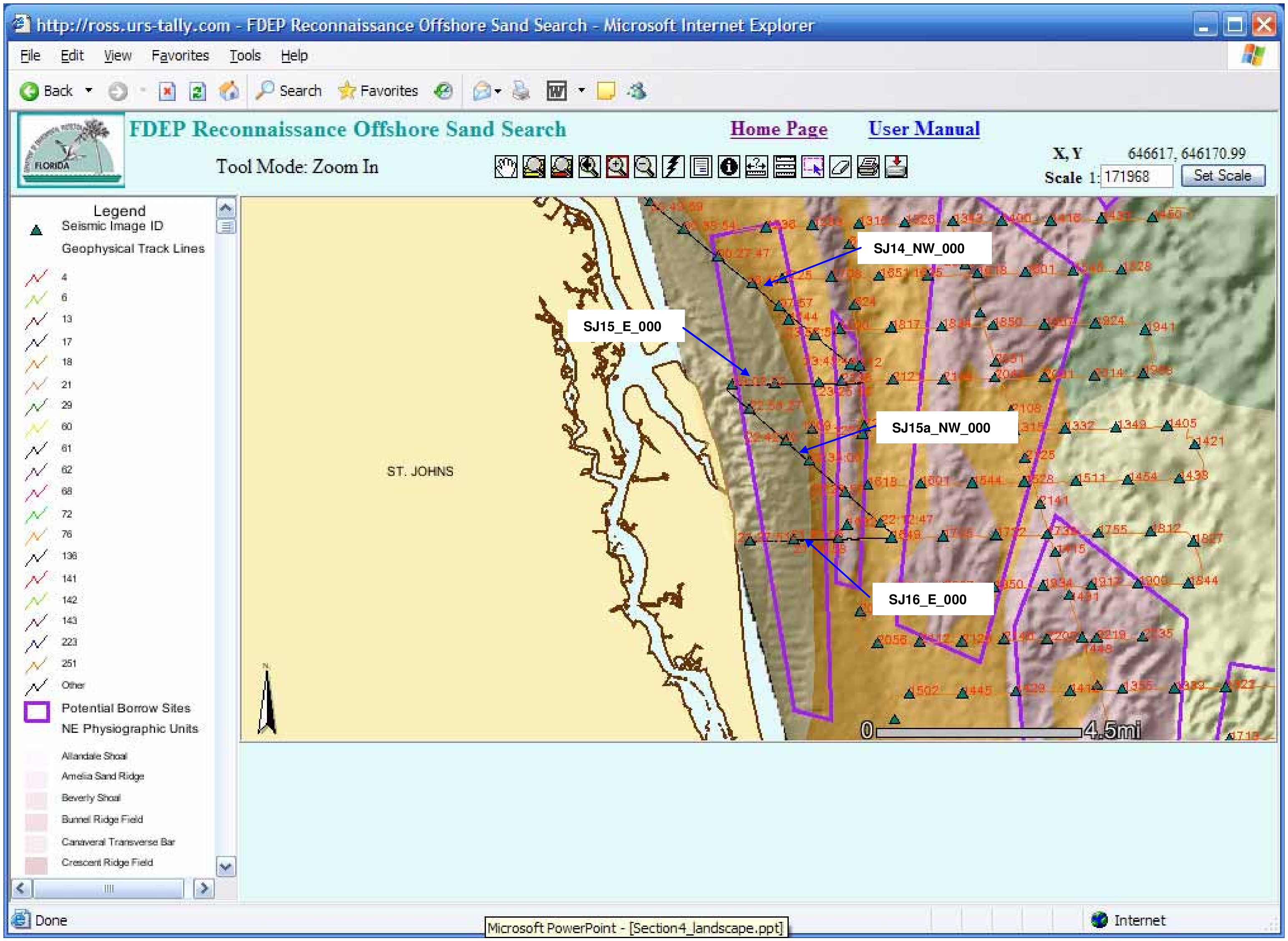
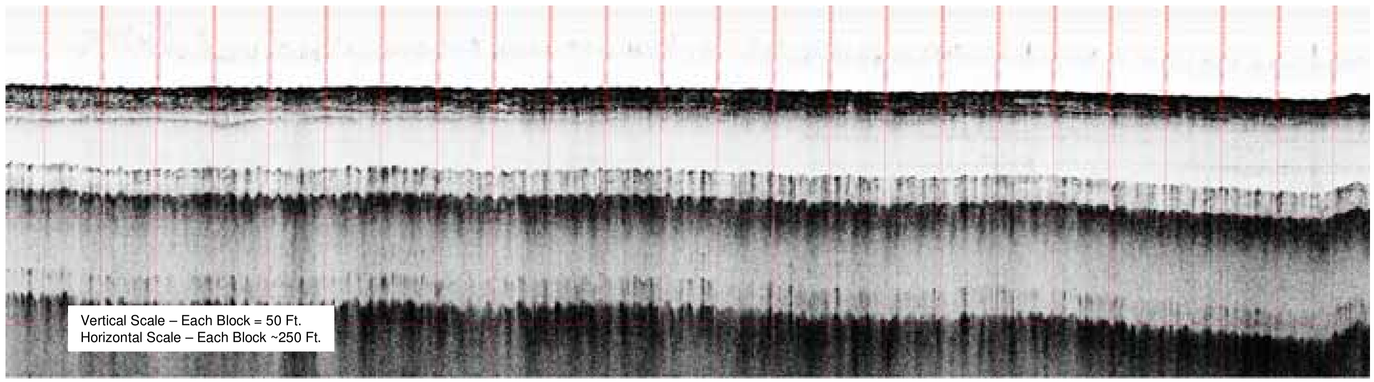


Figure 4-36. St. Johns County Area SJ-Primary-2 showing geophysical trackline locations and timestamps.



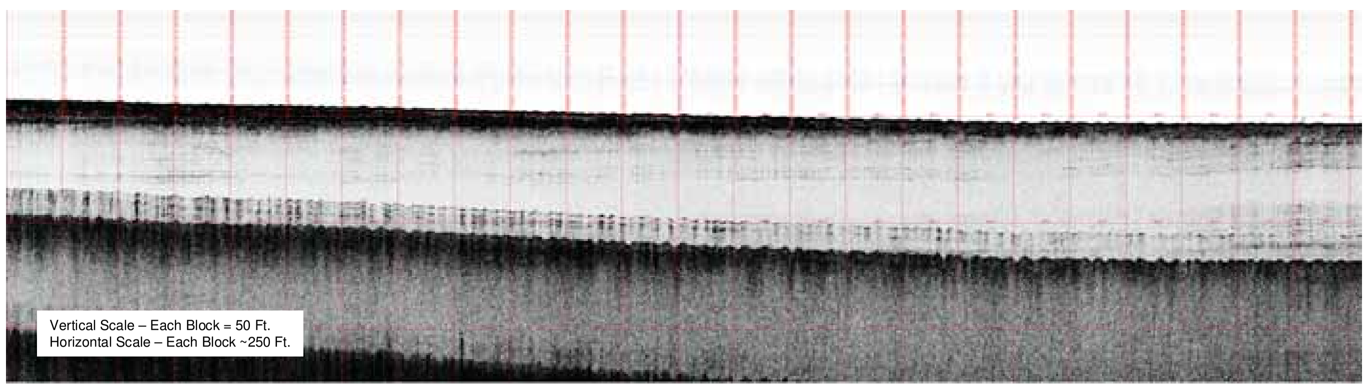


Figure 4-37. St. Johns County Area SJ Primary 2. Portions of lines SJ14_NW_001 (above) and SJ14_NN_000 (below).

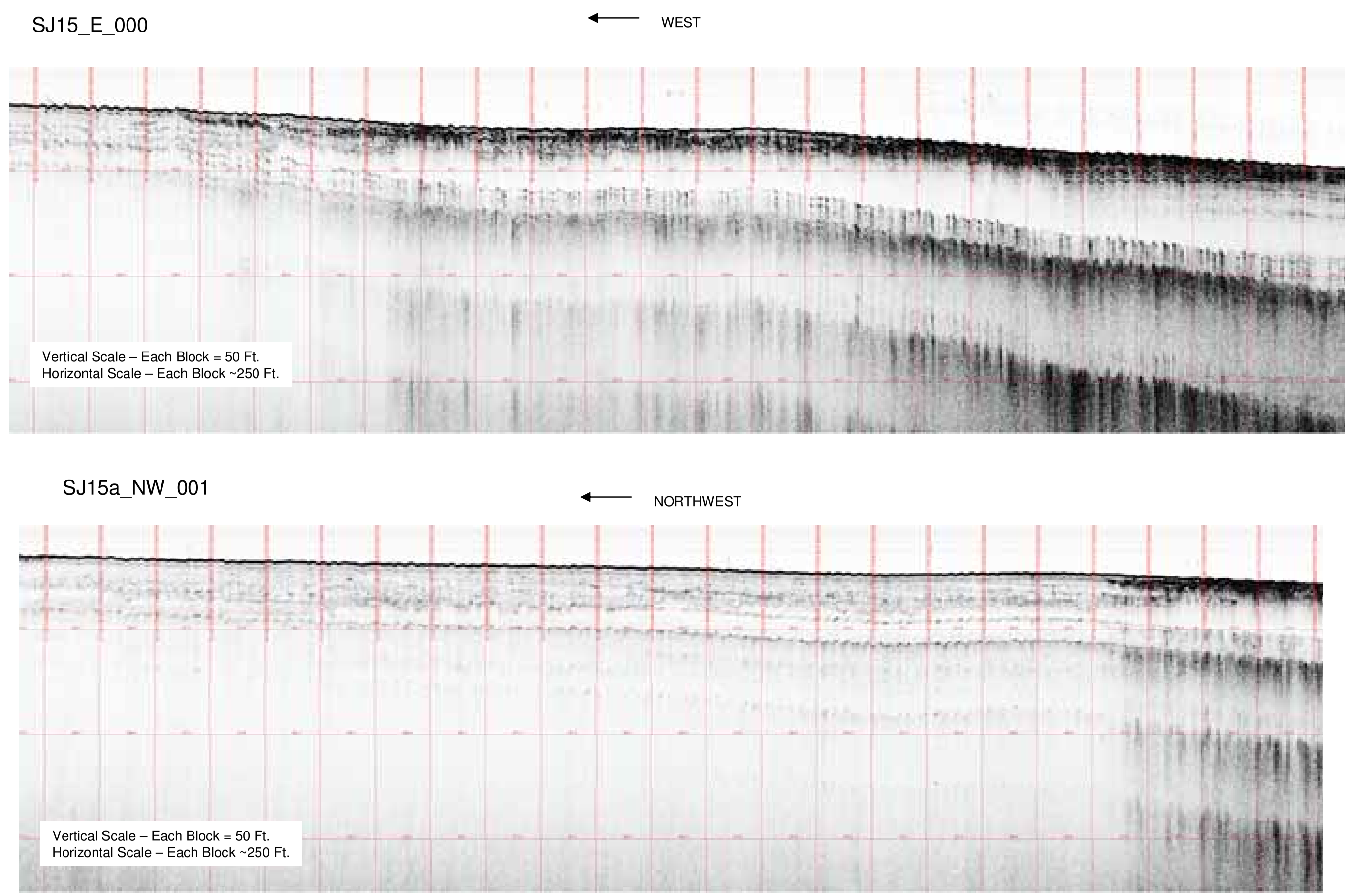


Figure 4-38. St. Johns County Area DU Primary 2. Portions of lines SJ 15_E_000 (above) and SJ 15a_NW_001 (below).

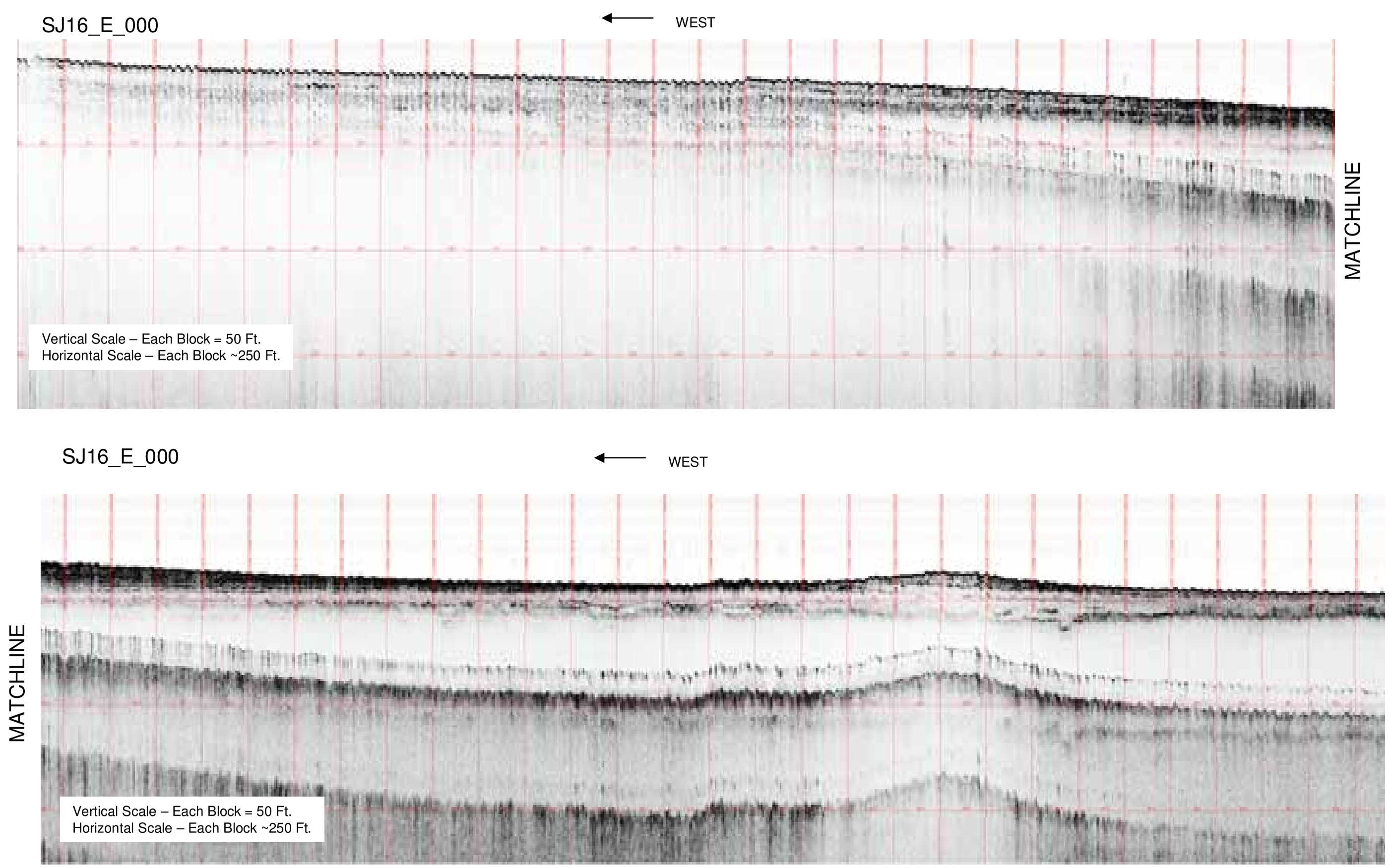


Figure 4-39. St. Johns County Area SJ Primary 2. Line SJ16_E_000

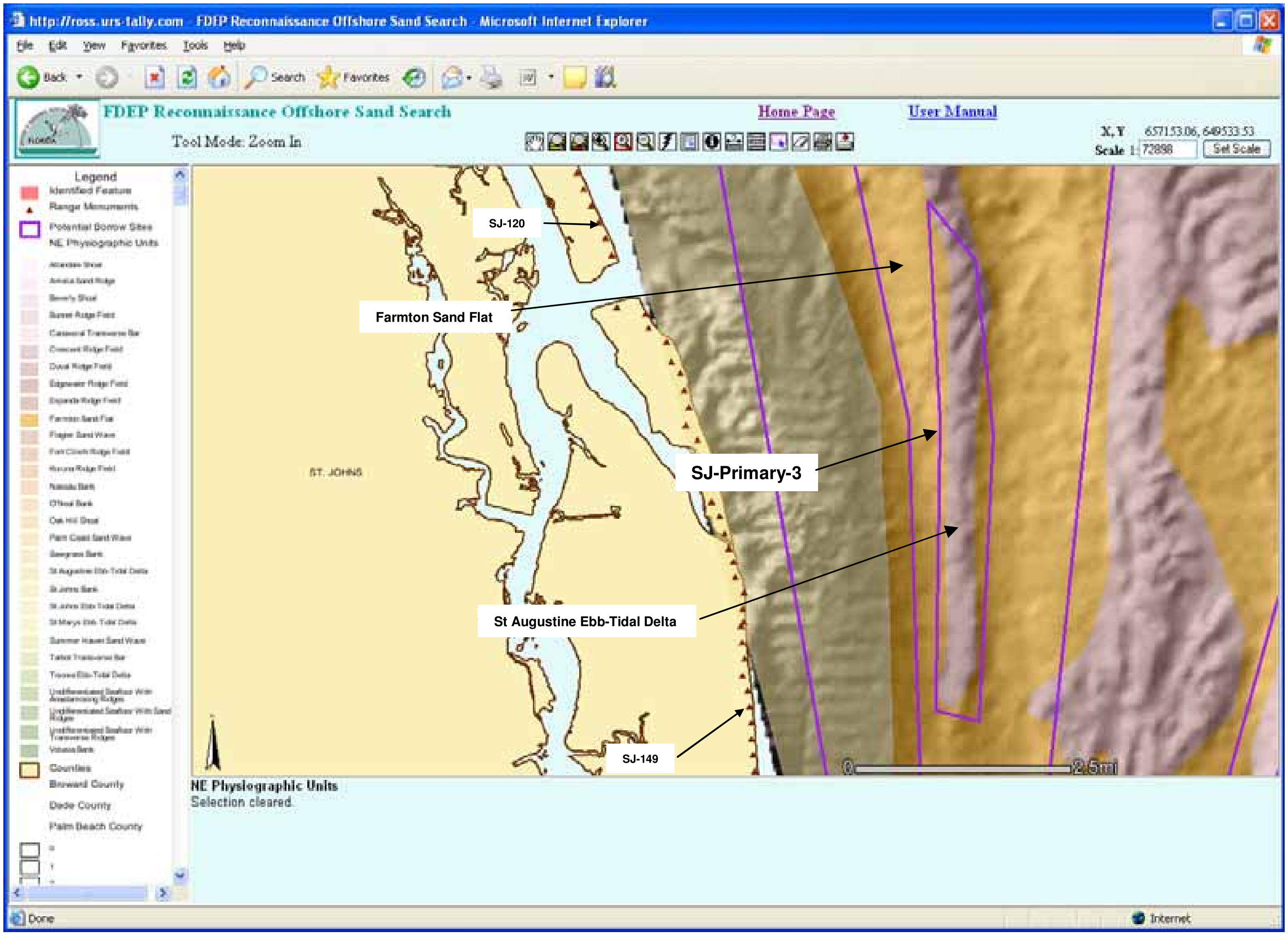


Figure 4-40. St. Johns County Area SJ-Primary-3 showing physiographic zones overlaying the gray scale image.

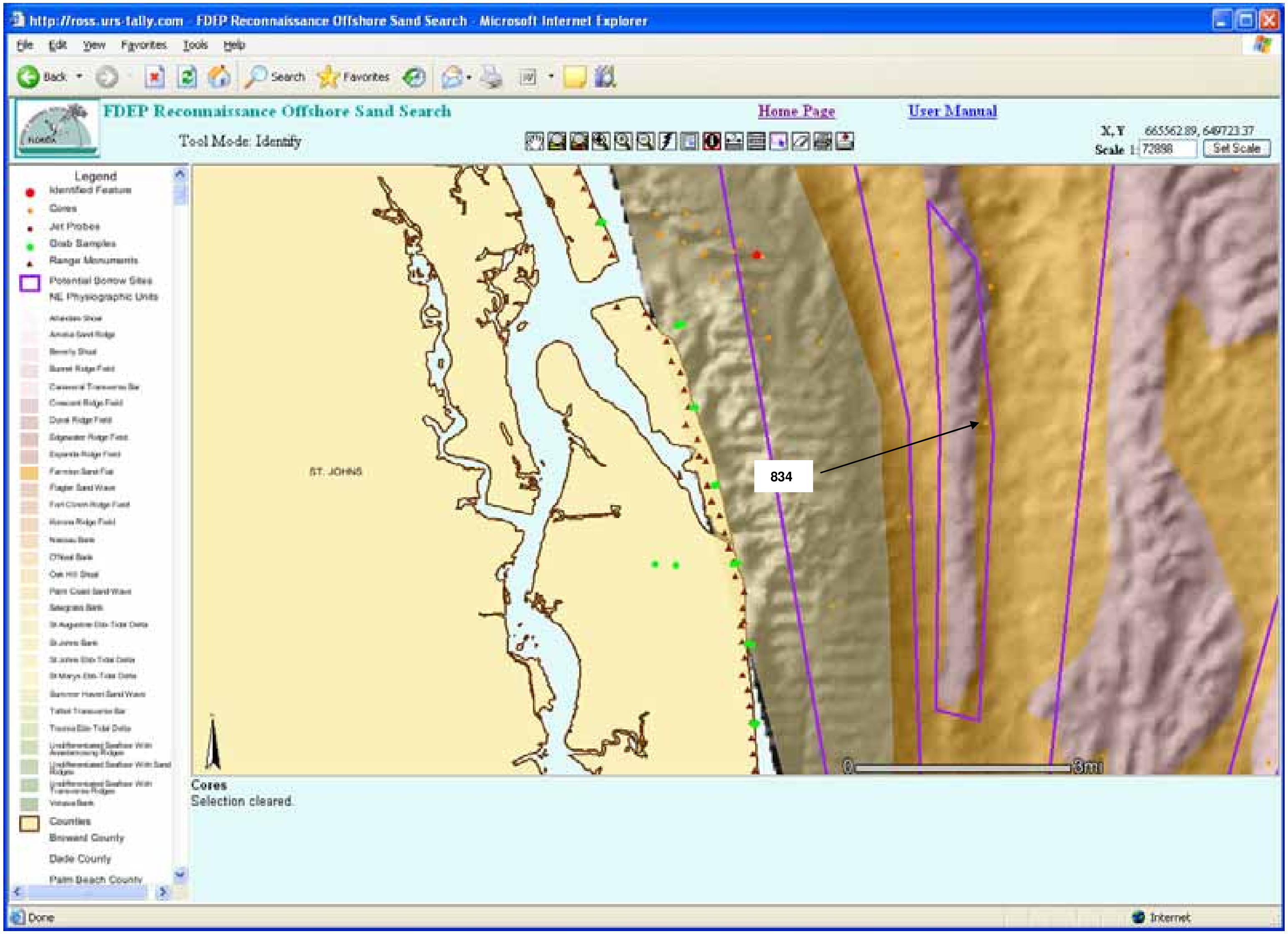


Figure 4-41. St. Johns County Area SJ-Primary-3 showing Vibracore and Grab Sample locations.

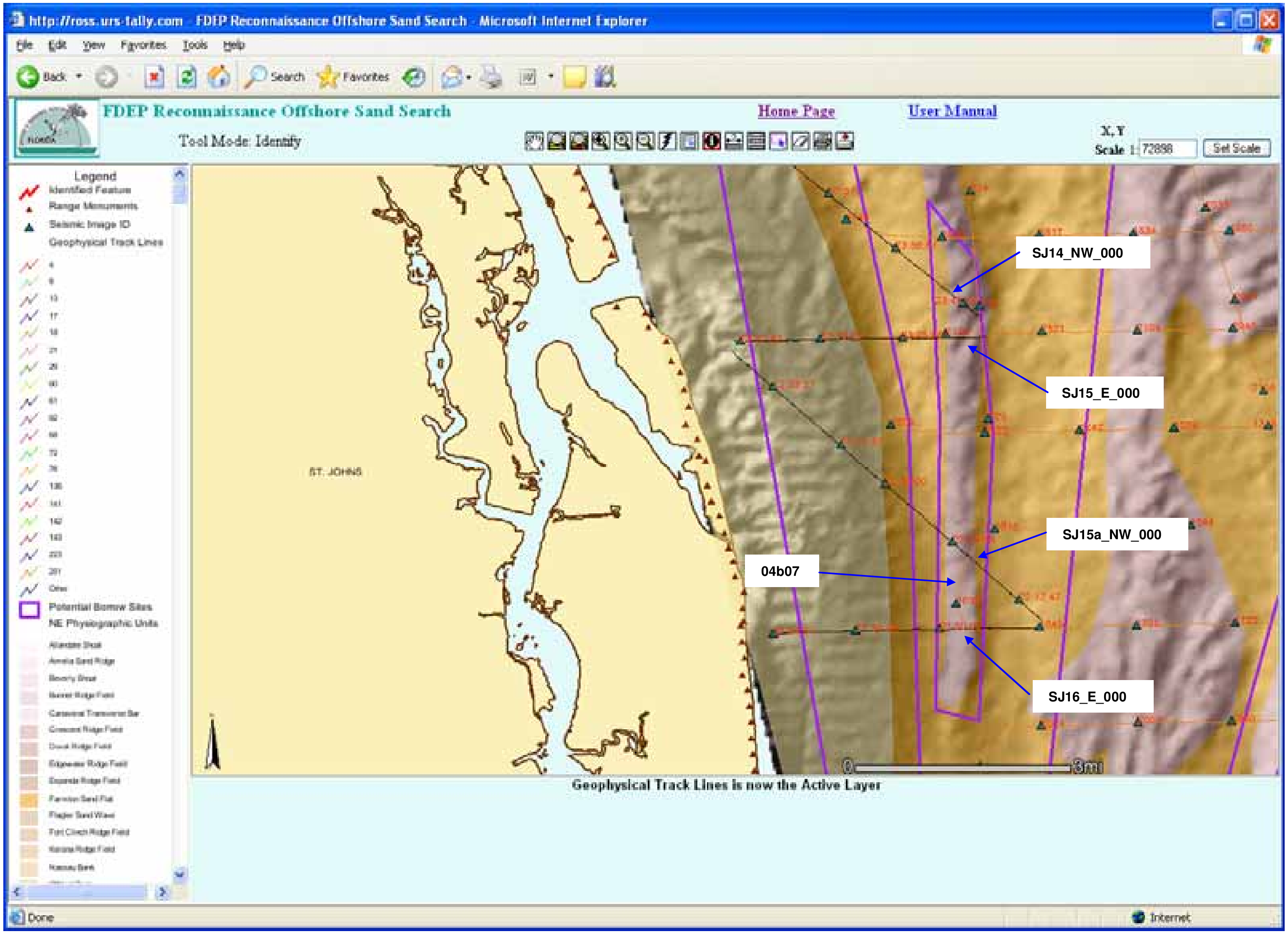
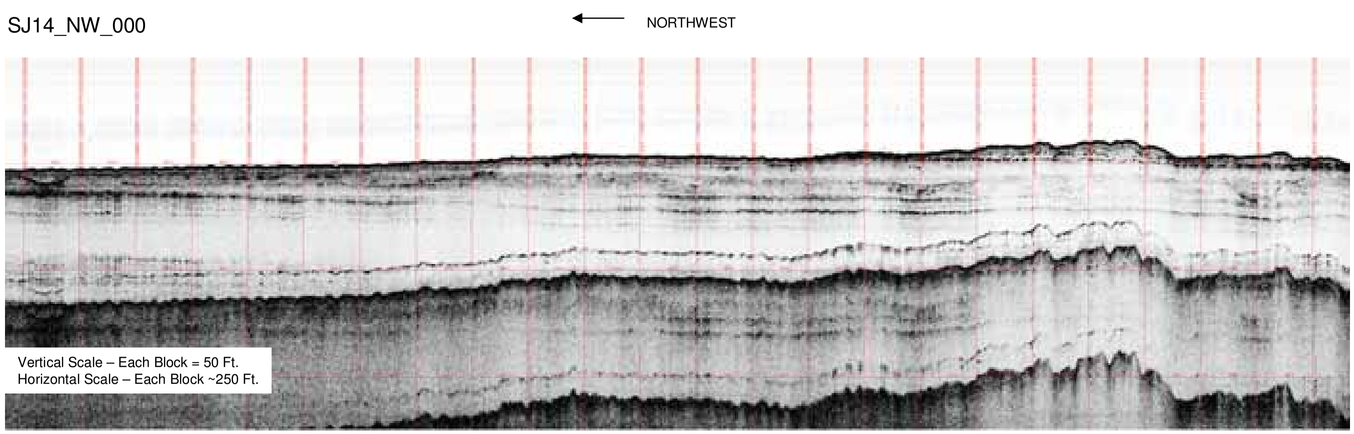


Figure 4-42. St. Johns County Area SJ-Primary-3 showing geophysical trackline locations and timestamps.

SJ14_NW_000



SJ15_E_000

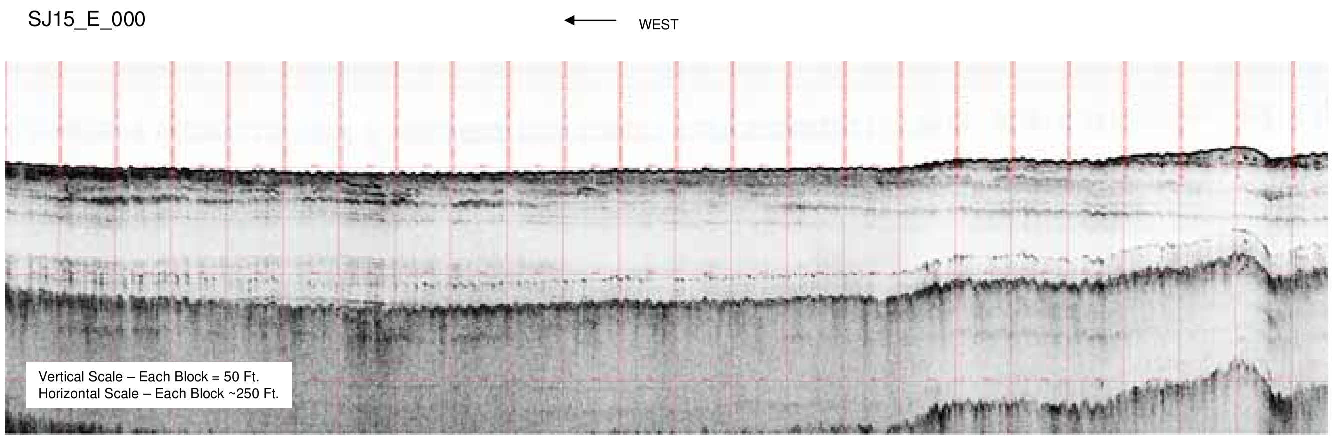
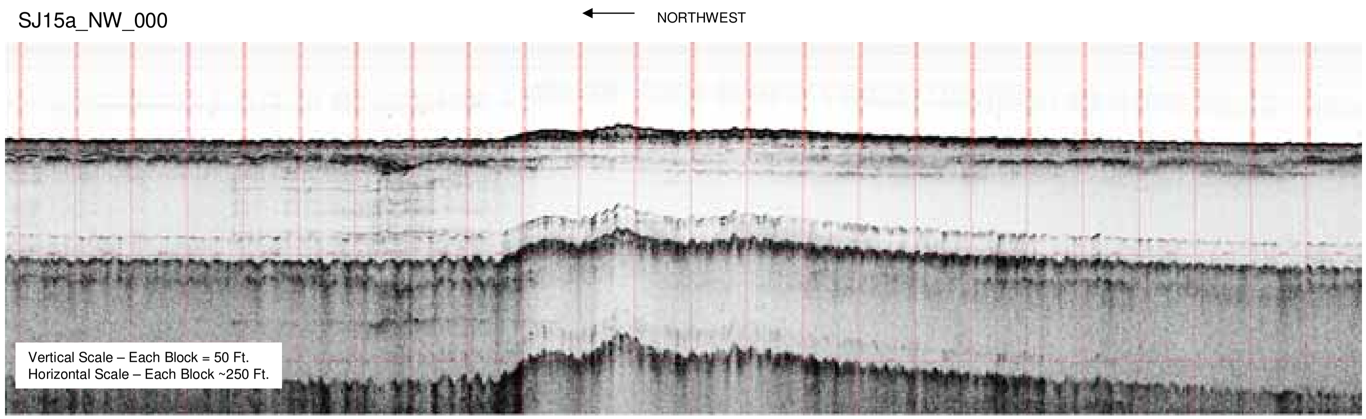


Figure 4-43. St Johns County Area SJ-Primary-3. Portions of lines SJ14_NW_000 (above) and SJ15_E_000 (below).



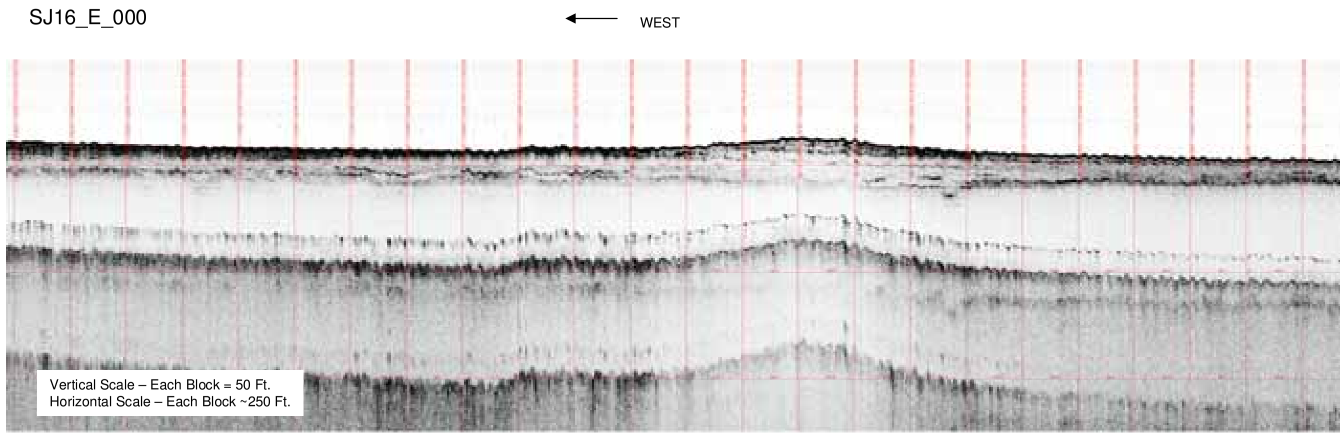
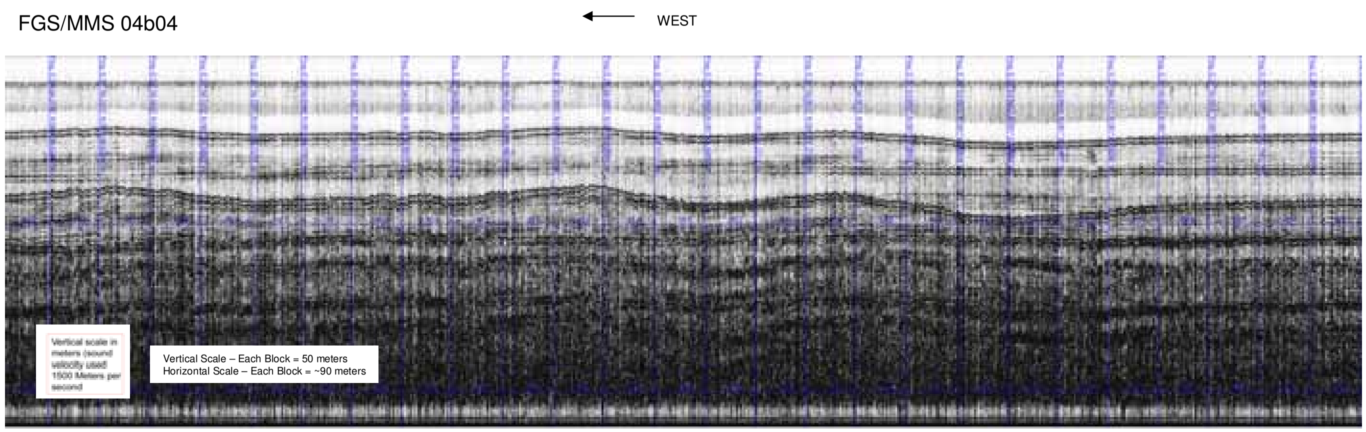


Figure 4-44. St Johns County Area SJ-Primary-3. Portions of lines SJ15a_NW_000 (above) and SJ16_E_000 (below).

FGS/MMS 04b04



FGS/MMS 04b05

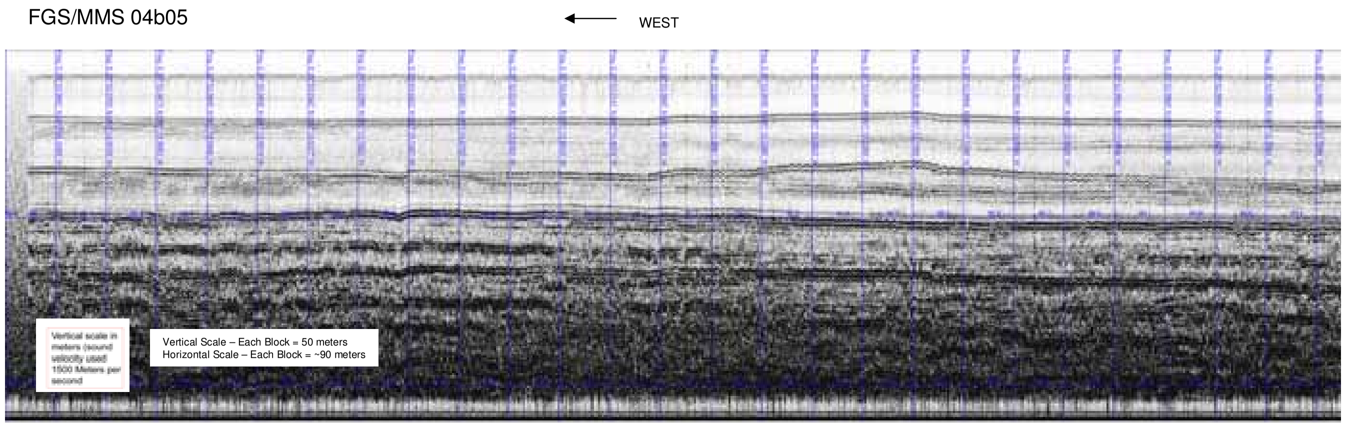
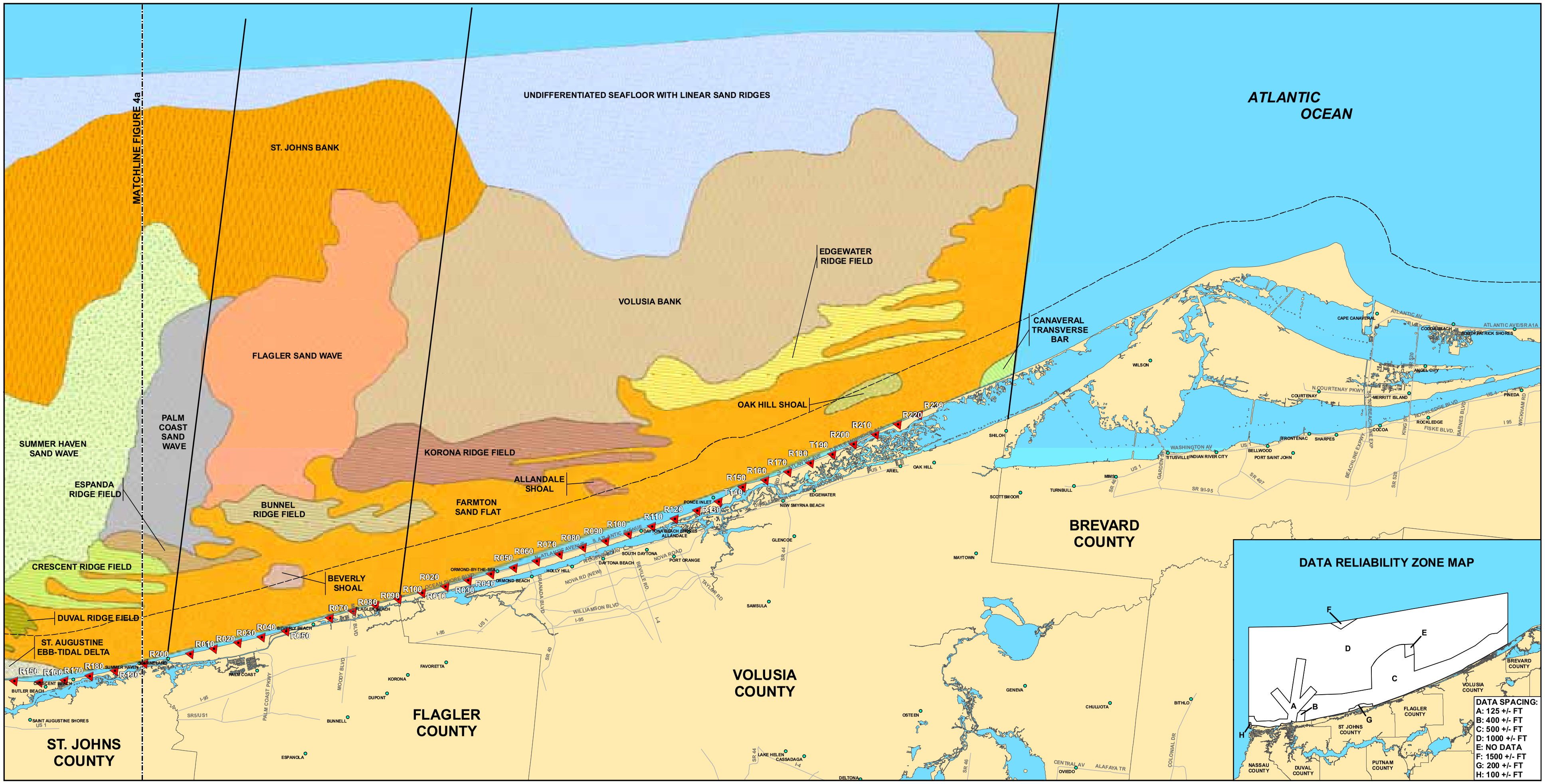


Figure 4-45. St Johns County Area SJ-Primary-3. Portions of FGS/MMS lines 04b04 (above) and 04b05 (below).



LEGEND:

- CITIES
- FDEP MONUMENTS
- ROADS
- COUNTY LINES
- FEDERAL / STATE BOUNDARY
- MATCHLINE

GEOMORPHOLOGY

RIDGES
- BUNNEL RIDGE FIELD
- CRESCENT RIDGE FIELD
- DUVAL RIDGE FIELD
- EDGEWATER RIDGE FIELD
- ESPANDA RIDGE FIELD
- KORONA RIDGE FIELD

SHOALS
- ALLANDALE SHOAL
- BEVERLY SHOAL
- OAK HILL SHOAL

BANKS
- ST. JOHNS BANK
- VOLUSIA BANK

SAND FLAT
- FARMTON SAND FLAT

SAND WAVES
- FLAGLER SAND WAVE
- PALM COAST SAND WAVE
- SUMMER HAVEN SAND WAVE

EBB-TIDAL DELTAS
- ST. AUGUSTINE EBB-TIDAL DELTA

TRANSVERSE BAR
- CANAVERAL TRANSVERSE BAR

UNDIFFERENTIATED SEAFLOORS
- UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGES

0 6 12 Kilometers

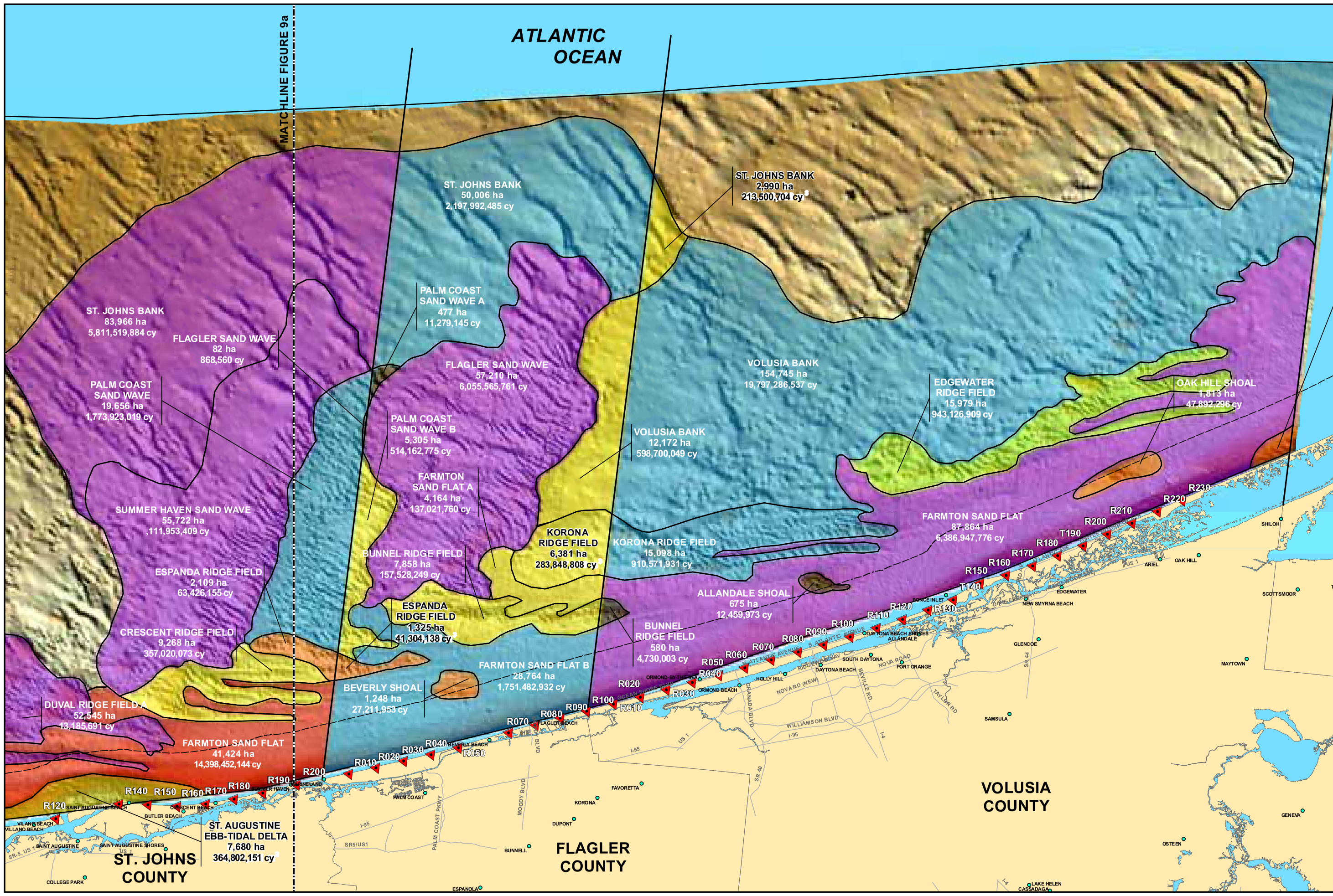
TITLE:

SEAFLOOR MAPPING UNITS ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07	BY: HMV	COMM NO: 7849.29	FIGURE 4-46

G:\DEP-URS\Northeast_Florida_MXD\GEOMORPHOLOGY_SHEET_2.mxd



ST. JOHNS COUNTY

Morphosedimentary Features	Shelf Area (ha)	% of County Continental Shelf Area	Height of Plane (ft)	Range (ft)	% Area Used in Volume Calculations	Sediment Volume (cy)
Cresent Ridge Field	9,268	2	-71.85	-71.85 to -42.65	0.80	357,020,073
Duval Ridge Field A	586	<1	-52.66	-52.66 to -41.67	0.90	13,185,691
Duval Ridge Field B	52,545	11	-82.35	-82.35 to -4.92	0.85	4,888,975,292
Espanda Ridge Field	2,109	<1	-71.85	-71.85 to -51.18	0.75	63,426,155
Farmton Sand Flat	41,424	9	-140.42	-140.42 to -4.17	1.00	14,398,452,144
Flagler Sand Wave	82	<1	-94.49	-94.49 to -83.43	0.60	868,560
Nassau Bank A	856	<1	-99.74	-99.74 to -81.04	0.85	35,783,098
Nassau Bank B	1,707	0	-100.07	-100.07 to -74.48	0.65	56,507,190
Palm Coast Sand Wave	19,656	4	-100.39	-100.39 to -50.85	0.90	1,773,923,019
Sawgrass Bank	58,653	12	-104.99	-104.99 to -49.87	0.75	4,843,895,097
St. Augustine Eeb-tidal Delta	5,680	1	-51.71	-51.71 to -1.97	0.70	364,802,151
St. Johns Bank	83,966	17	-125.89	-125.89 to -60.70	0.65	5,811,519,884
Summer Haven Sand Wave	55,722	11	-100.33	-100.33 to -48.56	0.70	4,111,953,409
Total	**332,253**	**69**				**36,720,311,763**

FLAGLER COUNTY

Morphosedimentary Features	Shelf Area (ha)	% of County Continental Shelf Area	Height of Plane (ft)	Range (ft)	% Area Used in Volume Calculations	Sediment Volume (cy)
Beverly Shoal	1,248	1	-64.30	-64.30 to -49.44	0.85	27,211,953
Bunnel Ridge Field	7,858	4	-76.44	-76.44 to -44.29	0.45	157,528,249
Espanda Ridge Field	1,325	1	-69.91	-69.91 to -51.84	0.95	41,304,138
Farmton Sand Flat A	4,163	2	-78.97	-78.97 to -53.48	1.00	137,021,760
Farmton Sand Flat B	28,764	16	-75.13	-75.13 to -8.60	1.00	1,751,482,932
Flagler Sand Wave	57,210	31	-98.56	-98.56 to -43.96	0.95	6,055,565,761
Korona Ridge Field	6,381	3	-81.04	-81.04 to -54.20	0.80	283,848,808
Palm Coast Sand Wave A	477	<1	-99.74	-99.74 to -84.74	0.75	11,279,145
Palm Coast Sand Wave B	5,305	3	-90.45	-90.45 to -49.54	0.95	514,162,775
St. Johns Bank	50,006	27	-111.55	-111.55 to -57.74	0.50	2,197,992,485
Volusia Bank	12,172	7	-103.67	-103.67 to -63.16	0.65	598,700,049
Total	**174,911**	**94**				**11,776,098,055**

VOLUSIA COUNTY

Morphosedimentary Features	Shelf Area (ha)	% of County Continental Shelf Area	Height of Plane (ft)	Range (ft)	% Area Used in Volume Calculations	Sediment Volume (cy)
Allandale Shoal	675	<1	-59.25	-59.25 to -41.67	0.75	12,459,973
Bunnel Ridge Field	580	<1	-67.09	-67.09 to -48.56	0.30	4,730,003
Canaveral Transverse Bar	929	<1	-51.71	-51.71 to -8.23	0.35	17,976,330
Edgewater Ridge Field	15,979	4	-76.12	-76.12 to -41.34	0.95	943,126,909
Farmton Sand Flat	87,864	23	-78.18	-78.18 to 0	1.00	6,386,947,776
Korona Ridge Field	15,098	4	-74.25	-74.25 to -35.76	1.00	910,571,931
Oak Hill Shoal	1,813	<1	-66.17	-66.17 to -32.81	0.60	47,892,296
St. Johns Bank	2,990	1	-113.16	-113.16 to -72.51	0.95	213,500,704
Volusia Bank	154,745	40	-115.81	-115.81 to -47.90	0.80	19,797,286,537
Total	**280,671**	**72**				**28,334,492,459**

LEGEND:

- CITIES
- FDEP MONUMENTS
- ROADS
- COUNTY LINES
- FEDERAL / STATE BOUNDARY
- MATCHLINE

OFFSHORE MORPHOLOGY VOLUME IN CUBIC YARDS:

- 57,609 - 13,000,000
- 13,000,000 - 130,000,000
- 130,000,000 - 650,000,000
- 650,000,000 - 1,300,000,000
- 1,300,000,000 - 4,000,000,000
- 4,000,000,000 - 7,800,000,000
- 7,800,000,000 - 14,000,000,000

N

0 6 12 Kilometers

TITLE:

POTENTIAL SAND RESOURCES ALONG THE NORTHEAST FLORIDA ATLANTIC COAST

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 07/27/07 | BY: HMV | COMM NO: 7849.29 | **FIGURE 4-47**

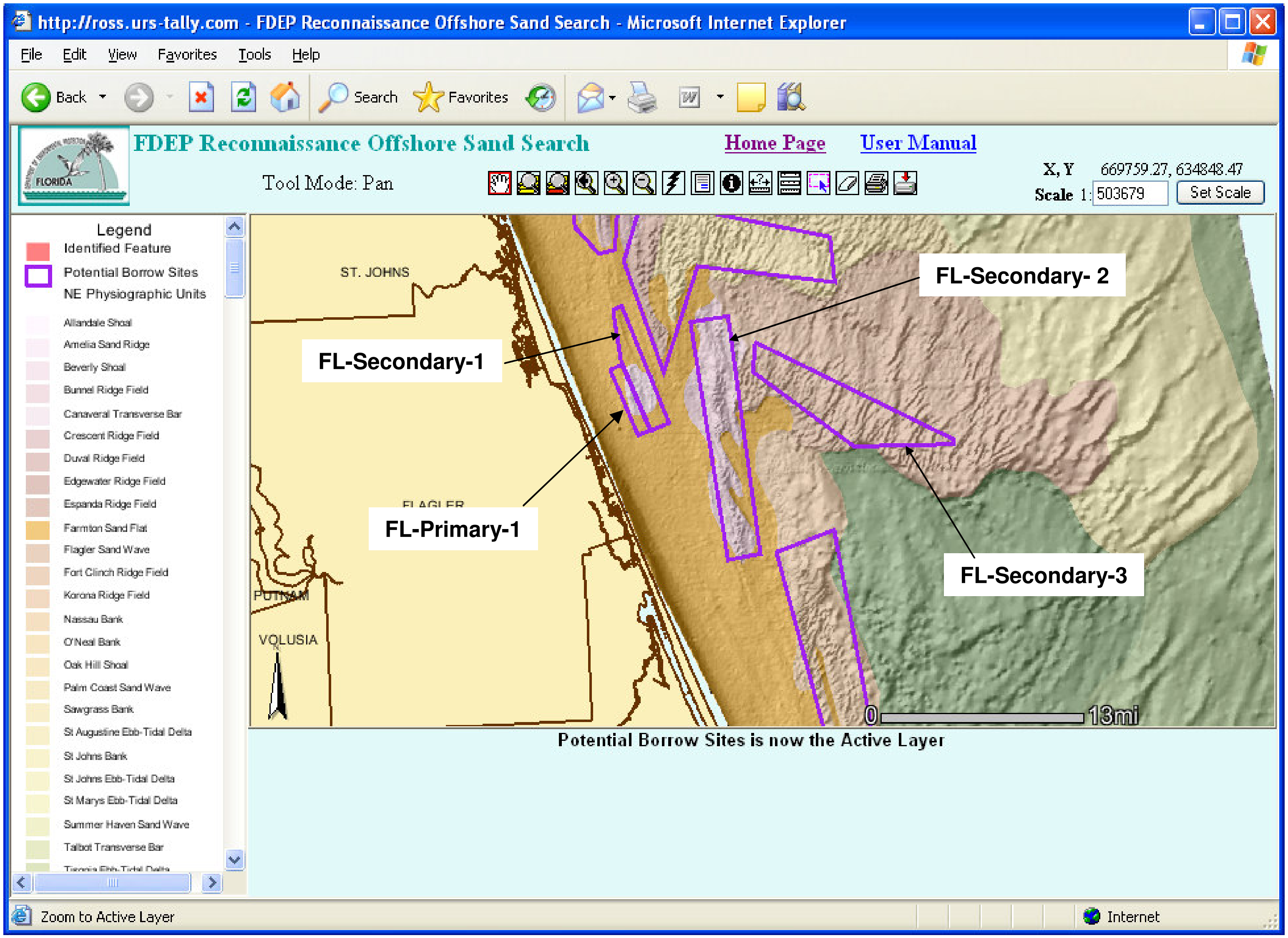


Figure 4-48. Flagler County Area showing nearshore Potential Borrow Areas and physiographic zones.

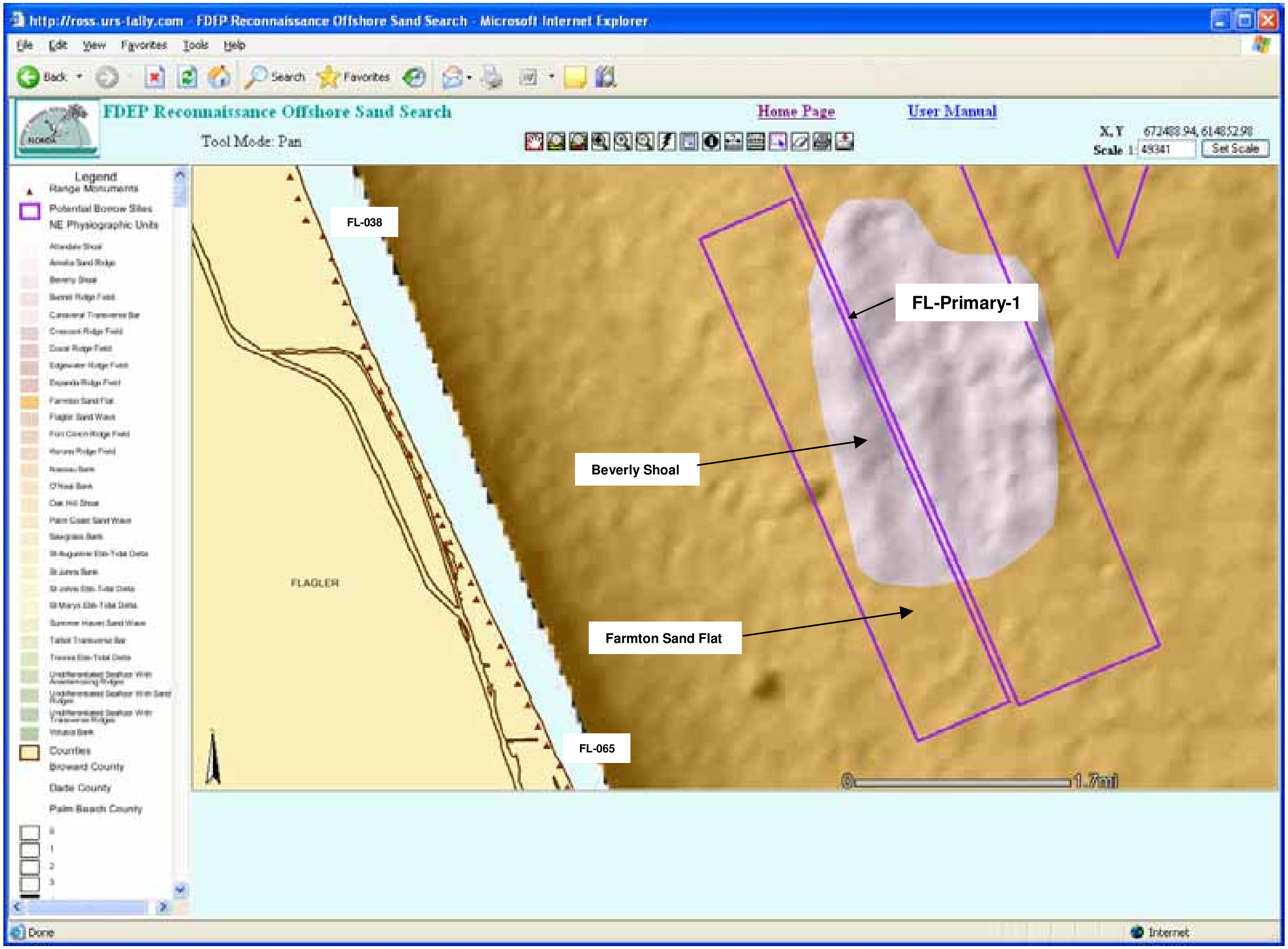


Figure 4-49. Flagler County Area FL-Primary-1 showing physiographic zones overlaying the gray scale image.

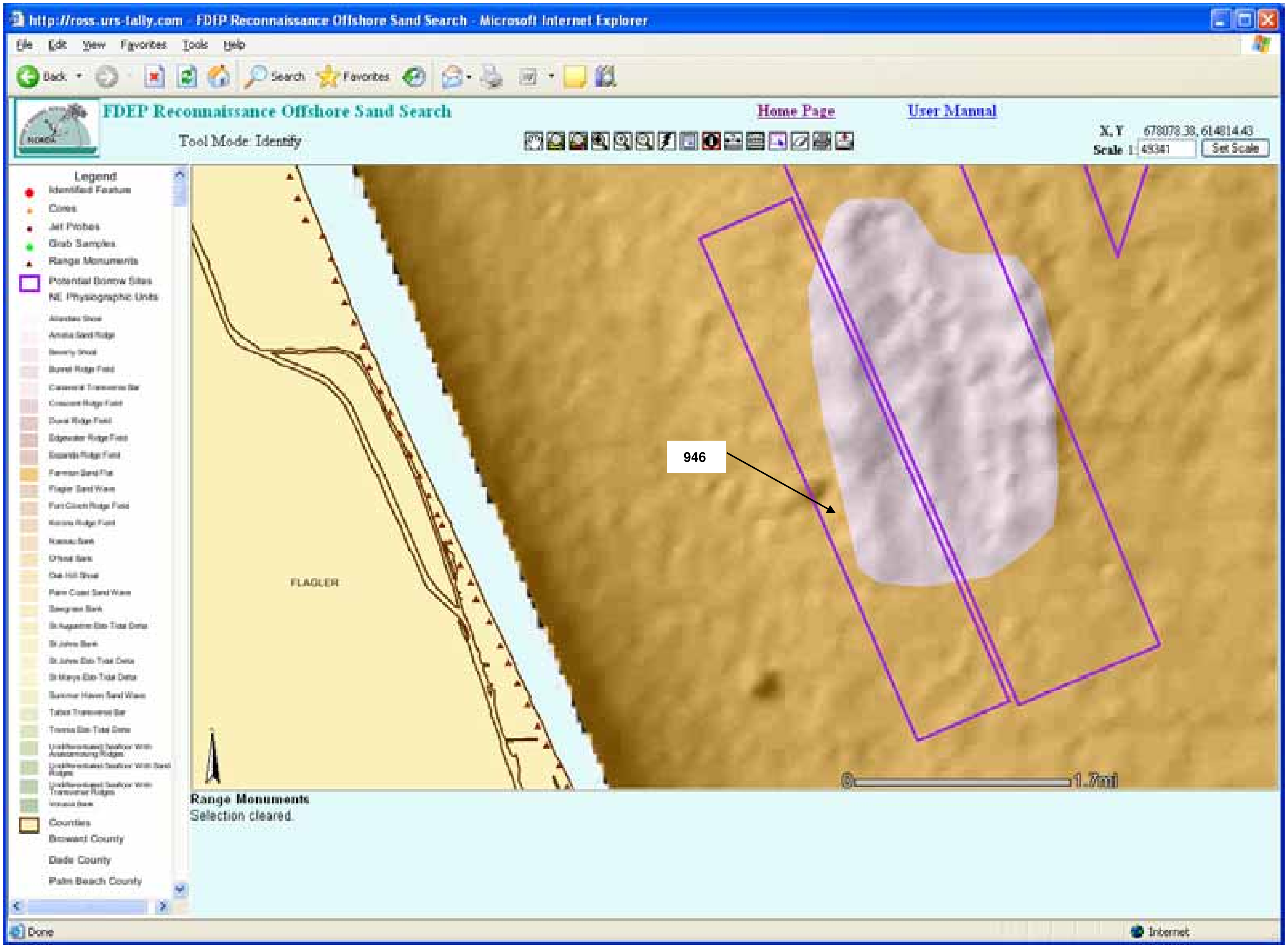


Figure 4-50. Flagler County Area FL-Primary-1 showing Vibracore location.

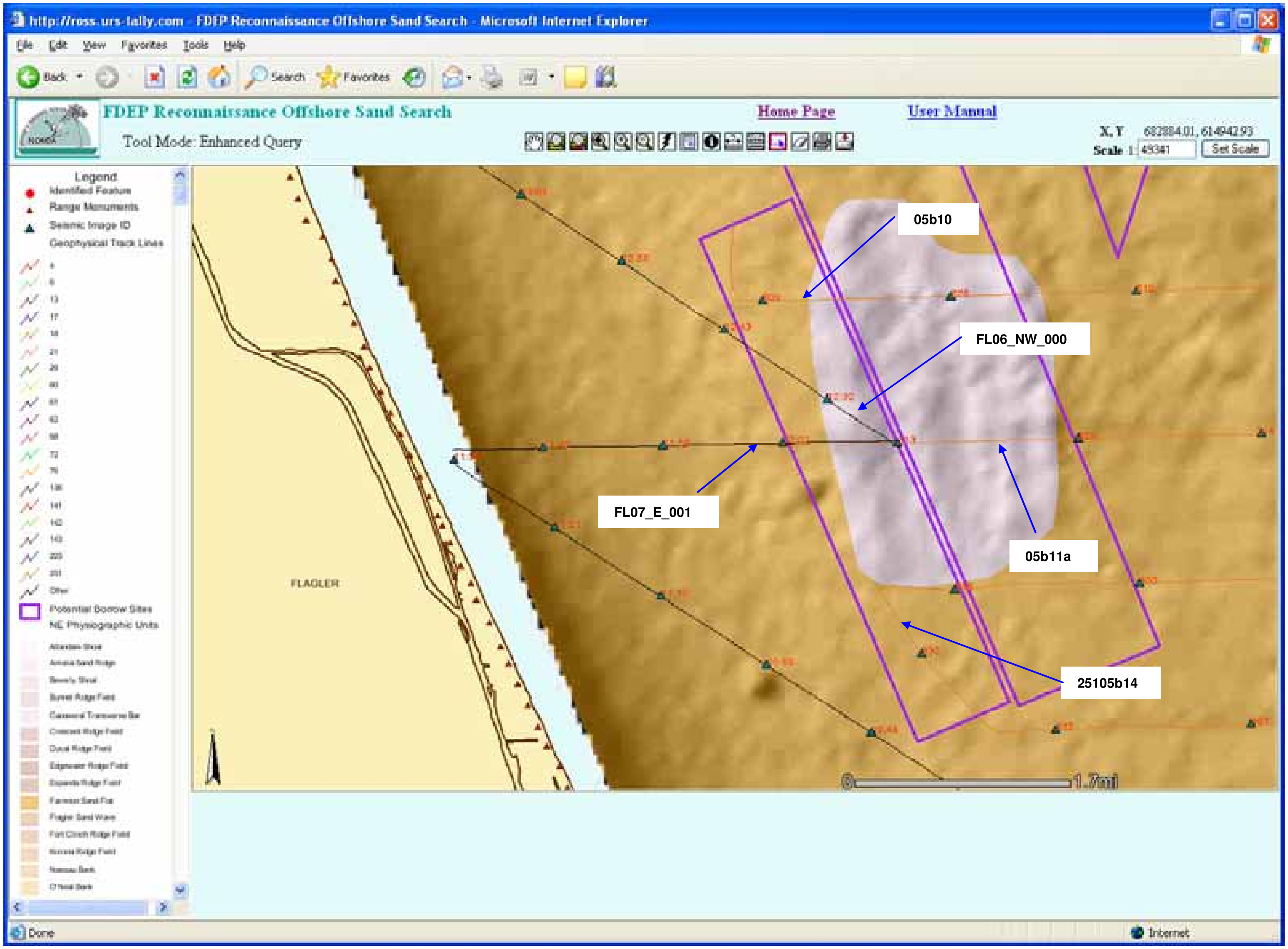
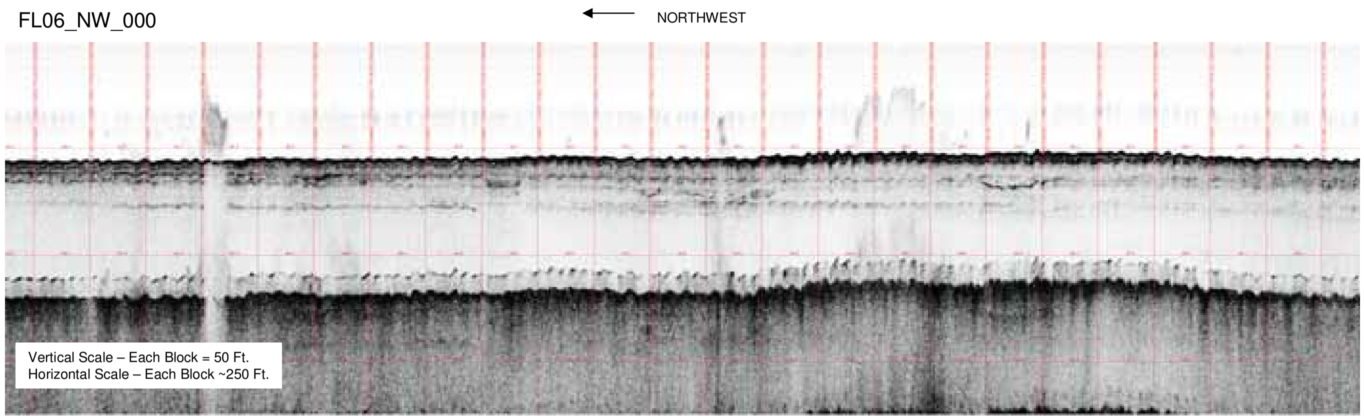


Figure 4-51. Flagler County Area FL-Primary-1 showing geophysical trackline locations and timestamps.

FL06_NW_000



FL07_E_001

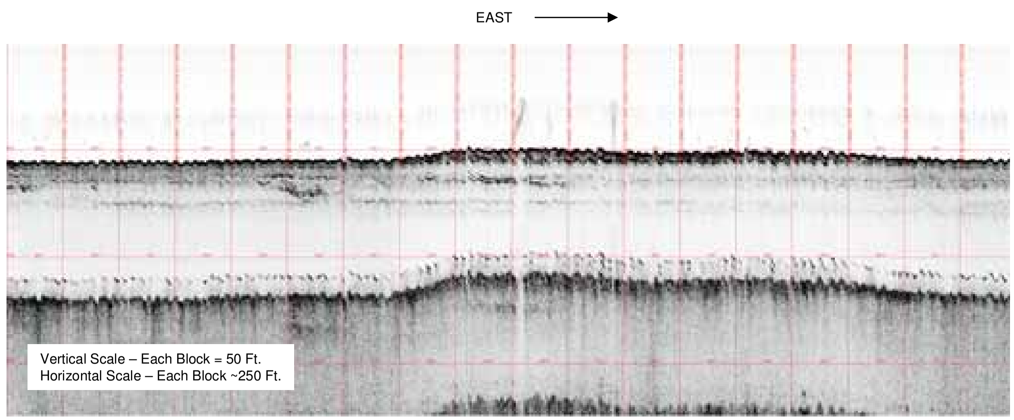


Figure 4-52. Flagler County Area FL Primary 1. Portions of linesFL06_NW_000 (above) and FL07_E_001 (below).

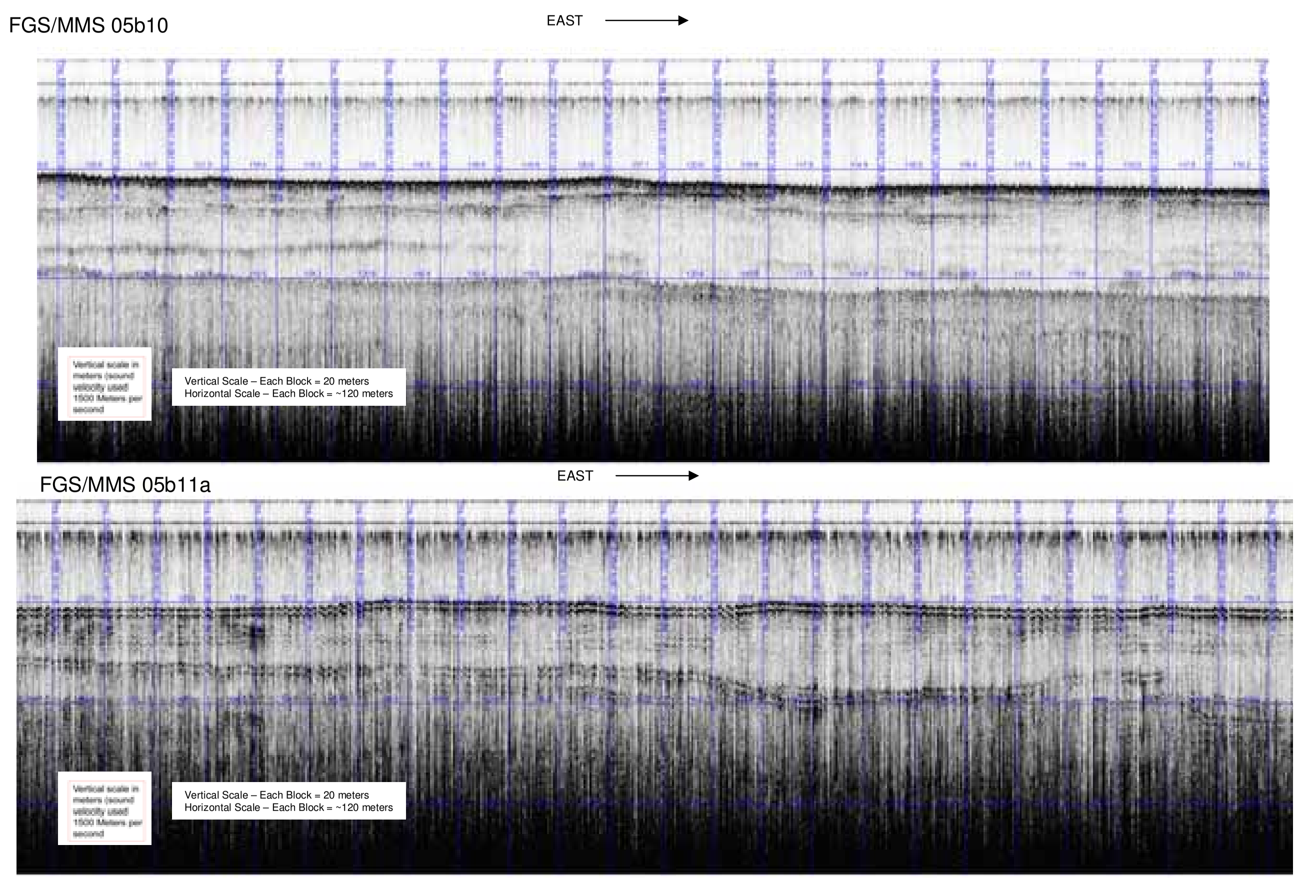


Figure 4-53. Flagler County Area FL Primary 1. Portions of FGS/MMS lines05b10 (above) and 05b11a (below) which cross over the main feature.

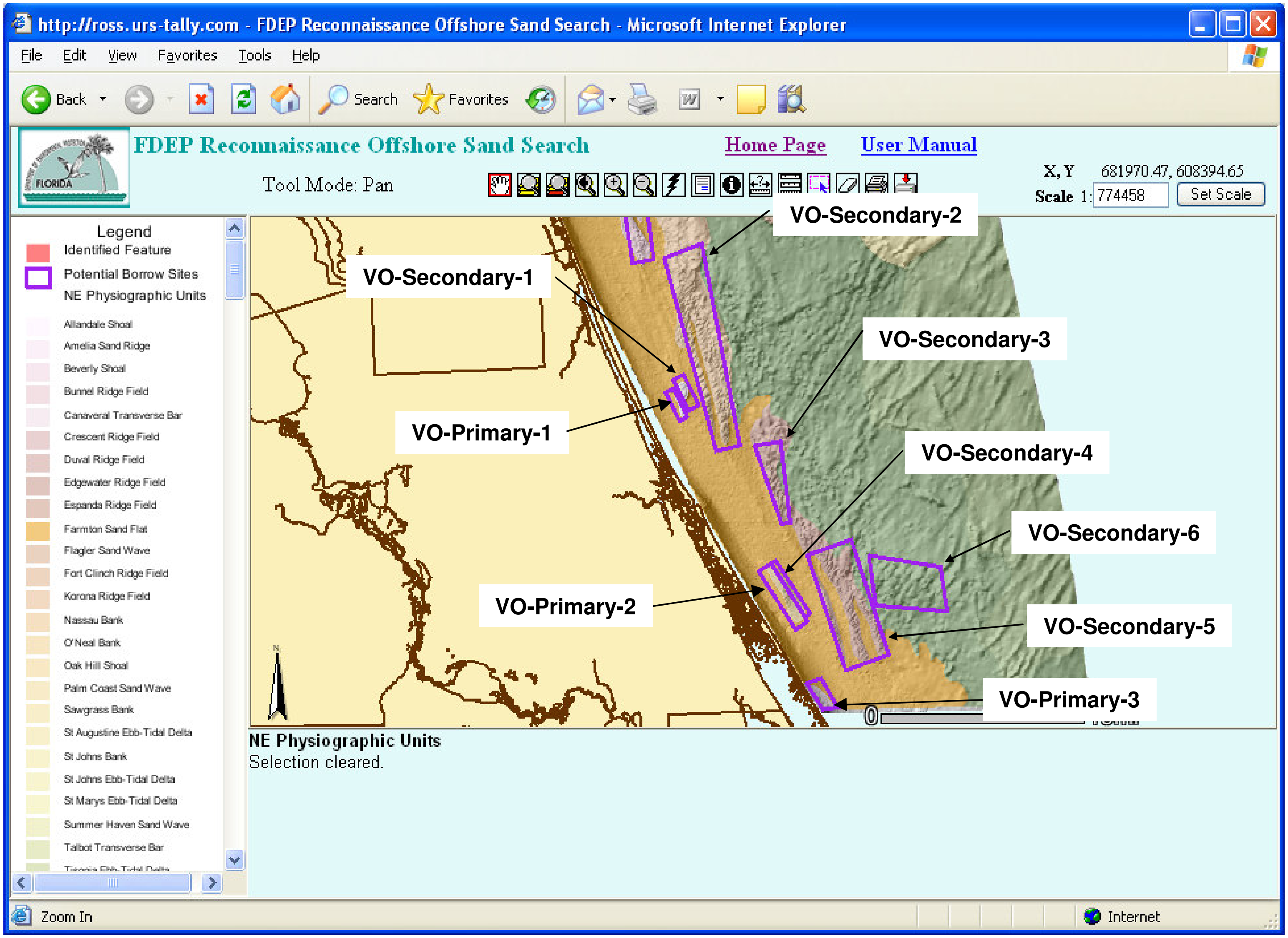


Figure 4-54. Volusia County Area showing nearshore Potential Borrow Areas

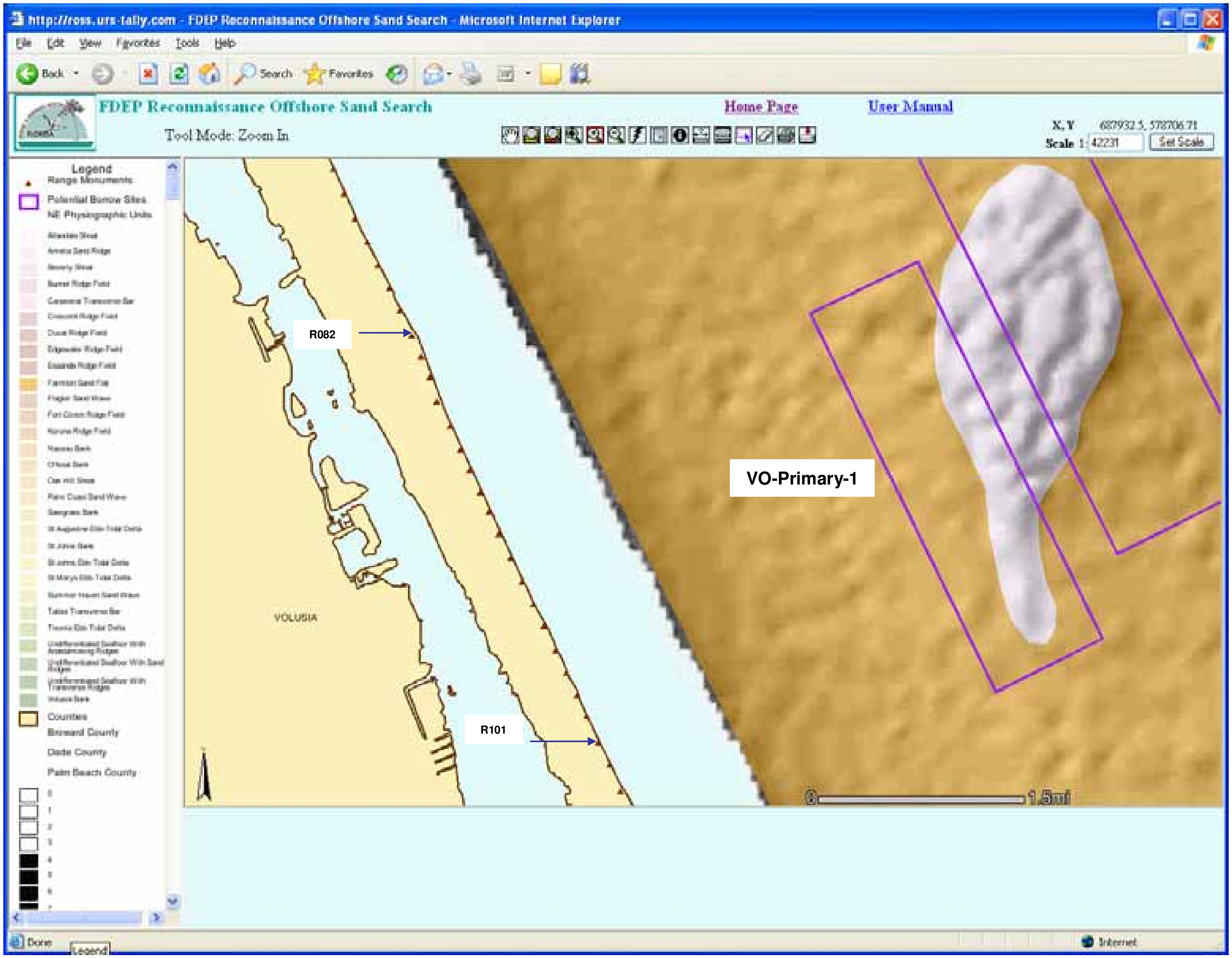


Figure 4-55. Volusia County Area VO-Primary-1 showing physiographic zones overlaying the gray scale image.

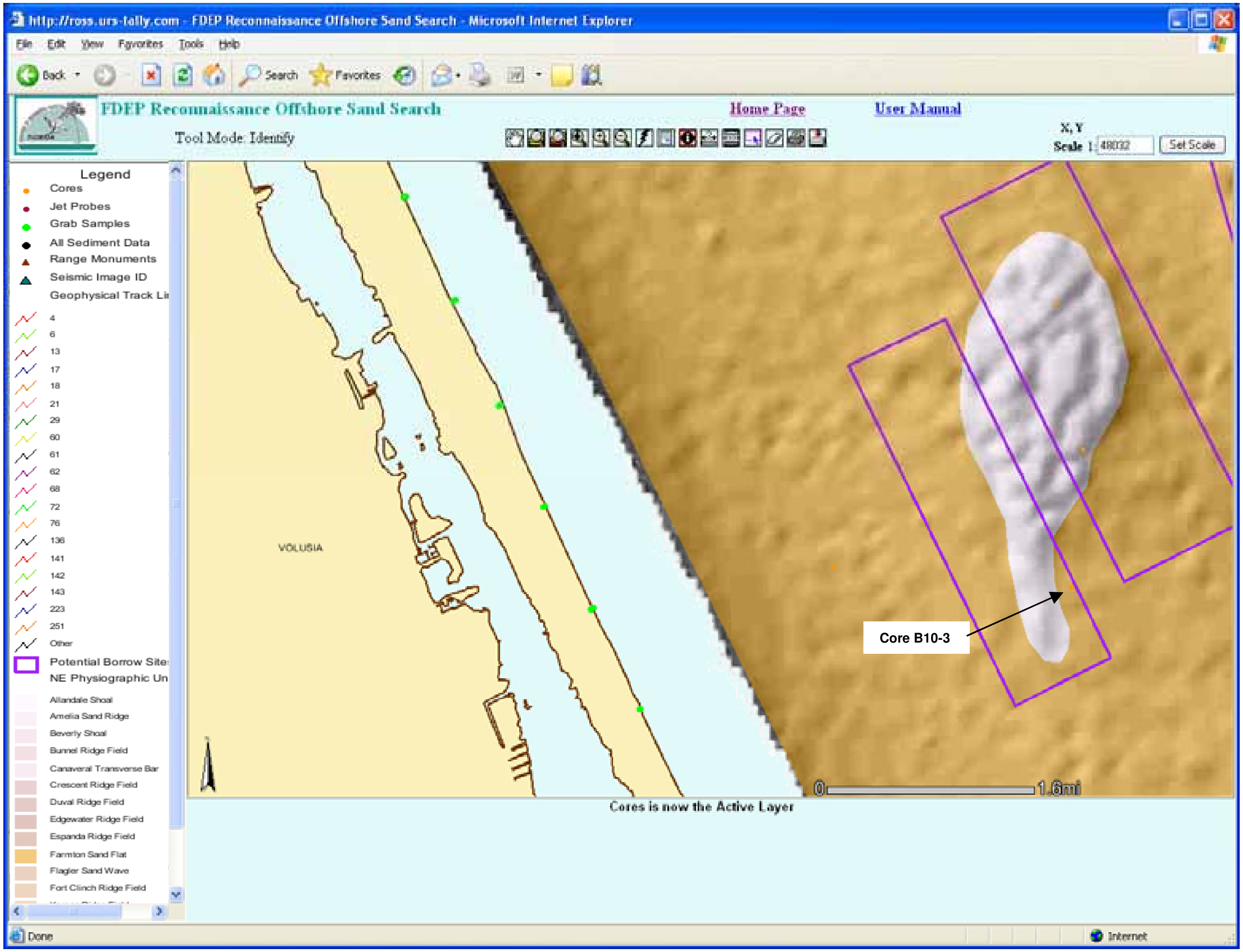


Figure 4-56. Volusia County Area VO-Primary-1 showing locations of vibracore B10-3.

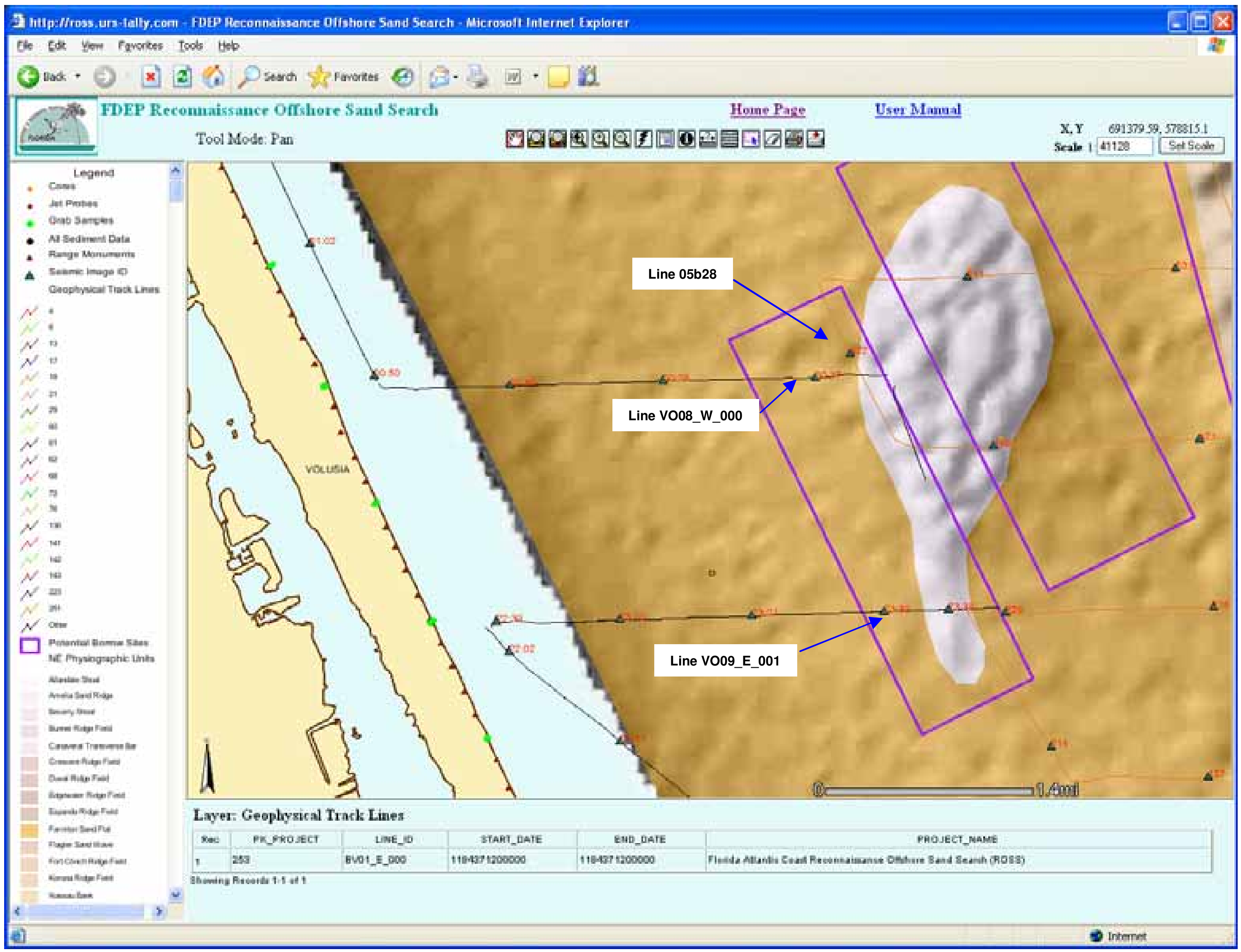
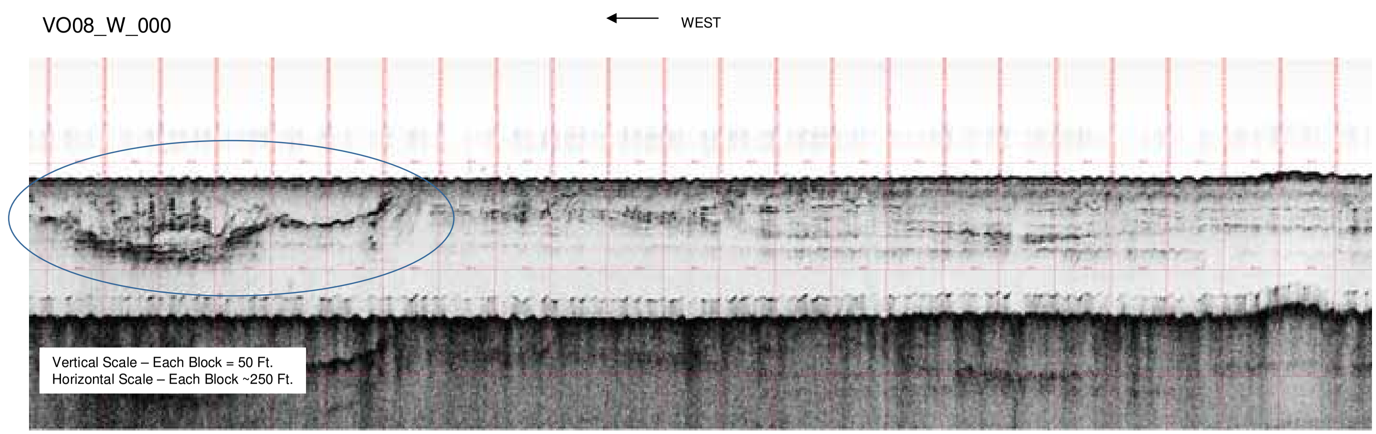


Figure 4-57. Volusia County Area VO-Primary-1 showing selected trackline locations.



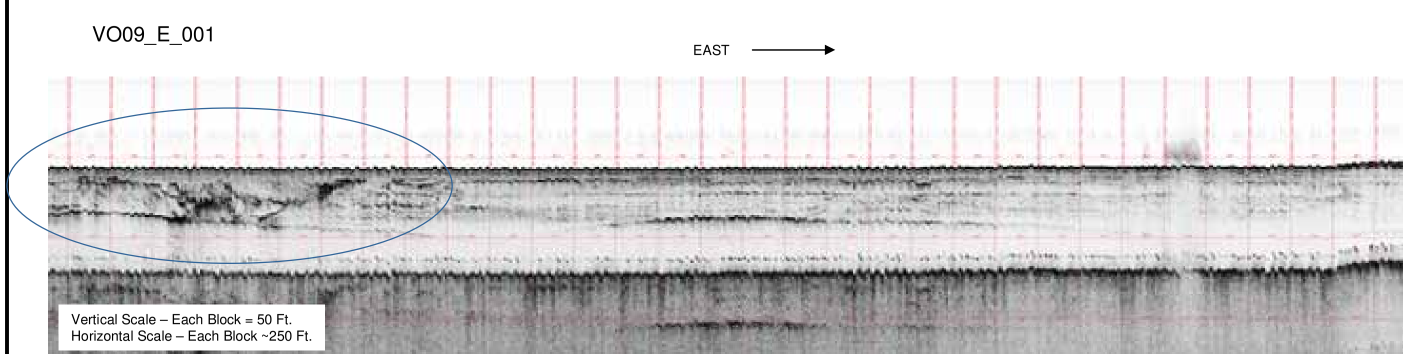


Figure 4-58. Volusia County Area VO Primary 1. Portions of linesVO08_W_000 (above) and VO09_E_001 (below). Paleo-channels are circled in blue.

FGS/MMS 05b28

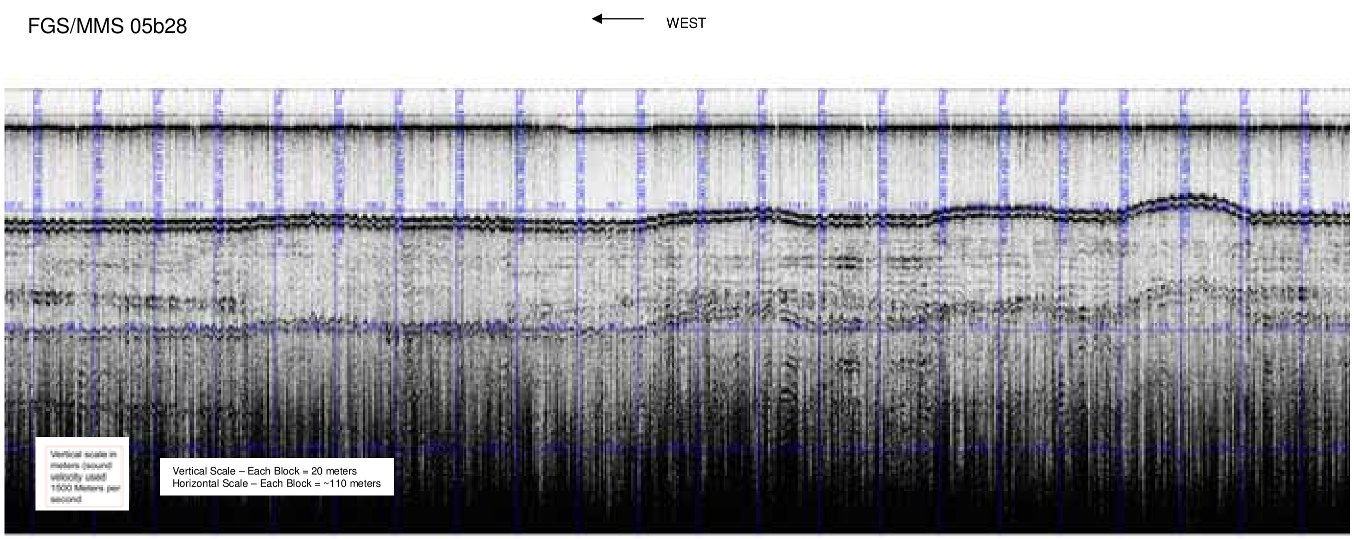


Figure 4-59. Volusia County Area VO Primary 1. Portions of FGS/MMS line 05b28 showing ridges of the Beverly Shoal in area VO Primary 1

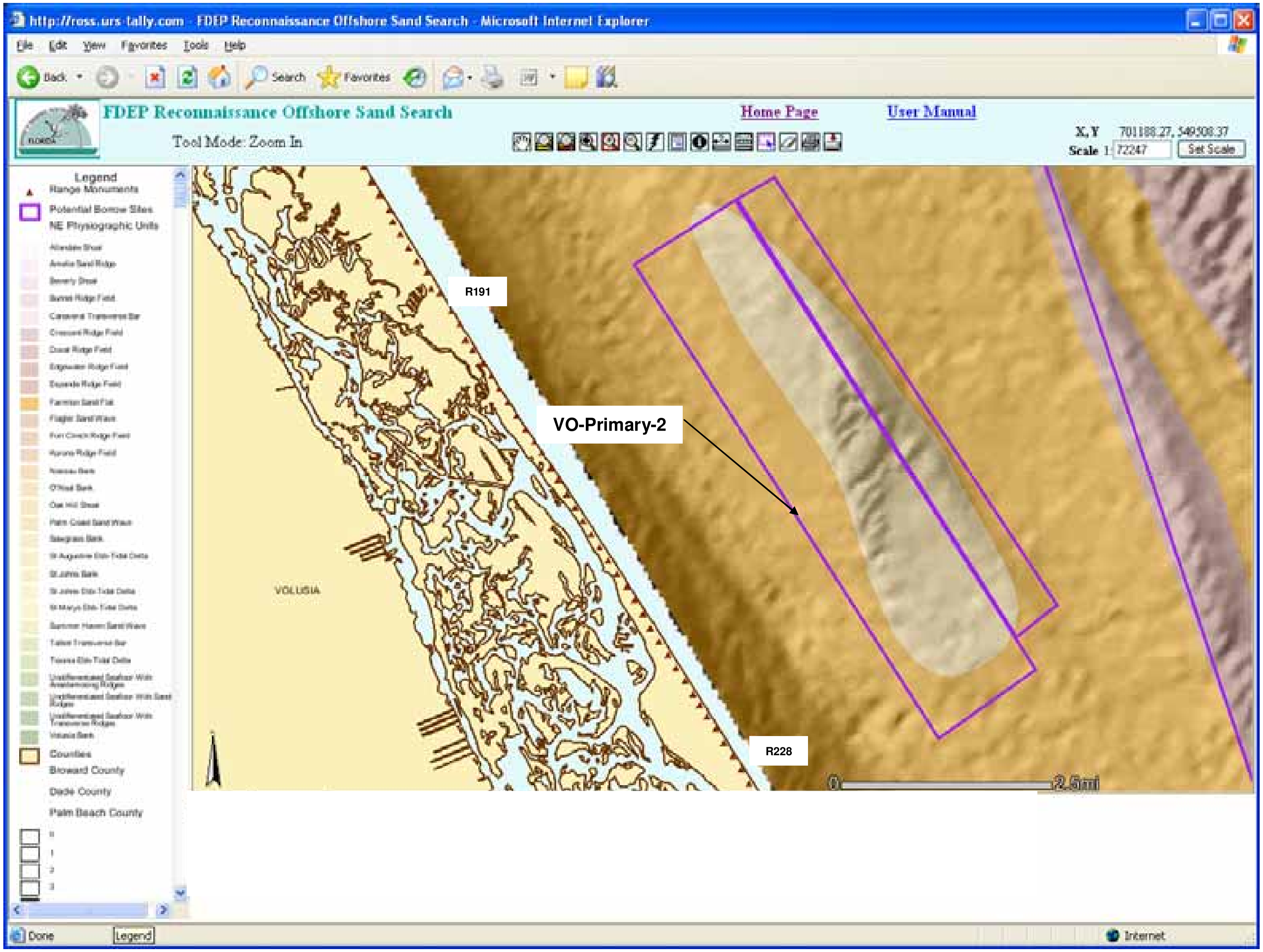


Figure 4-60. Volusia County Area VO-Primary-2 showing physiographic zones overlaying the gray scale image.

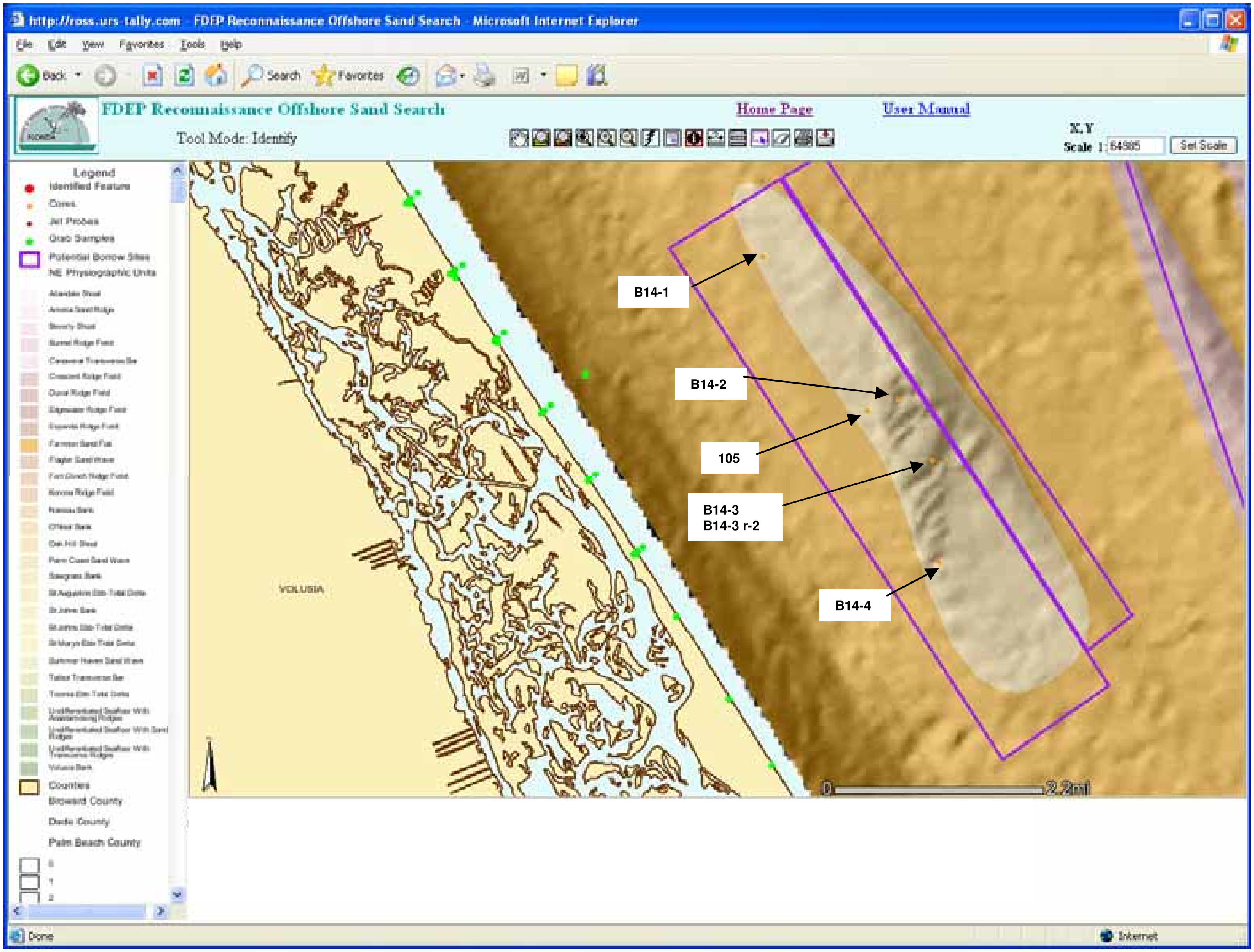


Figure 4-61. Volusia County Area VO-Primary-2 showing locations of cores.

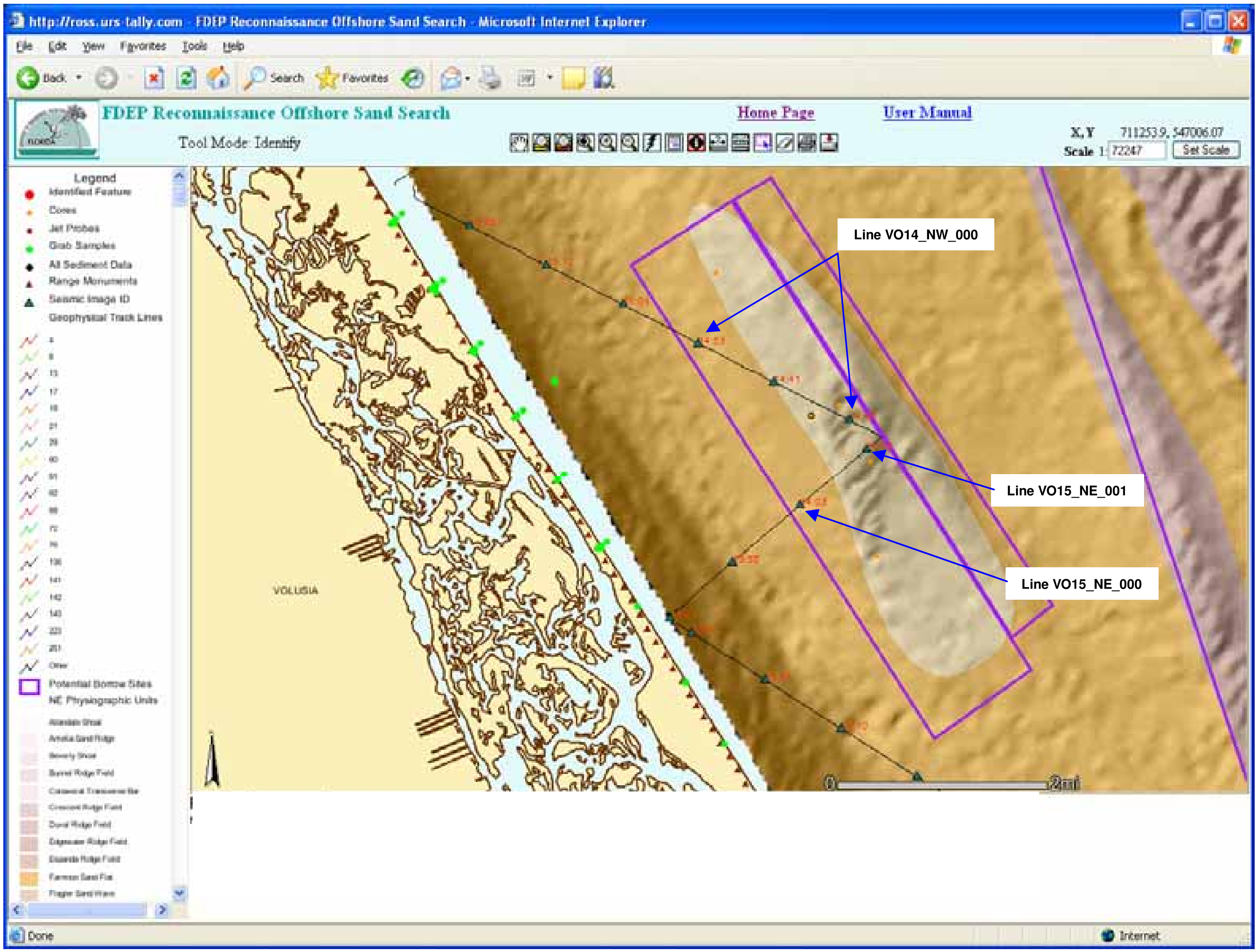


Figure 4-62. Volusia County Area VO-Primary-2 showing selected trackline locations.

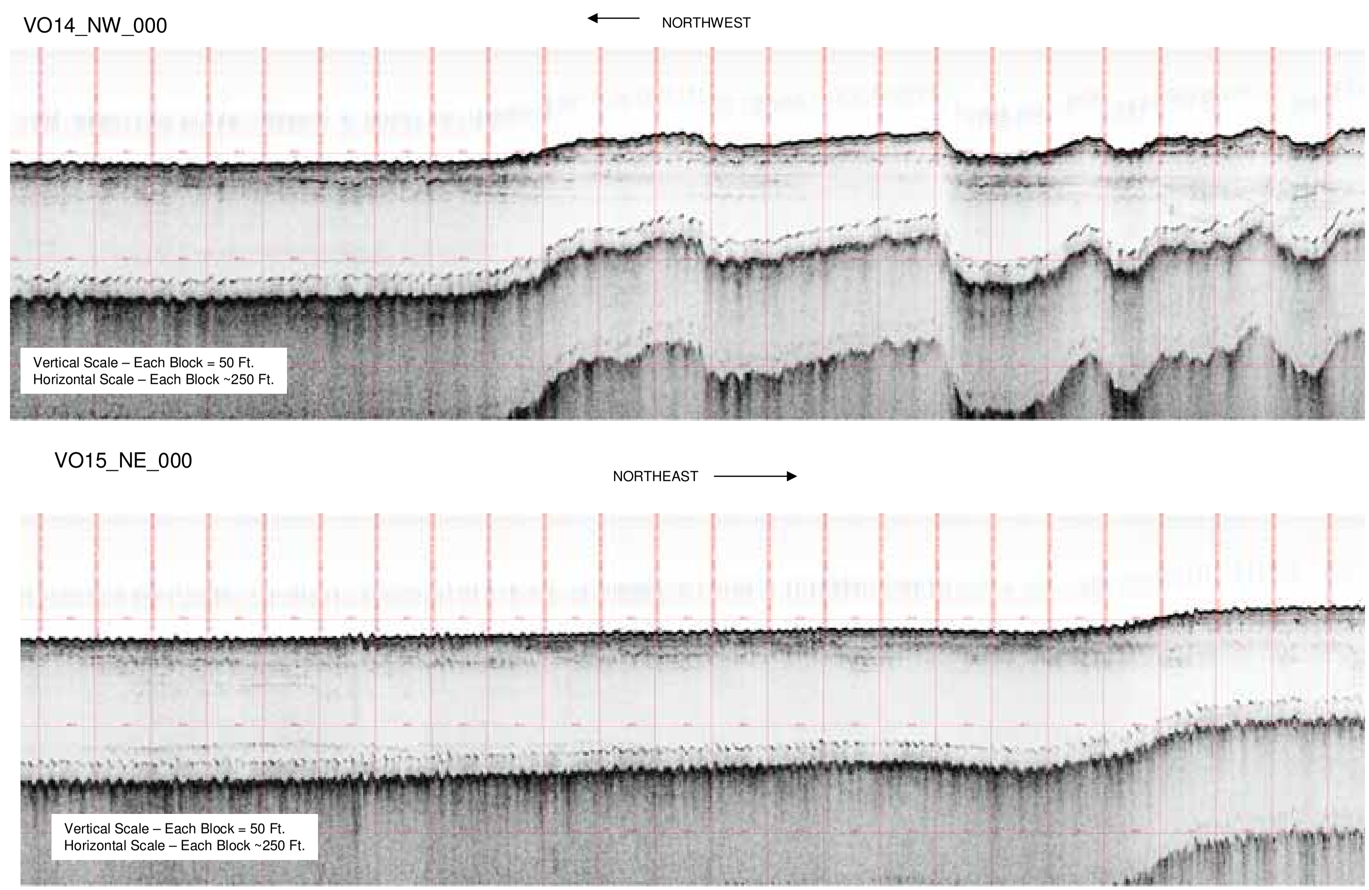


Figure 4-63. Volusia County Area VO Primary 2. Portions of linesVO14_NW_000 (above) and VO15_NE_000 (below).

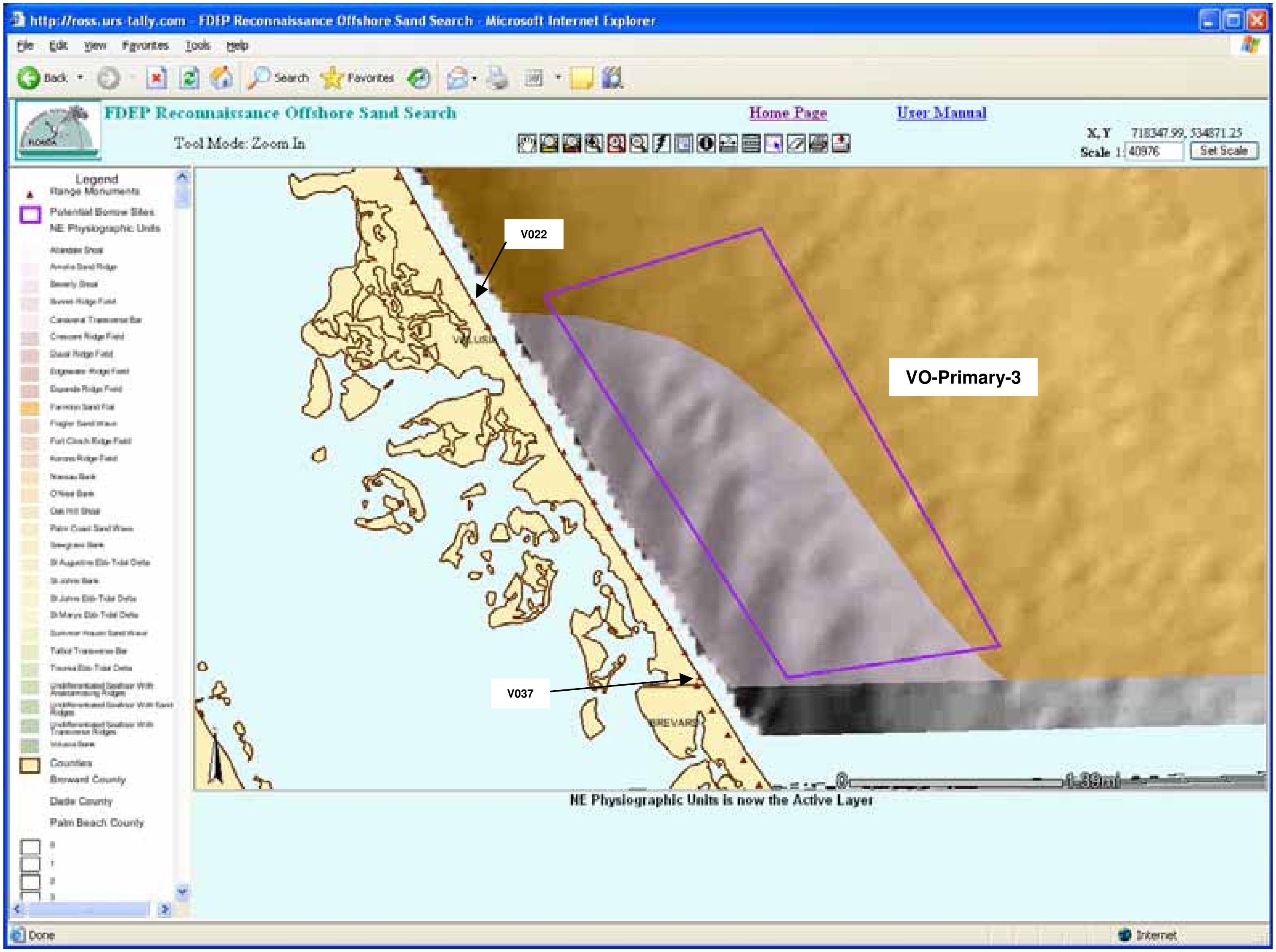


Figure 4-64. Volusia County Area VO-Primary-3 showing physiographic zones overlaying the gray scale image.

Environmentally sensitive areas, shown in Figures 5-1A and 5-1B, include artificial reefs, and various types of critical habitat. Other than the dredged materials disposal sites in Duval Ridge Field off Nassau and Duval counties, the right whale critical habitat, and the aquatic preserve on the Farmton Sand Flat off St. Johns County, most critical habits are located onshore. The latter category includes but is not limited to areas associated with the National Estuary Program, the Coastal Barrier Resource System, the Rare and Imperiled Waters, the Nature Conservancy Ecological Areas, and salt marshes. All of these areas are shown in relation to offshore morpho-sedimentary features or to onshore occurrences in relation to cadastral features. Thus, most of the environmentally sensitive areas do not occur offshore, but are restricted to estuarine waters that lie landward of barrier islands.

The data sources used to compile the geographic distributions of environmentally sensitive areas are summarized in Table 5-1. Although this list is not definitive, it provides the major sources of information where further data might be obtained, including GIS shape files.

The open ocean beach-dune system is more complicated than the offshore environmentally sensitive areas. Here, sea turtle nesting sites are generally pervasive through the study area. Piping plover critical habitat occurs near R080 (Nassau County) to R030 in Duval County (Figure 5-1A) within an aquatic preserve. Information related to environmentally sensitive areas may be found by visiting websites of the organizations listed in Table 5-1. More detailed information regarding environmentally sensitive areas should be obtained from the appropriate agency.

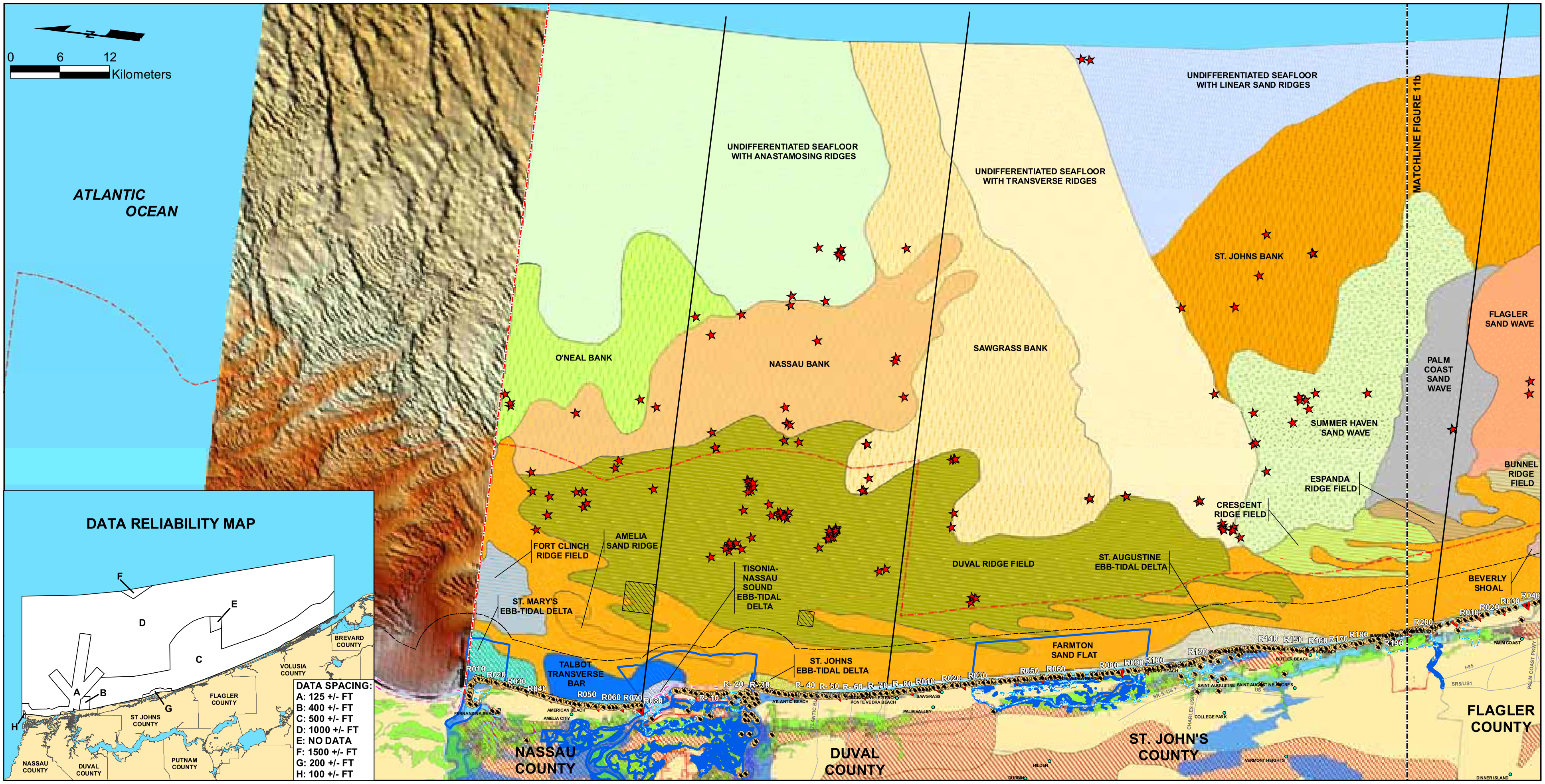
Each environmentally sensitive area retains it own specialized requirements for transit or access and the appropriate agency should be contacted to ensure conformation to rules and regulations. Even though most offshore potential sand resources are not severely impacted by environmental constraints, included here are examples of nearshore, onshore, and backshore environmentally sensitive areas that are sometimes involved in beach renourishment projects, especially in the case of dune restoration in conjunction with beach nourishment (berm building). The geographic distribution of environmentally sensitive areas shown in Figures 5-1A and 5-1B are thus examples of the types of environments that might be affected. These figures should not be construed as a final document and for that reason; appropriate agencies need to be contacted if and when beach nourishment activities are contemplated.

Table 5-1. Data sources used to compile Figures 5-1A and 5-1B showing environmentally sensitive areas on the northeast Florida Atlantic coast.

DATA	SOURCE
Aquatic Preserves[1]	Florida Department of Environmental Protection
Artificial Reefs[2] (Deployment Events)	Florida Fish and Wildlife Conservation Commission, Division of Marine Fisheries Management
Beach Renourishment Projects[a]	Beach Erosion Control Project Monitoring Database, Florida State University
Coastal Barrier Resource System[3]	National Oceanic Atmospheric Administration, Coastal Service Center
Johnson's Seagrass Critical Habitat[4]	National Coastal Data Development Center
Manatee Critical Habitat	United States Fish and Wildlife Service
Mangroves[5]	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
National Estuary Program Areas[6]	National Oceanic Atmospheric Administration, Coastal Service Center
Nature Conservancy Priority Ecological Resource Areas[7]	Florida Natural Areas Inventory
Piping Plover Critical Habitat[a]	United States Fish And Wildlife Service
Right Whale Critical Habitat[8]	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Salt marsh Locations[9]	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Seagrass[10]	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Sea Turtle Nesting Sites[a]	Florida Fish and Wildlife Conservation Commission
State Parks[11]	Florida Department of Environmental Protection
Watershed Locations Of Rare & Imperiled Fish[12]	Florida Fish and Wildlife Conservation Commission

1. 1997 publication date.
2. 2006 publication date.
3. 1998 ground condition.
4. USACE version not complete.
5. 1994 ground condition.
6. 2006 publication date.
7. 1991 ground condition.
8. 2002 ground condition.
9. 1999 publication date.
10. 1999 publication date.
11. 2006 publication date.
12. 2003 publication date.

a. Need to update with online report.



LEGEND:

- ARTIFICIAL REEFS
- SEA TURTLE NESTING
- CITIES
- FDEP MONUMENTS
- ROADS
- COUNTY LINES
- GEORGIA / FLORIDA STATE LINE
- FEDERAL / STATE BOUNDARY
- MATCHLINE
- RIGHT WHALE CRITICAL HABITAT
- NATIONAL ESTUARY PROGRAM
- DREDGE MATERIALS DISPOSAL SITES
- COASTAL BARRIER RESOURCE SYSTEM
- AQUATIC PRESERVES
- SALTMARSH
- RARE & IMPERILED WATERS
- NATURE CONSERVANCY PRIORITY ECOLOGICAL AREAS
- MANATEE CRITICAL HABITAT
- PIPING PLOVER CRITICAL HABITAT

GEOMORPHOLOGY

RIDGES
- AMELIA SANDRIDGE
- BUNNEL RIDGE FIELD
- CRESCENT RIDGE FIELD
- DUVAL RIDGE FIELD
- ESPANDA RIDGE FIELD
- FORT CLINCH RIDGE FIELD

SHOALS
- BEVERLY SHOAL

BANKS
- SAWGRASS BANK
- ST. JOHNS BANK
- NASSUA BANK
- O'NEAL BANK

SAND FLAT
- FARMTON SAND FLAT

SAND WAVES
- FLAGLER SAND WAVE
- PALM COAST SAND WAVE
- SUMMER HAVEN SAND WAVE

EBB-TIDAL DELTAS
- ST. AUGUSTINE EBB-TIDAL DELTA
- ST. JOHNS EBB-TIDAL DELTA
- ST. MARY'S EBB-TIDAL DELTA
- TISONIA-NASSAU SOUND EBB-TIDAL DELTA

TRANSVERSE BAR
- TALBOT TRANSVERSE BAR

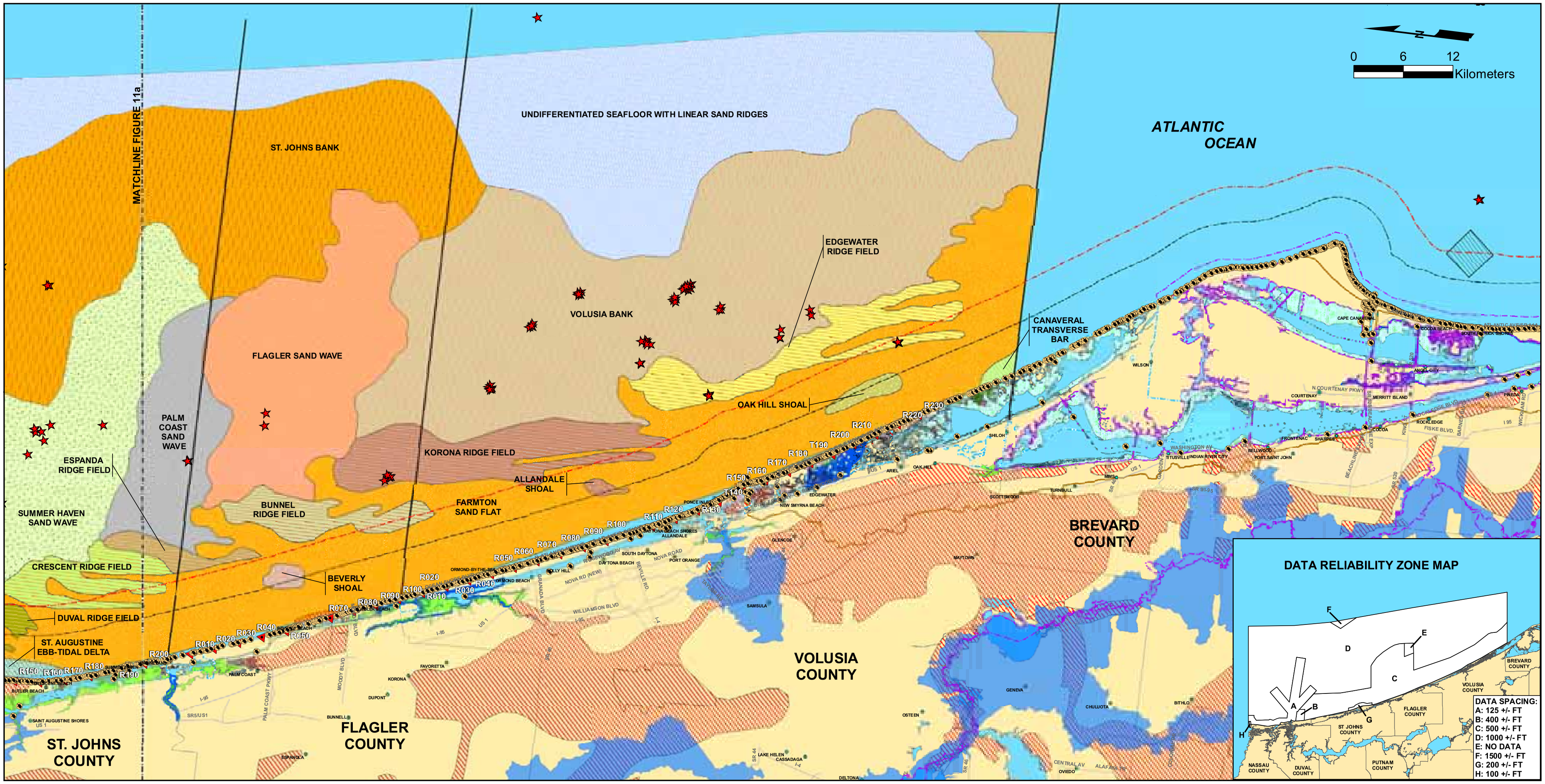
UNDIFFERENTIATED SEAFLOORS
- UNDIFFERENTIATED SEAFLOOR WITH TRANSVERSE RIDGES
- UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGES
- UNDIFFERENTIATED SEAFLOOR WITH ANASTAMOSING RIDGES

TITLE:

ENVIRONMENTALLY SENSITIVE AREAS IN NASSAU, DUVAL, ST. JOHNS, FLAGLER, & VOLUSIA COUNTIES NORTHEAST FLORIDA ATLANTIC COAST

CPE COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07	BY: HMV	COMM NO: 7849.29	FIGURE 5-1A



LEGEND:

- SEA TURTLE NESTING
- ARTIFICIAL REEFS
- FDEP MONUMENTS
- CITIES
- MATCHLINE
- FEDERAL / STATE BOUNDARY
- COUNTY LINES
- ROADS
- RIGHT WHALE CRITICAL HABITAT
- NATIONAL ESTUARY PROGRAM
- DREDGE MATERIALS DISPOSAL SITES
- COASTAL BARRIER RESOURCE SYSTEM
- AQUATIC PRESERVES
- SALTMARSH
- RARE & IMPERILED WATERS
- MANGROVES
- 1999 SEAGRASS
- NATURE CONSERVANCY PRIORITY ECOLOGICAL AREAS
- MANATEE CRITICAL HABITAT
- PIPING PLOVER CRITICAL HABITAT

GEOMORPHOLOGY

RIDGES
- BUNNEL RIDGE FIELD
- CRESCENT RIDGE FIELD
- DUVAL RIDGE FIELD
- EDGEWATER RIDGE FIELD
- ESPANDA RIDGE FIELD
- KORONA RIDGE FIELD

SHOALS
- ALLANDALE SHOAL
- BEVERLY SHOAL
- OAK HILL SHOAL

BANKS
- ST. JOHNS BANK
- VOLUSIA BANK

SAND FLAT
- FARMTON SAND FLAT

SAND WAVES
- FLAGLER SAND WAVE
- PALM COAST SAND WAVE
- SUMMER HAVEN SAND WAVE

TRANSVERSE BAR
- CANAVERAL TRANSVERSE BAR

EBB-TIDAL DELTAS
- ST. MARY'S EBB-TIDAL DELTA

UNDIFFERENTIATED SEAFLOORS
- UNDIFFERENTIATED SEAFLOOR WITH LINEAR SAND RIDGES

TITLE:

ENVIRONMENTALLY SENSITIVE AREAS IN NASSAU, DUVAL, ST. JOHNS, FLAGLER, & VOLUSIA COUNTIES NORTHEAST FLORIDA ATLANTIC COAST

CPE
COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 7/27/07 | BY: HMV | COMM NO: 7849.29 | FIGURE 5-1B

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6.1 METHODOLOGICAL APPROACH FOR SAND SEARCHES ON THE NORTHEAST COAST OF FLORIDA

Offshore sand resources along the northeast coast of Florida occur in six main depositional settings: (1) sand flats on the inner shelf, (2) ebb-tidal deltas on the inner shelf, (3) sand waves on the middle shelf, (4) shoals on the middle shelf, (5) banks on the middle shelf and (6) sand ridges on the outer shelf. The northeast coast of Florida lies on the Atlantic and Gulf Coast Physiographic Province (Walker and Coleman, 1987). The seaward side of the study area contains a portion of the Atlantic continental shelf. Almost all of it is covered by a surficial sand sheet (Hollister, 1985). The shelf is also characterized by fields of linear, northeast-trending sand ridges (Duane *et al*., 1972). These ridges are typically less than 10 m thick and contain medium grained, well-sorted sand that is similar to sand along the present shoreline.

Searches for beach quality sand in sand flats or in sand ridges should be based on investigations that follow a logical progression of steps. Sand search procedures developed, for example, by Finkl, Khalil and Andrews (1997), Benedet *et al.* (2004), Finkl and Khalil (2005) and Finkl *et al.* (2006) follow strategic sand search protocols that are widely accepted in the industry. The three-phased protocol suggests that, in areas where bathymetrically positive features (e.g. sand ridges, bars, and shoals) occur, reconnaissance investigations should concentrate on bathymetric data (preferably recently obtained) and reconnaissance sand samples (Phase I), followed by jet probes (Phase II) and finally seismic reflection (sub-bottom) profiles and vibracores (Phase III).

A logical sequence of offshore sand searches targeting sand resources along the northeast coast of Florida should approximate the following steps. These suggested procedures can be adapted to individual survey requirements, but they nevertheless provide a basic framework for sequencing steps in a logical cost-effective progression.

6.1.1 Review of Historical Data

Using the ROSS database, the investigator should download historical datasets containing seabed relief information, descriptions of geotechnical data (vibracores, jet probes, and grain size data) and geophysical data (sidescan sonar and seismic reflection profiles) to identify initial target areas for more detailed investigation. The gray scale shaded relief image available from ROSS should be used to identify offshore morphosedimentary features (sand flats, ebb tidal deltas, sand waves, sand shoals, and sand ridges) occurring near a project area. The geotechnical and geophysical layers should then be turned on to see if available sediment data overlie morphosedimentary features of interest. This data may provide initial information regarding deposit thickness and sediment textural properties. After target areas are identified and data availability checked, the investigator can design a reconnaissance survey plan.

6.1.2 Reconnaissance Survey Plan

The reconnaissance survey plan should focus on obtaining better definition of seafloor geomorphology and morphosedimentary properties. Commonly, a few (more than five) morphosedimentary features are selected on the basis of the Phase 1 analyses. This list of potential sand targets is typically then narrowed down to one or two features for more detailed field investigations that may define final borrow areas.

The bathymetric data that is used to define the morphosedimentary features of interest in Phase 1 will most likely consist of historical NOAA-NOS data that may be several decades old. Because morphosedimentary features tend to be modified by tidal currents and wave action, an updated bathymetric survey is required to determine whether seafloor features have changed shape or migrated over time. A reconnaissance seismic reflection profile survey can be conducted simultaneously with the bathymetric survey to determine sediment thickness. Bathymetric data and seismic records (obtained from chirp systems such as the Edgetech 512i) can be used to determine sediment thickness and the results displayed in an isopachous map. Undesirable materials such as rubble layers or fine-grained sediments can normally be identified in seismic records if calibration data (*i.e.* historical vibracores) is available. Line spacing in reconnaissance surveys depends on the survey area, but generally ranges from 1000 to 2000 feet.

Traditionally, sand quality and thickness are investigated during preliminary sampling surveys using surface grab samples and jet probes. Because vibracores are more expensive and time-consuming, they are usually reserved for the detailed phases of offshore investigation after the search area has been narrowed to target areas using other methods.

Sand quality and thickness may be investigated during preliminary sampling surveys using surface samples, jet probes or widely spaced vibracores. Surface grab samples can be deceiving because they only sample the upper few inches of seafloor sediment (generally sediment transported by modern processes) and do not show the characteristics of deeper lying sediments. Jet probes are a cost-effective method to estimate sediment thickness and sediment quality in deeper layers. Because sediment samples extracted from jet probes are disturbed by the water jet, silt content may be underestimated.

One important consideration of sediment variability is that sand quality on the surface, as indicated by surface samples and widely spaced jet probes may not always be the most effective procedure to select morphosedimentary features for further investigation during reconnaissance efforts. It may be found, for example, that relict sediments underlying the feature surface contain cleaner sandy sediments (e.g. fewer shell and rubble fragments) than surface sediments. This occurs because modern sedimentation processes that are linked to the upper layers of sedimentation on a sand ridge, for example, may be significantly different from relict sedimentation processes that formed the ridge. Evidence of relict processes is normally found in deeper subsurface layers that have been unaffected by subsequent events. Thus, it is suggested that during reconnaissance investigations of offshore morphosedimentary features on the northeast Florida Atlantic coast, at least one undisturbed sample (vibracore) be acquired to supplement jet probe and surface sample data for each morphosedimentary feature that is under investigation. The purpose of this suggestion is to provide better insight into the nature of sediments comprising the core of the feature under study.

Reconnaissance sampling plans should be designed to target the crests or divides of the main morphosedimentary features. Spacing between samples will, thus, vary depending on the size of the area under investigation, the total volume targeted, and the project budget.

Detailed Survey Plan and Preliminary Borrow Area Design

Following analysis of the data collected during Phase II, a plan to conduct detailed investigations over a smaller area should be prepared. Detailed investigation plans should strive to obtain enough information to define sand quality for specific quantities and to map the vertical and horizontal continuity of sand layers. This level of investigation also provides sufficient information to identify layers or zones of undesirable sediments that should be avoided during borrow area design. The detailed investigations usually consist of detailed bathymetry, sidescan sonar and seismic reflection profile surveys on 200 to 300 foot grids with vibracores obtained on 1,000 foot centers. Analysis of the information obtained in detailed surveys permits the preliminary design of offshore borrows area and the mapping of surface features (*i.e.* environmental resources, and possible obstructions to dredging) that occur in or near the borrow. Tools that assist in the visualization of deposit morphology, sediment thickness and general characteristics of the borrow include geological cross-sections and fence diagrams, three-dimensional isopach maps and bathymetric charts, color-coded interpretation of seismic records, etc.

Although these detailed investigations allow for preliminary borrow area design, they are usually adequate to meet final engineering requirements of complete borrow area design. It must be appreciated that the characteristics of sand resources, even in geologically well known sites, are still subject to interpretive errors that are linked to the spatial and temporal variability of natural environments.

Cultural Resource Investigations

Detailed geophysical investigations are required to determine whether cultural resources occur within the boundary limits of a proposed borrow. Geophysical surveys are usually conducted on a grid with tracklines spaced 30 m (98 feet) apart (note: cultural resource surveys are conducted on metric grids). The cultural resource surveys generally consist of magnetometer, sidescan sonar and seismic reflection profile surveys. Because these investigations must be conducted at 30 m intervals, other geophysical Phase III investigations are generally conducted along multiple trackline spacings at 60 m (196 feet) and 90 m (292 feet). These multiple spaced grids are spaced so that cultural resource investigations can make sure of data from Phase III by nesting additional tracklines between lines of prior Phase III geophysical surveys. It is desirable that the cultural resource investigations be conducted using the same type of geophysical equipment deployed in the previous Phase III geophysical surveys. In this way, borrow area design can be refined using the additional (cultural resource) data obtained, making for efficient use of separate surveys. Presence of cultural resources (*i.e.* shipwrecks, large cultural artifacts, etc.) requires redelineation of the borrow area design to avoid disturbing the mapped features. The addition of 200-foot no-dredge buffers around the cultural resource feature satisfies this requirement. The margins of the borrow area (when the cultural resource feature occurs near the borders of the borrow) may also be modified to meet cultural resource requirements.

Borrow Area Impact Analysis Environmental Investigation and Numerical Modeling

Data from Phases III and IV may also be used to map sensitive environmental resources (*e.g.* hardbottoms) occurring near the proposed borrow site. If sensitive environmental resources occur near the proposed dredge site, the borrow area design is modified.

In addition to cultural resources and the consideration of environmental impacts, there is a need to evaluate whether the proposed borrow sites will adversely affect the nearshore wave climate to cause additional erosion of adjacent beaches. This evaluation is preferably accomplished by using a range of numerical models that simulate wave transformation over the borrow sites.

These models can also simulate wave-induced currents, sediment transport, shoreline change and variation in beach morphology. Several wave models evaluate borrow area impacts on nearshore wave climates. In order to properly evaluate borrow area impact on nearshore waves, spectral wave models that incorporate most of the relevant physical processes of wave transformation (*e.g.* wave refraction, bottom friction and to a lesser extent diffraction) are recommended. Even though proposed borrows may induce changes in the nearshore wave climate, these changes may not necessarily cause additional erosion of adjacent beaches. To evaluate whether the impacts of borrow areas on nearshore waves is significant in terms of beach erosion and deposition patterns, shoreline change models or beach morphology change models can be used.

These models can be either empirical (*i.e.* sediment transport is calculated based on the output of a wave transformation model that feeds empirical sediment transport formulas) or process-based (output from a wave transformation model is used to calculate wave-induced currents and these are in turn used to calculate bed-load and suspended load sediment transport). Simulations are run for scenarios with and without the proposed dredging. By comparing the with/without dredging scenarios, the investigator can evaluate the impact of dredging on the beach deposition and erosion patterns. If numerical modeling indicates that significant undesirable impacts are expected on adjacent beaches due to borrow area dredging, borrow area design modifications may be required.

Final Borrow Area Design

Final borrow area designs, plans and specifications are prepared when all concerns regarding sediment quality, cultural resource potential, environmental impacts, and physical considerations are addressed. Due to implementation of no-dredge buffers that reduce negative impacts from dredging, the final shape and cut depths may differ significantly from the design prepared at the end of Phase III.

USING ROSS IN COMPREHENSIVE OFFSHORE SAND SEARCHES

There are no universal or comprehensive guidelines dictating which method should be followed when conducting a marine sand search investigation, but several guidelines for specific geographic regions have been developed (Finkl, Andrews, and Benedet, 2003; Finkl, Khalil, and Andrews, 1997; Finkl, Benedet, and Andrews, 2004; Benedet *et al.*, 2004; Finkl and Khalil, 2005a,b, Hatchett, et.al, 2007a and 2007b). This lack of general guidelines is a result of the fact that sand searches are site specific. Because sand searches must be geared or tailored to the geological conditions in the area of the study, the method of conducting the search must be compatible with the specific geographic parameters of that region. This means that exploration methodologies must be capable of resolving required detection limits that are determined by deposit configuration in different geographic areas. The same search techniques would not be deployed, by way of an extreme example, in the search for sand ridges on the West Florida Shelf as would be used for the detection of infilled sediment troughs (inter-reefal sand bodies) that commonly occur along the southeast Florida coast.

These general procedures consist of sequential tasks that are conducted in a phase-wise manner, as illustrated by Figure 7-1. This flow diagram illustrates a systematic approach to offshore sand searches based on ten major phases that incorporate a range of subset activities that are constrained by local circumstances. Each phase is meant to direct the course of subsequent actions so that sand searches follow a logical progression that results in an efficient exploration methodology. The sequence of investigation can be reduced to ten phases that include: (1) literature reviews and analyses of historic data, (2) development of action plans that incorporate the creation of digital (GIS) databases of historic data, (3) reconnaissance geotechnical and geophysical surveys (if needed), (4) identification of target area(s), (5) detailed geophysical surveys, (6) detailed geotechnical investigation, (7) evaluation of geophysical and geotechnical data, (8) hazard, natural resources (seagrasses, hardbottoms *etc.*) and archaeological assessment surveys (9) selection of borrow area(s), and (10) preparation of reports and other final deliverables. The ROSS system provides the information needed to complete Phases 1 and 2. It contains an extensive annotated bibliography to assist in the literature search. The investigator must augment this with the most recent and location-specific published and gray literature sources to compile a complete review. In some areas, where sufficient information is available, the data available in the ROSS system may provide enough information to substantially decrease the survey needs of Phases 3 and 4 by reducing the area to be surveyed in preliminary reconnaissance investigations. These investigations, which traditionally covered large expanses of the seabed, can now be simplified and abbreviated to verify existing data. Subsequent phases are still needed to verify legacy data due to: (1) the dynamic nature of sand ridges, ebb shoals and nearshore sand bodies, (2) advances in survey technology (accuracy and resolution), and (3) permitting requirements (*e.g.* cultural resources clearance).

To optimize resources, including time and effort, it is convenient to conduct detailed cultural resource surveys subsequent to definition of final borrow area boundaries so that only the area to be dredged is 'cleared'. The ROSS system contains several data coverages that can assist with this effort. There are ranges of sub-tasks within each of these main phases of work and the whole process may take up to several months to complete depending on project size, location, amount of previous work completed (assuming that the data collected is adequate, accurate, and relevant), available funding, weather conditions (especially sea state), etc. The availability of a comprehensive GIS database helps to optimize such investigations and significantly reduces costs and time involved with initial data compilation and analysis.

These guidelines are briefly summarized in terms of tasks to be completed within the ten main phases. The descriptions indicate general strategies that logically work toward completion of phases so that future work can build on prior accomplishments that, to a certain degree, direct the course of subsequent actions.

The first phase of a marine sand search involves both a literature search and the design of the exploration program. The ROSS system plays a major role in this phase. In the past, this initial review of background data was sometimes overlooked because it was considered to be too time consuming or possibly even irrelevant as much of the data was old, or in a format that didn't match today's conventions. Experience (CPE, 1992, 1999b; Andrews *et al*., 2002, 2004; Finkl, Khalil and Spadoni, 2002; Finkl, Andrews and Benedet, 2003; Finkl, Benedet and Andrews, 2004; Benedet *et al*., 2004) has shown that this phase is crucial to the re-evaluation of previously collected information, to the development of conceptual models of sedimentary environments, and to guide the planning of future survey activities. Thus, the purpose of the literature (data) review is to familiarize survey planners with local environmental conditions and to flag any special conditions that require avoidance or special attention. Unfamiliarity with the peculiarities of local environments or geomorphological features holds potential for obtaining undesirable results. Tasks proposed for the sand search are, therefore, adjusted to local conditions in the appropriate manner.

Thorough, comprehensive reviews of historical, technical, and scientific literature should include geological, geomorphological, and geophysical information or data. Basic literature sources that should be perused in terms of general geologic framework and coastal processes include books and primary scientific and engineering journals (*e.g. Journal of Coastal Research; Marine Geology; Journal of Sedimentary Research; Marine Resources and Geotechnology*) and conference proceedings (*e.g.* 'Coastal Sediments' sponsored by the American Society of Civil Engineers, ASCE). Data is always evolving as most of these publications are monthly and bimonthly and should be checked in the early stages of marine sand searches.

The gray literature includes materials that are produced on an irregular basis in the form of special reports that include but are not limited to consulting reports prepared for government agencies such as the Florida Department of Environmental protection (FDEP), Florida Geological Survey (FGS), U.S. Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA), and private consultants. These data, particularly individual consulting reports, are often hard to access.

Offshore geotechnical literature and geotechnical data including geological maps, bathymetric maps, seismic cross sections, geotechnical data, both geological and geophysical borehole logs, within an approximate 6.2 mile radius of the project area and adjacent sites should be consulted, analyzed, and reviewed. The intent of this phase is to initiate the development of a flexible reconnaissance survey plan for preliminary geotechnical investigations. This plan should be geared to the identification of potential sites for probable borrow areas by eliminating locations that are unsuitable for any reason.

PHASE II: PREPARATION OF A SYSTEMATIC ACTION PLAN

The development of a systematic action plan builds on the results of the Phase I tasks and involves reconnaissance geological and geophysical surveys that are guided by interpretation of spatio-temporal information contained in GIS databases. The ROSS system provides readily available data in GIS format, thus, eliminating the transition from analog data to GIS environments that is normally required during this Phase. Data derived from bathymetric, seismic, and limited vibracore surveys is used to map bottom types and to differentiate areas that have potentially useable sediments by using GIS spatial queries. Seismic sub-bottom profiles provide useful information where underlying bedrock restricts the thickness and lateral extent of inner shelf sand bodies. The use of this information in real-time mode via an interactive GIS/MIS platform onboard a survey vessel, for example, provides ready access to archival and legacy data that can assist in the decision-making process for modification of surveys on the fly. Potential targets can often be defined on the basis of bathymetry, image roughness of the seabed surface, sedimentary structures and sediment composition. The delineation of potential target areas excludes all other areas as being unsuitable due to the poor quality or absence of sediments (*i.e.* in the case of exposed bedrock). The purpose of subsequent phases and tasks is then to work toward eventual exploitation of targeted sand sources.

PHASE III: RECONNAISSANCE GEOLOGICAL AND GEOPHYSICAL SURVEY

This phase of work normally includes several integrated tasks that focus on regional bathymetric surveys, seismic investigation, and preliminary surface – subsurface sampling using grab samples and jet probes (Finkl and Benedet, 2005) to verify historic data and sand deposit location. After reviewing the existing information, supplemental geotechnical investigations are normally conducted to obtain sediment data that helps evaluate potential sand sources and determine the availability of adequate sand volumes in the areas delimited using historic data sources. In some areas, the ROSS system may provide enough legacy data to significantly reduce or eliminate survey needs of this phase.

In situations where reconnaissance data is required, the investigations normally include positioning by DGPS, bathymetric surveys (using digital fathometers), surface sediment sampling, jet probes and seismic survey – sub-bottom profiling (using a sub-bottom profiler such as chirp sonar). Reconnaissance surveys are normally conducted along widely spaced tracklines on a 300 to 1,000 m grid spacing. Preliminary sampling with grab samples and jet probes may be collected for initial evaluation, verification of historical data and delineation of potential sites where detailed surveys could be undertaken. Retrieval of sediment samples also facilitates the calibration of seismic records and thereby increases the interpretive value of geophysical data (Griffiths and King, 1981) for locating potentially usable sand.

PHASE IV: IDENTIFICATION OF POTENTIAL TARGET AREAS FOR DETAILED EXPLORATION

One of the outcomes of Phase III should be the creation of a base-map depicting potential target areas with detailed survey plans including proposed tracklines and sampling locations. If prepared using a suitable scale, this information can be presented to the sponsoring agencies for discussion and approval. It should be noted that changes and adjustments to the basic or initial plans are anticipated on the basis of the field data and analysis conducted during Phases I through III. In some cases, additional surveys in Phase III may not be necessary because potential target areas were successfully identified on the basis of geophysical and geotechnical data provided by the ROSS system and analyzed in Phases I and II. This situation may occur in areas that have been extensively explored previously or where there is a plethora of recent data that contains information useful to sand searches.

PHASE V DETAILED GEOPHYSICAL SURVEY

This phase of work involves conducting detailed geophysical investigations that include bathymetric surveys, and sub-bottom profiling (seismic) surveys. Basic literature about these survey procedures and requirements can be found in Wolf and Brinker (1994), Yilmaz and Doherty (2000), Baker and Young (1999), Baldwin and Hempel (1986), Blondel and Murton (1997), Griffiths and King (1981), Dragoset and Evans (1997), Gorman, Morang and Larson (1998), Hunt (1984), Langeraar (1984), Morang, Larson and Gorman (1997), Verma (1986) and Worthington, Makin and Hatton (1986). Detailed surveys typically follow a trackline grid spacing on the order of 300 m or less. This level of detail normally provides sufficient detail for defining potential borrow sites, but in some specialized cases that are geologically complex, a closer grid spacing may be used.

Planning survey trackline locations is a crucial part of any successful geophysical survey that requires the incorporation of scientific information (derived from the literature) and bathymetric data (from NOAA charts and bathymetric data collected during Phase II) (Hemsley, 1981). When the compiled base-map (result of Phases I and II) is completed, the area selected for detailed study is earmarked for closely-spaced tracklines. The most satisfactory results are generally obtained by running geophysical (especially seismic) surveys in a pattern that is orthogonal to the prevailing offshore geologic structures or surficial topography. If the prevailing offshore geology is not parallel to the shore, the survey lines should be positionally adjusted to best image the terrain. For offshore areas where little is known about the surficial geology, an alternative procedure is to run survey lines in a zig-zag pattern approximately perpendicular to the coast. Planning of track-lines is site-specific and should not be constrained by these broad suggestions and general recommendations.

The components of a comprehensive geophysical survey should include accurate navigational positioning, detailed bathymetric survey, and seismic stratigraphic survey. A basic requirement for detailed high-resolution seismic survey, subbottom profiling of delineated borrow areas is accurate navigational positioning or position control. DGPS is the primary positioning system that is used for hydrographic surveys. DGPS correctors can be obtained from the U.S. Coast Guard (USCG), Maritime DGPS Service, or other differential services, provided they meet accuracy requirements. Echosounders and digital fathometers are used for bathymetric survey based calibrations and corrections mentioned for the earlier phase work. A detailed bathymetric map should be prepared using a suitable isobath interval. Bathymetric surveys are required for many studies of geology and geomorphology in coastal waters (Morang, Larson and Gorman, 1997a, b), including offshore sand searches in attempts to define target areas that may eventually become borrows. Fathometers or echo sounders are most often used to measure water depths offshore. The distance between the sound source and the reflector (seafloor) is computed as the velocity of sound in water divided by one half of the two way travel time. It has been observed that even with the best efforts at equipment calibration and data processing, the maximum practicable achievable accuracy for nearshore depth surveys is about +/- 0.15 m. Errors in acoustic depth determination are caused by salient complicating factors or processes that include:

a) Differences in the velocity of sound in near-surface water (about 1500 m/sec) that varies with water density, which in turn is a function of temperature, depth and salinity.

b) Changes in the vessel's draft as fuel and water are depleted during the survey require boat-specific correction that is carried out by performing depth checks.

c) Waves cause the survey vessel to pitch up and down and the seafloor is recorded as a wavy surface. Transducers and receivers are now installed on heave compensating mounts to obtain the true seafloor. Post survey data processing is the most common means of removing wave signals.

When conducting a seismic survey using a subbottom profiler, (*e.g*. 3.5 kHz high-resolution profilers) a chirp subbottom profiler should preferably be used for proper depth-penetration and better resolution. This equipment comes in a variety of configurations. Each configuration has its own unique settings and methods of operation. Considerable planning is needed to select the proper equipment, operation mode and survey trackline layout. Furthermore, instrumentation continually evolves so the plan needs to include a search for, and evaluation of, the newest equipment. Seismic stratigraphy should be developed on the basis of subbottom profiles thus obtained. Detailed surveys typically follow trackline grid spacing on the order of 300 m or less. This level of detail normally provides sufficient resolution for defining potential borrow sites, but in some specialized cases, where the geology is complex, closer grid spacing may be used.

In the third phase, a comprehensive geotechnical field survey is planned, executed and analyzed. Preliminary maps based on this information can then be developed.

Successful sand searches rely on sonar imagery of the seafloor and sectional depth views along tracklines that show sedimentary layering. Seismic reflection profiling, calibrated to sand searches using vibracore data is crucial to the delineation of potential sand bodies in terms of depth and lateral extent. Sonar surveys provide useful proxy data that can be interpreted in terms of smoothness or roughness of the seabed, information that is useful for differentiating between outcroppings of rock and unconsolidated sediment.

In geophysical surveys, the distance between the sound source at the reflector is computed as the velocity of sound in that medium (rock, sediment or water) divided by one-half of the two-way travel time. This measurement is converted to an equivalent depth and recorded digitally or printed on a strip chart. A recent development that is extremely valuable to interpretation of bottom-sediment grain size is a signal-processing unit that can be interfaced with an echo sounder and used to indicate the size of seafloor sediments in terms of Wentworth or other general classification schemes (ASTM, 1994; Morang, Larson and Gorman, 1997a, b). This is accomplished by measuring two independent variables, roughness and hardness, from acoustic signals and interpreting these data in terms of sediment type.

The basic principles of sub-bottom seismic profiling and acoustic depth sounding are essentially the same. A lower frequency and higher power signal (to penetrate the seafloor) is employed in subbottom seismic devices. The transmission of the waves through earth materials depends on properties like density and composition. The signal is reflected from interfaces between sediment layers of different acoustical impedance (Sheriff and Geldart, 1982). Coarse sand and gravel, glacial till and highly organic sediments are often difficult to penetrate with conventional subbottom profilers, resulting in poor records with data gaps. Digital signal processing of multi-channel data can sometimes provide useful data despite poor signal penetration.

Seismic reflection profiles are roughly analogous to geologic cross-sections of subbottom materials because acoustic characteristics are usually related to lithology (Verma, 1986). Reflections may appear on the seismic record due to subtle changes in acoustic impedance that are associated with minor lithological differences between under- and overlying materials. Conversely, significant lithologic differences may not be recorded because of similar acoustic impedence values between bounding units, due to minimal thickness of stratigraphic units or because reflectors are masked by gas (Sheriff and Geldart, 1982). Because these complicating factors can mislead interpretation of the seismic record, seismic stratigraphy should always be considered tentative until supported or verified by direct lithologic evidence from core samples.

The two most important parameters of sub-bottom seismic reflection systems are vertical resolution, i.e. the ability to differentiate closely spaced reflectors, and depth of penetration (e.g. Parkes and Hatton, 1986). The dominant frequency of acoustic pulses increases signal attenuation and consequently, decreases the effective penetration. To resolve this problem, it is common to simultaneously deploy two seismic reflection systems during a survey. By combining results from one system that maximizes high resolution capabilities with those of another system that is capable of greater depth penetration, it is possible to retrieve high-resolution data to greater depths than would normally be possible with a single seismic reflection system.

The Chirp system has an advantage over single frequency (3.5 kHz) sub-bottom profilers (or "pingers" as they are commonly called) and boomer systems in sediment delineation because the reflectors are more discrete and less susceptible to ringing from both vessel and ambient noise. The full wave rectified reflection horizons are cleaner and more distinct than the half wave rectified reflections produced by the older analog systems.

All of the data collected in Phase V should be incorporated into the GIS database (ROSS) and compared with complementary legacy data.

PHASE VI – DETAILED GEOTECHNICAL INVESTIGATION

Detailed sampling using vibracores is an expensive procedure that involves significant effort and deployment of large vessels containing hoisting equipment and storage facilities for cores. Descriptions of vibracoring procedures and requirements can be found in Lee and Clausner (1979), Edgington and Robbins (1991), Larson, Morang and Gorman (1997), Finkl and Khalil (2005b). Costs for 20-foot vibracores often settle in the range of $5,000 to $7,000 which includes five to seven sediment samples per core depending on location and logistics. Core description and the analysis of selected sediment parameters adds additional laboratory fees to the total cost, making vibracoring a procedure that should be carefully planned to avoid wasted efforts. Potential vibracore sites should be judiciously selected to achieve the level of information and confidence needed for finding the target area, delineating borrow areas and for qualitative and quantitative evaluation of sand deposits (Finkl and Khalil, 2005b). Vibracore information is most beneficially employed in conjunction with subbottom data to gain maximum interpretive benefit of stratigraphic composition and sedimentary variation. Acoustic reflectors can often be identified on the basis of vibracoring, which in effect, links or calibrates seismic reflection patterns to specific sediment types. Generally, vibracore-sites should be spread throughout the survey area on a rectangular grid but preferably, in an alternative pattern that crosses the prevailing trend of the offshore geology. The standard accepted spacing between the core-sites is usually about 300 m. The minimum accepted recovery from each core is at least 80% in at least three attempts or trials. Core recovery is sometimes problematical, especially where there are contrasting materials that are stratigraphically juxtaposed (i.e. sand vs. shell hash vs. rock clasts).

PHASE VII EVALUATION OF GEOTECHNICAL DATA

The vibracores obtained during Phase VI are normally split longitudinally into two halves, with each portion labeled and dated for future reference. One half of the split core should be photographed and archived, the archived half being cut into sections (not longer than 1.5-m) that are also labeled and dated. The archived core sections should be properly wrapped in clear plastic to avoid contamination from other core materials.

The other half of the split core should be sub-sampled for laboratory analyses. The results of the analyses should be used in the development of visual lithologs (boring logs) based on USCS designations (ASTM D2487-92, 1994). One representative sample for grain size analysis should be obtained from each horizon or layer (in a core) subject to a minimum of three samples collected from each core. Grain size and other physical parameters should be analyzed either by mechanical sieving or by settling tube as per ASTM standard (ASTM D421/422). The Unified Soil Classification Scheme should be used to describe sedimentary materials and layering within the core.

A log should be prepared for each core describing the sediments by layer. Each layer description includes layer width, sediment color, texture, and presence of clay, mud, sand or shell and any other identifying features. Grain size analysis should be performed on approximately three or four sediment samples per core. Samples should be obtained from distinct layers in the sediment record, or periodically through the core record. This grain size analysis should be conducted for sand samples in accordance with the American Society for Testing and Materials (ASTM), Standard Material Designation D422-63 for partial size analysis of soils. Mechanical sieving should be accomplished using calibrated sieves, with a gradation of half phi intervals, per U.S. Army Corps of Engineers standards. Grain-size distribution curves should be prepared for each vibracore. The core logs, and raw sedimentological data should be developed into a GIS database and should be made available for electronic transfer to the State. At the end of the process all vibracore information (geographical location, logs, gradation analysis tables, sediment distribution curves and core photographs) should be stored in individual .pdf files that can be made readily available from the ROSS system in the form of download menus or hyperlinks.

All necessary calibrations and other related tests that are considered necessary for the accuracy of the data and survey should be performed as part of this task group. Similarly, all necessary corrections usually carried out as standard operating procedures for reconnaissance surveys should include ascertaining tide and water levels. Once the sedimentary grain-size parameters, and other qualifiers relevant to the suitability as beach sediments are established, potential borrow areas can be delineated.

7.8 PHASE VIII: HAZARD, NATURAL RESOURCES AND ARCHAEOLOGICAL ASSESSMENT SURVEY

Once a potential borrow area has been identified, a cultural resources study is conducted using a magnetometer, detailed seismic, sidescan sonar and bathymetry in compliance with local, state and federal government regulatory requirements. Detailed geophysical data from the archeological surveys should also be integrated into the borrow area design data giving more certainty on sand deposits within the proposed cuts and to avoid duplicate efforts.

The purpose of the magnetometer survey is to determine if there are any metallic objects in the borrow area which may be of historic value, such as shipwreck artifacts. The magnetometer investigations are also useful in identifying non-historical metallic objects that may interfere with the dredging process such as abandoned engine blocks, pipelines, metal cable, etc. The results of the survey are documented by a professional archeologist and reported to the State Division of Archaeology. If needed, the borrow area should be revised and buffers should be implemented to avoid objects of potential historical value.

Cultural resource surveys (Kidder, 1996; Green, 2004; Watts and Finkl, 2004a, b, c, d) should be conducted when required for permitting purposes. These surveys are often necessary to ascertain the presence of drowned habitation sites of paleoindians (paleoanthropological and archeological term referring to Native American cultures prior to 8,000 BC) or other cultural groups and also provide excellent datasets for refinement of borrow area design cuts. Underwater archaeology (continental shelf archaeology) is an important endeavor because it attempts to reconstruct where and how ancient peoples settled on coastal plains, portions of the modern continental shelf that were subaerially exposed during times of lower sea level, and when they began to access and procure near-coastal and marine resources. In addition to the detection of Pleistocene settlements on exposed continental shelves there are important cultural remains on the seafloor that are related to contemporary society. Many of these artifacts (*e.g.* anchors, cables) have no cultural significance, but they can damage dredges. Other cultural features such as buried pipelines and fiber optic cables require identification prior to dredging for definition of setbacks.

Due to the level of detail that is required for cultural surveys, sidescan sonar and magnetometer surveys are conducted on a close line spacing (~30 m). Normally, for such surveys the specifications and guidelines are provided by the permitting agency. Sidescan sonar surveys, which are conducted for identification of surface structures and hazards including debris, pipelines, shipwrecks, normally using dual-frequency sidescan sonar, are normally accompanied by a magnetometer survey (using either Proton or Cesium Magnetometer). Generally, 100% swath coverage is needed for a sidescan sonar survey. This survey is normally done under the supervision of a professional marine archaeologist.

Natural resources are also a major concern. Off the southeast coast of Florida, environmental concerns tend to focus on the presence of hardgrounds. Information that includes shapefiles from the Florida Geographic Data Library (FGDL) like the seagrass beds, salt marshes, tidal flats, artificial reefs and aquatic preserve boundaries and side-scan sonar mapping are used to ascertain the occurrence of sensitive environments. If such environments are detected, they are delineated and avoided.

PHASE IX BORROW AREA SELECTION AND CALCULATION OF SAND VOLUME

Finally, the selection of potential borrow areas requires re-evaluation of all geotechnical and geophysical data obtained during Phases I through VIII, including updates or additions to prior surveys, and the determination of outer limits of borrow areas. Geologic cross-sections, compiled on the basis of sub-bottom data and vibracore logs, should be produced showing the sand layers and the proposed depths of cut. Isopach maps showing sediment thickness should be prepared to show the stratigraphic position of target sands and layers that should be avoided.

Because the depth, location, and orientation of borrow areas affects the adjacent shoreline, a thorough impact study should be conducted not only for borrow-site environmental assessment but for physical impact-assessment. These studies tend to focus on induced changes to wave propagation patterns and coastal circulation patterns for different depths of sediment removal (Bender and Dean, 2003).

The cost of dredging potential borrow areas can be a crucial consideration, especially where long haul or pump distances from borrow to project area are an issue. The cost of dredging sediments is affected by the following major factors: type of sediment, distance from the borrow area to the project site, length and width of the beach being restored, depth of water and depth of dredging in the borrow area, depth of water adjacent to the project site, and thickness of the dredge cut.

The type of sediment determines dredge horsepower requirements, which in turn affects the cost of dredging. The distance from the borrow area to the extreme limits of the beach restoration project also affects project cost and equipment selection. When dredging with pumping distances up to 6.2 mi, a cutterhead dredge (including the ocean-going dustpan) is the most efficient method. These dredges have 10,000 to 15,000 horsepower, which can pump non-cohesive sediments over these distances. When the distance from the borrow area to the project site exceeds 7.5 to 9.9 mi, hopper dredges become more efficient in transporting the sediment. Thickness of cut in borrow areas also affects equipment selection and productivity. For cutterhead dredges to be productive, the cut must be at least 1 to 2 m thick. For cuts less than 2 m, cutterhead dredges can still operate but at less than optimum efficiency. For shallow cuts, hopper dredges and the ocean-going dustpan are more efficient because they excavate sediments in layers. If an insufficient number of cores are present in the borrow area, dredging contractors often add significant contingency fees to account for unknown or unfavorable conditions that might be encountered. Once a borrow area is selected, it may be worthwhile to go back for an additional round of vibracoring to effectively determine sediment variability. Additional vibracoring with spacing no greater than 200 m apart may provide greater confidence in sedimentary conditions and significantly reduce dredging costs. Better estimates of sediment volumes by grain size for % sand (D_{50}, D_{85}) or % silt, shells, gravels, *etc.* may also reduce (offset) dredging costs.

PHASE X DEVELOPMENT OF GEOTECHNICAL REPORT

The last phase of a sand search involves the preparation of final reports, appendices and digital data deliverables. As far as general guidelines are concerned, this final phase is perhaps the most important because a poorly prepared or presented report, wastes a great deal of effort. In the same way, if the datasets created are not incorporated into a digital GIS database (ROSS) information will be lost and future efforts in the same area may be conducted by uninformed groups. It is thus essential that reporting procedures be followed using correct formats and styles. It is expected that final sand search reports will document the techniques, methods, analyses, and results. It should be common practice that all newly generated data in marine sand searches is submitted in a GIS format that can be incorporated into ROSS with minimal effort.

FINAL CONSIDERATIONS

Comprehensive reviews of previous offshore sand searches and legacy data is now facilitated by the existence of a comprehensive offshore marine sand search database (ROSS). Careful analysis of these legacy data, for example, should provide clear directives to the survey of target areas with the most potential for locating usable sand sources and significantly optimizing future sand search efforts. Selection of potential borrow areas, the ultimate goal of offshore sand searches, depends on adherence to established search protocols that are tempered by practical adjustments to local conditions.

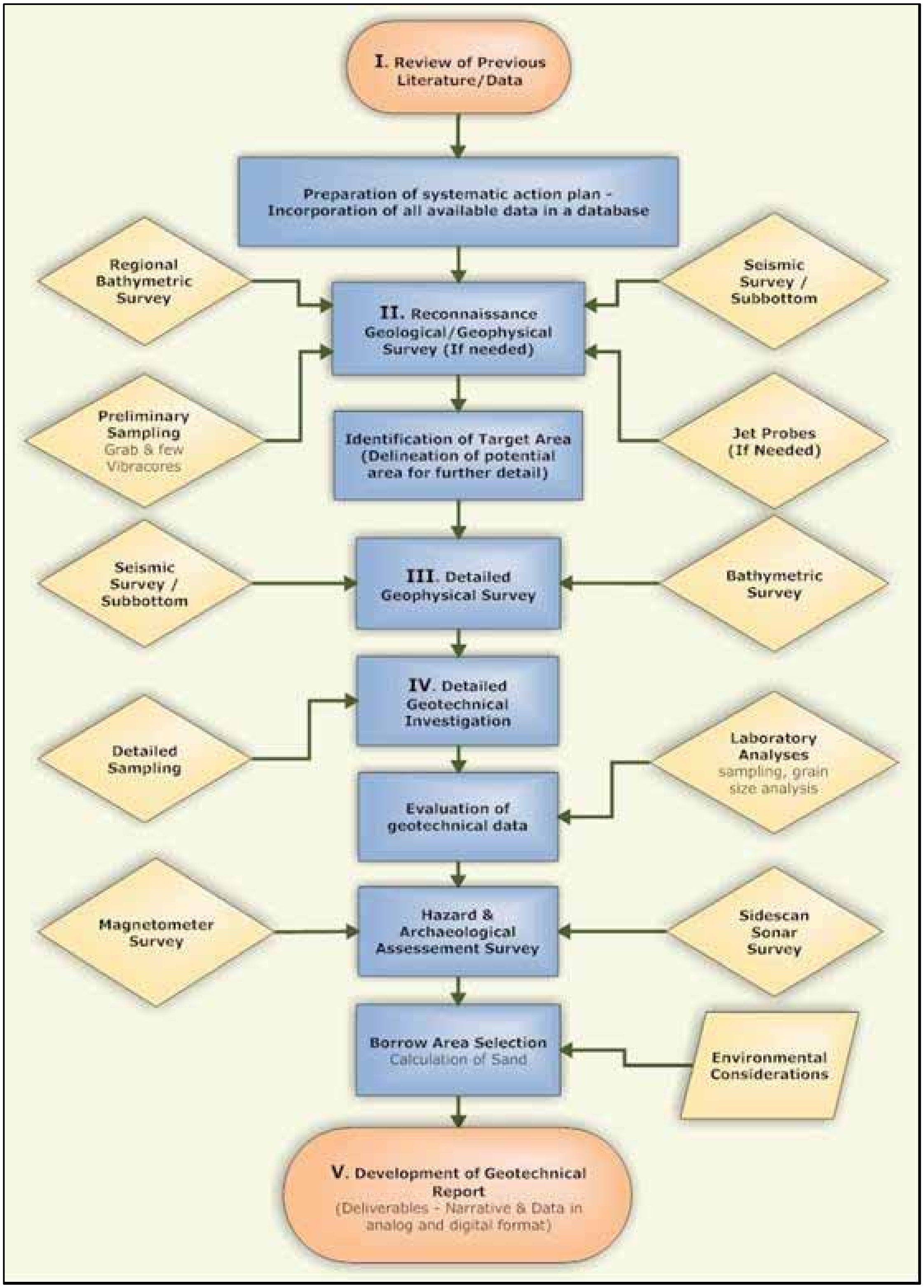

Figure 7-1. Flow diagram showing systematic approaches to offshore sand searches, based on major steps that incorporate a range of subset activities that are restrained by local circumstances. Each task is meant to direct the course of subsequent actions so that sand searches along sandy coasts proceed following a logical strategy that produces an efficient exploration methodology.

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Appendix

Online Query Builder Users Manual

Reconnaissance Offshore Sand Search

Online Database Query Builder

Building a Custom Query

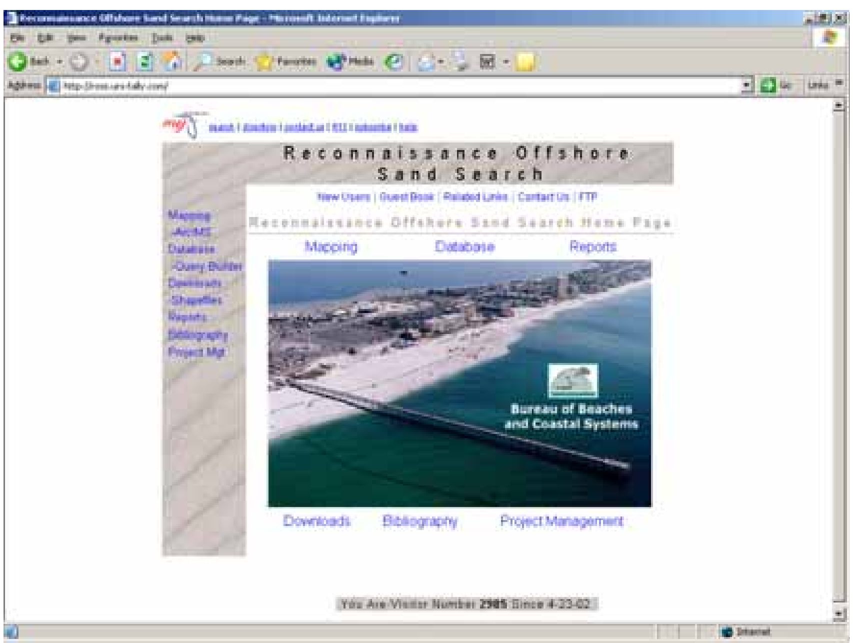
Introduction:

The query builder works by allowing you to create a "where" clause that is added to an SQL (Structured Query Language) selection statement. This selection statement tells the database to retrieve rows where the conditions you have set are true.

The query is made against one of two database views that join together data from several different database tables. Because of the structure of the database, you must specify whether the query should be run against the samples or core view. The sample view includes all data in the samples data, plus related data in the core table. The core view includes all data in the core table plus related data in the samples table. They appear to be very similar, but they are different representations of the data.

Creating a custom query

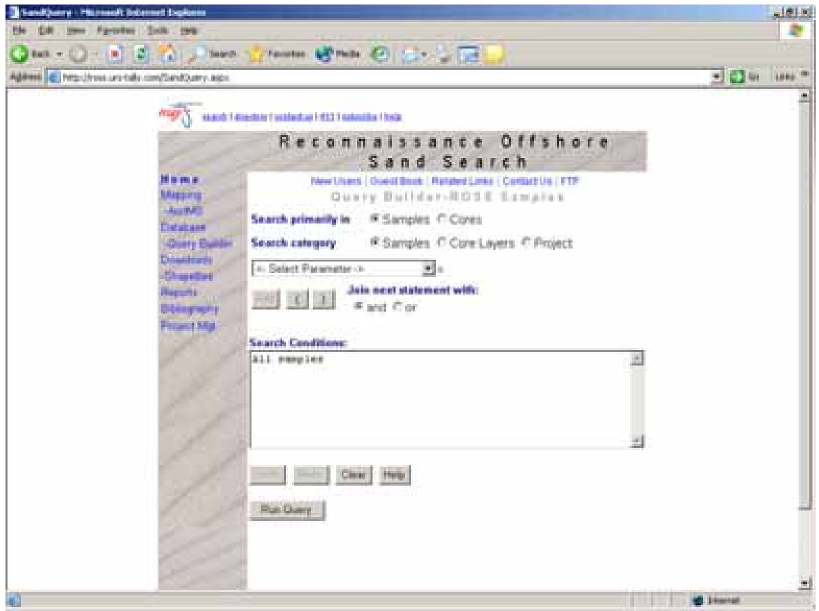
First you need to get to the Query Builder page.



Click on the link titled ‘Query Builder’ on the ROSS Main page.

You should now see the Online Query Builder page. From this page you can select the query criteria you want to use to filter the data.

The query parameters are categorized into three different groups. The Sample group, which provides parameters associated with the samples table. The Cores group, which provides parameters associated with the cores and core layers tables, and the Project group, which provides parameters associated with the project table.



Depending on which parameter you choose, the screen will change to allow you to enter an appropriate value.

If you choose a numeric or date parameter (such as Mean Grain Size, or Sample Date), the screen will change to show you a drop-down list of relational operators ("=", ">", "<", etc.) and a text box into which you can enter a number or date, as appropriate.

If you choose a text parameter, the screen will change to show you a different set of relational operators ("=", "<>", "like" and "not like"). The first two operators allow you to search for a specific text value, while the latter two operators allow you to search using a wildcard character ("*") to represent any text. The following examples demonstrate the difference between the relational operators:

For example, searching for a sample record that contains the word "island" in the project location field yields the following results based on the relational operator

- The “=” operator requires an EXACT match to return any results
- The “like” and “not like” require the use of the ‘wildcard character’ (‘*’, an asterisk) placed in the appropriate location within the search criteria for example
    - Choose “like” then enter “*island*” this will return ANY Project location that has the word island anywhere in the location
        - Captiva **Island**

        - Sanibel and Captiva **Island**s
        - Captiva **Island**, Lee County, Florida
    - Choose "like" then enter "*island" this will return results where the word "island" is at the end of the project location.
        - Captiva **Island**
    - Choose "like" then enter "island*" this will return results where the word "island" is at the beginning of the project location.
        - Currently there are no Project Locations that begin with the word "island"

There are several parameters (such as Layer Structure) you can use that provide you with a lookup list. If you choose one of these parameters, a drop-down list containing the acceptable values will appear.

There are other parameters that provide an even more customized query interface. These include Munsell color, named descriptive color, and core layer qualifiers. These screens are described in more detail below.

Search by range of dates or numbers

If you choose one of the numeric or date parameters, you will see the "between" relational operator appear in the drop-down list. This allows you to enter two values in the textbox and return records whose values fall between the two numbers (or dates). For example, to search for samples with a mean grain size greater or equal to -1 and less than or equal to 2, you would select the "between" relational operator and enter "-1 and 2" in the textbox.

Acceptable date formats

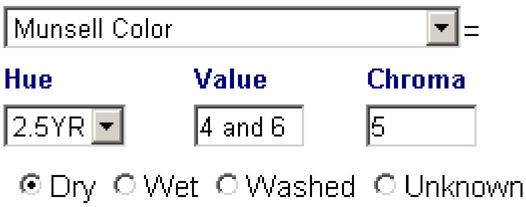
The query builder allows you to enter a date in a variety of formats, including:

Format	Example
mm/dd/yyyy	12/31/2003
mm dd yyyy	12 31 2003
mm-dd-yyyy	12-31-2003
mm.dd.yyyy	12/31/2003
mm/dd/yyyy	12/31/2003
dd month yyyy	3 May 2004
month dd yyyy	May 3 2004
dd mon yyyy	3 Jan 2006
mon dd yyyy	Jan 3 2006

If you leave the year off, it will assume you mean the current year. Enter the date in whatever format you are most comfortable with, and the query builder will reformat the date into a standard MM/DD/YYYY format for you.

Searching by Munsell color

If you choose the Munsell color parameter, the screen will change to show a drop-down list and two textboxes. To enter a Munsell color, select the hue from the drop-down list, and enter numbers in the value and chroma text boxes.



You can also search by a range of Munsell values or chromas. To do this, enter the lower and upper limits of the range you wish to search in the value or chroma textboxes. For example, to search for Munsell colors with a range of values between 2 and 5, enter "2 and 5" in the value textbox.

Searching by named color

If you choose Named Color as the parameter, the screen will display three drop-down lists. These allow you to enter a descriptive color name.

Undo and Redo

If you make a mistake and enter a query condition accidentally, you can "undo" the mistake simply by clicking the Undo button. You can undo as many changes as you like. If you undo one too many changes, hit the Redo button to reapply the last change.

Joining Query Conditions

The conditions you enter must be joined together by a combinatorial operator, either "and" or "or". "And" signifies that all conditions must be true to return a record, while "or" signifies that only one must be true. You can group conditions together to clarify how the "or" operator is to be applied. For example, to search for samples with a mean grain size of -1 phi with a color of 2.5yr 5/6 or 5yr 5/6, you should group the color conditions together within parentheses. To do this:

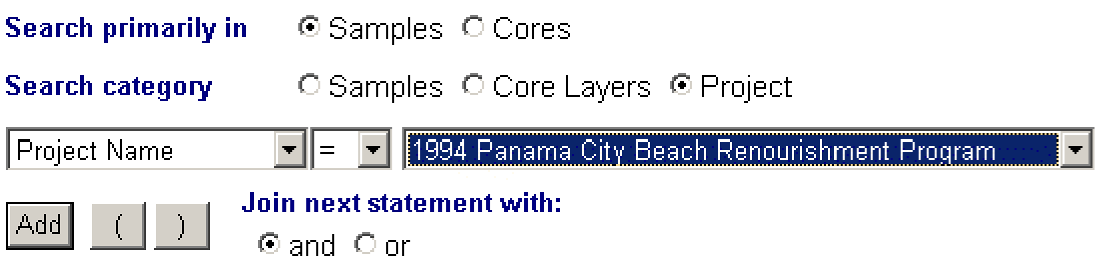
1. Enter the grain size condition
2. Change the join operator to "and"
3. Click the "(" button
4. Enter the first color
5. Change the join operator to "or"
6. Enter the second color
7. Click the ")"

Example

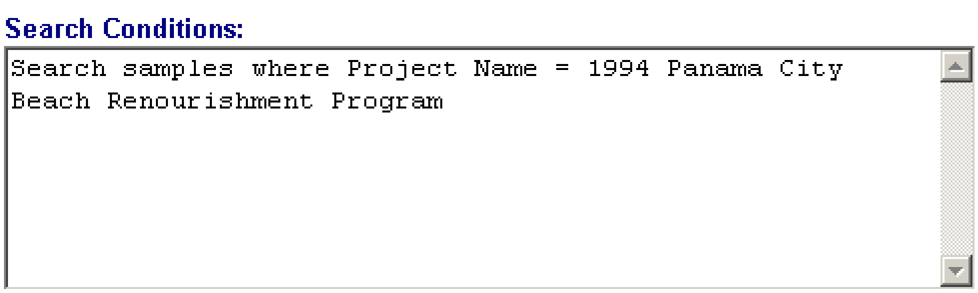
Now that you know how to provide the information to the Query Builder, Its time to put that knowledge to the test and create a query. Let's say that you want to run a query for All Samples in the 1994 Panama City Beach Renourishment Program that contain at least 80% Fine Sand (as determined by the Unified Soils Classification) that are found within 2 feet of the bottom*. You would open the Query Builder page and select the following:

Part 1: Add project condition

1. Select the Project search category.
2. Select the Project Name parameter.
3. Select 1994 Panama City Beach Renourishment Program from the drop-down list that appears after you select the project name.
4. Click the Add button.

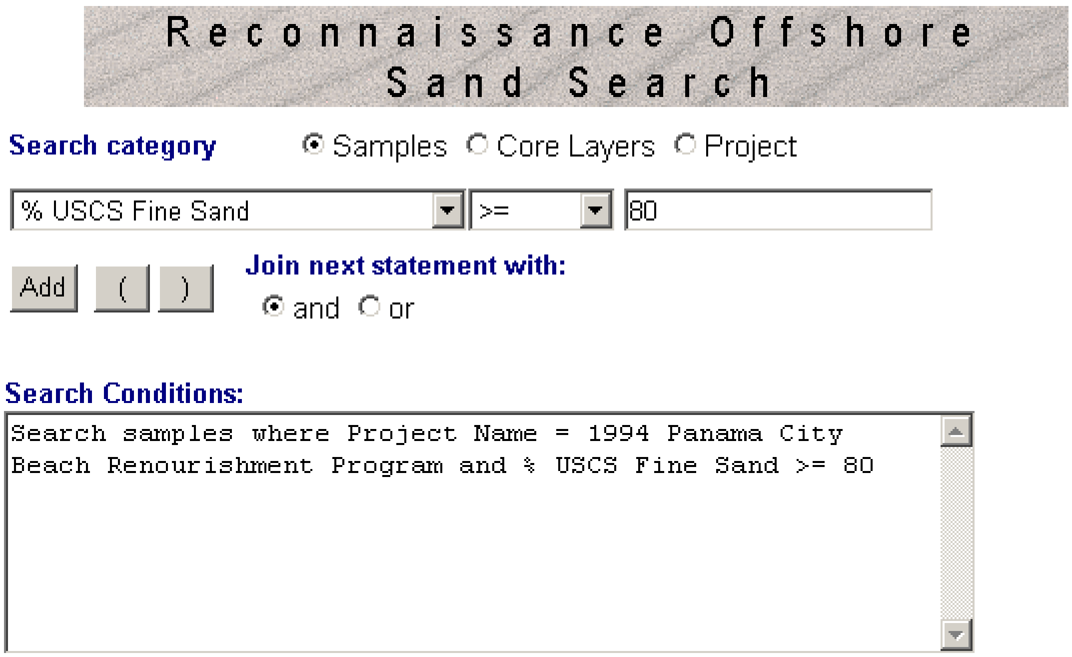


You will see the first query condition appear in the Search Conditions textbox.



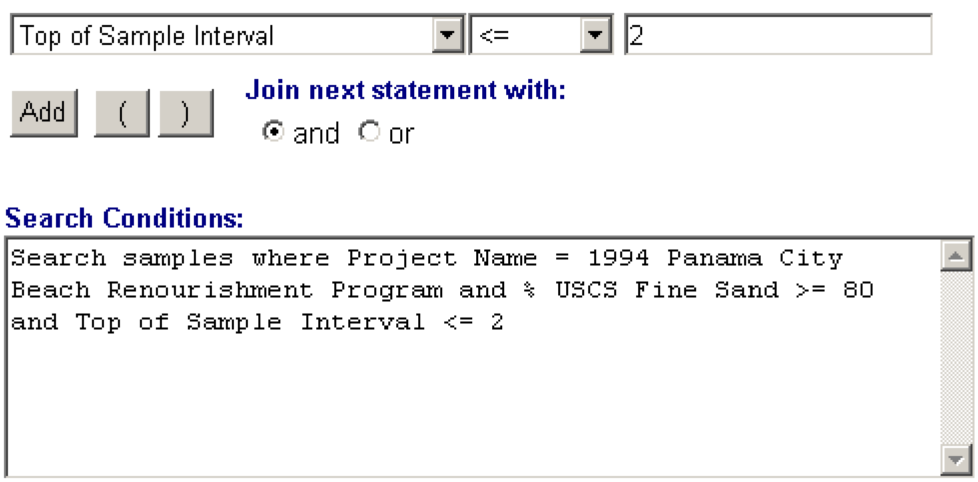
Part 2: Add the USCS Find Sand condition

1. Select the Samples search category
2. Select the % USCS Fine Sand parameter
3. Change the relational operator to ">="
4. Enter 80 in the text box.
5. Click the Add button.



Part 3: Add the depth condition

1. Select the Top of Sample Interval parameter
2. Enter 2 in the text box.
3. Click the Add button.



Now that you have entered all of the search conditions, click the Run Query button.

Query Results

The next screen that appears shows you a table of the results of your query.

Reconnaissance Offshore Sand Search

Sand Sample Query Results

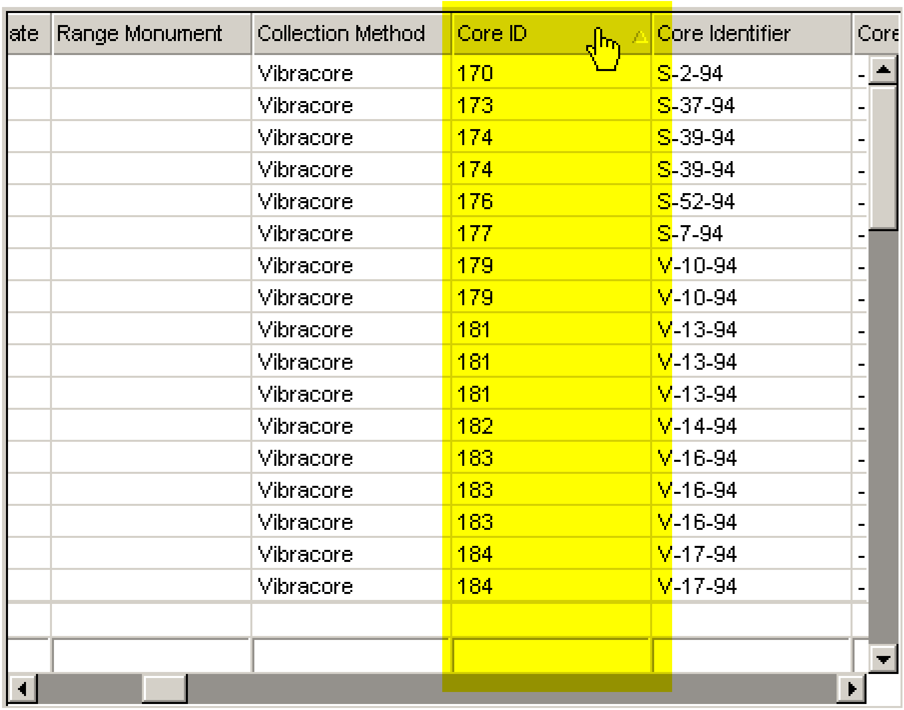
Project Name = 1994 Panama City Beach Renourishment Program and % USCS Fine Sand >= 80 and Top of Sample Interval <= 2

Project Name	Project Date	Project Location	Agency Managing	Agency I
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
1994 Panama City B	01/01/1994	Panama City Florida	Army Corp of Engine	Army
64/64				

Download | View Map | Query Builder

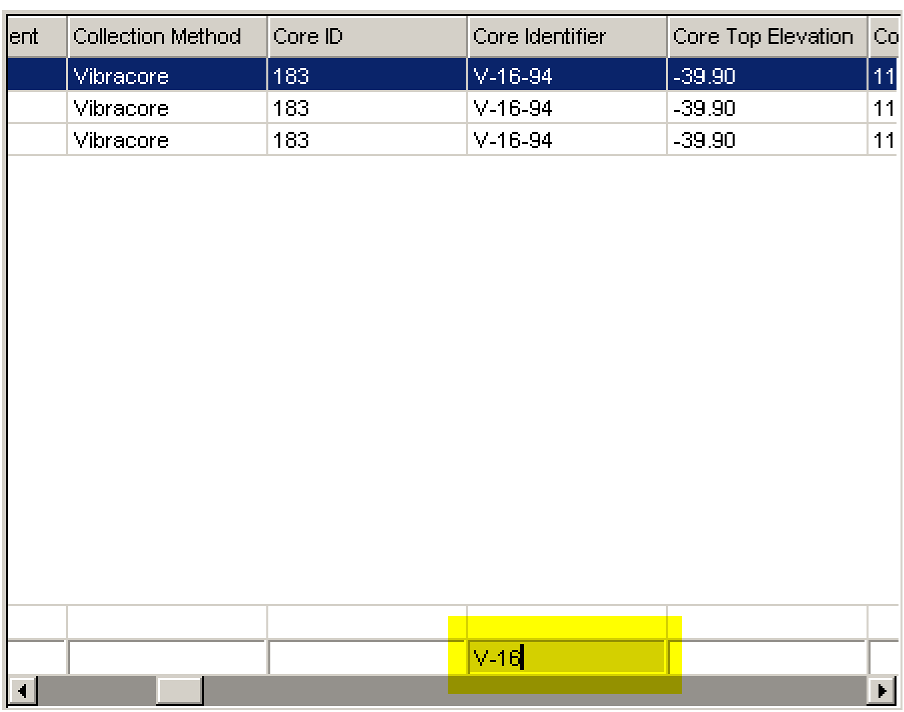
Sorting Query Results

You can sort the results that appear in this table by clicking on one of the column headings Click the column heading again to reverse the sort order.



Filtering Query Results

You can further narrow the results of your search by either clicking the Query Builder button to go back to the query builder, or you can filter the results on the fly using the filter bar.

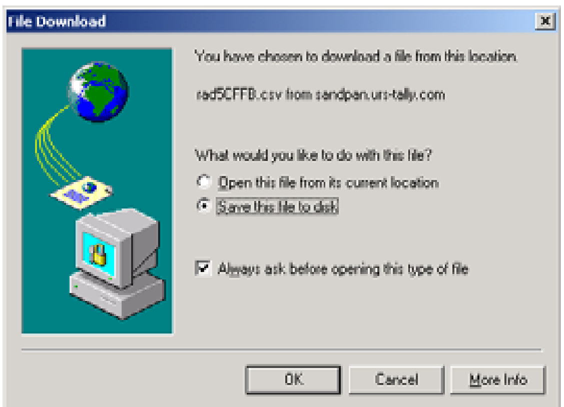


To query using the filter bar, simply start typing a pattern in the column of data you want to filter. In this example, only samples from cores with a core identifier like "V-16" are shown. It's important to note that the filter bar does not requery the database, so you cannot use it to add results to your output.

Downloading Query Results

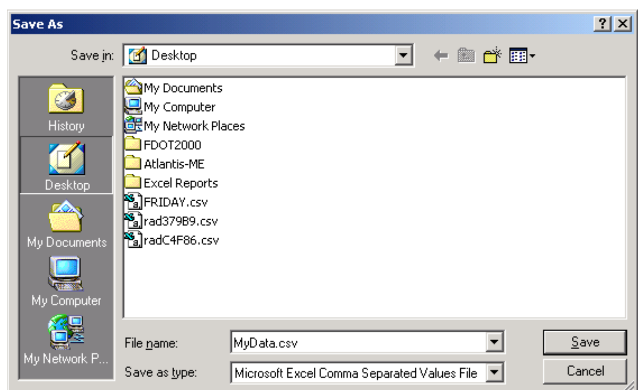
To export the filtered data from the table into a tab-delimited format suitable for import into a spreadsheet program, click the Download button. This will open up a new browser window.

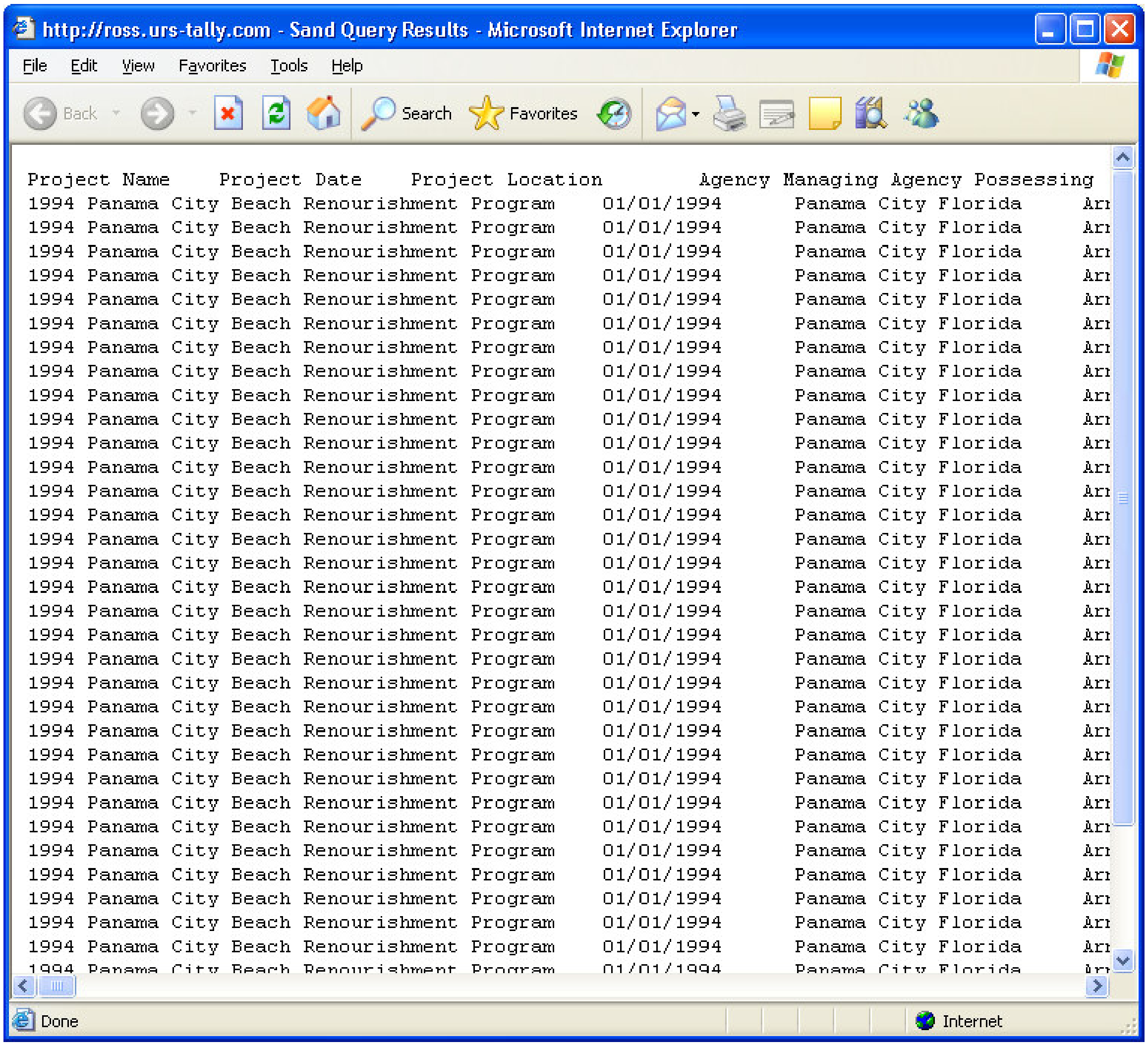
Most browsers, however, will show the data as text in the window. Simply select all of the text and copy and paste it into a blank spreadsheet page. (Hit Ctrl-A, Ctrl-C, switch to your spreadsheet program and hit Ctrl-V).



On some browsers you will be prompted to save the data, or it may open up directly in your spreadsheet program. You may see a window that looks like the one to the left. Select 'Save this file to disk' and click 'OK'

You should see a window that looks like the one to the right. Select the location where you wish to save the file. Rename the file if you wish. Now click 'Save' and the download will begin.





Saving the downloaded File as a .dbf File to use with ArcView

After you download the file, open it using Microsoft Excel. To properly save the file as a .dbf that can be used in ARCview, you will need to format each of the columns for the data type that the column contains. For example, format the State_X and State_Y columns as number columns that have 6 or 8 decimal places. If you do not reformat EVERY COLUMN, the process of saving the file as a .dbf will concatenate each column to 10 characters and you will lose valuable information.

View in ArcView

If you would like to graphically see where the samples you have queried for lie on a map, click the 'View In ArcIMS' button at the bottom of the page. An ArcIMS window will load that will display the area your samples exist and highlight the samples within that area that meet the query criteria you specified.

Appendix

Online Mapping Users Manual

Reconnaissance Offshore Sand Search

New Users | Guest Book | Related Links | Contact Us | FTP

Interactive Mapping

Internet Map Services

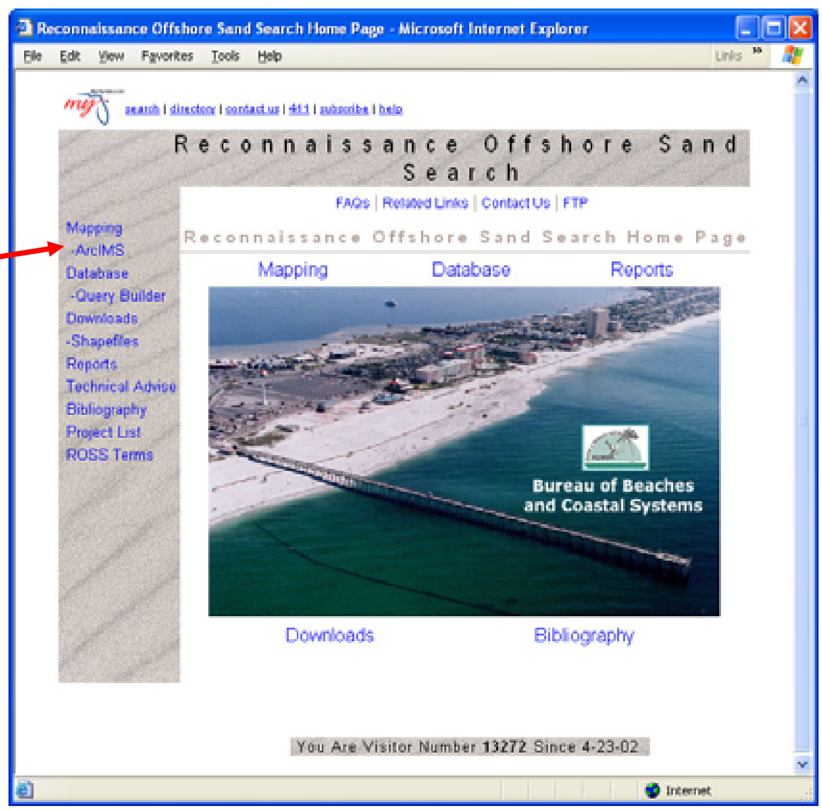
What does an Internet Map Service do?

An Internet Map Service (IMS) displays a map image based on an underlying database of spatial information. The map service allows the user to interact with the map display and query the underlying spatial data. The technology used to coordinate the database and map display is ArcIMS. More information on ArcIMS can be found on the web at http://www.esri.com/software/arcims.

Creating an Interactive Map

First you need to get to the Interactive Mapping page.

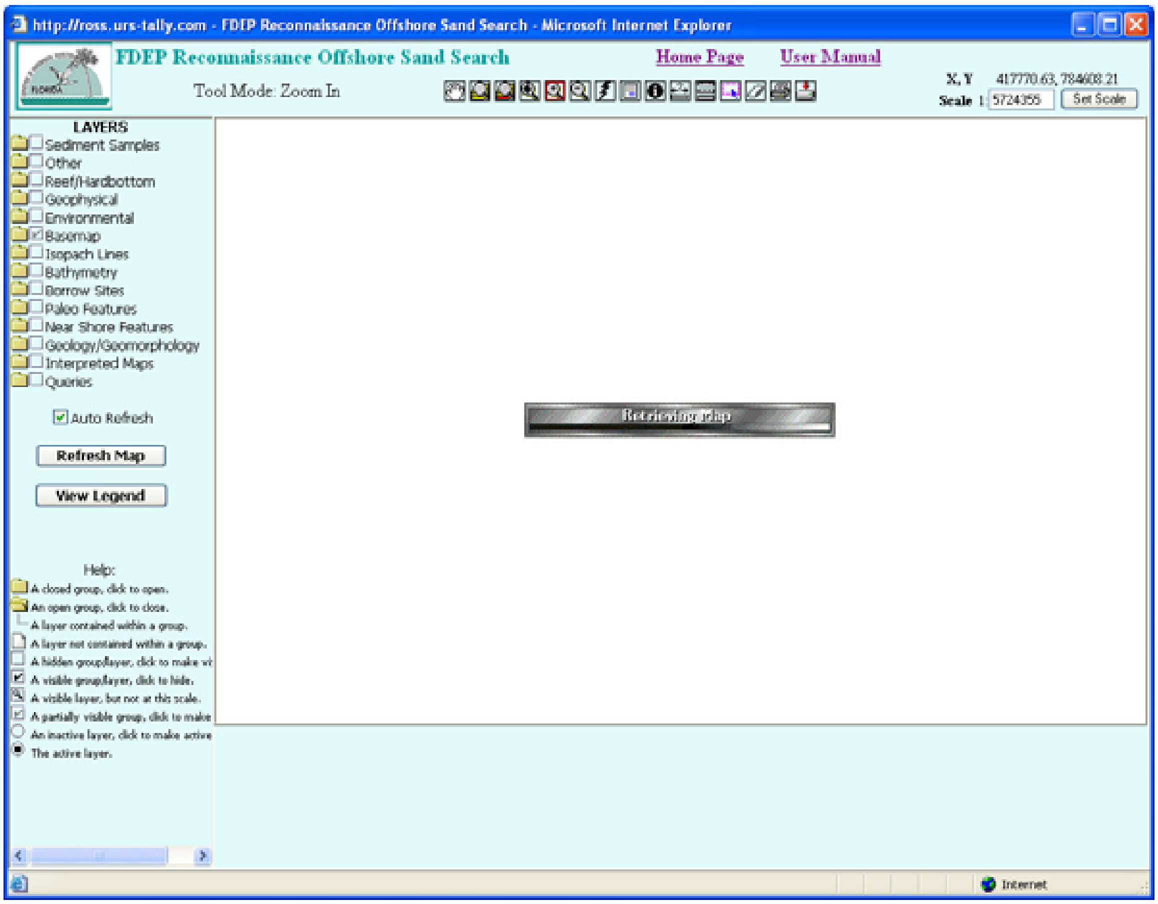
Click on the link titled 'ArcIMS' on the navigation bar of the BBCS Reconnaissance Offshore Sand Search web page.



You should now see the Interactive Mapping page in a new browser window. From this page you can use a variety of tools to navigate the map and query the underlying data.

The map image displays the full extent of the spatial data contained in the database. You may navigate through any part of the map shown in this initial extent. Below the map is an area for displaying responses from the database to your requests.

When you make requests of the map service, a response to your request is generated by the server and sent to your browser for display. The response may be a new map or the results of a query for tabular information. A response may take anywhere from a few seconds to a couple of minutes to process, depending on its complexity. During this processing time, the ArcIMS map viewer will be in Retrieving mode, preventing it from producing further requests until a reply from the server is received.

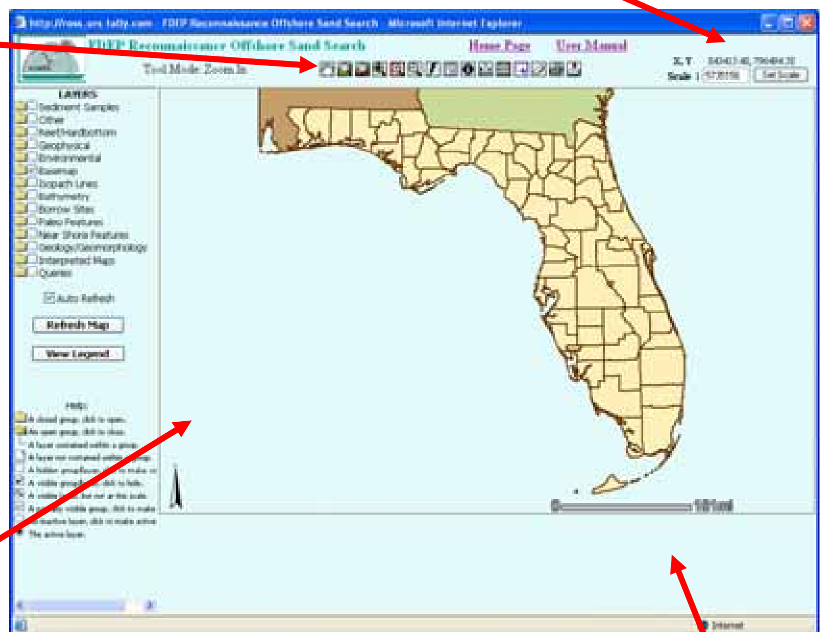


Navigating an Interactive Map

The interactive map page has a variety of tools for manipulating the map and querying the underlying spatial data. Here is a general overview of the Interactive Map page.

Across the top of the interactive map is a toolbar that includes tools for navigating, querying, and printing. A tool mode message next to the tool bar indicates the currently selected tool.

As the mouse cursor moves over the map, the map coordinates under the cursor are displayed in the top right frame, along with the current reference scale.



Appearing in the left-hand frame is the Table of Contents (TOC).

The map frame displays the interactive map.

The results frame below the map displays the records associated with the results of queries and selections, as well as various messages.

Next we will examine in detail the various frames that make up the interactive mapping website.

Table of Contents Frame

The Table of Contents (TOC) contains a list of all the data sets, or layers, that can be viewed and queried in the ROSS database. The data sets and queries are organized in category folders.

The first section of the TOC is the Layer List, which displays all of the spatial data sets that are potentially visible.

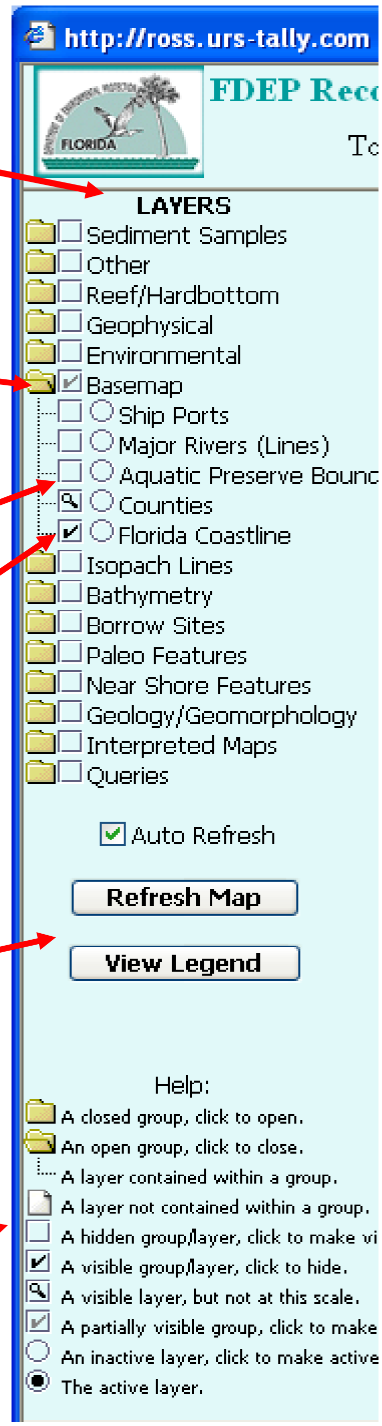
Each of the category folders contains a list of layers. Next to the folder icon is a check box for making all of the layers in the folder visible.

Each layer name appears next to a check box and radio button. The check box indicates if the layer is currently visible on the map, and the radio button indicates if the layer is activated for use with the query, select, and identify tools.

A magnifying glass symbol in the checkbox lets you know that the layer is not visible at the present scale. To improve performance by reducing the map drawing speed, some very detailed layers can only be displayed when the map area is small.

Below the Layer List is the Refresh Map and View Legend buttons. Use the Refresh Map buttons to apply changes to the visible layers. The View Legend button loads a map legend that shows the meaning of all the symbols in the map.

At the bottom of the frame is a Help section that describes all of the icons used in the TOC.



Results Frame

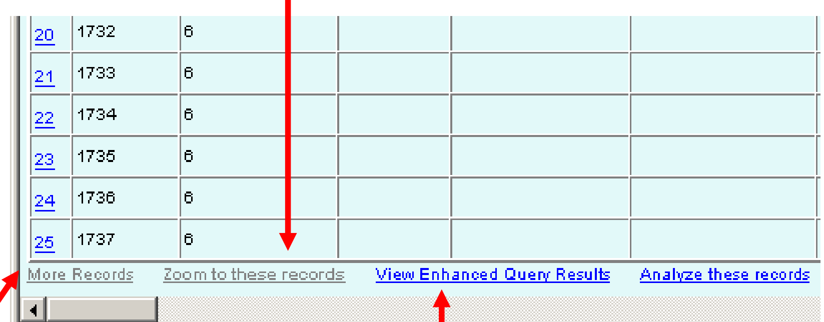
The Results Frame is the area below the map image that is used to display several kinds of textual information, such as:

- Diagnostic messages
- Tabular results from identifying, selecting, and querying features
- Forms for user input
- Hyperlinks to related documents

Below is a screen capture of the results from a selection by rectangle on the All Sand Samples layer. The Select By Rectangle tool is described in detail in the Toolbar Frame section.

Each record has a number that can be used to highlight the feature on the map.

Use the 'Zoom to these records' link to focus the map on the results of the selection.



Identify, query, and selection results records are displayed in the results frame in sets of 25; If there are more than 25 records, a link below the records retrieves the next/previous 25 records.

Features from any of the Sand Samples layers can be analyzed in more depth once they are identified, selected, or returned by a query. See the section on Additional Tools for more details.

Toolbar Frame

The toolbar buttons that appear near the top of the window are used to navigate around the map and query the database for more information about the visible features on the map.

Important Notes:

- Many tools are dependent on whether or not a layer is Visible and/or Active. To make layers visible, check the box next to the layer name, and then click the Refresh Map button at the bottom of the TOC. To make a layer active, click the radio button next to the layer name. Only one layer can be active at a time.

- Tool icons with a red outline are persistent, which means these tools remain enabled until another tool is selected. The name for the currently enabled tool, or Tool Mode, is displayed to the left of the toolbar. When the map page first loads, the Zoom In tool is automatically selected.

Next is a description of how each toolbar button operates.

Pan: Select the pan tool, and then hold the mouse cursor over any part of the map. The mouse cursor will appear as a pair of arrows. By clicking and holding down the left mouse button, you can drag the map image around the map frame. Release the mouse button to re-center the map in a new position.

Zoom to Full Extent: Clicking this button returns the map image to the initial statewide view of Florida.

Zoom to Active Layer: Each spatial data set occupies some region, or extent, on the map. For example, potential borrow areas have been identified off the Florida Panhandle. Clicking the Zoom to Active Layer button will produce the map with the smallest scale at which the selected layer is entirely visible.

Back to Last Extent: This tool returns the map to the previous spatial extent and scale. This button will cycle back through all of the map images that have been viewed, ending with the statewide view of Florida.

Zoom In: There are two ways to use this tool to zoom in on the map:

- **Zoom to Point**: Click anywhere on the map image to re-center the view on that point, and zoom in by a factor of two.

- **Zoom to Box**: Use this mode to define a rectangular region to zoom in on. Hold the mouse cursor over the map image at the top left corner of the new viewing rectangle. Click and hold down the left mouse button, then drag the cursor across the map to create a zoom box. Release the mouse button to complete the rectangle and produce a new map image.

Zoom Out: This button works similarly to the Zoom In tool, allowing you instead to zoom out.

Hyperlink: The hyperlink tool allows you to view documents related to features in some designated layers on the map. There are currently two layers with hyperlinks, Core Locations and Data Buoys. One of these layers must be visible and active to use this tool.

- *Core Locations*: Select the hyperlink tool, and then click on any core location (represented by an orange dot). If there are core logs or photos for that core location, links to these documents will be presented below the map. Click on the links to open these documents.

- *Data Buoys*: Select the hyperlink tool, and then click on the data buoy location (represented by a yellow triangle). If available, a link to the National Data Buoy Center website for the selected buoy will be presented below the map. Click on the link to open the web page containing statistics for the selected buoy.

View Metadata: This button opens a document describing in detail the currently active layer. This document, referred to as the metadata, is presented in Federal Geographic Data Committee (FGDC) format. The information in the metadata file includes a general description of the data set, a description of all the attribute columns that are associated with the data set features, and information about the data set's spatial projection, just to name a few of the available items.

Identify: More than just graphics, features on the map are related to a database record of attribute information. This information can be displayed by using the Identify tool. Any visible map features that are part of the currently active layer can be identified by selecting the identify tool and clicking on a map feature that belongs to the active layer. The database record for that feature will be retrieved and displayed in below the map.

Measure: The measure tool is used to determine the distance along a line segment or series of connected line segments, or path. Select the Measure tool and click once on the map to create a starting point. A new map image will be retrieved showing this starting point. On the new map, click again to mark the ending point of the line segment. A new map will again be retrieved showing the line segment. Continue this process of adding points to create a path. Near the top of the map are two boxes showing the length of the current path, as well as the distance from the last point added to the position of the mouse cursor. The current path may be cleared at any time using the Clear Selection tool, described below.

Set Units: The map units can be changed to feet, miles, meters, or kilometers by selecting this tool and completing the Set Units dialog that appears. A drop-down menu provides the various options for units, and a submit button is provided to apply the changes to the map display units.

Enhanced Query: Use this tool to select points from any of the Sand Samples layers and send the area of interest to the advanced Query Builder. The advanced Query Builder can be used to refine the query, sort the results, and download them for further study. See the section on Additional Tools for more information.

Clear Selection: This button clears the current selected features and compound select areas from the map image, resets the measure tool, and clears any buffers from the map.

Print: Opens the print dialog for printing the current map image. A title can be added before creating the print page. The print page opens in a new browser window, and the File menu of the new window may be used to print the map image.

FTP link: Opens the Regional Offshore Sand Search FTP site in a separate browser window. The FTP site contains the seismic images and GIS shape files for download.

Additional Tools

Enhanced Query

The results from selecting by rectangle or querying can be viewed in the Interactive Query Builder portion of the Sand Search website.

Select the enhanced query tool and draw a rectangle around features of interest on the map. Make sure the sand samples layer you want to query is visible and active.

-OR-

Identify, select, or query any Sand Sample layer, as described in the Toolbar Frame section. Click on the 'View Enhanced Query Results' Link that appears below the table in the Results Frame.