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**FLORIDA GEOLOGICAL SURVEY**  
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**A Geological & Geophysical Site Survey of Deadman's Island and  
Old Navy Cove at Gulf Breeze, Florida**

Submitted to the City of Gulf Breeze, Florida

by

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# **A Geological & Geophysical Site Survey of Deadman's Island and Old Navy Cove at Gulf Breeze, Florida**

by

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## **INTRODUCTION**

Deadman's Island is located near the mouth of Pensacola Bay adjacent to the City of Gulf Breeze in Santa Rosa County, Florida. Deadman's Island, as shown in [Figure 1](#), is a narrow northeast/southwest trending island. It has been experiencing shoreline erosion, especially at its northern end, in recent years. It and the adjacent waters of Old Navy Cove to its west comprise an historically sensitive area. Old Navy Cove consistently appears in all available historical maps of the region. The cove is bordered by a shoal to the northeast, Deadman's Island to the southeast, a peninsula to the south with fringing shoals that become more prominent as one proceeds to the southwest and by Pensacola Bay to the west and north. Old Navy Cove has, and still provides, a protected anchorage for vessels from the colonial period to the modern era. This investigation, conducted by the Florida Department of Environmental Protection's (FDEP) Florida Geological Survey (FGS), was designed to better understand:

- the near surface geology of Deadman's Island;
- the nature and distribution of the sediments lying on the seabed adjacent to Deadman's Island; and
- to determine if sediments from dredge spoil areas on the south end of Deadman's Island and to the northeast of it sufficiently match those on the north end for the purposes of its restoration.

The FGS team collected 14 grab samples of the island's sediments and additionally collected ground penetrating radar data in two transects trending the length of the island ([Figure 1](#)). The FGS team also collected a total of six vibracores from the island itself; one vibracore each from the waters adjacent to it to the north and south, as well as three vibracores from a proposed borrow site external but proximal to it ([Figure 1](#)). Three hammer cores, each approximately 1.6 feet (0.5 meter) long, were collected in shallow waters immediately north of the island ([Figure 1](#)). These hammer cores and the one vibracore collected immediately to the north of Deadman's Island were collected in the area known as Town Point ([Figure 1](#)). This area has recently undergone erosion and is slated to be restored. Eight grab samples were collected from the seabed of Old Navy Cove, lying to the west of the island, for the purposes of bottom characterization ([Figure 1](#)). Including reshoots, approximately 105.91 miles of line (170.823 kilometers) were shot in the waters of Old Navy Cove and approximately 1.82 square miles (4.73 square kilometers) of seabed was imaged ([Figure 2](#)). Analysis of these data provided the following:

- a bathymetric chart of Old Navy Cove;
- side scan sonar mosaics imaging the seabed of Old Navy Cove;
- a stratigraphic analysis of the sediments immediately underlying Deadman's Island;
- a granulometric analysis of the *in situ* sediments of Deadman's Island; and
- a granulometric analysis of those sediments, both on and off Deadman's Island, which are anticipated to be used to restore its northern end, as well as a comparison of how well they match the sediments in the area to be restored.

This report documents the findings of the FGS investigation. It discusses in detail those data obtained and presents conclusions drawn from that data. Information derived from this study will assist state and local officials in making decisions concerning the restoration of Deadman's Island and the protection of the resources of the island and Old Navy Cove immediately adjacent to it.

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This report includes photographs and granulometric analyses of samples collected by the FGS on Deadman's Island and from a proposed borrow site nearby, as well as descriptions of sediments collected offshore in Old Navy Cove. Additionally, the ground penetrating radar data collected on the island and side scan sonar data collected in Old Navy Cove are presented as radargrams and side scan sonar mosaics, respectively. This information can be accessed using one of the following methods:

1. From the appendices listed in the table of contents.
2. Through the "on-disk" ESRI ArcGIS project. The ArcGIS Project contains links to web pages and PDF files of vibracores, hammer cores, beach samples, seabed samples, and sidescan sonar data residing on the CD. There are three ways to view the ArcGIS Project:
  - a. From the ArcMap Project  
You must have ArcMap 8.x or later in order to open the ArcMap Project. If you do not have this software, please use the ArcPublisher Project (see below).
  - b. From the ArcPublisher Project  
You must load ArcReader in order to view the ArcPublisher Project. This free viewer can be installed with the executable file included on the CD. Instructions are included on the ArcGIS page of the CD. Updates and further information may be obtained from the ESRI website at <http://www.esri.com>
  - c. From a PDF generated from the ArcMap Project. This document is zoomable and contains hyperlinks, but is otherwise static.
3. From the appropriate indices within the CD.
4. From the appendix citations within this report text.

## DEFINITIONS

Fines are those sediments which will pass through a 4.00 phi, 0.0025 inch (63 micron) mesh opening, # 230 sieve.

Granulometric analysis is sediment analysis conducted to characterize a surficial island sediment, vibracore or hammer core sample's grain size distribution. This analysis is graphically displayed in grain size determination (GSD) curves. GSD curves created from surficial island sediment samples, vibracore samples, and hammer core samples can be found in Appendices [A](#), [B](#), and [C](#), respectively.

Seabed samples are grab samples of surficial seabed sediments. The locations of these seabed samples are shown in [Figure 1](#). Photographs of individual seabed samples can be found in [Appendix D](#).

A side scan sonar survey is the data collection process consisting of the collection of returning reflections off the seabed received by a transducer as pressure pulses. The system utilized by the FGS for this survey produced acoustic impulses, known as "pings", at a sonic frequency of 1200 kHz.

Targets are reflections from suspected manmade objects lying on the seabed. Examples of targets are illustrated in [Figure 3](#).

## GEODETICS AND UNIT CONVERSIONS

Maps included in this document use either the North American Datum of 1983 (NAD83), or the World Geodetic System of 1984 (WGS84), as their primary projection. The imagery included in many figures in this report are made up of DOQQ 2004 aerials with original projections in Florida Department of Environmental Protection customized Albers Equal Area Conformal Conic. All side scan sonar data was

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exported in WGS84, UTM Zone 16. Sample location data was mapped using NAD 83 Geographic. Global Positioning System (GPS) instrumentation was used to collect all geographic position information.

All "unit conversion factors", English to the International System of Units, i.e. Le Système International d'Unités, (SI) and SI to English, used in this report can be found listed in [Table 1](#). These conversion factors were obtained from Eshbach and Souders (1975). Within the body of this report, when recourse to quantification of distance, weight or volume is required, quantifications are first expressed in English units followed, enclosed in brackets, by their expression in SI units.

### **PREVIOUS WORK**

While Marsh (1966) discussed the geology of Santa Rosa County, that work primarily focused on stratigraphy, structure and hydrogeology. Erosion of the Holocene sediments of Town Point, which forms the northern end of Deadman's Island, was not addressed by him. The U.S. Army Corps of Engineers, Mobile District (USACE-M) proposed installing a shoreline protection system at Town Point. This work would have entailed the placement of a wall of vinyl sheet pile offshore of the island and the planting of vegetation on the island itself. Due to the archaeological sensitivity of the island, the USACE-M requested that an underwater remote sensing and terrestrial survey be carried out in the areas to be affected by construction activities. That investigation was conducted by personnel from Panamerican Consultants, Inc. (PCI) in August 2002. The results of that research (Tuttle and James, 2003) identified a total of 17 magnetic anomalies. That report, included as [Appendix E](#), discusses in detail the history of Deadman's Island. Four of the magnetic anomalies, located in the proposed sheet pile alignment, were recommended for further investigation. That additional investigation resulted in a report, Watts and Tubby (2004), which further investigated magnetic anomalies located in Old Navy Cove in close proximity to Town Point. That report, included as [Appendix E](#), also discusses in detail the history of Deadman's Island.

The historical shorelines of Deadman's Island from 1940 through 2006 are shown in [Figure 4](#). As can be seen, since 1940 both the northern and the western shorelines have retreated, with little or no change along the southwestern section of the island (Houser, 2007). The analysis of this shoreline retreat is included as [Appendix G](#).

### **DEADMAN'S ISLAND DATA COLLECTION**

The Deadman's Island data collection phase of the investigation was conducted using equipment and a vessel owned and operated by the FGS/FDEP. The island's beaches were sampled at an interval of 125 meters or less. These beach sampling locations are shown in [Figure 1](#). GPS readings were taken at each sampling location. At each sampling location, three individual replicate samples, each totaling approximately 2 ounces (56.7 grams) of sediment, were obtained for granulometric analysis. Samples were collected by scooping sediments from the surface to an approximate depth of 1 inch (25.4 millimeters) at each sample point using a 2 ounce (56.7 gram) scoop. Eleven beach sampling locations were sampled ([Figure 1](#)). Three locations were sampled from the interior of the island ([Figure 1](#)).

A total of eleven vibracores were collected to refusal. Six of those vibracores were collected on Deadman's Island, one each from the waters adjacent to it to the north and south and three from a proposed, external to the island, borrow site. All of the vibracores were less than 10 feet (3 meters) in length. The locations of these cores are shown in [Figure 1](#). Individual vibracores were sampled at 2.0 foot (0.6 meter) intervals and/or at significant changes in the strata.

Three hammer cores, each approximately 1.6 feet (0.5 meter) in length, were collected immediately north of the island. The locations of these cores are shown in [Figure 1](#). Individual hammer cores were sampled at 1.0 foot (0.3 meter) intervals and/or at significant changes in the strata.

A limited ground penetrating radar (GPR) investigation of Deadman's Island was performed using a Mala RAMAC backpack GPR attached to a Mala 250MHz shielded antenna as well as to a Garmin 172 handheld GPS unit. The resulting data were processed with the ReflexW package produced by

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Sandmeier Software. The ground track of the investigation is provided in [Figure 1](#) superimposed on an aerial orthophotograph of the area. Two transects were performed and are provided in [Figure 5](#).

### OLD NAVY COVE DATA COLLECTION

The Old Navy Cove data collection phase of the investigation was conducted using equipment and vessels owned and operated by the Florida Geological Survey. This included data collection in Old Navy Cove using the FGS's 22-foot research vessel, *R/V GeoProbe*, on March 11, 12 and 13, 2008 and April 2 and 3, 2008 and the FGS's 24 foot Carolina Skiff on May 21, 2008. The survey plan was based primarily on a grid of northwest-southeast oriented track lines approximately 1 mile (1.61 kilometers) in length with a line to line spacing of 50 ft (15.2 m). Including reshoots, approximately 105.91 miles of line (170.82 kilometers) were collected and approximately 1.82 square miles (4.73 square kilometers) of seabed was imaged. Individual lines in the primary grid took approximately 15 minutes or less of ship time to acquire. Two marine geophysical systems were utilized in the study, a Marine Sonic Sea Scan System operating at a frequency of 1200 kHz, and a Garmin 168 global positioning system containing a sonar depth sounder unit operating at a frequency of 50 kHz. The FGS also collected 8 grab samples from the cove's seabed for the purposes of bottom characterization ([Figure 1](#)).

#### Side Scan Sonar

The side scan sonar device utilized to image the seabed in Old Navy Cove generates sonic pulses and records their reflections. This instrument, typically referred to as a "tow fish", was towed at approximately 4.4 knots (4.4 nautical miles per hour) at a side look range of 65.6 feet (20 meters) that imaged a swath 131.2 feet (40 meters) in width. Marine Sonic, the manufacturer, states that the 1200 kHz "tow fish" used in this survey achieves an effective 1.5 inch (3.9 centimeter) resolution when set at a 65.62 feet (20 meter) side look range (imaging a 131.24 foot (40 meter swath)). As the planned distance between track lines for the survey's primary grid was 50 feet (15.2 meters) and the side look range selected was 65.62 feet (20 meters) a substantial overlap of adjacent side scan sonar swaths was built into the survey's primary grid. This produced sufficient overlap for the purposes of building a side scan sonar mosaic and afforded, in sequentially adjacent lines, multiple views of areas and objects of interest on the seabed. The survey grid as shot is shown in [Figure 2](#). A side scan sonar mosaic is provided as a low resolution (3.28 foot (1 meter)) mosaic, see [Appendix H](#), tied to individual mosaic tiles created at the full resolution (0.15 foot (0.04 meter)) of these data. Also presented in [Appendix H](#) is a medium resolution (0.82 foot (0.25 meter)) side scan sonar mosaic.

The water depths in the survey area ranged from less than 10 feet (3.3 meters) to greater than 15 feet (4.6 meters). The "tow fish" was towed at an average height of 6 feet (1.8 meters) above the seabed with essentially no layback from the GPS antenna over most of the survey area. Zero layback was achieved by placing the GPS antenna on a boom directly over the "tow fish's" transducers. At line ends proximal to the shore, when the survey vessel moved into water depths of less than 8 feet of water, the "tow fish's" layback was altered to avoid impacting the bottom. This resulted in some separation of the image of individual objects on consecutive lines. Due to the water depths found in the survey area and equipment constraints, the "tow fish" was, by necessity, towed proximal to both the sea surface and the survey vessel. In certain infrequent sea conditions, due to the "tow fish's" proximity to the sea surface, objectionable reflections from the sea/air interface were observed in these data. The "tow fish's" proximity to the vessel resulted in some minor degradation of the center portion of individual records due to the effects of prop-induced cavitation. The quality of side scan sonar data obtained in this survey was also occasionally impacted by marginal or adverse sea conditions. In addition to imaging the seabed, the side scan sonar system also intermittently imaged sea life in the water column above the sea floor. The occasional incidental crossing of another vessel's fresh wake also degraded the instrument's ability to image the sea floor in the immediate vicinity of that vessel's path. When data quality on extensive line segments was deemed marginal, it was reacquired on a subsequent day. The above noted caveats notwithstanding, the quality of the side scan sonar data collected is, on the whole, quite good. All field records were digitally recorded and retained for long term storage. They are available for general distribution by contacting the Florida Geological Survey.

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### **Echosounder**

The echosounder data collected was fed as a data stream to a lap top computer and saved as a text file. The depth sounder transducer utilized was mounted below the stern of the vessel. The GPS antenna that collected navigational information tied to bathymetry was mounted directly over the transducer. The transducers depth below working water level was determined under still water conditions (*i.e.*, no wave activity) and found to be 8.0 inches (20.33 centimeters).

### **Seabed Sampling**

Eight seabed samples were collected in the waters of Old Navy Cove for the purposes of bottom characterization. The locations of these samples are shown in [Figure 1](#). These samples were collected with a "clam shell" grab sampler.

## **SEDIMENT SAMPLE PROCESSING**

### **Granulometric Analysis**

All sediment samples, except for the eight obtained from the seabed in Old Navy Cove, were granulometrically analyzed. All granulometric analyses were conducted using the general guidelines of the American Society for Testing and Materials (2002, 2007) and specific procedures conducted by the FGS sedimentology laboratory (Balsillie, 1995, 2002a, 2002b, Balsillie and Tanner, 1999; Balsillie, *et al.* 1999; Balsillie *et al.* 2002a; Balsillie *et al.* 2002b; Balsillie and Dabous, 2003). Each sample was initially weighed after oven drying. The sample was then wet sieved through a 230 sieve (0.63 mm or 4 phi), oven dried and reweighed with the weight loss being assigned to the fine fraction. The sample was then dry sieved with the portion of the pan fraction obtained during dry sieving also assigned to the fine fraction. A single sample from one of the vibracores exhibited a significant amount of carbonate material that was digested. That sample was digested with a 4 M hydrochloric acid solution, rinsed, oven dried, resieved and weighed again. The conversion between phi size and sieve mesh size can be found in [Table 2](#).

Prior to preliminary dry sieving, those samples exhibiting a significant percentage of fines were additionally analyzed. After wet sieving (4 phi) to separate the fine fraction, a pipetting technique, using methodology in Folk (1974) and Galehouse (1971), was employed to determine the amounts of silt and clay present. The weight of the fine fraction, consisting of the weight loss from wet sieving plus weight of the fraction passing through the sieve nest to the pan, was assigned to the finer than 4 phi fraction.

### **Additional Analysis**

Both the vibracores and hammer cores were photographed and briefly described as a whole, while individual core samples were described more thoroughly. Photographs and descriptions of vibracores and hammer cores can be found in Appendices [B](#) and [C](#), respectively. All non-core samples, including the eight samples obtained from the seabed of Old Navy Cove for the purposes of bottom characterization, were both described and photographed. These images can be accessed via the index for beach and seabed samples under the photograph page column or by accessing Appendices [A](#) and [D](#), respectively. For each island sediment, vibracore, and hammer core sample, data from granulometric analysis and visual description was entered into an individual spreadsheet, the result of which includes a summary page and a Grain Size Distribution (GSD) Curve. The data for the individual island sediment, vibracore and hammer core samples collected are provided in Appendices [A](#), [B](#), and [C](#), respectively.

### **Restoration-Quality Sand Parameters**

It is important to note that in addition to color and mean grain size the suitability of restoration-quality sand is determined by the percent fines content. Restoration-quality sand resources for beaches are often limited vertically by the depth at which the fines content exceeds 5%. This requirement is specified in Chapter 62-41.007(2)(j) of Florida Administrative Code (Florida Administrative Code, 2001), unless the fines content in the area to be restored exceeds 5% and then only up to that percentage.

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### COMPUTER PROCESSING OF GEOPHYSICAL DATA

Processing of the side scan sonar data was accomplished using the Sonar Web Pro and SonarWiz.MAP Office software packages developed by Chesapeake Technologies Inc. The side scan sonar data are provided as a low resolution (3.281 foot (1 meter)/pixel) mosaic (see [Appendix H](#)) tied to individual mosaic tiles created at the full resolution (0.15 foot (0.04 meter)/pixel) of these data. These resolutions were selected because multiple features typically present in such survey areas are best observed using different resolutions.

Processing of the ground penetrating radar data was accomplished using the ReflexW software package. The processed data, provided as the ground penetrating radar transects, are shown in [Figure 5](#).

Processing of the bathymetric data was conducted by sampling the data set at an interval approximately equal to 50 feet, which was the planned spacing between adjacent survey lines. The parsed data was then corrected for tidal variation to mean sea level and the depth of the transducer below the sea surface. Values from the closest tidal monitoring station, Pensacola, were used as this station is located directly across Pensacola Bay from Old Navy Cove. When the daily datasets were merged, it became apparent that there were standard differences between depth readings for different days. The largest dataset, consisting of data collected on April 2<sup>nd</sup>, 2008, was used as a controlling variable to which the other daily datasets were adjusted. The results are displayed in [Figures 6](#) and [7](#), a bathymetric chart overlaying the 0.82 foot (0.25 meter) side scan sonar mosaic and a bathymetric chart, respectively.

### DATA ANALYSIS, DEADMAN'S ISLAND

#### Surficial Sediment Samples from the Island

Photographs, descriptions and granulometric analyses of the individual surficial samples collected are provided in [Appendix A](#). [Figure 8](#) displays GSD curves for all of the beach samples. The beach sample's sediment grain size distribution is bimodal north to south. Those beach samples collected from the south end of the island, samples SRB-001 through 003, in the area least affected by shoreline retreat have the finest grain sizes, with an average mean of 1.3554 phi and an average median of 1.2481 phi. On the north end of the island, where shoreline retreat is most pronounced, samples SRB-004 through 007 have an average mean of 1.2038 phi and average median of 1.0669 phi. If sample SRB-006 is excluded, their average mean and median becomes 1.1372 and 1.002 phi respectively. Sample SRB-004B lying midway between the north and south ends of the island is bimodal in grain size distribution. As samples SRB-008 through 011 have an average mean of 1.3106 phi and an average median of 1.1758 phi, there appears to be a different dynamic going on regarding the narrow spit that connects the island to the mainland. Samples SRB-008 through 011 are bimodal in sediment grain size distribution with SRB-008 and 010 being finer and SRB-009 and 011 coarser in grain size. The inland/dune samples, samples SRB-003D through 005D have an average mean of 1.2256 phi and an average median of 1.225 phi. These samples have an average standard deviation of 0.3521 while in comparison, the beach samples have an average standard deviation of 0.3091. This suggests that, in addition to being coarser, these sediments are also more well-graded. Additionally, when compared with the beach samples, these samples are more consistent with each other.

#### Vibracores

Descriptions and photographs of individual vibracores are provided in [Appendix B](#). Granulometric analysis of individual samples taken from vibracores as well as GSD curves for all of these samples are also provided in [Appendix B](#). Vibracores VSRB-01 through VSRB-06 are annotated on the GPR transects provided as [Figure 5](#).

Figures 9 and 10 respectively show the GSD curves for the samples taken from vibracores obtained from the proposed borrow sites on the south end of Deadman's Island and off of the island. The sediments from the proposed borrow site on the south end of the island were coarsest. For the top 7.3 feet of

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VSRB-01 and the top 6.0 feet of VSRB-02, the average mean is 0.9750 phi with an average standard deviation of 0.3941 and an average median of 0.8377 phi. The bottom samples of each core have an average mean of 1.2011 phi with an average standard deviation of 0.4307, and an average median of 1.0589 phi. The sediments from the proposed borrow area off the island, as revealed in the granulometric analysis of VSRB-9 through VSRB-11, were bimodal in distribution with peaks at approximately 0.875 and 1.375 phi.

### **Hammer Cores**

SRBC-1 and SRBC-3 are composed primarily of coarse sand while SRBC-2 is composed primarily of sandy peat. Photographs and descriptions of individual hammer cores are provided in [Appendix C](#). Granulometric analysis of individual samples taken from these hammer cores as well as GSD curves for all of these samples are also provided in [Appendix C](#).

### **Ground Penetrating Radar**

Provided, as [Figure 5](#) with vibrocores and some interpretation superimposed, are the two GPR transects. The ground track of the investigation is shown in [Figure 1](#). These transects are not elevation corrected. It will be noted that the apparent deeper penetration at the south end of the island is actually due to elevation increases of a maximum of 9.8 feet (3.0 meters) while crossing a mound of dredge spoil located in this area. Penetration was generally limited to about 6.6 feet (2.0 meters) due to saline groundwater below this level. The vibrocores, VSRB-01 through VSRB-07, superimposed on the transects appear to penetrate to the limits of the GPR data. There is a prominent persistent reflector which lies near the base of penetration in the data which is conjectured to be an erosional surface.

Certain apparently anomalous reflections evidenced in the transects suggest that Deadman's Island may have a number of buried artifacts, many of which may be metallic. The apparently metallic indications all appear to lie above the undulating strong reflection visible at one to two meters depth, attributed to a prior erosional surface. It is conjectured that the location with evenly spaced shallow contacts toward the center of the island may have some relationship to careening, a method of cleaning sailing ship hulls, once done nearby in Old Navy Cove, possibly being "deadman" posts used to anchor careening cables.

## **DATA ANALYSIS, OLD NAVY COVE**

### **Side Scan Sonar Data**

On a macro scale over most of the survey area, there is no evidence of natural features elevated substantially above what is a relatively flat sea floor. A bottom feature present across the eastern extent of the survey area can be seen on the mosaics. This feature is caused by differences in sediment reflectance, the nature of which is not always immediately apparent on individual lines. This feature, as shown in [Figure 6](#), exhibits higher than average reflectance, with an orientation generally parallel to the shore line of the south end of Deadman's Island which broadens south and west of the island. This trend is clearly visible in the mosaics provided and, based on the ground truthing provided by the seabed samples collected, reflects a transition from sandy bottom sediments to finer grained sediments. Small scale shore parallel ripple marks characterize the seabed immediately adjacent to the shore of Deadman's Island.

On certain side scan sonar lines, most notably on line segments proximal to the western shore of Deadman's Island and on the shoal proximal to the north end of Deadman's Island, features indicative of the presence of submerged anthropogenic material were noted. These features can be divided roughly into four categories:

1. features extending from the seabed to above the sea surface;
2. areas of bottom with features exhibiting generally atypical reflectance characteristics, relief, linearity and occasionally right angles;

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3. large isolated features showing relief, linearity and/or right angles; and
4. isolated single objects that exhibited relief, right angles and/or are linear and narrow.

The first of these categories consists of two locations with reflections associated with the legs of bottom supported navigational light platforms, see [Figure 11](#) for an example, and one location with reflections associated with a seawall at the south end of Deadman's Island which extends out from the shore into Old Navy Cove. On a feature by feature basis the second and third of these categories, based on consultation with Dr. Roger Smith of the Florida Bureau of Archaeology, appear to correspond strongly with known or suspected locations of shipwreck debris. These features can be viewed on the 1.6 inch (4 centimeter) resolution mosaic "tiles" included in [Appendix H](#). An example of one of the features in category 2 is provided as [Figure 12](#). An example of one of the features in category 3 is provided as [Figure 13](#). The features illustrated in [Figures 12](#) and [13](#) are crossed by the paths of the towfish. The fourth category, again on a feature by feature basis, appears to comprise incidental modern debris, such as an occasional section of pipe or, more commonly, modern crab traps. Examples of three of the features in category 4 are provided as [Figure 3](#). One of the two light platforms appears to have debris on the seabed proximal to and apparently associated with it. This target is presumed to fit into the fourth category (see [Figure 14](#)). That figure also illustrated the legs of the second of the two bottom supported navigational light platforms seen in the survey area.

On the shoal proximal to the north end of Deadman's Island in and adjacent to the area intended for restoration, a number of features, which fit into categories 3 and 4, were noted on the seabed. These features definitely appear to be anthropogenic in origin. [Figure 15](#) (Empie, 2007) illustrates the area of proposed restoration. [Figure 16](#) is a side scan sonar mosaic of the area of proposed restoration and the seabed adjacent to it. A comparison of the manmade features noted in [Figure 15](#) with targets seen in [Figure 16](#) reveals a substantial agreement between the two figures. Additionally [Figure 16](#) shows more individual targets on the sea floor than depicted in [Figure 15](#) (Empie, 2007). This is corroborated by [Figure 3](#) in that it appears to image three pipes on the seabed in an area where only two pipes are noted on [Figure 15](#) (Empie, 2007). Of particular interest to the proposed restoration work is that, except for one target at the southern end of the structure, no targets are seen on the seafloor which appear to be in the path of the proposed breakwater structure. While most of the targets seen in the vicinity of the area to be restored appear to be relatively recent in origin, some targets (in particular the one intersected by the proposed structure as shown in [Figure 16](#)) may be ballast stone piles dating from the age of sail ([Figure 17](#)). As shown in [Figure 18](#), one unidentified target appears to be hexagonal. Its sides are roughly 8.2 feet (2.5 meters) long and, measured from opposite sides, it is roughly 14.54 feet (4.5 meters) across. Contained within this target and off centered is a square measuring approximately 4.82 feet (1.5 meters) across. One corner of the square is against the center of one of the sides of the hexagon. The opposite corner of the square appears to be connected by a narrow linear feature to the interior corner of the hexagon on the opposite side.

### Bathymetry

As shown in [Figure 7](#), the seabed of Old Navy Cove forms a very gently northwest dipping surface which rises steeply onto the shoals and shore line which surround the cove on three sides. The only deviations from this are a localized trough in the northeastern edge of the survey area adjacent to the shoal that forms the northeastern boundary of the cove and a broader trough on the southern edge of the survey area adjacent to the shoal that forms the southern boundary of the cove. Review of the bathymetric data reveal features which correlate with those seen in side scan sonar data as shown on the low resolution mosaic included in [Appendix H](#). Lower reflectance areas seen in side scan sonar data generally correspond to bathymetrically low areas while higher reflectance areas correspond to bathymetric high areas present on the margins of the survey area.

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## **Seabed Samples**

[Appendix D](#) provides descriptions of the eight seabed samples collected. Samples SRB-G5 and SRB-G6 are located proximal to the shore south and west of Deadman's Island ([Figure 1](#)). They lie within the area of higher reflectance noted in the side scan sonar data and illustrated on the low resolution side scan sonar mosaic found in [Appendix H](#). Sample SRB-G8 lies proximal to the shoal at the northern boundary of the survey area. It also lies in an area of higher reflectance. Samples SRB-G5, SRB-G6 and SRB-G8 are comprised primarily of sandy sediments. Samples SRB-G1, SRB-G2, SRB-G3 and SRB-G6 lie in deeper water in an area of lower reflectance. They are comprised primarily of silts and clays. Sample SRB-G3 is comprised of shelly material.

## **CONCLUSIONS AND RECOMMENDATIONS**

A comparison of the locations of surficial sediment samples SRB-006, SRB-007, SRB-008, and SRB-009 as plotted in [Figure 1](#), with the areas of recent erosion shown in [Figure 4](#), reveals that these samples are proximal to the portion of Town Point that recently eroded. A comparison of the locations of vibracores VSRB-4 and VSRB-8 as plotted in [Figure 1](#), with the areas of recent erosion shown in [Figure 4](#), reveals that VSRB-4 is also proximal to the portion of Town Point that recently eroded and that VSRB-8 was recovered immediately north of that area. Additionally, a comparison of [Figure 1](#) with [Figures 15](#) (Empie, 2007) and [16](#) will show that VSRB-8 lies within the area to be remediated and proximal to the structure to be installed. A comparison of the locations of the hammer cores collected, as plotted in [Figure 1](#), with the areas of recent erosion shown in [Figure 4](#), reveals that these cores were recovered from the portion of Town Point that recently eroded. SRBC-1 and SRBC-3 are composed primarily of sand and are believed to be representative of the eroded sediments of Town Point. It is suggested that the granulometric analysis performed on samples from these cores and on the grab samples be used in selecting proposed restoration sediments. To further that end, [Figures 19](#) and [20](#), respectively, graphically compare the GSD curves of samples collected from vibracores taken from the two proposed borrow areas with samples, collected in the area to be remediated off the north end of the island, from the two hammer cores, SRBC-01 and SRBC-03, and the one vibracore, VSRB-08, collected in the area. These two figures also compare them with samples collected from vibracore VSRB-04 taken on the north end of the island and beach samples collected from the north end of the island peripheral to the area to be remediated (SRB-06 through SRB-09).

As can be seen from the curves displayed in [Figures 19](#) and [20](#), the sediments in the proposed borrow areas are an acceptable grain size match with the sediments in the area to be remediated as well as the sediments of that portion of the island adjacent to it. In total, the sediments of the proposed borrow site external to the island are slightly finer grained while those of the on island site are slightly coarser grained.

The vibracores, VSRB-01 through VSRB-07, superimposed on the GPR transects appear to penetrate to the limits of the GPR data. There is a prominent, persistent reflector which lies near the base of penetration in the data which is conjectured to be an erosional surface. This reflector may relate to changes in sediments at depth seen in VSRB-03 through VSRB-06. It may also relate to changes in sediment types seen in the seabed samples which appear to be tied to changes in seabed reflectance as seen in the side scan sonar data. These changes in seabed reflectance, as shown on [Figure 6](#) and the southern third of the high resolution side scan sonar mosaic tiles, lies parallel to and along the shoreline west of the southern end of Deadman's Island.

Please note that in selecting which line segments to include in the side scan sonar mosaics other line segments were not displayed. Only one feature of concern, a suspected ballast stone pile as shown on [Figures 16](#) and [17](#), was noted in the path of the breakwater structure. Review of all of the side scan sonar segments along the full path of the breakwater structure, as shown on [Figures 15](#) (Empie, 2007) and [16](#), by a marine survey archeologist is suggested.

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Certain, apparently anomalous, reflections evidenced in the GPR transects suggest that Deadman's Island may have a number of buried artifacts, some which may be metallic. A location with evenly spaced shallow contacts toward the center of the island may have some relationship to known historical activities performed both on the island and in Old Navy Cove. The anomalous reflectors noted lie at various depths within the transects. This suggests that they are not all contemporaneous. As geologists, investigations of such features are well outside of our field of expertise. It is suggested that the investigation of these and other anomalous reflections be referred to professionals in the field of historical research.

Included with this report is a PowerPoint presentation that illustrates the main points raised within this report. This presentation can be found in [Appendix I](#).

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