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## A Geotechnical Evaluation of Chesapeake Beach Shoal for Beach Quality Sand

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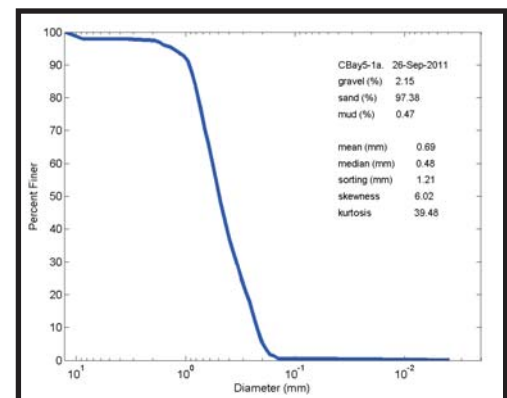
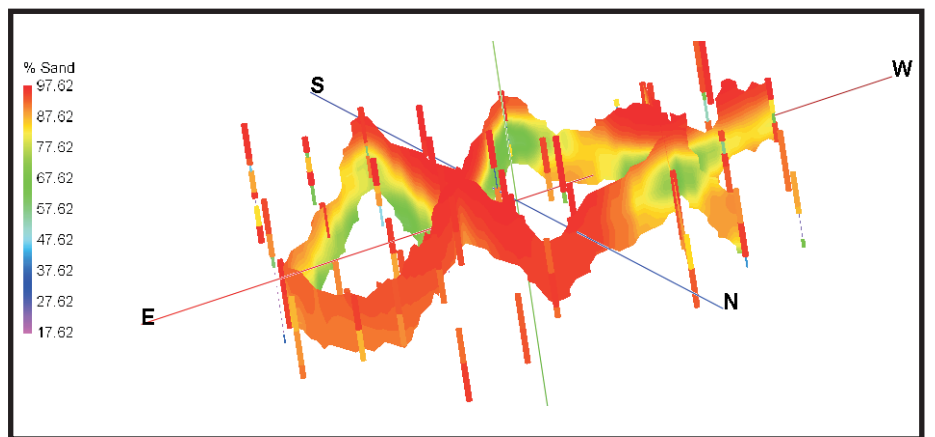
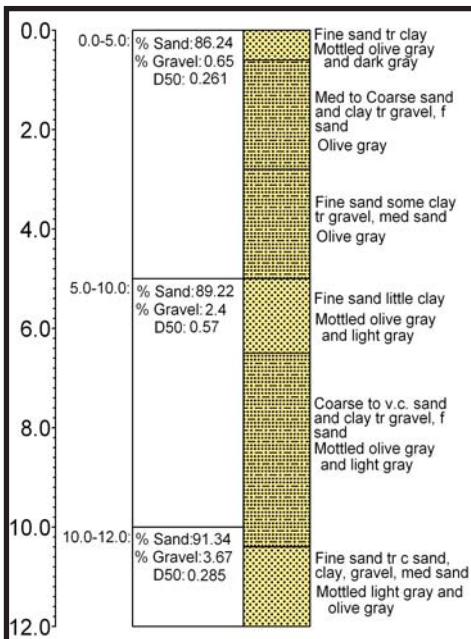
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# A Geotechnical Evaluation of Chesapeake Beach Shoal for Beach Quality Sand



Shoreline Studies Program  
 Department of Physical Sciences  
 Virginia Institute of Marine Science  
 College of William & Mary

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# Table of Contents

Table of Contents .....	i
List of Figures .....	ii
Introduction .....	1
Methods .....	2
Cores	
<i>Field Sampling</i> .....	2
<i>Description and Sampling</i> .....	3
<i>Data Compilation and Analysis</i> .....	3
Nearshore Modeling .....	4
Results and Discussion .....	6
Cores .....	6
Nearshore Modeling .....	7
Conclusions .....	7
References .....	8

- Appendix A Final Report submitted to VIMS by Athena Technologies, Inc.
- Appendix B Core Photos
- Appendix C Core Logs
- Appendix D Sediment Sample Grain Size Characteristic Graphs
- Appendix E Sub-Bottom Cross-Sections derived from Core Data
- Appendix F Wave Modeling Result Summary

## List of Figures

Figure 1-1. Location of Chesapeake Beach on Chesapeake Bay. . . . .	9
Figure 1-2. Location of cores taken for this project, and the location of the core taken by Hobbs <i>et al.</i> (1981). . . . .	10
Figure 2-1. Data sources for the nearshore modeling grids. The other elevation data needed for the modeling grids came from NOAA's Tsunami Inundation DEMs ( <a href="http://www.ngdc.noaa.gov/mgg/inundation/">http://www.ngdc.noaa.gov/mgg/inundation/</a> ). . . . .	11
Figure 2-2. Nearshore bathymetry used in the wave refraction model. A) is the area modeled for waves approaching from the east. B) is the area modeled for waves approaching from the north and northeast. . . . .	12
Figure 2-3. Proposed 5 ft and 10 ft dredging scenarios for modeling purposes, and output station locations for the nearshore wave modeling. . . . .	13
Figure 3-1. Mean-weighted average of the percent of sand and gravel in the first 5 ft of each core. Also shown is the mean-weighted D50 in mm and the percent of sand and gravel. 2009 VGIN image. . . . .	14
Figure 3-2. Mean-weighted average of the percent of sand and gravel in the first 10 ft of each core. Also shown is the mean-weighted D50 in mm and the percent of sand and gravel. 2009 VGIN image. . . . .	15
Figure 3-3. Proposed dredge scenarios for the areas on the east and west side of the Chesapeake Bay Bridge Tunnel. 2009 VGIN image. . . . .	16

## List of Tables

Table 1. Tide datum elevations for Chesapeake Bay Bridge Tunnel relative to mean lower low water for the 1983-2001 tidal epoch (NOAA, 2011) . . .	5
Table 2. Summary of input wave conditions to STWAVE. . . . .	5
Table 3. Projected volume (cubic yards) for six dredge scenarios as shown in Figure 3-3. . . . .	6

## Introduction

Chesapeake Beach Shoal is located along the southern coast of Chesapeake Bay in Virginia Beach, Virginia (Figure 1-1). Chesapeake Beach, which is nearly adjacent, has a history of chronic beach erosion which threatens upland infrastructure. Beach nourishment occurs on Ocean Park Beach to the east from intermittent dredging of Lynnhaven Inlet (Figure 1-2), but the effects do not always translate westward to Chesapeake Beach. The general alongshore sand movement is east to west. The purpose of this project is to establish a reliable source of beach sand for Chesapeake Beach via the nearshore shoal.

Many issues, including identifying the location and volume of suitable material, cost effectiveness, permitting requirements (marine habitat impacts) and impacts to the local wave climate, must be addressed before mining sand from offshore shoals. Permits for sand mining for beach nourishment in the Bay have been granted for the Buckroe and Factory Point areas, but extensive environmental assessments are required. First, the sand resource must be identified in order to develop a dredging/mining plan.

A single core, taken by VIMS in 1981 (Hobbs *et al.*, 1981), showed that the first 20 feet of material in the subbottom was at least 97% sand (Figure 1-2). According to results from Hobbs *et al.* (1981), the surface sediments in Chesapeake Beach Shoal are mostly very fine grained silty-sands, grading to gray medium sand near the beach. The core shows a sand horizon starting at the beach which has an overburden of inorganic clays and silts that thickens to the north and west. However, a surface deposit has a thickness of between 7 and 20 ft and an estimated volume of material with an overfill ratio of less than 2.0 is about 3.0 million cubic yards (Hobbs *et al.*, 1981). According to the Army Corps of Engineers (1990) the average mean grain size of the beach sands along Ocean Park is 0.35 mm (medium-grained). This analysis is no doubt influenced by recent beach fill projects. Hobbs *et al.* (1992) found the sediments in the nearshore to be between 0.2 mm and 0.35 mm.

This report focuses on the acquisition of short cores and site data in order to establish the extent of the sand resource and provide data for developing a sand-mining plan. Athena Technologies took 42 vibracores in August 2011. These were analyzed to determine grain size characteristics which would define the location and suitability of beach quality material in the nearshore off Chesapeake Beach. In addition, a selected storm wave was modeled to determine the effect of the proposed dredging in the nearshore.

## Methods

### Cores

#### *Field Sampling*

Athena deployed their 35 foot research vessel, *Artemis*, as the primary sampling platform. It utilized a Trimble DGPS (sub-meter accuracy) interfaced through HYPACK® and a Sitex CVS-106 fathometer (accurate to 0.1 ft) for basic horizontal and vertical positioning. Final elevations were derived using tidal data provided by the National Oceanic and Atmospheric Association (NOAA) for station 8638863, Chesapeake Bay Bridge Tunnel ([http://tidesandcurrents.noaa.gov/data\\_menu.shtml?stn=8638863%20Chesapeake%20Bay%20Bridge%20Tunnel%20VA&cype=Tide%20Data](http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8638863%20Chesapeake%20Bay%20Bridge%20Tunnel%20VA&cype=Tide%20Data)).

The coordinates of the sample stations were provided to Athena by VIMS (Figure 1-2). A three-point anchoring system secured the vessel during the deployment of Athena's custom designed and built vibracoring system. This system consists of a mechanical vibrator attached directly to the sampler apparatus. The sample barrel was a three inch, 16 gauge steel tube. The sample barrel was lowered to the sea-floor through a moon pool in the deck by attaching lengths of drill stem. The vibrator was then turned on and drove the sample barrel until it reached the target depth or refusal. Jetting was required at station VIMS-37. This involved attaching a jet pump to the sample barrel and lowering it to the sea floor. The pump was then turned on and the sample barrel was advanced to one foot above the previously penetrated depth. The vibrator was then turned on driving the barrel further into the bottom. The sample barrel was then retrieved using an electric winch. Once the sample was on deck, the sample barrel was cut into five foot sections, capped, labeled, and measured.

A video camera recorded penetration as the vibracore system advanced into the bottom. The equipment is marked in half-foot increments, and advancement is determined in the office by calculating the amount of time passing for each one-foot interval of insertion.

The completed cores were opened, transferred to PVC pipe, wrapped in plastic wrap and then placed into heavy-duty plastic tubing. They were then transferred to VIMS for processing. (From "Field Sampling Methodologies Used for the Collection of Vibracore Samples Offshore of Virginia Beach, Virginia in the Vicinity of the Chesapeake Bay Bridge Tunnel," Athena Technologies, Inc. report, [Appendix A](#))

## *Description and Sampling*

At VIMS, each five foot section was opened and photographed in one-foot intervals on a 17% gray background ([Appendix B](#)). The sections then were systematically logged from top down ([Appendix C](#)). The descriptions included color, major and minor constituents, foreign/miscellaneous material, and soil types. Color was determined using the Geotechnical Gauge card manufactured by McCollough. Major and minor constituents specified grain size using the Wentworth Classification: very coarse sand (1.0-2.0 mm), coarse sand (0.50-1.0 mm), medium sand (.25-.50 mm), fine sand (0.125-0.25 mm), very fine sand (0.0625-0.125 mm), silt (0.0039-0.0625 mm), and clay (0-0.0039 mm). Minor constituents included the qualifiers trace (1-10%), little (10-20%), some (20-35%), and (35-50%). Foreign/miscellaneous material consisted of shell fragments, wood fragments, and organics. Unified Soil Classification System (USCS) soil types were assigned to the sediment. These included SP (poorly graded clean sand), SW (well graded clean sand), SM (silty sand), SC (clayey sand), ML (inorganic silts with v.f. sand or clay), and CL (inorganic clays with sand or silt). In addition, clays were described as very soft, soft, medium stiff, stiff, very stiff, or hard.

A channel sample collected down center of each section of core provided a representative sample. If a core section contained substantially different lenses of sediment, each was sampled separately. The sediment sample was homogenized. Samples were sent to the sediment lab to determine grain-size distribution. Sediments were sieved to determine percent gravel, sand, silt and clay ([Appendix D](#)). The sand fraction was analyzed with VIMS' Rapid Sediment Analyzer. These data were combined to calculate entire sample statistics, including the D50, using a custom Matlab® program created as per Blott and Pye's (2001) description of the arithmetic method of moments. Each sample's frequency curve and sample statistics are presented in [Appendix D](#).

## *Data Compilation and Analysis*

The program RockWorks, a software for downhole data by RockWare®, was used to store and analyze the core data. Information entered into RockWorks included location, sediment descriptions, color, soil type, sample statistics, and core photographs. 2D strip logs were created for each core depicting sediment description and color ([Appendix C](#)). Sample statistics of % gravel (>2 mm), % sand (2mm>sand<0.0625 mm), % silt (0.0625mm<silt>0.0039mm), % clay (<0.0039mm), total % fines (%silt + %clay) and total sand and gravel (%gravel + %sand) were used to generate models of the shoal depicting the location of acceptable material content (>90% material is sand and the D50 >0.25 mm). Because the channel samples had varying lengths down the core, the weighted mean was calculated with the individual



sample statistics of percent sand and gravel and the D50 in order to summarize the overall core statistics.

## Nearshore Modeling

The Coastal Engineering Design & Analysis System (CEDAS) modeling system (Veri-tech, Inc., 2012) was used to model potential changes to waves due to dredging. It consists of the Nearshore Evolution MOdeling System (NEMOS) and STWAVE. NEMOS is a set of computer codes that operates as a system to simulate the long-term evolution of the planform of the beach in response to wave conditions, coastal structures, and other engineering activity (*e.g.*, beach nourishment). Within NEMOS, grids and spectral wave data are created for STWAVE. STWAVE uses a 2-D finite-difference representation of a simplified form of the spectral balance equation to simulate near-coast, time-independent spectral wave energy propagation.

Data from several sources were used to create a nearshore modeling grid that was as accurate as possible. The data sources include shore zone survey by Shoreline Studies Program personnel (Jun-Aug 2006) and the U.S. Army Corps of Engineers (January 2007) at Little Creek Naval Amphibious base during several Shoreline Studies projects, and nearshore survey in September 2010 by Waterways Survey and Engineering, LTD for the City of Virginia Beach (Figure 2-1). The data for the rest of the grid came from the Navy's contour map dated August 2003 and from the NOAA's Tsunami Inundation DEMs (<http://www.ngdc.noaa.gov/mgg/inundation>). These data were converted from various vertical datums to mean high water (MHW). The mean tide range at the Chesapeake Bay Bridge Tunnel is 2.55 ft and the diurnal tide range is 2.90 ft (Table 1). Two grids were created to model effect of nearshore dredging, one for north and northeast waves, and the second for waves coming through the mouth of the Bay (Figure 2-2).

The same storm condition was modeled for both grids (Table 2). A wave gage was deployed in March 2006 in the southern Chesapeake Bay in 22 m of water approximately 1 mile off Norfolk's shoreline and 6 miles west of the Chesapeake Bay Bridge Tunnel (CBBT) (Puckette and Gray, 2008). This gage recorded a significant wave height ( $H_s$ ) of 8.7 ft on November 22, 2006. This was greater than the 7.7 ft  $H_s$  during Tropical Storm Ernesto on September 1, 2006. Data from the CBBT on November 22, 2006 shows a maximum storm surge of 3 ft with sustained winds averaging 40 mph.

Two dredging scenarios were modeled for their effect on waves. The first scenario was a 5 ft dredge cut across the entire sampling area (Figure 2-3). The second scenario was dredging 10 ft in the offshore area only. In order to

model these scenarios, the existing bathymetry was modified to reflect the proposed changes in bottom elevation due to the dredging. Because of the restricted zone near the bridge where no dredging will occur, the bathymetry was not modified in this area. Transformation of storm waves was modeled on the existing bathymetry and on the modified bathymetry.

The results for predicted wave height and wave angle from the modeling runs for selected stations for all three scenarios (existing, 5 ft, and 10 ft) were compared. For wave height, positive differences indicate that the wave height is larger, while negative differences indicate a reduction in wave height. For wave angle, positive values indicate that the wave will have a more westerly heading while negative values indicate the waves become more easterly.

Table 1. Tide datum elevations for Chesapeake Bay Bridge Tunnel relative to mean lower low water for the 1983-2001 tidal epoch (NOAA, 2011).

Tidal Datum	Elevation (ft MLLW)
Mean higher high water	2.90
Mean high water	2.68
Mean sea level	1.42
Mean low water	0.13
Mean lower low water	0
NAVD88*	1.65

\*Elevation at Sewells Point

Table 2. Summary of input wave conditions to STWAVE.

Orientation	Hs (m)	T(s)	angle	Wind (mph)	Surge (ft)
North	2.650	5.000	5° TN	40	3
Northeast	2.650	5.000	45° TN	40	3
East	2.650	5.000	90° TN	40	3

## Results and Discussion

### Cores

Analysis of the vibracores indicates that the shoal area offshore of Virginia Beach consists of sand suitable for dredging and placement on the beach. Cross-sections along the coring grid show that sediments with a suitably high combined percent of sand and gravel are thick throughout the study area (Appendix E).

The percent of sand and gravel sample statistics were mean-weighted with sample length to determine the overall statistics in the first five feet of each core and was plotted to determine suitability for the 5 ft dredging scenario (Figure 3-1). Most of the study area is greater than 90% sand and gravel with  $D_{50}$ s greater than 0.25 mm in the first five feet below the bottom. When the mean-weighted percent sand and gravel for the first 10 ft of each core is plotted, the nearshore region at depth is finer than the first 5 ft (Figure 3-2). The offshore area has suitable material for the 10 ft dredging scenario.

The proposed dredge scenarios are shown in Figure 3-3. The 5 ft scenario includes the area in green dredged on both sides of CBBT. If just the east side of the study area were dredged, approximately 3.8 million cubic yards (cy) of material with an average  $D_{50}$  of medium sand would be available (Table 3). If only the offshore area, as depicted by the cross-hatching, is dredged on the east side, approximately 4.1 million cy of material would be available for placement.

Table 3. Projected volume (cubic yards) for six dredge scenarios as shown in Figure 3-3.

Case	Dredge Scenario	Side	Volume (cy)	Average $D_{50}$ (mm)
1	5 ft	East	3,810,000	0.41
2	5 ft	West	1,080,000	0.51
3	10 ft	East	4,140,000	0.37
4	10 ft	West	980,000	0.51
5	5 ft & 10 ft	East	5,890,000	0.46
6	5 ft & 10 ft	West	1,570,000	0.44

## Nearshore Modeling

Nearshore modeling indicates little change to the wave height or direction as a result of either dredging scenario (Appendix F). For waves from the north, only two sites have a change in wave height greater than 0.1 m and only 3 sites have wave angles that varied by more than 5 degrees. The largest change occurred at station #82 which went from 0.8 m on the existing bathymetry to 1.1 m on both dredge scenarios. Several sites had wave heights reduced by as much as -0.1 m. The angle varied less than 10 degrees. Results at stations #60 through #82 indicated that the waves may approach the shoreline in a more easterly direction. However, the average change in the angle was -1.7 degrees with a range of 0 to -6 deg.

For the northeast waves modeled, only two sites had wave height change larger than 0.1 m while several sites had wave heights reduced by as much as -0.1 m for both the 5 ft and 10 ft scenarios (Appendix F). The northeast had more wave variation under the 5 ft and 10 ft scenarios than the north. At thirty four stations (5 ft scenario) and 78 stations (10 ft scenario) wave angle varied more than 1 degree. With the exception of stations #29 and #32, all the large changes in angle (greater than 10 degrees toward the west) are along the shoreline.

Not all of the output stations were included in the analysis for the storm wave condition from the east. Stations, along the shoreline and across the proposed dredge area, were included (Appendix F). This analysis showed that wave height did not change by more than  $\pm 0.1$  m for both scenarios. Wave angle was more variable, but only 3 stations (#31, #61, and #82) changed by more than  $\pm 5$  degrees under the 5 ft dredge scenario and no stations changed by more than 5 degrees under the 10 ft scenario.

## Conclusions

Suitable material is available offshore of Chesapeake Beach for beach nourishment purposes. Much of the area has greater than 90% sand and gravel-sized material with an average  $D_{50}$  greater than 0.25 mm. Case 3, the 10 ft dredging scenario on the east side of CBBT, will provide the most material for beach nourishment. Getting permission to dredge on the west side of the CBBT may be difficult since it is a military restricted area, but the material is suitable for beach nourishment. The limited analysis of wave climate performed for this project indicates that minor alterations to the wave climate could occur during storms. However, they generally will tend to drive more material westward.

## Acknowledgments

Thanks to Carl Hobbs, III and Lyle Varnell for serving on the contract committee and editing this report. Thanks to Cynthia Harris for helping us navigate the contract process.

## References

- Athena Technologies, Inc., 2011. Field Sampling Methodologies Used for the Collection of Vibracore Samples Offshore of Virginia Beach, Virginia in the Vicinity of the Chesapeake Bay Bridge Tunnel. Data report submitted to the Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia.
- Blott, S.J., and K. Pye, 2001. Gradistat: a grain size distribution and statistics package for the analysis of unconsolidated sediments. *Earth Surf. Process. Landforms* **26**, 1237-1248.
- Hobbs, C.H., III, R. J. Byrne, and R.A. Gammisch, 1981. Inventory of Sand Resources in the Southern Portion of Chesapeake Bay. Final report to the Coastal Erosion Abatement Commission, Commonwealth of Virginia. Virginia Institute of Marine Science, School of Marine Science, College of William & Mary.
- Hobbs, C.B., III, J.P. Halka, R.T. Kerhin, and M.J. Carron, 1992. Chesapeake Bay sediment budget. *J. Coastal Res.* **2**:292-300.
- NOAA, 2011. [http://tidesandcurrents.noaa.gov/data\\_menu.shtml?stn=8638863](http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8638863) Chesapeake Bay Bridge Tunnel, VA&type=Datums
- Puckette, P.T. and G.B. Gray, 2008. Long-term performance of an AWAC wave gauge, Chesapeake Bay, VA. Proceedings IEEE/OES/CMTC Ninth working conference on Current Measurement Technology, 119-124. <http://www.nortekusa.com/lib/bibliography/long-term-performance-of-an-awac-cmtc2008>
- U.S. Army Corps of Engineers, 1990. Ocean Park Beach. Section 933 Evaluation Report, Norfolk, VA, 75 pp.
- Veri-tech, Inc., 2012. <Http://www.veritechinc.com>.

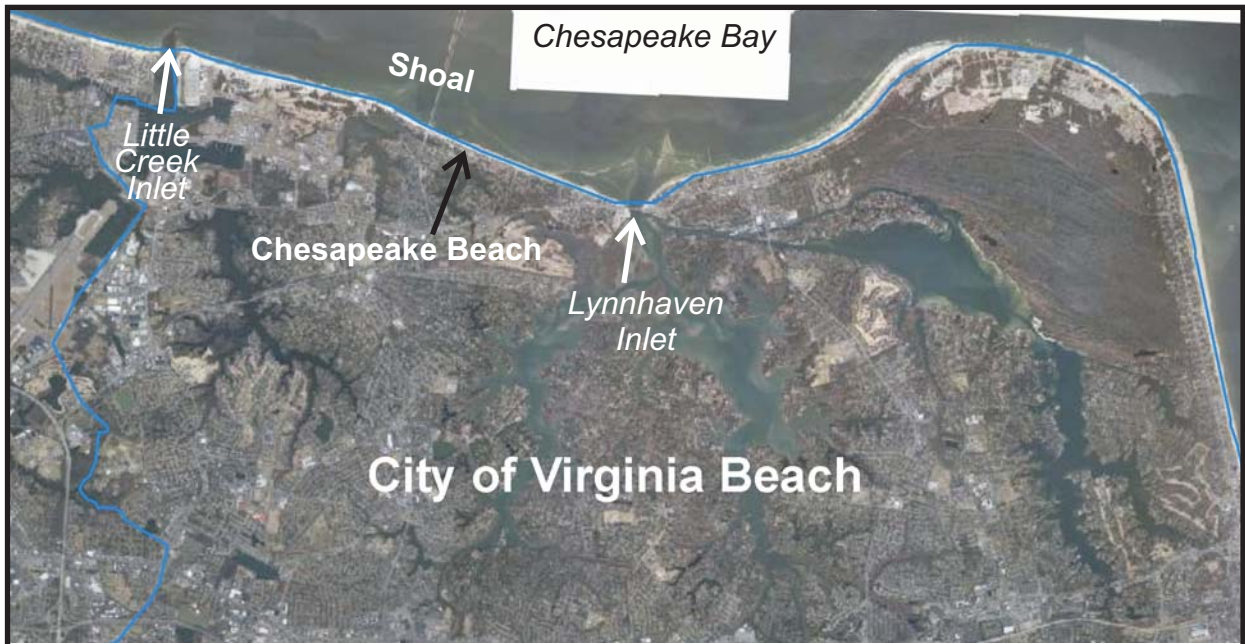
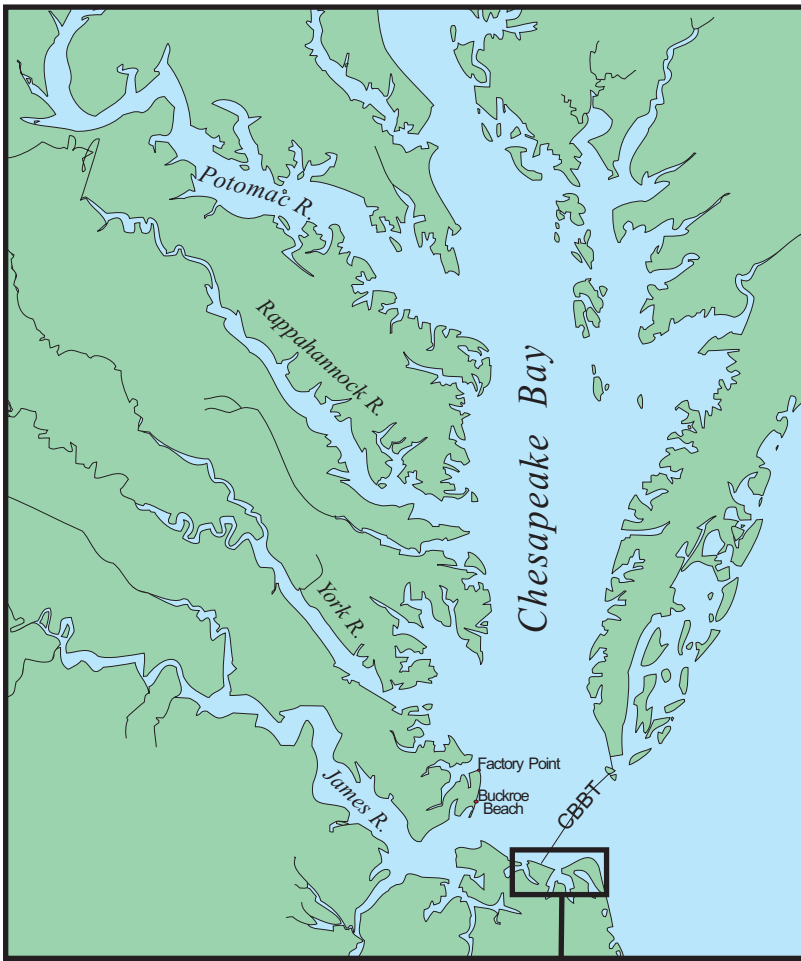


Figure 1-1. Location of Chesapeake Beach on Chesapeake Bay.



Figure 1-2. Location of cores taken for this project, and the location of the core taken by Hobbs *et al.* (1981).

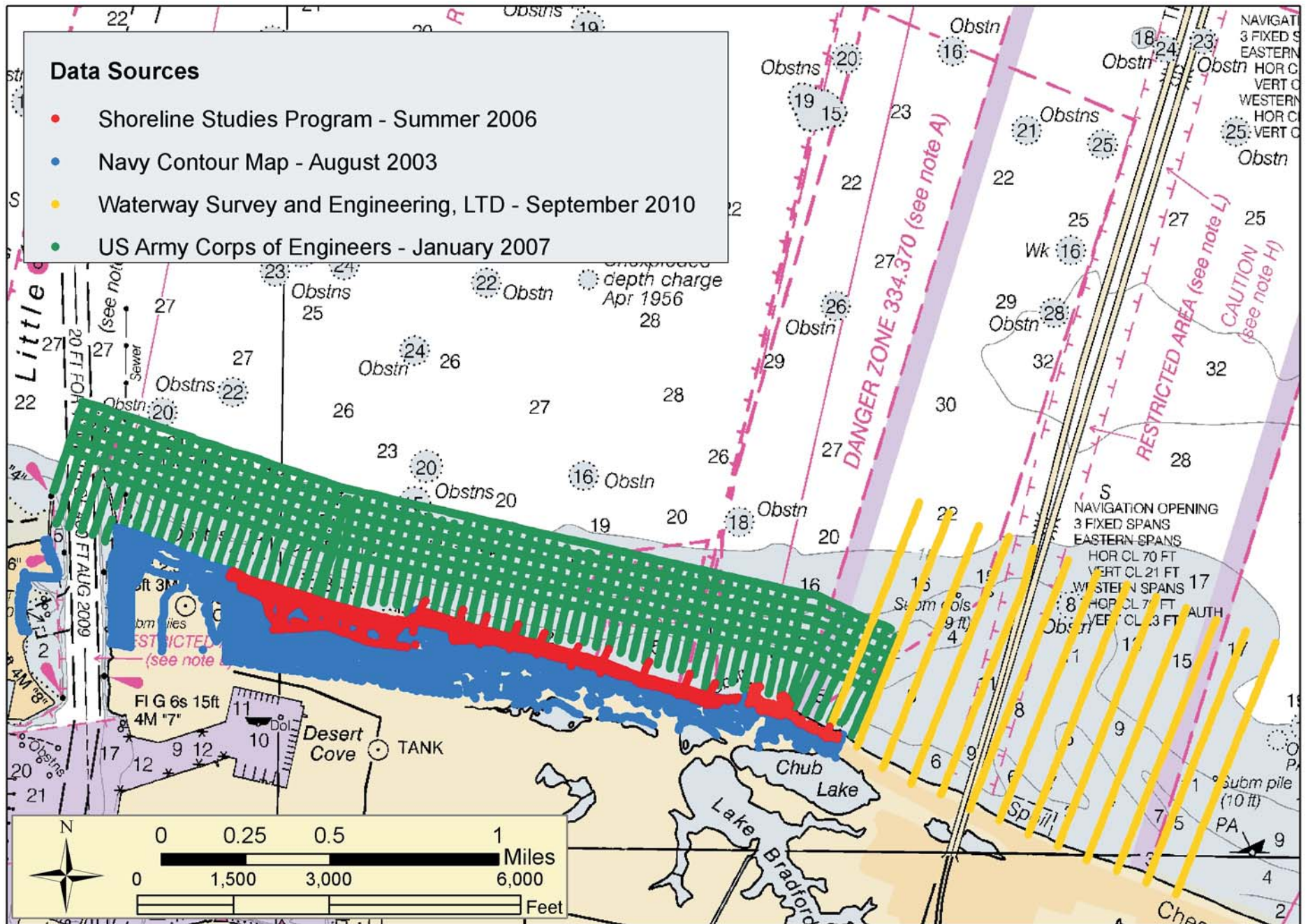


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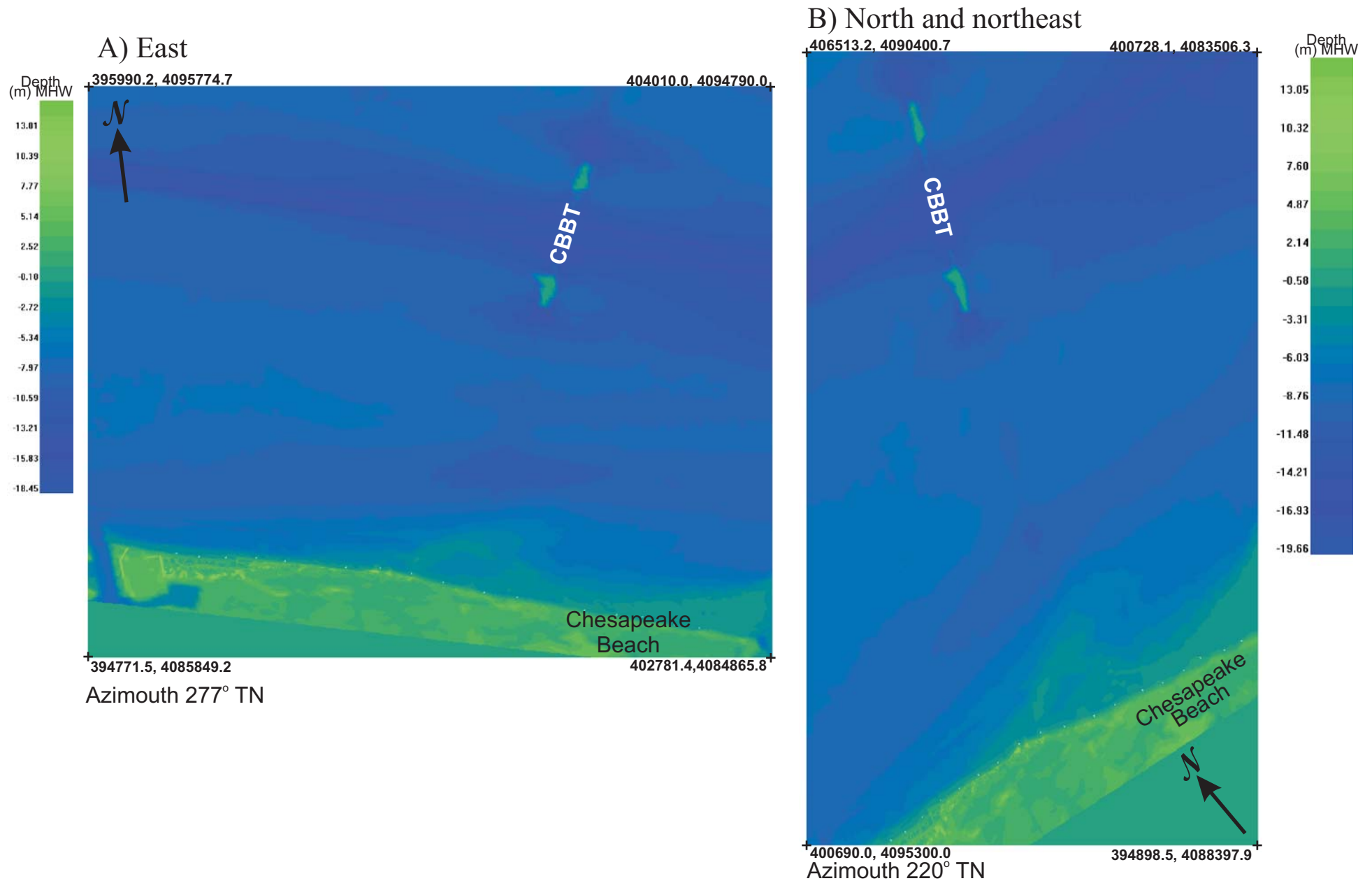


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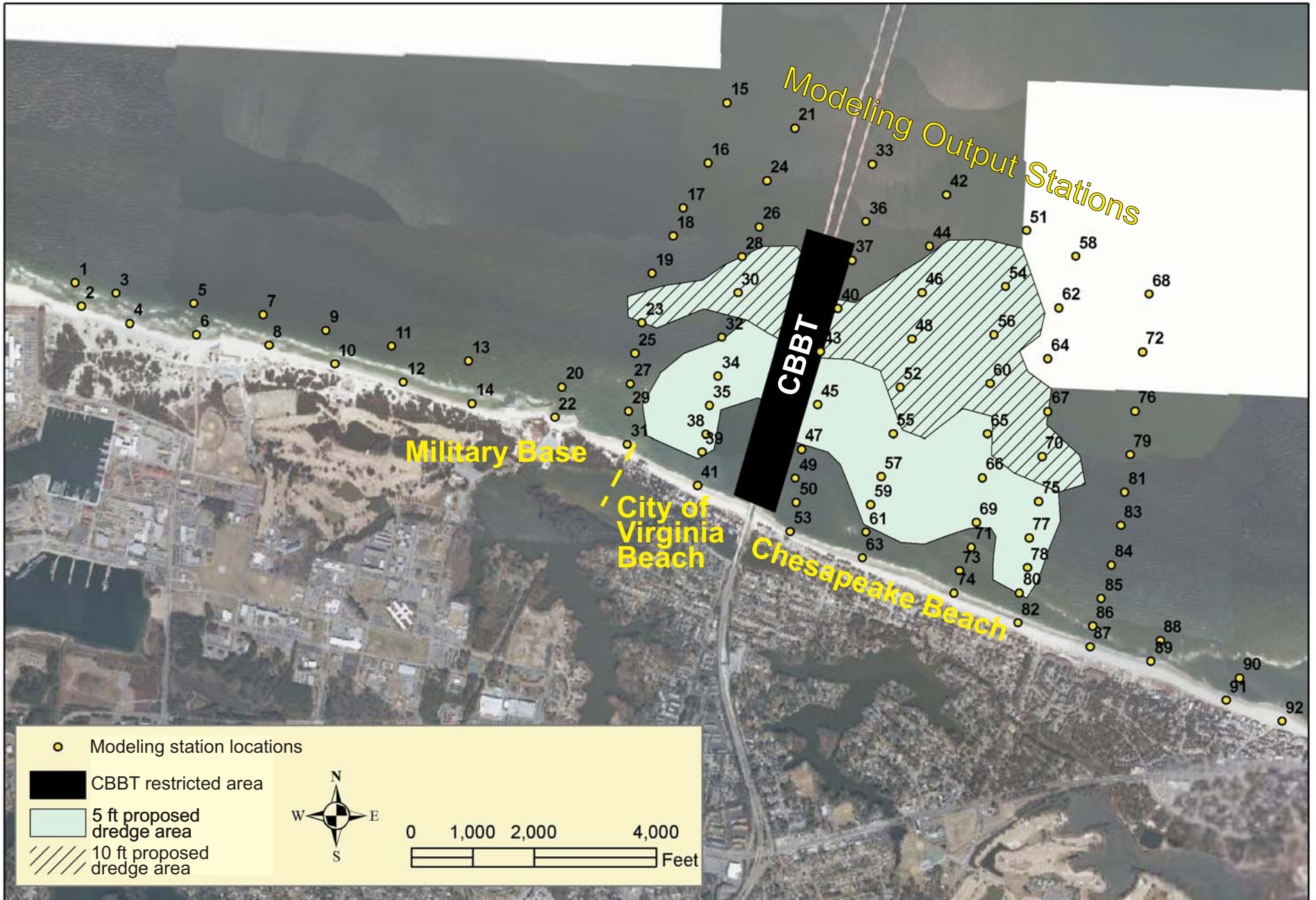


Figure 2-3. Proposed 5 ft and 10 ft dredging scenarios for modeling purposes, and output station locations for the nearshore wave modeling.

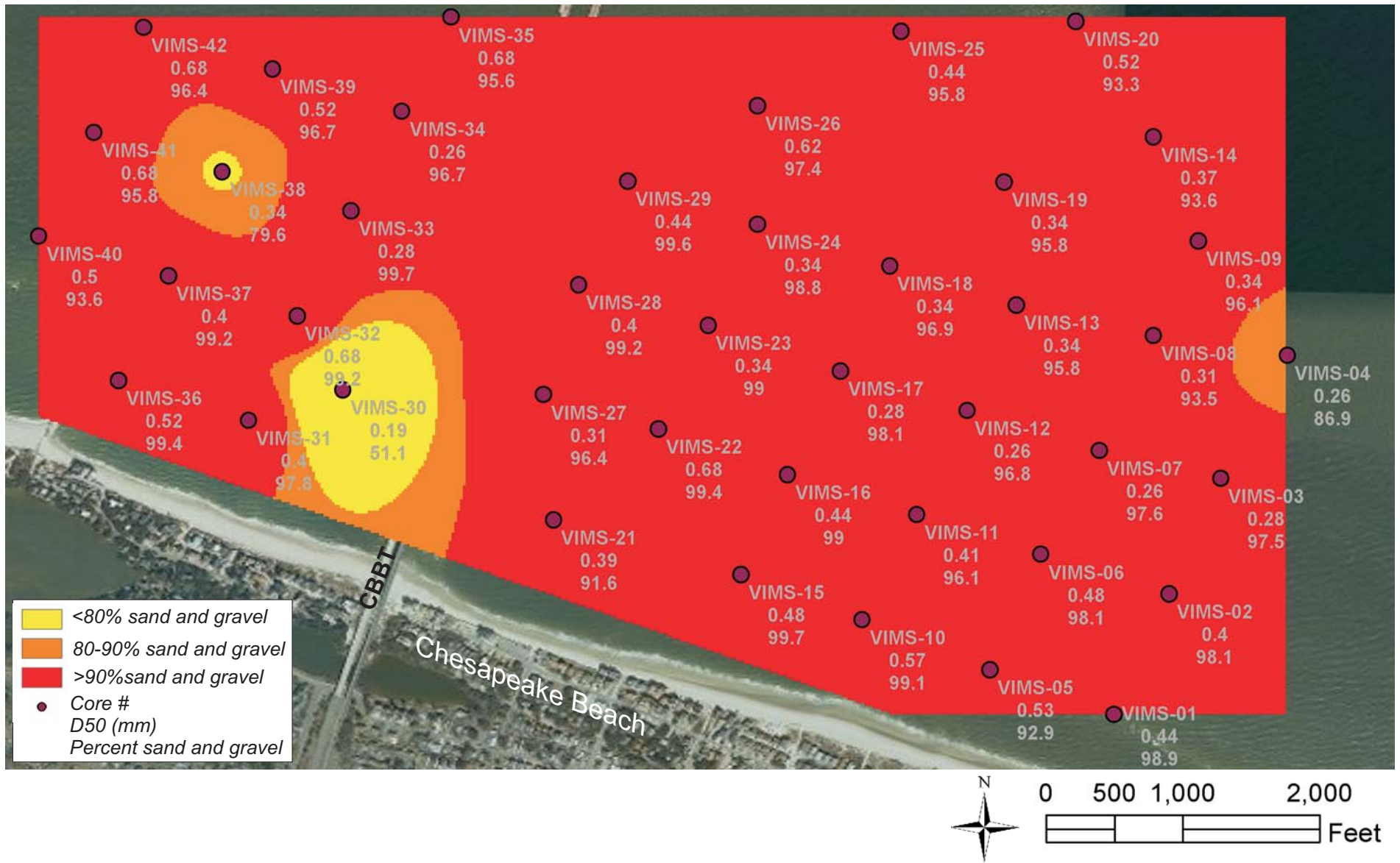


Figure 3-1. Mean-weighted average of the percent of sand and gravel in the first 5 ft of each core. Also shown is the mean-weighted D50 in mm and the percent of sand and gravel. 2009 VGIN image.

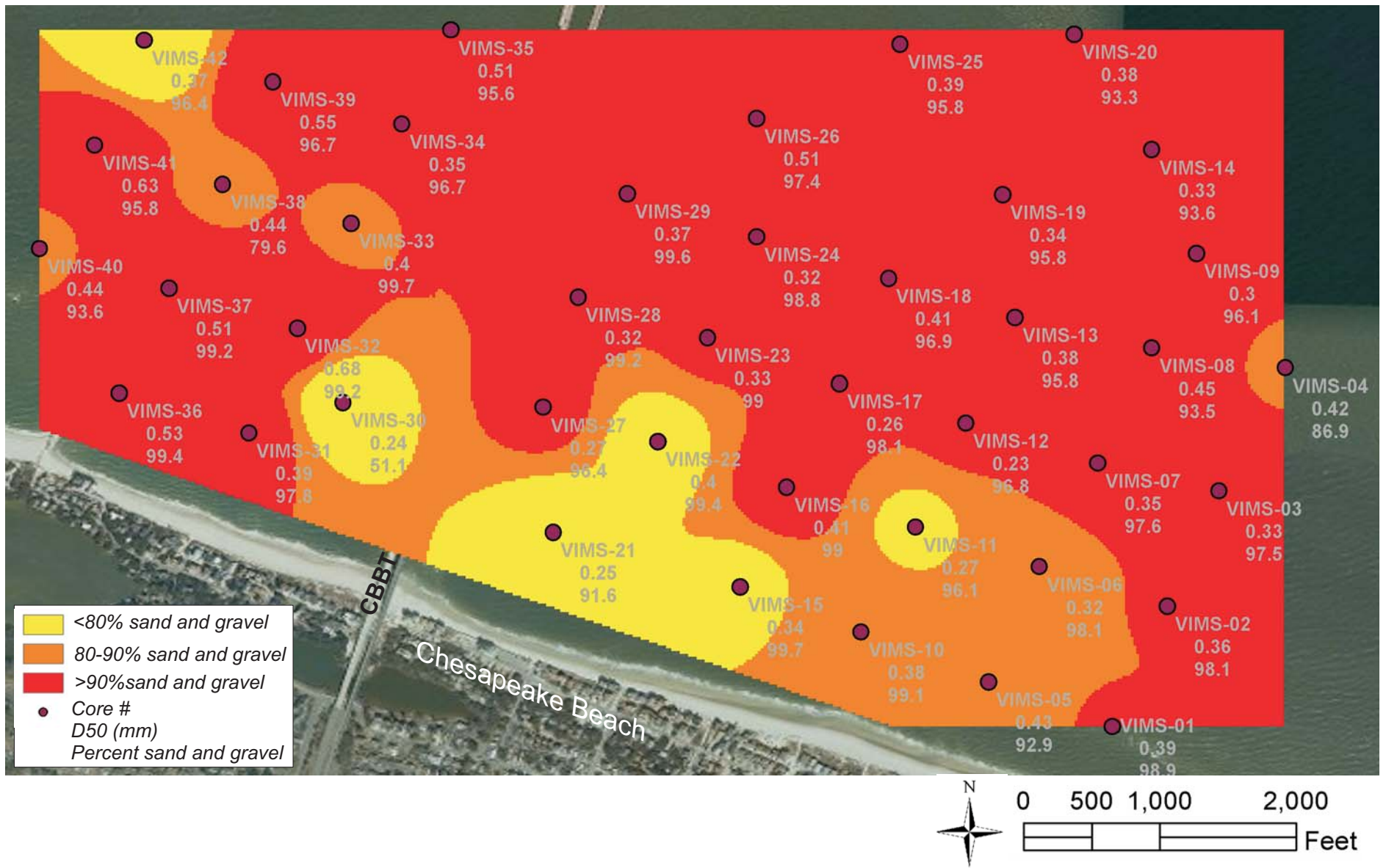


Figure 3-2. Mean-weighted average of the percent of sand and gravel in the first 10 ft of each core. Also shown is the mean-weighted D50 in mm and the percent of sand and gravel. 2009 VGIN image.



Figure 3-3. Proposed dredge scenarios for the areas on the east and west side of the Chesapeake Bay Bridge Tunnel. 2009 VGIN image.