Assessment of offshore sand resources for beach remediation in Virginia

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DISCLAIMER

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ABSTRACT

The Virginia Department of Mines, Minerals and Energy's Division of Geology and Mineral Resources (DGMR) and U.S. Bureau of Ocean Energy Management (BOEM) initiated a multi-year cooperative agreement in 2014 to assess marine sand resources on the Outer Continental Shelf (OCS) for future beach restoration needs. As part of the project, BOEM contracted the Chicago Bridge and Ironworks Company (CB&I) in 2015 and 2017 to collect geophysical data and sediment core samples in two study areas located three to eight nautical miles offshore of the Virginia coast. With assistance from DGMR geoscientists, CB&I used existing bathymetric data to target areas where sand shoals are present. The two targeted areas are proximal to beaches that have significant erosion risks and have required sand nourishment in the past to protect the coastal infrastructure and habitat. The northernmost area (Wallops) is located offshore of Assateague and Wallops Islands and encompasses about 245 square kilometers (km^2; 72 square nautical miles, nm^2). The southernmost area (Sandbridge) is offshore of Sandbridge and False Cape State Park and encompasses about 187 km^2 (54 nm^2).

DGMR geoscientists analyzed 201 line-km (109 line-nm) of reconnaissance-scale seismic survey data collected by CB&I to assess the quality, thickness, and extent of sand deposits that could be used for beach restoration. Geophysical data analysis was accomplished using Chesapeake Technology's SonarWiz6 seismic processing software and ESRI's ArcMap GIS software. CB&I and the Delaware Geological Survey provided lithologic logs and grain size analytical data for samples taken from 15 vibracores in the two study areas.

Lithologic logs from the vibracores were used to correlate reflectors identified in the seismic sub-bottom data and to map the distribution and thickness of sand deposits. This analysis enabled volumetric calculations of the potential sand resources in areas containing a minimum sand thickness of 5 feet, and areas with a minimum sand thickness of 10 feet. The results of mapping also indicate areas where the sand thickness is less than 5 feet and unlikely to occur in recoverable quantities.

Beach-quality sand occurs in Holocene-age sand shoals, sheets, and paleo-channel infill deposits above fluvial and estuarine sediments of Pleistocene and Pliocene age in both resource areas. In the Sandbridge area, we estimate about 333 million cubic yards of fine to medium grained sand with a minimum thickness of 5 feet, and 271 million cubic yards with a minimum thickness of 10 feet. The mean grain size is 0.32 mm ($\phi M=1.68$). To the north in the Wallops area, we estimate about 421 million cubic yards of fine grained sand with a minimum thickness of 5 feet, and 393 million cubic yards of sand with a minimum thickness of 10 feet. The mean grain size is 0.21 mm ($\phi M=2.44$). The preliminary volumetric estimates will require additional infill data collection and analysis to confirm viable resources.

INTRODUCTION

Following the devastating erosional impacts of Hurricane Sandy along the Atlantic coastline in 2012, the U.S. Bureau of Ocean Energy Management (BOEM) initiated cooperative agreements with 13 coastal states, including Virginia, to identify sand resources on the Outer Continental Shelf (OCS) suitable for beach nourishment and other coastal protection and restoration projects. In the initial cooperative agreement that extended from May 2014 to May 2016, the Department of Mines, Minerals and Energy's Division of Geology and Mineral Resources (DGMR) created an inventory of existing offshore geophysical surveys and geotechnical data from vibracore logs and seafloor grab samples, and a geodatabase containing analytical results for new samples characterizing sand and heavy mineral resources. The results are summarized in *Cooperative Agreement M14AC00013: Virginia Summary Report 2016 – Assessment of Offshore Sand Resources for Virginia Beachfront Restoration* (available on-line, https://www.boem.gov/Virginia-Projects/).

Virginia's State Cooperative Agreement was renewed for the period extending from August 2016 to May 2019 (M14AC00013 Modification 2) to conduct site-specific assessments of sand and heavy mineral resources using geologic data collected as part of the BOEM-sponsored Atlantic Sand Assessment Project (ASAP). BOEM contracted the Chicago Bridge and Ironworks Company (CB&I) in 2015-17 to collect geophysical data and sediment cores in resource areas located in Federal waters between three nautical miles (nm) and eight nm off the Virginia coast (Figure 1). In the Wallops resource area, located offshore of Assateague and Wallops Islands, reconnaissance geophysical surveys and 10 vibracores (including 2 twinned holes) were completed in an area encompassing about 245 square kilometers, km^2 (72 nm^2). In the Sandbridge area, located offshore of Sandbridge Beach and False Cape State Park, reconnaissance geophysical surveys and 5 vibracores (including 2 twinned holes) were completed in an area covering about 187 km^2 (54 nm^2). In the Delmarva area, offshore of the "Chincoteague Bight", 14 vibracores were completed in 2016-17 to evaluate sand deposits and heavy mineral occurrences. Heavy mineral resources were tested in the Smith Island area by 4 vibracores completed in 2017.

The Wallops and Sandbridge areas were targeted for evaluation of sand resources using existing bathymetric data that indicated the presence of extensive sand shoals. Both of these areas are located just offshore of beachfronts that have required erosion abatement measures in the past to protect vital coastal infrastructure and habitat.

The purpose of DGMR's investigation was to analyze the ASAP geophysical and vibracore information acquired in 2015-17 to assess the quality, thickness, lateral extent and volume of sand resources in each area. The volumetric estimates considered three main criteria: 1) areas with a 5-foot minimum thickness of beach-quality sand, 2) areas with a 10-foot minimum thickness, and 3) exclusion of areas where overburden exceeds 2 feet. This report presents DGMR's findings in partial fulfilment of the work product deliverables for Cooperative Agreement M14AC00013 – Modification 2.

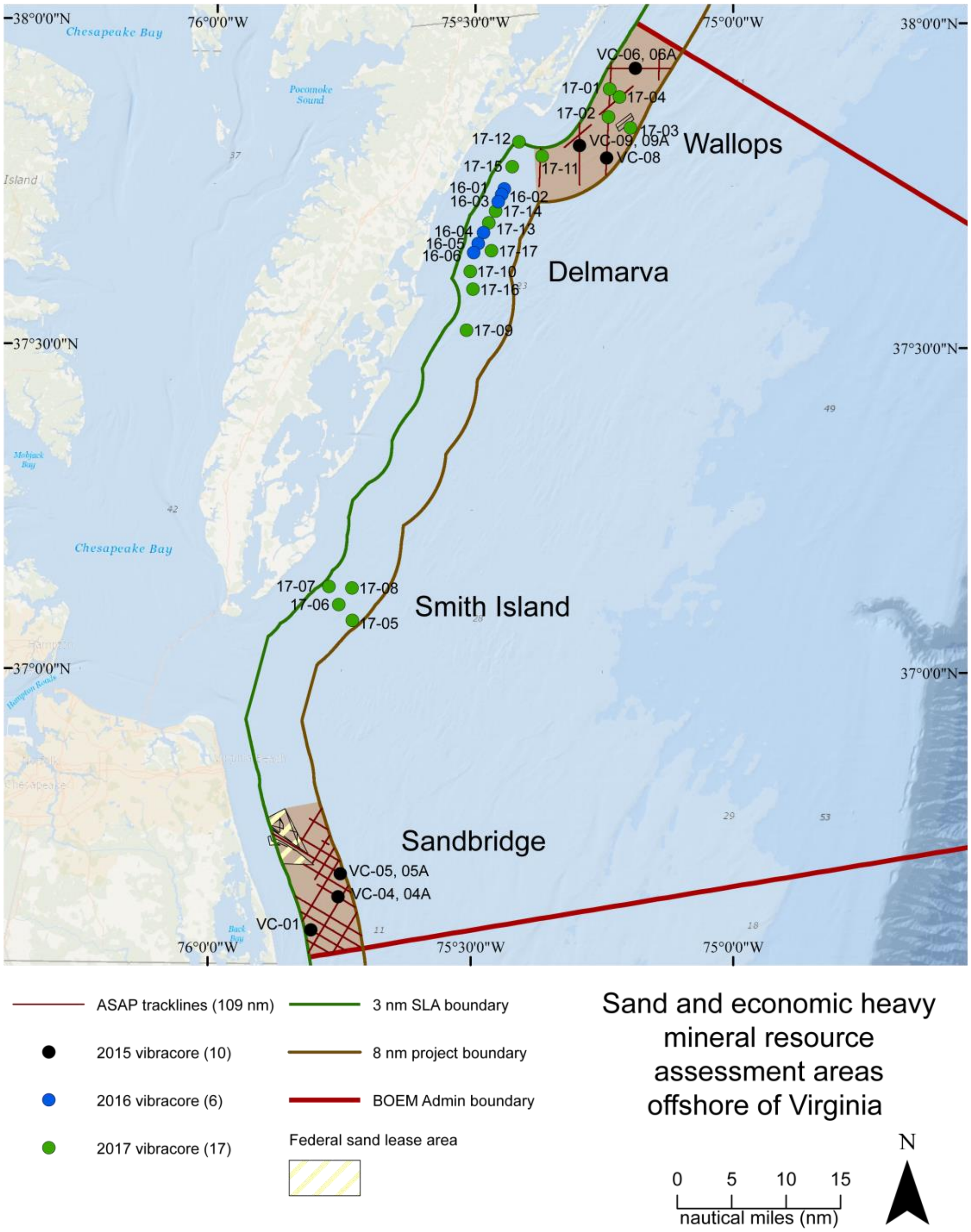

Figure 1. Marine mineral resource assessment areas evaluated as part of ASAP. Volumetric assessments of beach-quality sand were conducted in the brown-shaded areas at Wallops and Sandbridge.

PURPOSE AND RELEVANCE

Since the late 1940s, sand taken from inland borrow areas, channel maintenance dredging, and offshore Federal sand lease areas has been used to restore Virginia's beaches following erosional events that resulted in significant land loss. Beach sand nourishment supplements the natural supply of sediment to help reduce the negative impacts of coastline erosion caused by three main processes: (1) the natural action of waves and tidal surges, exacerbated by the enhanced energy of large storm events, (2) natural or man-made reductions in sediment supply to the beach, and (3) sea-level rise (Williams, 1987).

Recurring beach replenishments are essential for sustaining economic growth in popular tourist destinations such as Chincoteague Island and Virginia Beach. Records for beach nourishment projects between 1951 and 2000 for the Virginia Beach Resort area show the increasing quantities of sand required to remediate erosional losses (Figure 2). Periodic beach nourishment projects have also protected important coastal infrastructure including NASA's Wallops Flight Facility at Wallops Island, and the Department of Defense facilities at Naval Station Oceana, Dam Neck Annex. Increasingly, material sourced from Federal sand lease areas on the OCS has been utilized for these projects. To address the needs for the future, new sources of beach-quality sand must be identified.

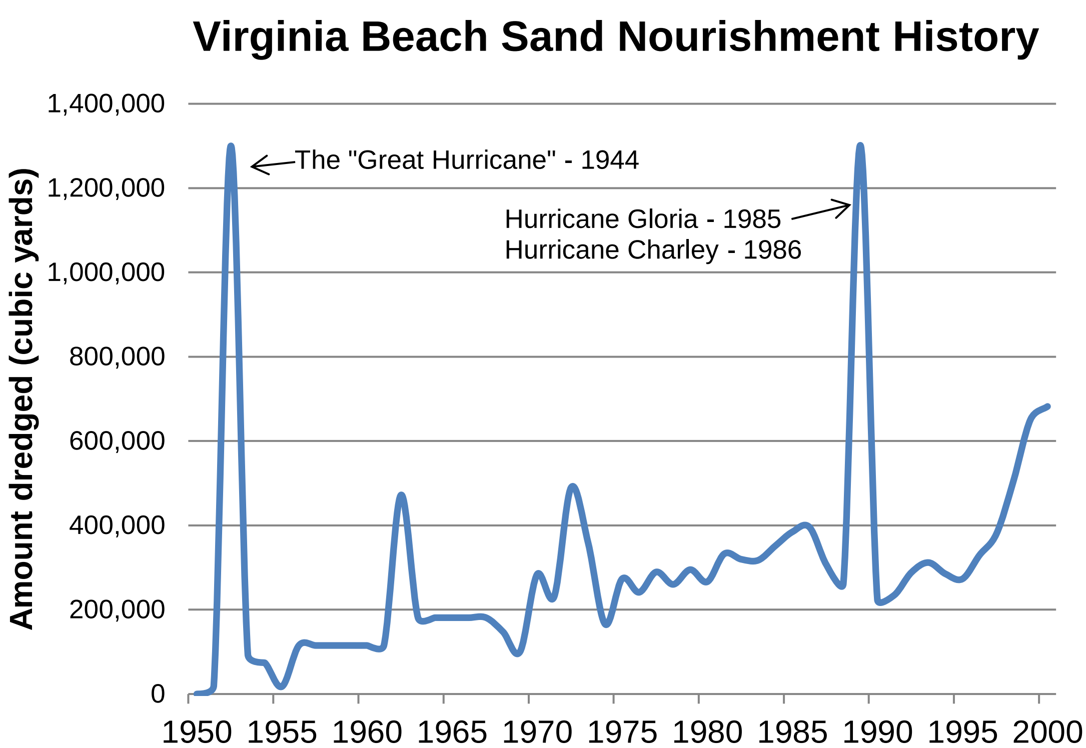

Figure 2. Annual volumes of sand dredged for beach nourishment projects at Virginia Beach (USACE, 2000).

METHODS AND ANALYSES

Characterizing "beach-quality" sand

The term "beach-quality" is used throughout this report to characterize the compatibility of offshore sandy sediments for use in beach nourishment projects. In Virginia, there are two main beach areas that receive periodic beach nourishments, and the specifications with regard to sand grain size, shape, color, sorting, mineral and chemical composition vary somewhat.

The commercial-tourist beaches at Virginia Beach and Sandbridge are frequented by millions of visitors each year, and the aesthetics and texture of the beach are important economic considerations. The City of Virginia Beach has established a preference for sand fill material that is predominantly medium to fine grained in texture (>50% in the range of 0.20 - 0.25 mm, phi ϕ~2), with low shell and gravel content, low opaque mineral content, and no more than 5% passing the 200-mesh (0.074 mm) sieve (Roehrs, 2017).

The beach at NASA Wallops Island Flight Facility has fewer constraints on the aesthetic properties of the sand, such as color, shape and grain size. Beach fill material serves a more important role as a protective buffer against storm damage to the coastal Federal government infrastructure. Native beach sand material on Wallops Island is reported to have median grain sizes ranging from about 0.18 mm to 0.27 mm (NASA, 2013), which is classified as fine grained sand. Beach nourishments in the past have utilized offshore material dredged from the Federal sand lease "Shoal A" area, which is coarser in texture, with median grain sizes ranging from 0.28 mm to 0.54 mm (NASA, 2013). The specifications listed for a beach fill operation conducted in 2007 at Wallops were stated to be, "materials classified in accordance with ASTM D2487 as SW, SP, SP-SM containing not more than 10 percent fines passing a U.S. Standard Sieve No. 200 are satisfactory for beach fill" (NASA, 2007).

Other factors that can negatively impact the viability of offshore sand resources include environmental and safety considerations, water depths that exceed the working limits of the dredging equipment, limited lateral extent of the sand deposit and thickness less than 5 feet, and overburden thickness in excess of 1-2 feet.

ASAP vibracores

The findings presented in this report are derived from DGMR's analysis and interpretation of data collected as part of the BOEM-sponsored ASAP. CB&I collected 10 vibracores and 201 kilometers (109 nm) of track line geophysical data between April 2015 and December 2015. The cores were taken at three locations in each of the Sandbridge and Wallops resource areas (Figure 1, Table 1). The cores were taken along the seismic data collection track lines to assist in the interpretation of subsurface geology. Depths to the seafloor ranged from 48.5 feet to 67.8 feet below mean sea level. At core sites VC-04, VC-05, VC-06, and VC-09, penetration refusal was encountered at a shallower depth than expected and twin cores were collected that were slightly offset from the initial location. These were core sites VC-04A, VC-05A, VC-06A, and VC-09A, which were completed by jetting to the refusal depth and resumed coring to the planned target depth.

In 2016, six vibracores were completed by Alpine Ocean Seismic Survey, Inc., as part of a BOEM-sponsored reconnaissance survey to evaluate sand resources in the Delmarva area (Figure 1, Table 1). These cores were outside of the Wallops and Sandbridge resource areas and not included in the resource assessments.

CB&I completed a follow-up vibracoring campaign with no additional geophysical data collection in December 2017. Seventeen coring locations were selected to provide marine minerals information in prospective areas offshore of the Delmarva Peninsula (Figure 1, Table 1), including five within the Wallops assessment area (17-01, 17-02, 17-03, 17-04, and 17-11). No cores were collected in the Sandbridge resource area in 2017.

The ASAP vibracores were split by the contractor and sampled for grain size analysis by CB&I and the Delaware Geological Survey (DGS). The DGS also selected shell samples for amino acid racemization (AAR) dating. CB&I provided DGMR with lithologic logs and granularmetric reports for the ASAP cores completed in 2015. The DGS also provided lithologic logs and grain size data for the cores taken in 2015, 2016 and 2017. After logging and sampling were completed, the ASAP core halves were transferred from the DGS facilities in Newark, DE to DGMR in Charlottesville, VA, where separate geologic examinations and sampling for heavy minerals analysis were performed by DGMR geoscientists. In general, this report utilizes the DGS logs and CB&I grain size data as the primary sources for stratigraphic and lithologic characterizations. The DGS lithologic logs are included in Appendix A.

ASAP seismic sub-bottom data acquisition

Equipment utilized by CB&I included an EdgeTech 3200 sub-bottom profiler with a 512i towfish to collect high-resolution seismic reflection profile data. The navigation and horizontal positioning for the sub-bottom profiler system was provided by the C-Nav 3050 DGNSS system via Hypack 2015 using the Hypack standard towfish layback driver. Towfish position was accounted for during acquisition so there was no need to apply an additional layback when processing the data. Side-scan sonar data was collected using an EdgeTech 4200-HFL sidescan sonar system at 300 kHz and a range scale of 150 meters. Interferometric bathymetry data was collected using an EdgeTech 6205 fully-integrated swath bathymetry and dual frequency sidescan sonar system at a frequency of 550 kHz, which is optimal for shallower water depths. The bathymetric data was corrected for navigational offsets, and patch tests were conducted prior to data delivery. The data coordinates were provided in NAD 1983 Universal Transverse Mercator (UTM) Zone 18N format. The total length of survey tracklines for the two areas of study was 201 km (109 nm) (Table 2).

Seismic data and core analysis

CB&I provided the geophysical data to DGMR in JSF file format. The digital data was analyzed using Chesapeake Technologies, Inc. SonarWiz Office post-processing software. Side-scan sonar data was imported with 8X gain, a swell filter of 3-feet was applied to the Chirp sub-bottom data to account for wave action, and the water column was blanked. Lithologic units described in the vibracore logs were imported to correlate sediment characteristics with acoustic signals and seismic reflectors observed in the sub-bottom profiles.

The vibracores provided ground truth controls for the seismic images, and each identified lithologic unit was classified in terms of "beach-quality" or "not beach-quality". Recognizing the reconnaissance scale of the geophysical data acquisition, together with the very limited number of vibracore control points, many assumptions were necessary in the interpretation of the profiles. In most of the seismic sub-bottom profiles, the seafloor surface layer consisted of material classified as beach-quality sand, likely of Holocene age.

Major reflectors were traced manually across each of the Sandbridge and Wallops resource areas using the reflector feature in the sub-bottom profile viewer. We identified 3 major reflectors and 4 separate lithologic units, and the thicknesses of each unit were calculated using the SonarWiz thickness calculator. The thickness data were imported into ESRI's ArcGIS and contour maps were produced using spline interpolation with a cell size of 100 feet and a smoothing factor of 0.3. The smoothing factor was chosen after re-creating the spline several times using different smoothing factors. Using the 0.3 smoothing factor projected the interpolated data far enough to allow for interpretation, but not so far as to generate unrealistic data artifacts. From the thickness maps, contour lines were generated, and the 5-ft and 10-ft contour lines were traced and clipped to produce individual shapefiles for each. The volumes of sand contained within the contoured 5-ft and 10-ft areas were calculated using the surface volume tool in ArcGIS.

The final data plots showing the contoured sand thickness isopachs were compared with grain size data available for seafloor grab samples collected by DGMR in previous surveys and as part of the U.S. Geological Survey data releases for the Delmarva Peninsula (DMME, 2012; Sweeney and others, 2015; Pendleton and others, 2016). Although this information was not used in the interpretation of lithologies in the subsurface, the data provided a means for cross-checking our geophysical data interpolations for the presence of beach-quality sand at the seafloor.

Table 1. ASAP vibracores collected offshore of Virginia in 2015, 2016, and 2017.

Core ID (*map identifier*)	**DGS ID**	**Collector**	**Date**	**Latitude (dec deg N)**	**Longitude (dec deg W)**	**Hole depth (ft)**	**Hole depth (m)**	**Elevation (water depth corrected, ft)**
VA-2015-*VC-01*	Zz82-63	CB&I	9/16/15	36.60230	-75.80410	20.0	6.1	-55.6
VA-2015-*VC-04*	Zz82-64	CB&I	9/16/15	36.65378	-75.75324	20.0	6.1	-48.6
VA-2015-*VC-04A*	Zz82-65	CB&I	9/16/15	36.65378	-75.75325	21.6	6.6	-55.7
VA-2015-*VC-05*	Zz82-66	CB&I	9/16/15	36.68917	-75.74902	11.4	3.5	-48.8
VA-2015-*VC-05A*	Zz82-67	CB&I	9/16/15	36.68914	-75.74899	20.0	6.1	-62.0
VA-2015-*VC-06*	Xh54-01	CB&I	9/17/15	37.93084	-75.18973	15.6	4.8	-61.9
VA-2015-*VC-06A*	Xh54-02	CB&I	9/17/15	37.93084	-75.18983	20.0	6.1	-48.5
VA-2015-*VC-08*	Zh31-01	CB&I	9/17/15	37.79299	-75.24478	17.4	5.3	-67.8
VA-2015-*VC-09*	Zg23-01	CB&I	9/17/15	37.81161	-75.29728	20.0	6.1	-55.6
VA-2015-*VC-09A*	Zg23-02	CB&I	9/17/15	37.81162	-75.29730	20.0	6.1	-55.5
VA-BOEM-*16-01*	Zz82-68	Alpine OSS, Inc.	8/20/16	37.74446	-75.44266	17.91	5.5	-47.6
VA-BOEM-*16-02*	Zz82-69	Alpine OSS, Inc.	8/20/16	37.73616	-75.44757	17.68	5.4	-49.2
VA-BOEM-*16-03*	Zz82-70	Alpine OSS, Inc.	8/20/16	37.72501	-75.45413	16.77	5.1	-51.5
VA-BOEM-*16-04*	Zz82-71	Alpine OSS, Inc.	8/20/16	37.67709	-75.48265	17.89	5.5	-51.5
VA-BOEM-*16-05*	Zz82-72	Alpine OSS, Inc.	8/20/16	37.66037	-75.49265	17.73	5.4	-45.2
VA-BOEM-*16-06*	Zz82-73	Alpine OSS, Inc.	8/20/16	37.64635	-75.50089	18.59	5.7	-40.2
VA-20*17-01*	Yh21-01	CB&I	12/04/17	37.89898	-75.23902	19.97	6.1	-56.6
VA-20*17-02*	Yh41-01	CB&I	12/04/17	37.85601	-75.24102	19.25	5.9	-56.5
VA-20*17-03*	Yh54-01	CB&I	12/04/17	37.83901	-75.19899	19.46	5.9	-67.3
VA-20*17-04*	Yh22-01	CB&I	12/04/17	37.88700	-75.21997	19.69	6.0	-48.9
VA-20*17-05*	Zz82-83	CB&I	12/05/17	37.07900	-75.72999	19.12	5.8	-47.2
VA-20*17-06*	Zz82-84	CB&I	12/05/17	37.10300	-75.75600	19.98	6.1	-38.5
VA-20*17-07*	Zz82-85	CB&I	12/05/17	37.13100	-75.77499	19.63	6.0	-35.9
VA-20*17-08*	Zz82-86	CB&I	12/05/17	37.12901	-75.73102	19.31	5.9	-41.2
VA-20*17-09*	Zz82-87	CB&I	12/03/17	37.52700	-75.51400	17.04	5.2	-30.2
VA-20*17-10*	Zz82-88	CB&I	12/03/17	37.61752	-75.50779	19.11	5.8	-39.2
VA-20*17-11*	Zz82-89	CB&I	12/03/17	37.79522	-75.36953	19.99	6.1	-33.3
VA-20*17-12*	Zz82-90	CB&I	12/03/17	37.81714	-75.41420	19.86	6.1	-30.2
VA-20*17-13*	Zz82-91	CB&I	12/03/17	37.69208	-75.47215	19.27	5.9	-47.5
VA-20*17-14*	Zz82-92	CB&I	12/03/17	37.71048	-75.45907	19.28	5.9	-45.9
VA-20*17-15*	Zz82-93	CB&I	12/03/17	37.77876	-75.42712	19.98	6.1	-37.7
VA-20*17-16*	Zz82-94	CB&I	12/03/17	37.58991	-75.50193	18.46	5.6	-33.8
VA-20*17-17*	Zz82-95	CB&I	12/03/17	37.64925	-75.46678	19.24	5.9	-39.8

Table 2. Geophysical survey tracklines acquired offshore of Virginia in 2015.

Trackline ID (*map identifier*)	**Collector**	**Date**	**Resource Area**	**Line miles (km)**	**(nm)**
VA_001	CB&I	06/02/15	Sandbridge	1.86	1.01
VA_001_1	CB&I	06/02/15	Sandbridge	2.87	1.55
VA_002	CB&I	06/02/15	Sandbridge	8.19	4.42
VA_003	CB&I	06/02/15	Sandbridge	6.56	3.54
VA_003_1	CB&I	06/02/15	Sandbridge	5.38	2.90
VA_004	CB&I	06/02/15	Sandbridge	2.79	1.51
VA_004_1	CB&I	06/02/15	Sandbridge	10.58	5.71
VA_005	CB&I	06/02/15	Sandbridge	7.60	4.11
VA_006	CB&I	06/06/15	Sandbridge	9.48	5.12
VA_007	CB&I	06/06/15	Sandbridge	14.40	7.77
VA_008	CB&I	06/06/15	Sandbridge	7.96	4.30
VA_009	CB&I	06/06/15	Sandbridge	1.34	0.72
VA_010	CB&I	06/06/15	Sandbridge	3.64	1.97
VA_011	CB&I	06/02/15	Sandbridge	8.21	4.43
VA_012	CB&I	06/06/15	Sandbridge	13.36	7.21
VA_013	CB&I	06/06/15	Sandbridge	12.14	6.56
VA_014	CB&I	06/02/15	Sandbridge	6.25	3.37
VA_015	CB&I	06/06/15	Sandbridge	5.61	3.03
VA_016	CB&I	06/06/15	Sandbridge	6.48	3.50
Total length				*134.68*	*72.72*
VA_017	CB&I	06/10/15	Wallops	6.49	3.51
VA_018	CB&I	06/11/15	Wallops	10.60	5.72
VA_019	CB&I	06/11/15	Wallops	7.53	4.07
VA_019_1	CB&I	06/11/15	Wallops	10.71	5.78
VA_020	CB&I	06/11/15	Wallops	5.13	2.77
VA_21	CB&I	06/11/15	Wallops	6.05	3.27
VA_21_1	CB&I	06/11/15	Wallops	0.99	0.54
VA_21_O	CB&I	06/11/15	Wallops	6.08	3.28
VA_21_O_1	CB&I	06/11/15	Wallops	2.02	1.09
VA_022	CB&I	06/11/15	Wallops	10.74	5.80
Total length				*66.34*	*35.82*
Total both resource areas				**201.02**	**108.54**

RESULTS

Seismic data interpretation and stratigraphic correlation

Four major lithologic units were identified in each of the Sandbridge and Wallops resource areas from interpretations of acoustic impedance changes in the CB&I seismic sub-bottom profile data. All four units are separated by strong, but often discontinuous reflectors. These units are consistent with interpretations reported elsewhere (Colman and others, 1988;

Hobbs, 1990; Shideler and others, 1972; Swift and others 1977). In ascending order starting from the deepest beneath the seafloor, these are: unit A, unit B, unit C, and unit D (Figure 3).

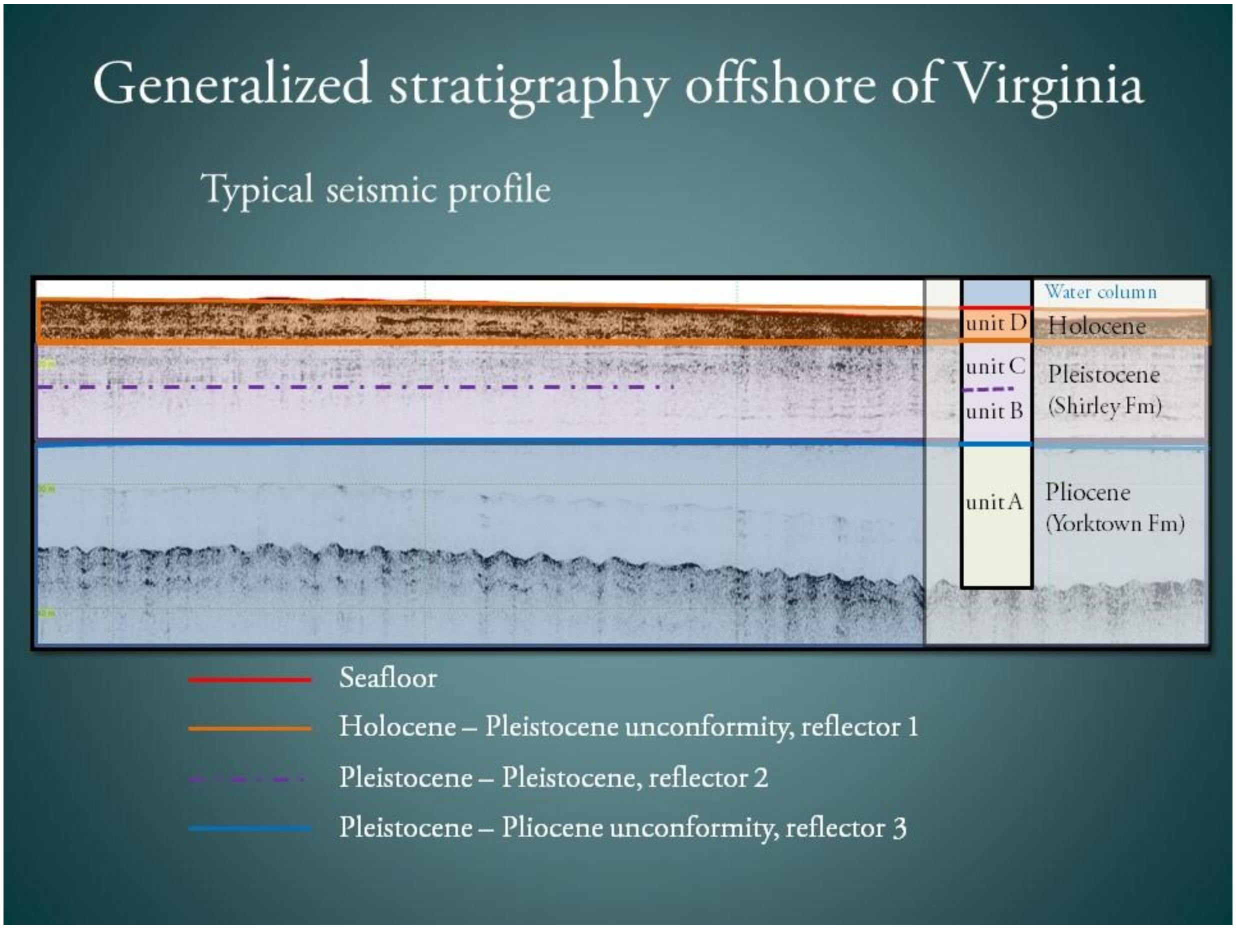

Figure 3. Four lithologic units and three major reflectors were identified in CB&I seismic sub-bottom profiles.

Unit A was interpreted from the seismic data, but was not penetrated by any of the vibracores. There were no observable internal structural features, and the unit is most likely equivalent to the basal Yorktown Formation of Pliocene age. In the Sandbridge area, on-shore geologic mapping completed in the Norfolk North and Norfolk South 7.5-minute quadrangles reported the silt content in the basal Yorktown consistently above 20%, while in the overlying units, it was consistently below 20% (Barker and Bjorken, 1978a, 1978b).

Unit A is separated from overlying unit B by a major seismic reflector (reflector 3), which is the only continuous reflector throughout the entire study area. This reflector ranges in depth from 30 m to 40 m below the seafloor. Beneath sand shoal features, this reflector does not show in the seismic data probably because the seismic signal did not penetrate the shoal sand. It was assumed, however, that reflector 3 is present below these features. The thickness of unit A is unknown since the base of the unit exceeded the depth of the seismic profile.

Units B and C are likely equivalent to the Pleistocene-age Shirley and Tabb Formations, respectively. These units are difficult to distinguish in many of the seismic images. They are separated by reflector 2, which is not evident in many of the images. The middle Pleistocene Shirley Formation was deposited in a marginal marine environment and consists of fluvial-estuarine facies that vary laterally and vertically (Powars and others, 2016). The late Pleistocene Tabb Formation consists of fluvial-estuarine fining-upward sequences that typically grade upward from basal pebble-sand deposits to sandy and clayey silt. Neither of these units contain sufficient thicknesses of beach-quality sand to be considered in the resource estimates.

The upper-most unit D is equivalent to Holocene-age sediments consisting mainly of fine to coarse grained sand. It is separated from units C, B, and A, depending on the location, by reflectors 1, 2, or 3. The sediments in unit D occur as sheet sand and shoal deposits of variable thickness that range from thin (3-6 feet) to very thick (>30 feet) on the crest of shoals. The mud content is low and there is no overburden. Unit D represents the primary beach-quality sand resource in both study areas. Reflector 1 is continuous throughout the entire Sandbridge area, and in most of the Wallops resource area. Shideler and others (1972) reported a radiocarbon age of about 4,220 years BP for an articulated *Mercenaria* sp. extracted from a core at a depth of 1.7 m below the seafloor in the Sandbridge resource area. This unit was deposited and continues to be modified during the current transgression (Swift and others, 1977).

Sand distribution, thickness and quality

Sandbridge

The locations of the ASAP geophysical survey tracklines and vibracores in the Sandbridge area are shown in Figure 4, which also shows the NOAA multibeam bathymetric data and core locations from previous DGMR studies (Berquist and others, 2016; Berquist and others, 1990). With the exception of the Sandbridge Shoal area, most of the earlier coring was conducted outside of the present study area and was not used for the resource estimate reported herein. In the northern Sandbridge resource area, sand deposits from unit D (Holocene-age) occur as shoals and relatively continuous sheet sands with thickness ranging from 0 feet up to about 10 feet. The sands are incised by several paleochannels, particularly evident in the seismic profile VA-016 (Figure 4). The southern area is characterized by thicker sand deposits, up to 30 feet thick in larger shoals, and also in relatively continuous sheet deposits that are typically less than 10 feet in thickness.

Grain size analysis of samples from 5 vibracores completed in the Sandbridge area indicate the presence of beach-quality sand to a depth of about 15 feet in most holes (Table 3). The mean grain size of samples collected from the seafloor to a depth of 15 feet is about 0.32 mm (ϕM=1.68), and the average cumulative percent of sediment retained by the 60-mesh sieve (0.25 mm) is 68.77%. Samples below a depth of about 15 feet in cores VC-04, VC-04A, and VC-05A contained more silt and clay than would be suitable for beach fill material.

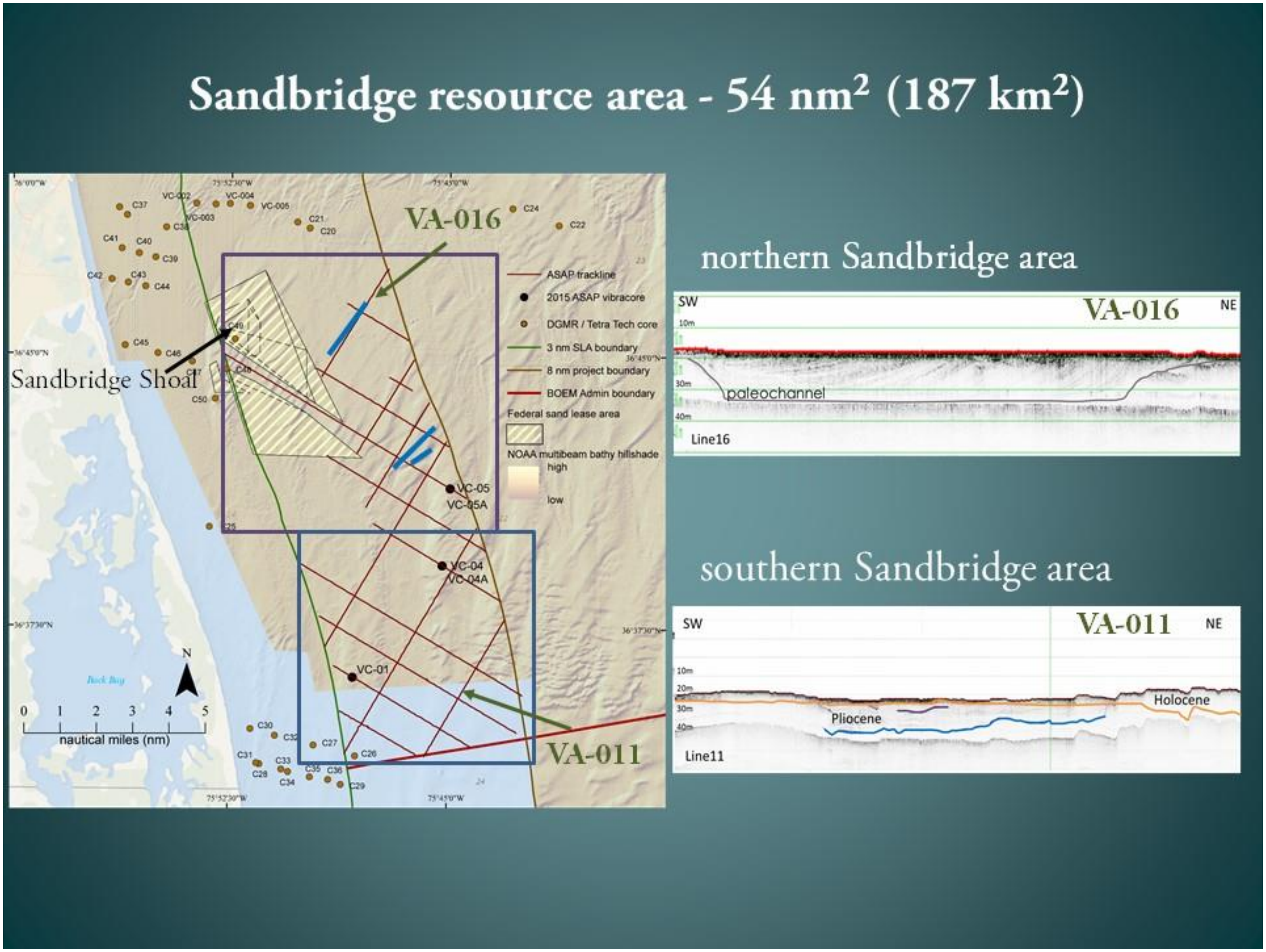

Figure 4. Location map and selected seismic sub-bottom profiles in the Sandbridge resource area.

Table 3. Grain size parameters for samples from ASAP vibracores in Sandbridge resource area.

Vibracore ID	Sample depth ft	Sample depth m	Mean grain size mm	Mean grain size ϕ	% retained #60 ϕ = 2, 0.25mm	% fines #230 ϕ=4, 0.062mm	Carbonate %
VC-01	0 - 2	0 – 0.6	0.46	1.14	88.53	0.06	
	1.1	0.3	0.47	1.08	86.50	0.98	5
	2 - 7	0.6 – 2.1	0.36	1.53	72.56	0.90	
	5.0	1.5	0.32	1.65	62.07	1.55	6
	8.8	2.7	0.21	2.25	65.85	3.18	1
VC-04	1.5	0.5	0.31	1.67	73.98	1.01	1
	0 - 6	0 – 1.8	0.33	1.59	78.47	0.16	
	1.5	0.5	0.31	1.67	73.98	1.01	1
	4.0	1.2	0.29	1.79	64.87	1.57	1
	6 - 11	1.8 – 3.4	0.32	1.65	73.27	0.52	
	11 – 15.9	3.4 – 4.8	0.24	2.07	40.82	1.21	
	15.8	4.8	0.22	2.16	18.94	35.66	14
VC-04A	14 – 17.1	4.3 – 5.2	0.26	1.96	45.53	1.84	
	18.8	5.7	0.08	3.61	0.75	61.79	10
VC-05	0.3	0.1	0.31	1.69	71.44	1.78	1
	2.0	0.6	0.33	1.58	77.41	0.97	1
	0 – 3.5	0 – 1.1	0.35	1.51	79.36	0.06	
	3.5 – 8.5	1.1 – 2.6	0.46	1.21	81.17	0.17	
	6.0	1.8	0.25	1.99	88.37	1.42	1
	8.5 – 13.5	2.6 – 4.1	0.25	1.99	47.78	2.38	
	10.8	3.3	0.23	2.15	26.08	2.94	1
VC-05A	11.2 – 16.1	3.4 – 4.9	0.33	1.74	54.15	0.84	
	15.5	4.7	0.24	2.05	42.96	2.04	1
	16.1 – 21.2	4.9 – 6.5	0.27	1.87	62.31	0.50	
	18.0	5.5	0.22	2.19	29.03	3.49	0
	21.0	6.4	0.19	2.41	15.79	6.67	1
Mean all			0.29	1.85	58.54	5.18	3
s.d. all			0.09	0.49	24.47	13.41	4
Mean 0-15’			0.32	1.68	68.77	1.20	2
s.d. 0-15’			0.08	0.32	16.58	0.90	2

Data in shaded rows from CB&I; all others from DGS.

Wallops

In the Wallops resource area, sand deposits from unit D (Holocene-age) occur in generally northeast-trending shoal features that are well delineated by the NOAA multibeam bathymetric data (Figure 5). The sand distribution appears to be much less uniform than in the Sandbridge area, where sheeted sand deposits are more common. Figure 5 shows the locations of the ASAP geophysical survey tracklines and vibracores, and the existing Federal sand lease area at Shoal A. The thickness of the sand shoals ranges from 0 feet up to in excess of 30 feet, as depicted in the north-south oriented seismic profile VA-018. The data in this profile also indicates that units B and C (Pleistocene-age) may be exposed at the seafloor between shoal features. Two relatively large paleochannels were noted in the northern area along tracklines VA-019 and VA-022. The ASAP vibracore 2017-01 intercepted dark bluish-grey silty clay from the seafloor to the completion depth of 18.4 feet, and confirmed the presence of the paleochannel depicted on profile VA-019.

Grain size analysis of samples from 9 vibracores indicate the predominance of fine grained sand in much of the Wallops resource area (Table 4). The mean grain size of samples collected from the seafloor to a maximum depth of about 22 feet is 0.21 mm (ϕM=2.44), and the average cumulative percent of sediment retained by the 60-mesh sieve (0.25 mm) is about 25.41%. Based on the grain size specifications for past beach fill projects at Wallops Island, this material generally qualifies as beach-quality sand. Sand identified in the top 8 feet of core VC-06 clearly qualifies; the average grain size for four samples in that interval is 0.37 mm (ϕM=1.49), and the cumulative percent of sediment retained by the 60-mesh sieve (0.25 mm) is 75.79%.

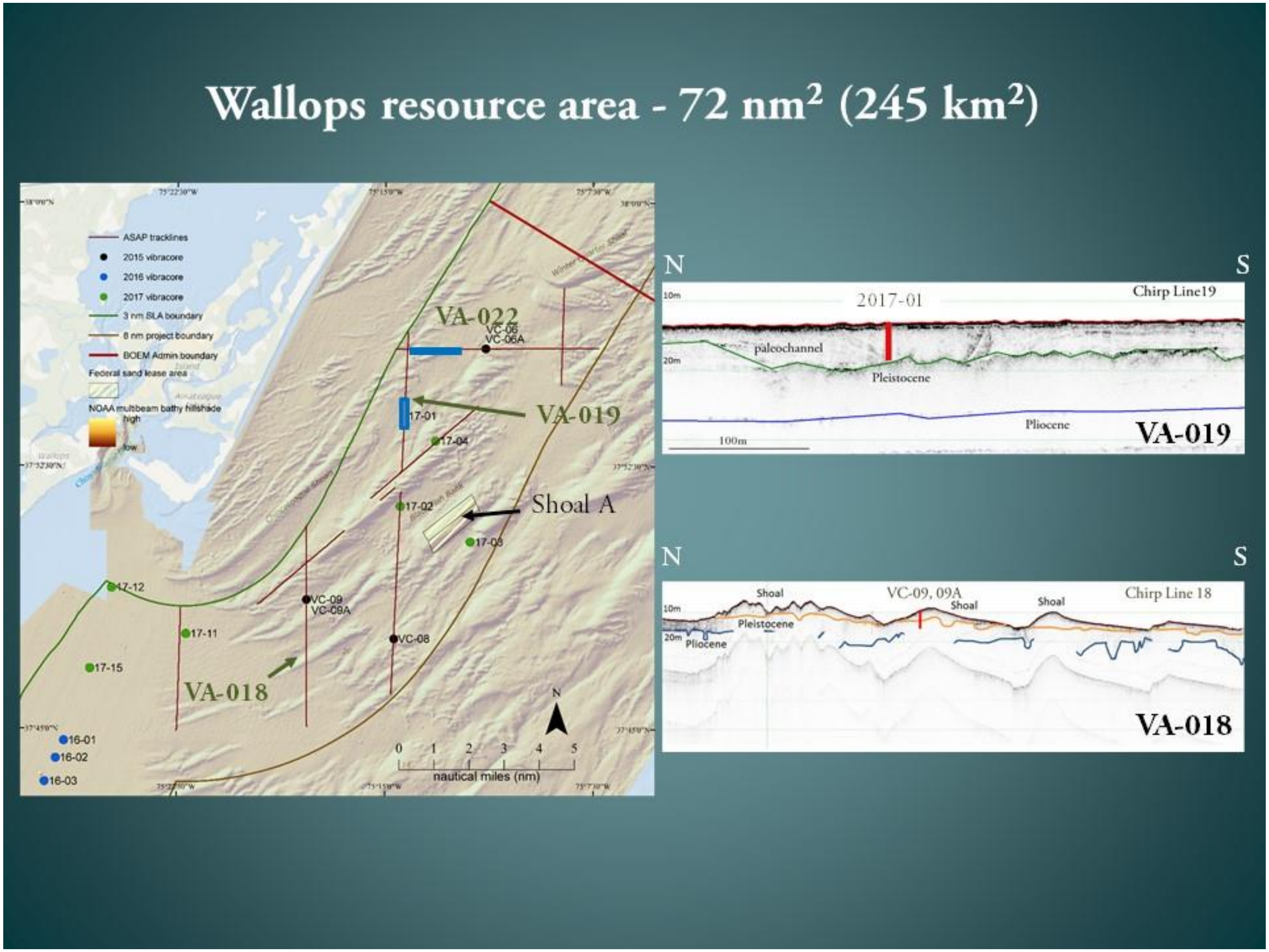

Figure 5. Location map and selected seismic sub-bottom profiles in the Wallops resource area.

Table 4. Grain size parameters for samples from ASAP vibracores in the Wallops resource area.

Vibracore ID	Sample depth ft	Sample depth m	Mean grain size mm	Mean grain size ϕ	% retained #60 ϕ = 2, 0.25mm	% fines #230 ϕ=4, 0.062mm	Carbonate %
VC-06	0 -3.3	0 – 1.0	0.37	1.45	82.55	0.11	
	3.5	1.1	0.51	0.96	95.42	0.71	1
	3.3 – 8.3	1.0 – 2.5	0.37	1.47	79.25	0.50	
	7.0	2.1	0.23	2.09	45.95	2.96	1
	10.0	3.0	0.20	2.32	22.20	19.52	0
	12.2	3.7	0.18	2.50	17.12	13.84	0
VC-06A	15.9	4.8	0.23	2.15	31.70	14.04	0
	19.6	6.0	0.27	1.87	50.14	3.47	0
	22.4	6.8	0.38	1.41	82.75	1.29	0
VC-08	0 – 1.5	0 – 0.5	0.19	2.40	19.01	0.87	
	2.0	0.6	0.18	2.51	13.25	2.30	4
	3.8	1.2	0.24	2.03	27.24	2.31	10
	1.5 – 6.5	0.5 – 2.0	0.54	1.16	66.88	0.18	
	8.0	2.4	0.13	2.97	0.98	5.64	3
	6.5 – 11.5	2.0 – 3.5	0.14	2.86	11.60	2.41	
VC-09	3.0	0.9	0.16	2.62	12.69	4.49	2
	3.3 – 8.3	1.0 – 2.5	0.19	2.40	26.56	1.49	
	6.8	2.1	0.43	1.22	54.38	2.77	4
	10.0	3.0	0.14	2.84	0.76	6.48	3
VC-09A	10.6 – 13.3	3.2 – 4.1	0.15	2.70	12.91	1.76	
	13.3 – 18.3	4.1 – 5.6	0.16	2.64	16.19	2.17	
17-02	0 - 5	0 – 1.5	0.15	2.79	3.74	3.98	
	5 - 10	1.5 – 3.0	0.15	2.72	4.69	3.41	
	10 - 15	3.0 – 4.6	0.15	2.73	1.70	2.77	
	15 – 17.2	4.6 – 5.2	0.17	2.55	4.43	3.48	
17-03	0 – 0.2	0 -0.1	0.31	1.70	43.98	3.07	
	0 - 5	0 – 1.5	0.12	3.03	4.68	14.05	
	5 - 10	1.5 – 3.0	0.18	2.52	47.41	24.20	
	10 - 15	3.0 – 4.6	0.15	2.79	28.04	24.22	
	15 – 19.2	4.6 – 5.2	0.17	2.52	4.43	3.96	
17-04	0 – 0.2	0 – 0.1	0.16	2.61	11.86	2.96	
	1 – 2.2	0.3 – 0.7	0.14	2.85	0.62	6.29	
	8 – 9.7	2.4 – 3.0	0.11	3.14	4.50	14.84	
	10 – 12.2	3.0 – 3.7	0.14	2.81	19.47	15.26	
17-11	0 - 5	0 – 1.5	0.11	3.15	0.69	6.62	
	5 – 10	1.5 – 3.0	0.11	3.20	2.98	11.08	
	10 – 15	3.0 – 4.6	0.11	3.16	5.66	13.26	
	15 – 17	4.6 – 5.2	0.08	3.72	7.07	33.13	
Mean all			0.21	2.44	25.41	7.26	
Std. dev.			0.11	0.64	26.90	7.89	

Data in shaded rows from CB&I; all others from DGS.

Volumetric calculations of beach-quality sand

Sandbridge

The contoured thickness maps for the 5-ft and 10-ft minimum sand thicknesses are shown in Figures 6 and 7, respectively. The 5-ft thickness map also shows the locations of seafloor grab and core samples collected by DGMR as part of earlier sand characterization studies with the mean phi values from grain size analytical data (Berquist and others, 1990; DMME, 2012). The calculated volumes of sand are shown in Table 5.

Table 5. Estimated volumes of beach-quality sand in the Sandbridge resource area.

	Area			Volume		
	Ft^2 ($x10^6$)	**km^2**	**nm^2**	**Ft^3 ($x10^6$)**	**m^3**	**yd^3**
Total resource area assessed	2,007	186.5	54.4	--	--	--
5-ft minimum thickness	1,799	167.1	48.7	8,995	254,701,712	333,137,406
10-ft minimum thickness	732	68.0	19.8	7,319	207,250,911	271,074,075

Wallops

The contoured thickness maps for the 5-ft and 10-ft minimum sand thicknesses are shown in Figures 8 and 9, respectively. The 5-ft thickness map also shows the locations of seafloor grab and core samples collected by DGMR as part of earlier sand characterization studies with the mean phi values from grain size analytical data (Berquist and others, 1990; DMME, 2012). The calculated volumes of sand are shown in Table 6.

Table 6. Estimated volumes of beach-quality sand in the Wallops resource area.

	Area			Volume		
	Ft^2 ($x10^6$)	**km^2**	**nm^2**	**Ft^3 ($x10^6$)**	**m^3**	**yd^3**
Total resource area assessed	2,642	245.4	71.6	--	--	--
5-ft minimum thickness	2,273	211.2	61.6	11,364	321,805,703	420,906,150
10-ft minimum thickness	1,060	98.5	28.7	10,598	300,108,130	392,526,783

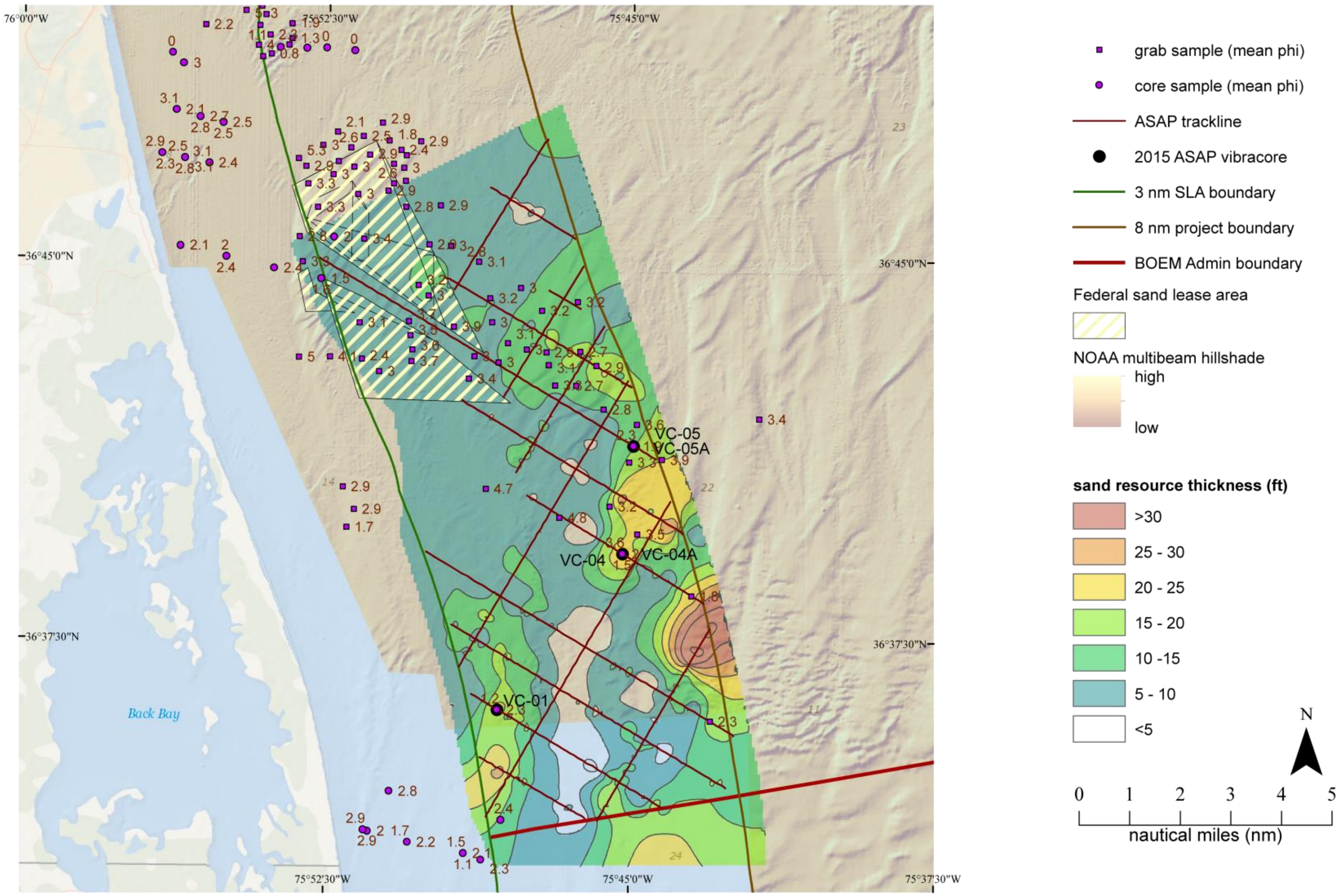

Figure 6. Sandbridge resource area, sand thickness >5 feet; showing locations of seafloor samples with mean phi values.

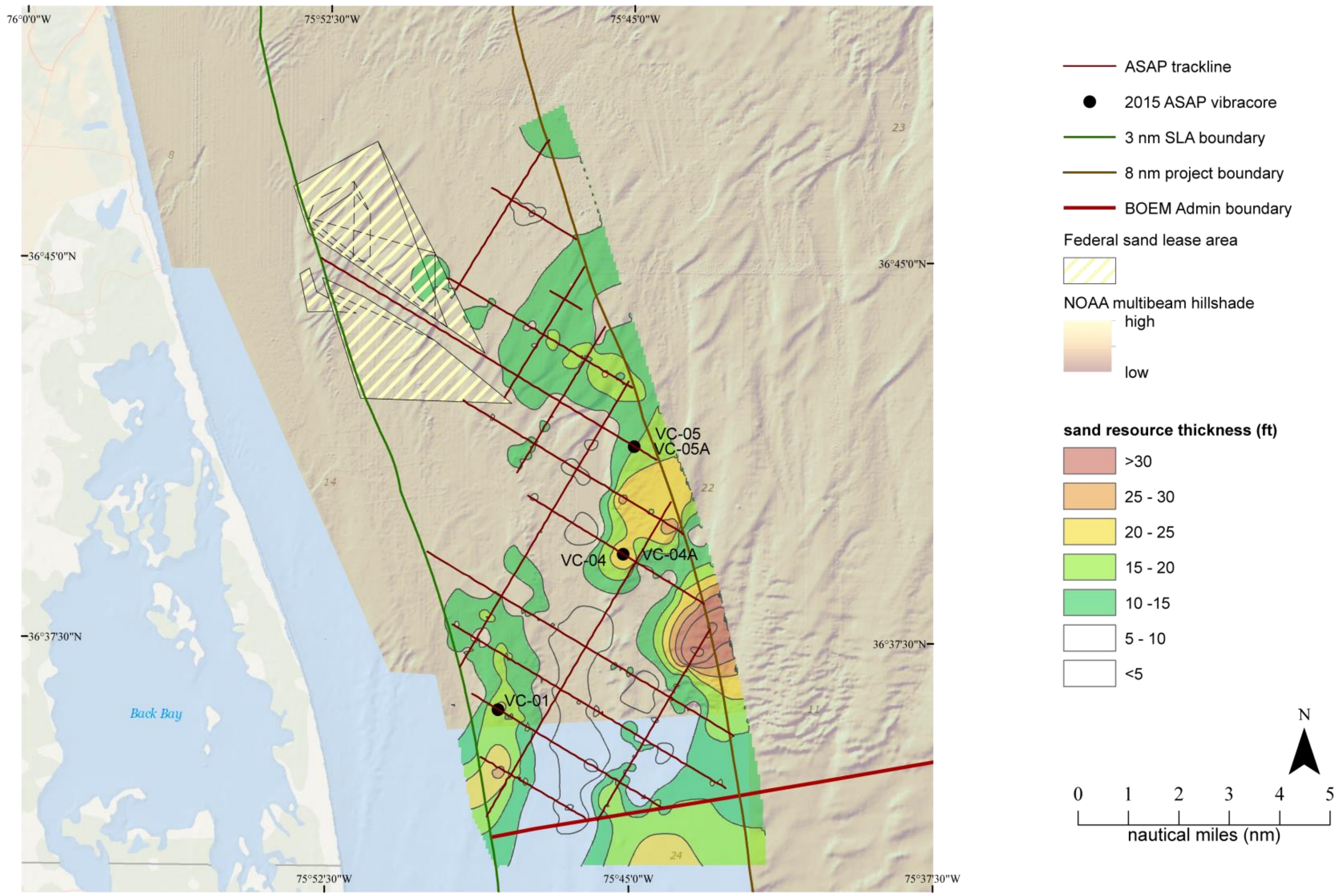

Figure 7. Sandbridge resource area, sand thickness >10 feet.

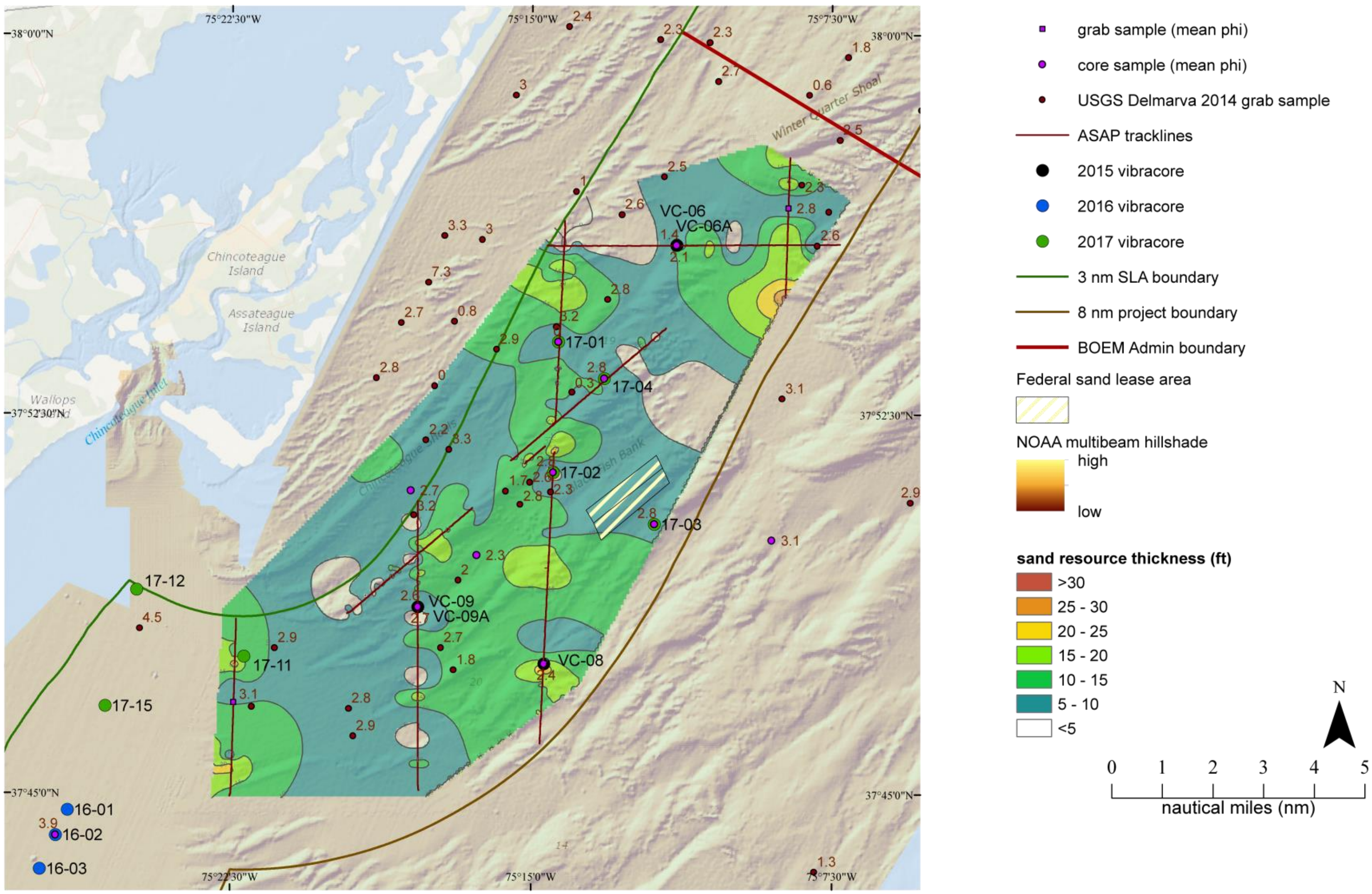

Figure 8. Wallops resource area, sand thickness >5 feet; showing locations of seafloor samples with mean phi values.

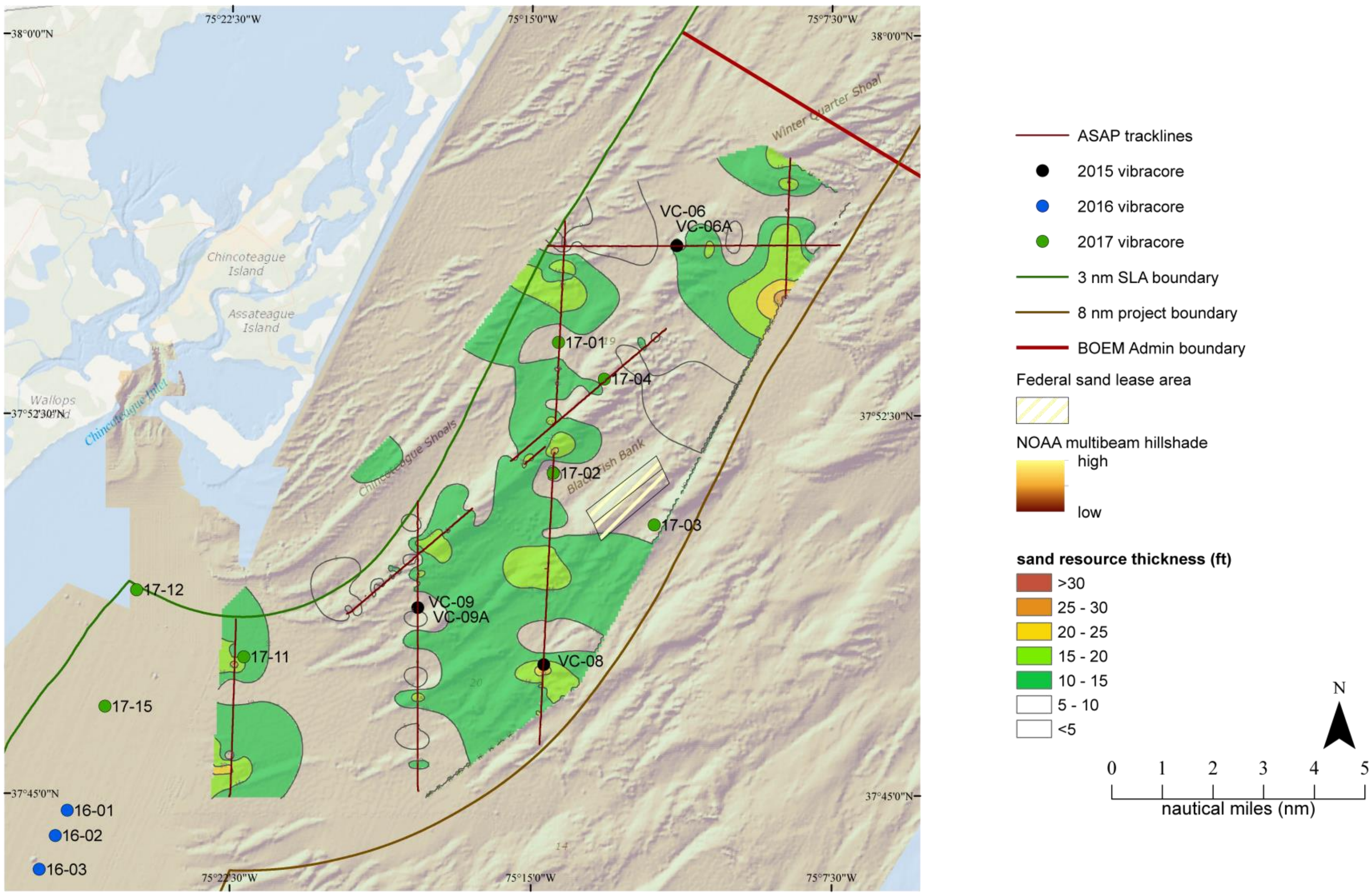

Figure 9. Wallops resource area, sand thickness >10 feet.

CONCLUSIONS

Beach-quality sand resources occur in the offshore Wallops and Sandbridge resource areas in Holocene-age shoals and sheet sand deposits. The average depth below mean sea level to the seafloor in both areas is about 54.8 feet. The sand deposits range in thickness from 0 feet up to 30-plus feet and typically occur above fluvial and estuarine sediments of Pleistocene age.

In the Sandbridge resource area, we estimated the total volume of sand having a minimum 5-ft thickness to be about 333 million cubic yards. The volume of sand with a minimum 10-ft thickness was estimated to be 271 million cubic yards.

In the Wallops resource area, we estimated about 421 million cubic yards of sand with a minimum 5-ft thickness, and 393 million cubic yards with a minimum 10-ft thickness.

In general, our analysis of seismic sub-bottom data, correlated with lithologic information from a very limited number of vibracore logs, allowed for *reconnaissance level* spatial interpolations of sand thicknesses across two relatively large assessment areas. The average spacing between geophysical survey tracklines in the Sandbridge site was about 2 – 3 km (1.1 – 1.6 nm), while in the Wallops site it was 4 – 5 km (2.2 – 2.7 nm). Calculating sand volumes using such widely-spaced data requires assumptions of continuity between known data points. There are few meaningful ways to measure the uncertainty in such calculations. However, our results do identify prospective locations that deserve additional data collection and evaluation.

In the southern and central Sandbridge area, two disconnected northeast-trending lobes of sand with a minimum 15-ft thickness appear to reinforce available bathymetric data showing northeast trending shoal fields (Figure 6). There are few surface grab samples in these areas, indicating widely varying sand textures ranging from medium grained to very fine grained (ϕ= 1.5 – 3.9). Vibracores VC-01 and VC-04 contained good quality sand up to 15 feet in thickness.

In the Wallops area, there appears to be a possible shoal field, shown as the large 10-ft thick swath in the middle of the target area (Figure 9). This feature was also broadly identified by Pendleton and others (2014), as part of the geologic framework study along the Delmarva Peninsula. Surface grab samples within this feature indicate fine- to medium grained sand textures (ϕ= 1.7 – 2.9).

ACKNOWLEDGEMENTS

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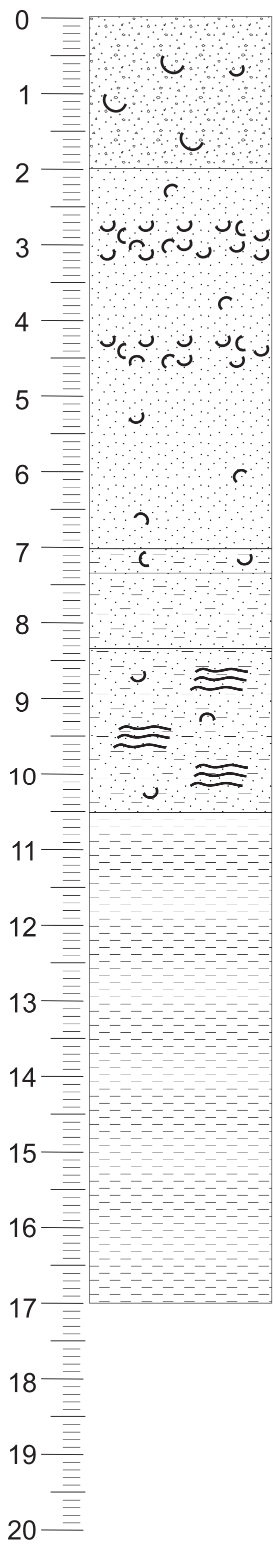
APPENDIX A. ASAP Vibracore logs

Provided as PDF files to accompany this report

DGSID Zz82-63 DATE DESCR. 08/17/17 WATER DEPTH (FT) 45.93

LOCAL ID. VA BOEM-15-01 DESCR. BY CRM

SAMPLE #	DEPTH (FT)
114861	0–2
114862	2–7
114863	7–12
114864	12–17



LITHOLOGIC DESCRIPTION

SAND: m-crs, ylsh-gry (2.5 Y 6/3), Q & lith, abd shl frags (bivalves <1 cm), dwncre fining.

SAND: m, ylsh-gry (2.5 Y 6/3), Q & lith, abd shl frags @4.2-4.6' and 2.7-3.2', lg shl frag (>1 cm) @ 6' and 6.6', clr chng to brn (2.5Y 3/2) @6.9-7.0'.

SAND: m, slty, brn (2.5Y 3/2), Q & lith, scat shl frags.

SAND: f, slty, olv gry (5Y 6/2), scat shl frags (<1 cm), shrp cntct @ base.

SAND: f, slty (lams), olv gry (5Y 4/2), scat shl frags, bioturb, abd shl frags @9.6-10.5', shl frag > 1 cm @10.0 and 10.1', shrp cntct @ base.

CLAY: slty-sdy, dk grnsh gry (5Y 3/2), dense, scat orgs, bioturb/sd-fill Bur (f, 5Y 7/1) or lenticular bedding throughout.

DGSID Zz82-64 DATE DESCR. 08/15/17 WATER DEPTH (FT) 52.49

LOCAL ID. VA BOEM-15-04 DESCR. BY CRM

DEPTH (FT)

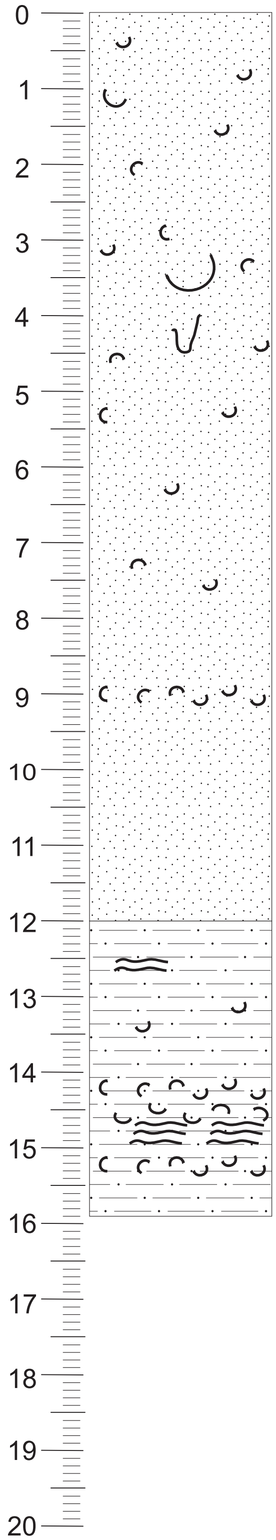
LITHOLOGIC DESCRIPTION

SAMPLE #

114865

114866

114867

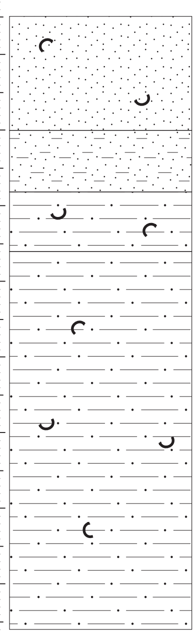


SAND: m, srted, lt or-gry (2.5Y 7/4), Q, lith, scat OHM, scat shl frag, shl frag >1 cm @3.5', brnsh (2.5Y 4/1) cly/slty cly-fil Bur @4-4.5', whole shell valve (>1 cm) @ 6.5’, bioturb & clr chng to dk brn (2.5Y 4/2) @ 8.7-9’, abd shl frags @ 9’, grad chng @ base.

SAND: f-vf, slty, scat shl/shl frags (bivalves), cly lams/drapes (dk gry - 4/10Y) @ 12.6’, cly lams (dk gry - 4/10Y) @ 14.7-15’, whole bivalve halves @14-14.7’ and 15.2-15.5’.

DGSID Zz82-65 DATE DESCR. 08/16/17 WATER DEPTH (FT) 52.49

LOCAL ID. VA BOEM-15-04a DESCR. BY CRM



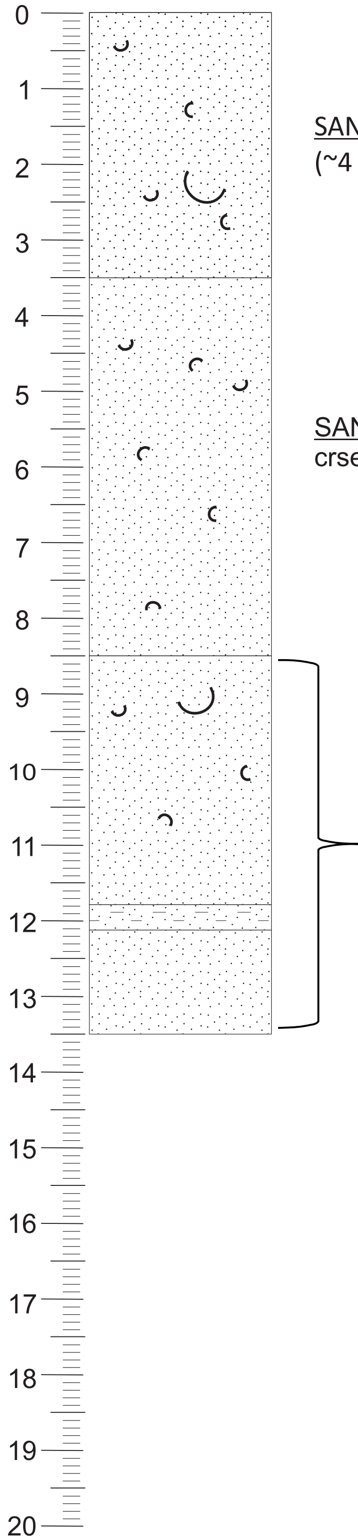
SAMPLE #	DEPTH (FT)	LITHOLOGIC DESCRIPTION
	14	
	15	SAND: f, ylsh-gry (2.5Y 6/3), Q & lith, scat shl (bivalves <1 cm).
114868	16	SAND: Interbed sd (f, ylsh gry 2.5Y 6/3) & sdy (vf) slt (brn 2.5Y 4/2).
	17	SILT: sdy (vf), brn 2.5Y 4/2, scat shl (<1 cm bivalve).
	18	
	19	
114869	20	SILT: sdy (vf), clyey, scat shl (bivalves <1 cm), scat orgs, micaceous.
	21	
	22	

DGSID Zz82-66 DATE DESCR. 08/15/17 WATER DEPTH (FT) 45.93

LOCAL ID. VA BOEM-15-05 DESCR. BY CRM

DEPTH (FT) LITHOLOGIC DESCRIPTION

SAMPLE #



114870

SAND: m, lt or-gry (2.5Y 7/4), srted, Q, lith, few OHMs, scat shl frags, lg oyster valve (~4 cm) @ 2.3-2.4'.

114871

SAND: m, lt or-gry (2.5Y 7/4), srted, Q, lith, few OHMs, scat shl frags, dwncre crsening to m/c sd, incr OHM @ 4-6.5'.

114872

SAND: f, lt ol-gry/or-gry (2.5 Y 6/4), Q, lith, few OHMs, scat shl frags, lg (> 1 cm) oyster frag @9-9.1', gastropod shl (<1 cm) @ 11.9', slty @11.8-12.4'.

DGSID Zz82-67 DATE DESCR. 08/17/17 WATER DEPTH (FT) 45.93

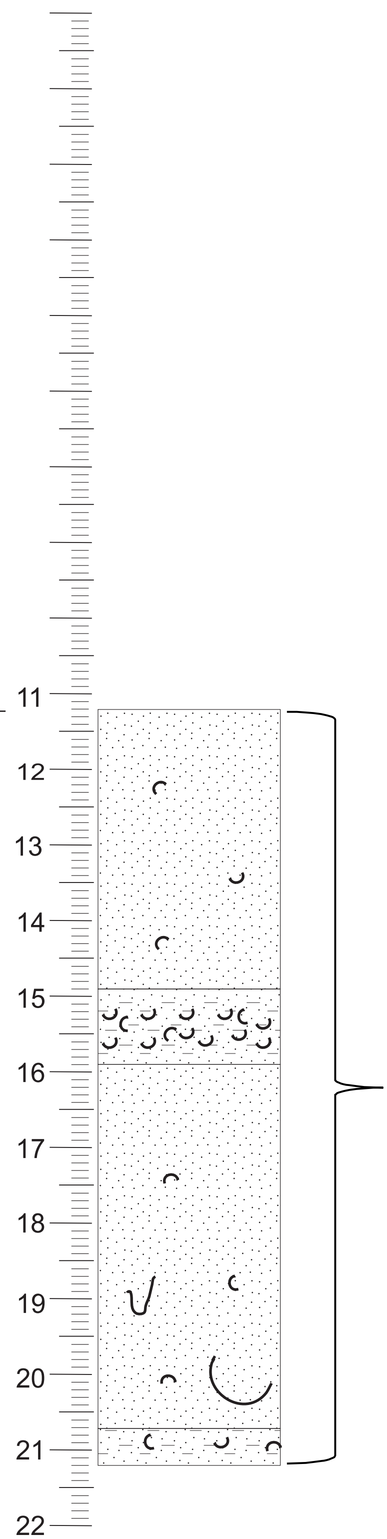
LOCAL ID. VA BOEM-15-05a DESCR. BY CRM

DEPTH (FT) LITHOLOGIC DESCRIPTION

SAMPLE #

114873

114874



SAND: f, ylsh-gry (2.5Y 6/3), Q, lith, few OHM, scat shl frag (<1 cm), bioturb & chng to slty/clyey sd w/ abd shl frags (<1 cm) @14.9-15.9', cly-fil Bur @ 19', lg shl frag (>1 cm) @ 20.3', clr chng to olv-gry (5Y 5/3) slty sd (f) w/ scat shl frags @20.7 to EOC.

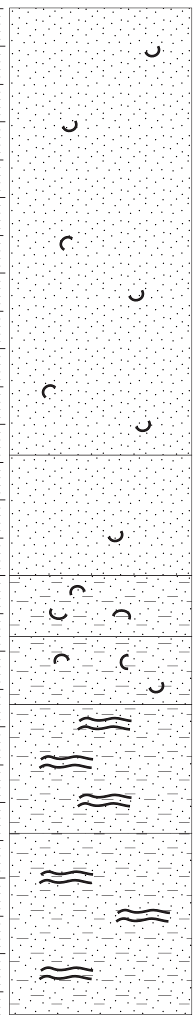
DGSID Xh54-01 DATE DESCR. 01/30/17 WATER DEPTH (FT) 54.72

LOCAL ID. VA BOEM-15-06 DESCR. BY KWR

DEPTH (FT) LITHOLOGIC DESCRIPTION

SAMPLE #

SAMPLE #	DEPTH (FT)
114875	0–3
114876	3–8
114877	8–13



0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

SAND: Sand: f-m, abd vf, ylsh (2.5Y 7/4), abd OHM, few shl frag, clean, mod w srted, crs-vcrs cn, gry cly/slt-fill Bur @ 2', faint OHM + txt lam.

Sand: as above, color grd to lt gry (2.5Y 7/2).

Sand: f-vf, gry (2.5Y 6/1), slty, abd OHM, inlam ww/ slt & sdy (vf)/slty cly (gry - 2.5Y 5/1), Bur, few-cn shlf frag (spisula?).

Sand: f-vf, m cn, gry (2.5 6/1), slty-vslty, few shl frag.

Sand: vf-f, mod slty, dk gry (2.5Y 4/1), lam w/ sd (lt gry - 2.5Y 7/2) & v slty cly w/ olv yl stains (2.5 6/6).

Sand: vf, slily slty, lt gry (2.5Y 7/2), w/ relict disrupted gry slty lam, abd OHM.

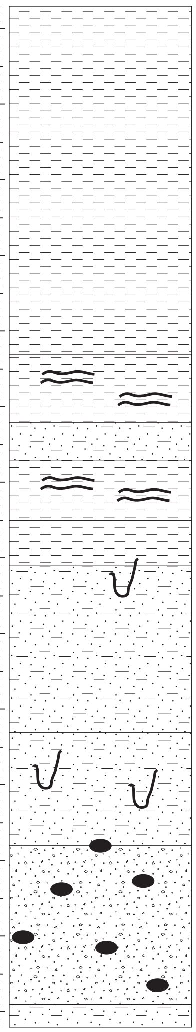
DGSID Xh54-02 DATE DESCR. 01/30/17 WATER DEPTH (FT) 54.72

LOCAL ID. VA BOEM-15-06a DESCR. BY KWR

DEPTH (FT) LITHOLOGIC DESCRIPTION

SAMPLE #

10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30



SAMPLE #	LITHOLOGIC DESCRIPTION
114878	CLAY: mod slty, tr-few vf-m sd, dk gry (5Y 4/1), slt-vf sd-size org frag abd, dries on surf cut core weak red (10R 4/2).
114879	SILT: slily sdy (vf), pale yl (5Y 8/3), w/ lam slty cly (as 10.2-14.8).
	SAND: vf, slty, pale yl (5Y 8/3), biotub w/ cly from above, tr - few OHM.
	CLAY: as 10.2-14.8, few sd lam @ 16.2-16.3'.
	CLAY: as above, bioturb w/ slt-vf sd.
	SAND: vf, slily slty, OHM cn-abd, lt brnsh-gry (2.5Y 6/2), cly-lined Burr from above, few pink sd grains (stained qtz).
114880	SAND: vf, f cn, OHM cn, pale yl (2.5Y 7/3), few slty cly lam & cly Burr, bioturb, 1 pbl @ base.
	SAND: m-f, crs cn, vcrs-gran few-cn, few sml pbl crsns dn to crs-m, vcrs cn, pale yl (2.5 Y 6/3), few gran-size plant frags.
	SAND: vf-f, slily slty, abd OHM, w srted, gry (2.5Y 6/11).

DGSID Zh31-01 | DATE DESCR. 02/01/17 | WATER DEPTH (FT) 60.37

LOCAL ID. VA BOEM-15-08 | DESCR. BY KWR

DEPTH (FT) | LITHOLOGIC DESCRIPTION

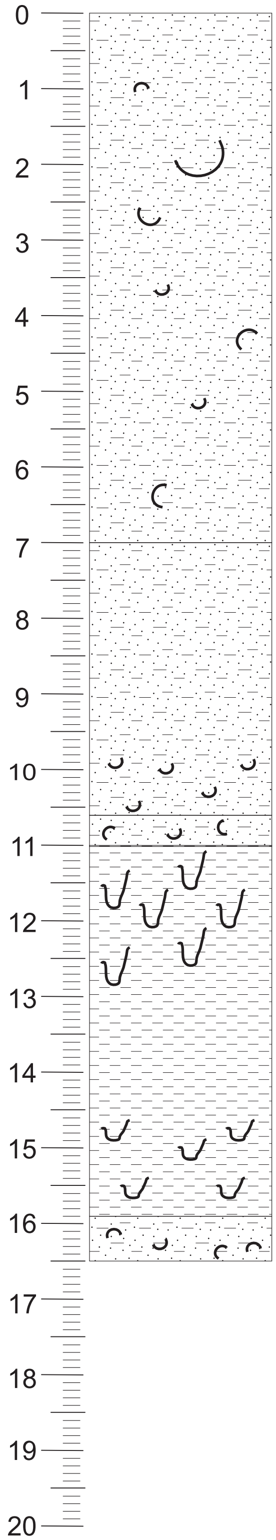
SAMPLE #

114881

114882

114883

114884



SAND: vf-f, olv gry (5Y 5/2), abd OHM, few forams, v well srted, tr silt, vcrs shl frag cn, no sed structure - bioturb?, shl frag up to 1.5 cm cn (Spisula) @ 2-5.3', gradational cntct @ base.

SAND: vf, slty, olv gry (5Y 5/2), abd OHM, few echiniod spines, rare gran-size shl frag, few 1-2 cm shl frag (Spisula) @ 9.7-10.6'.

SAND: vf, mod slty, compact, olv gry (5Y 4/2), cn OHM, cn grn-size shl frag, few echinoid spines.

CLAY: slily-mod slty, dk olv gry (5Y 3/2), plastic, abd vf shly clyey sd-fill Bur, f sd-size org frag cn, fewer sd-fill Bur @ 12.9-14.5', less sd & burrows compacted @ 14.5-15.4' shrp cntct @ base.

SAND: vf-f, olv-gry (5Y 5/2), OHM cn-abd, tr shl (crs-sd sized).

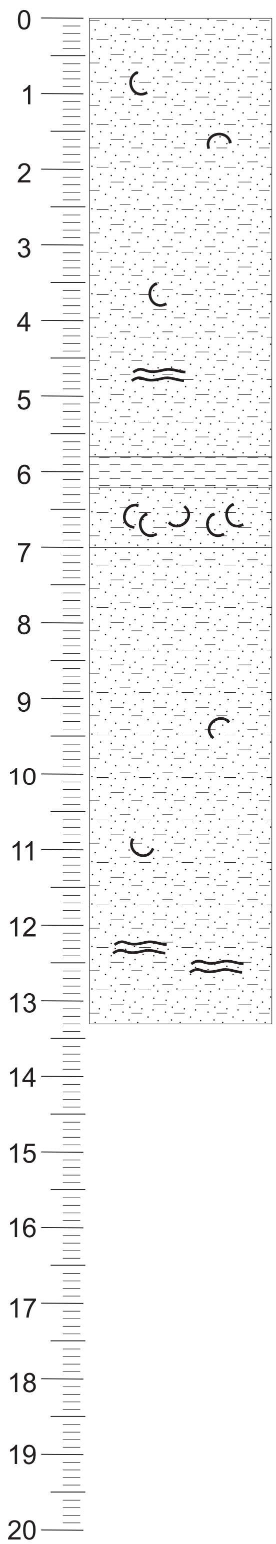
DGSID Zg23-01 DATE DESCR. 02/01/17 WATER DEPTH (FT) 50.85

LOCAL ID. VA BOEM-15-09 DESCR. BY KWR

DEPTH (FT)

LITHOLOGIC DESCRIPTION

SAMPLE #



114885

SAND: vf, slily slty, lt olv-gry (5Y 6/2) to olv gry (5Y 5/2), cn-abd OHM, few gran, crs-size shl frag, w srted, bioturb, shl frag cm @ 3.6' (Spisula & Crassostrea), lam shl frag and f-vf sd @ 4.7-4.8'.

114886

CLAY: slily slty, olv-gry (5Y 4/2), bioturb w/ sand from above.

CLAY: f-crs, slily-mod slty, abd crs-1 cm shl frag (Crassostrea, Arca, Mulinia), lt olv gry (5Y 6/2).

114887

SAND: vf, mod slty, lt olv gry (5Y 6/2), bioturb, rare shl frag, w srted, slily clyey/slty lam @ 12.3-12.7'.

DGSID	Zg23-02	DATE DESCR.	02/01/17	WATER DEPTH (FT)	50.85
LOCAL ID.	VA BOEM-15-09a	DESCR. BY	KWR		

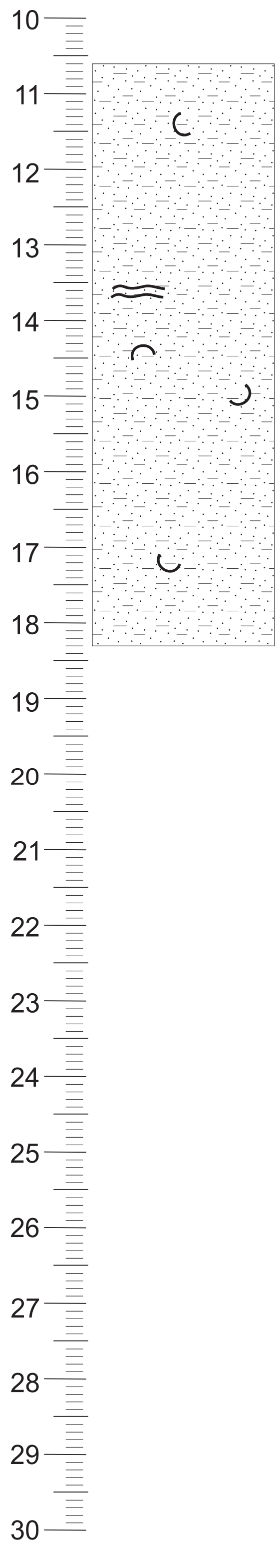
DEPTH (FT)

LITHOLOGIC DESCRIPTION

SAMPLE #

114888

114889



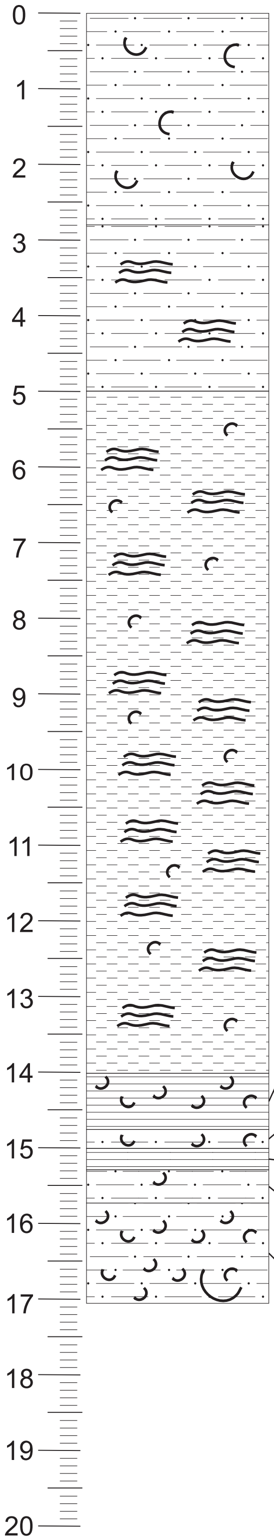
SAND: vf, mod slty, lt olv gry (5Y 6/2), bioturb (slty zones), rare shl frag, w srted, cn OHM, olv gry (5Y 5/2) slily clyey lam @ 13.6'.

DGSID Zz82-68 DATE DESCR. 11/16/17 WATER DEPTH (FT) 47.6

LOCAL ID. VA BOEM-16-01 DESCR. BY CRM

DEPTH (FT) LITHOLOGIC DESCRIPTION

SAMPLE #



SAMPLE #	
115289	SAND: vf, slty/clyey, dk grnsh gry (1 GLEY 3/10Y), scat shl frag, gastropod shl @2.0 and 2.5'.
	SAND: vf, clyey interlam.
115290	
115291	CLAY: slty, interbed sd (vf), dk grnsh gry (1 GLEY 3/10Y), scat orgs, scat mica, scat shl.
	CLAY: slty, interbed sd (vf), dk grnsh gry (1 GLEY 3/10Y), abd shl frags (up to 4 cm diam).
	SAND: f-m, slty, scat shl frags, dk grnsh gry (1 GLEY 3/10Y).
	CLAY: dk grnsh gry (1 GLEY 3/10Y).
115292	SAND: f, dk grnsh gry (1 GLEY 4-5/10Y), shl frag @ 15.4'.
	SAND: f, cly interbed/interlam, abd shl, shl frag ~5 cm diam @ 16.8-17.0'.

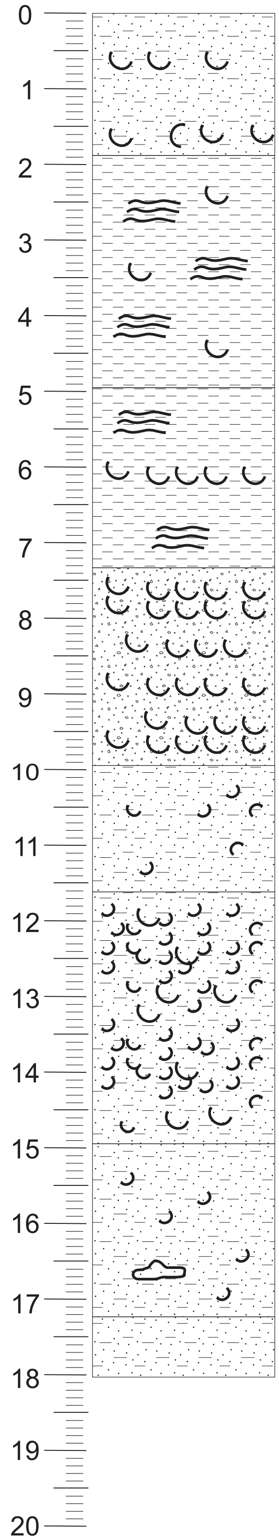
DGSID Zz82-69 DATE DESCR. 11/16/17 WATER DEPTH (FT) 49.2

LOCAL ID. VA BOEM-16-02 DESCR. BY CRM

DEPTH (FT)

LITHOLOGIC DESCRIPTION

SAMPLE #



115293

115294

115295

115296

SAND: vf, slty, clyey, bioturb (cly-fil Bur), Shl frags @ 0.6' and 1.5-1.9', crsening up-core.

CLAY: slty, dk gry (1 GLEY 5/5GY), interlam sd/slty sd (vf) - 1 GLEY 4/5GY), scat Shl frags abd @2-2.1', 2.5, & 3.7', scat clr chng to brn (7.5 YR 4/2).

CLAY: interbed/interlam w/ slty cly & slty sd (vf), dk grnsh gry (1 GLEY 5/10GY), abd Shl @ 6-6.1'.

SAND: vrs, abd lg Shl frags (>5 cm).

SAND: f-m, clyey, slty, dk grnsh gry (1 GLEY 3/10Y), scat Shl frags (grav-sz).

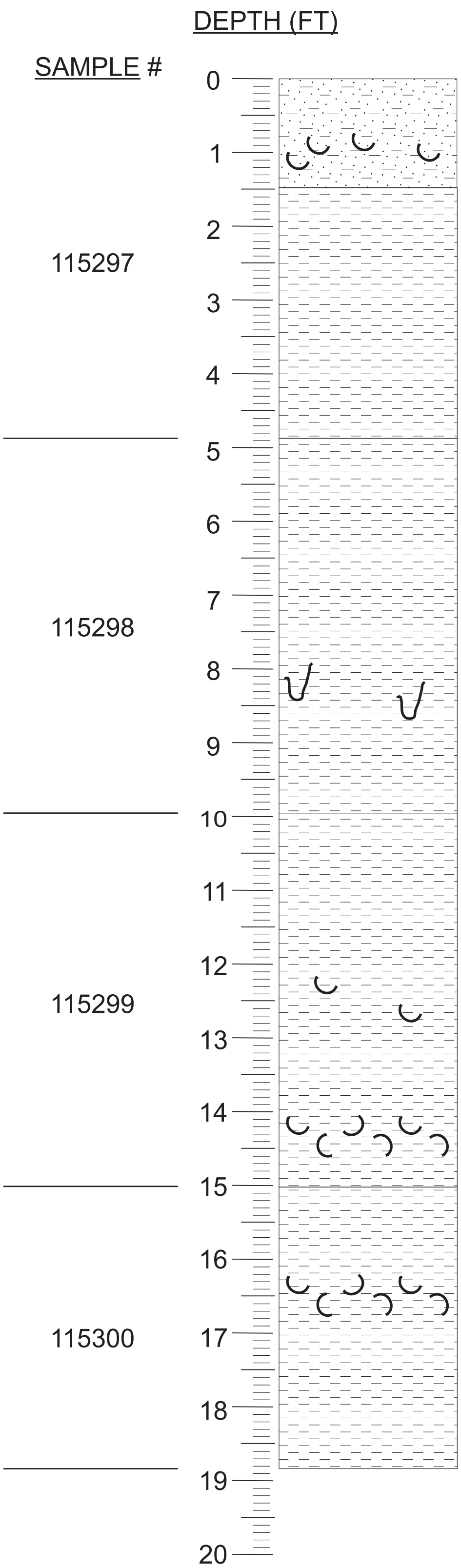
SAND: f-m, slty, abd Shl frag (>5 cm).

SAND: f-m, slty, clyey, sml Shl (bivalves <1 cm), orgs @ 16.6 (woody).

SAND: vf-f, clyey, bioturb.

DGSID Zz82-70 DATE DESCR. 06/27/17 WATER DEPTH (FT) 51.5

LOCAL ID. VA BOEM-16-03 DESCR. BY CRM



LITHOLOGIC DESCRIPTION

SAND: f, clyey-slty, olv gry (1 GLEY 4/5Y), slty cly @ 0-0.3', scat shl frag, lg shl frag (> 2cm) @ 0.2', sml shl frags @ 0.8' and 1.1'.

CLAY: slty, olv gry (1 GLEY 4/5Y), motts.

CLAY: slty, olv gry (1 GLEY 4/5Y), motts, scat orgs (5.6' and 7.5'), bioturb, sd-fill Bur @8.3' and 8.5-8.6'.

CLAY: slty, stiff, olv gry (1 GLEY 4/5Y), scat shl frag, orgs @12.2' and 12.8', lg shl frag > 2 cm (oyster) @ 14.1-14.7.

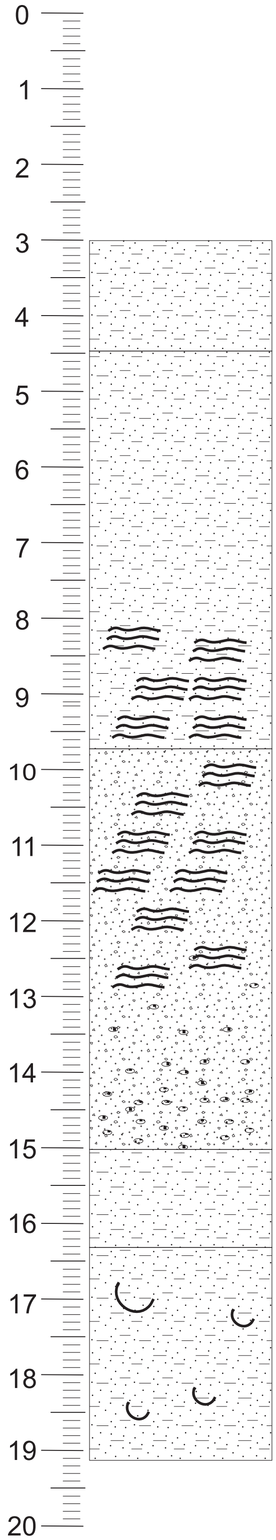
CLAY: slty, stiff, olv gry (1 GLEY 4/5Y), abd shl @16.3-16.7' (oyster).

DGSID Zz82-71 DATE DESCR. 07/05/17 WATER DEPTH (FT) 51.5

LOCAL ID. VA BOEM-16-04 DESCR. BY CRM

DEPTH (FT) LITHOLOGIC DESCRIPTION

SAMPLE #



VOID

115301

SAND: vf-f, clyey, abd Q, scat OHM, lt ol gry (1 GLEY 7/10Y) to dk gry (1 GLEY 5/5GY), bioturb.

115302

SAND: f-crs, Q, lt gry (1 GLEY 7/10Y), scat OHM, OHM lams @ 8.2-9.7', scat crs sd grains.

115303

SAND: m-vcrs, scat grav, lt gry (1 GLEY 7/10Y-5/5GY), OHM lam, dncore crsening.

SAND: vf, slty, dk gry (1 GLEY 5/5GY), bioturb, scat org.

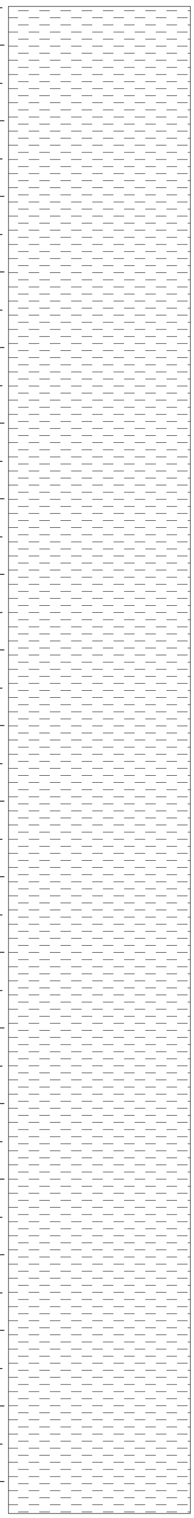
115304

SAND: vf, slty-clyey, dk gry (1 GLEY 3/10Y), scat shls, bioturb, lg (>5 cm) shl frag (bivalve) @ 16.8-17'.

DGSID Zz82-72 DATE DESCR. 06/26/17 WATER DEPTH (FT) 45.2

LOCAL ID. VA BOEM-16-05 DESCR. BY CRM

SAMPLE #	DEPTH (FT)	LITHOLOGIC DESCRIPTION
115305	0–5	CLAY: slty slty, olv gry (1 GLEY 4/5G).
115306	5–10	
115307	10–15	
115308	15–20	

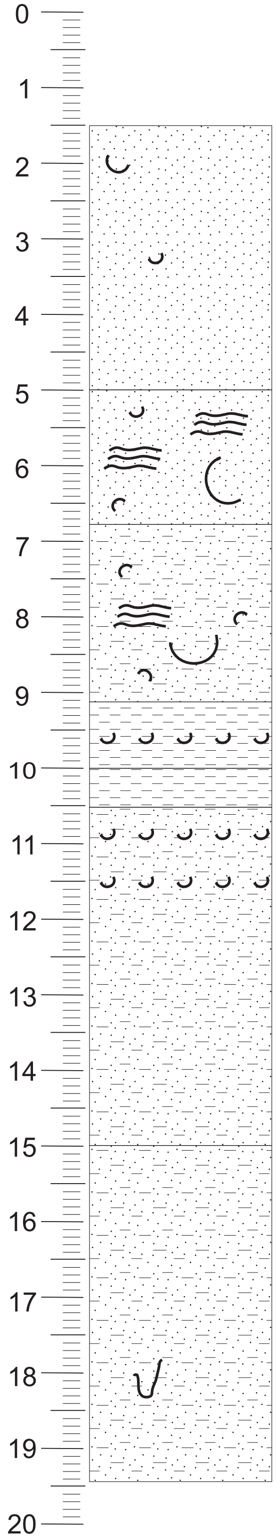


DGSID Zz82-73 DATE DESCR. 08/20/17 WATER DEPTH (FT) 40.2

LOCAL ID. VA BOEM-16-06 DESCR. BY CRM

DEPTH (FT) LITHOLOGIC DESCRIPTION

SAMPLE #



VOID

115309

SAND: f-m, olv gry (5Y 6/4 to 5Y 6/2), scat shl frags, shl >2 cm @2', shl>1 cm @ 3.35', scat OHM.

SAND: f-m, lt olv gry (5Y 7/3), lams, scat shl, oyster valve > 5 cm @ 6.6-6.7'.

115310

SAND: vf-m, slty, dwncre clr chng from dk olv gry (5Y 4/1) to lt olv gry (5Y 6/3), scat shl frags, lams @ 7.8-8.1, 5 cm shl frag (oyster) @ 8.4-8.5'.

CLAY - SILTY CLAY: dk olv gry (5Y 4/2), sd-fill Bur, 4 cm shl frag @9.6 - 9.8' (oyster).

CLAY: dk olv gry (5Y 4/2), dwncre crsening to clyey/slty sd (vf).

115311

SAND: vf-f, clyey-slty, dk brn (5Y 4/1), incr cly @11.5-12.3', abd shl frags @ 11.5, shl frags (vc) in brn cly (7.5 YR 4/6) @ 10.8-11'.

115312

SAND: vf-f, clyey-slty, dk brn (5Y 4/1), dncore incr cly @ 18' (cly rip-up or cly-fil Bur?).

DGSID Yh21-01 DATE DESCR. 02/13/18 WATER DEPTH (FT) 57.18

LOCAL ID. VA-2017-01 DESCR. BY CRM

DEPTH (FT)

LITHOLOGIC DESCRIPTION

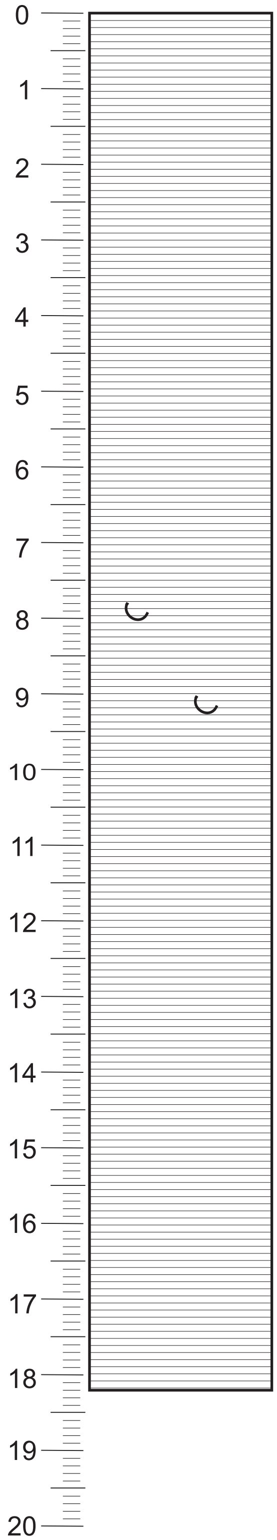
SAMPLE #

117269

117270

117271

117272



CLAY: dk blsh gry (1GLEY 4/10Y), slty, bioturb-strless, few mica, few sd grains (scat); Fe-cement shl nodule @ 2.4-2.6 & 2.7-2.9', cement f sd nodule (clr = lt gry/1GLEY 7/10Y) @ 3.5-3.7'; dwncre decrease bioturb.m abd @ 0.4-2.6'; dwncre incr slt @ 6.2-10'; lg shl frags (>2 cm) @ 7.9 & 9.4'.

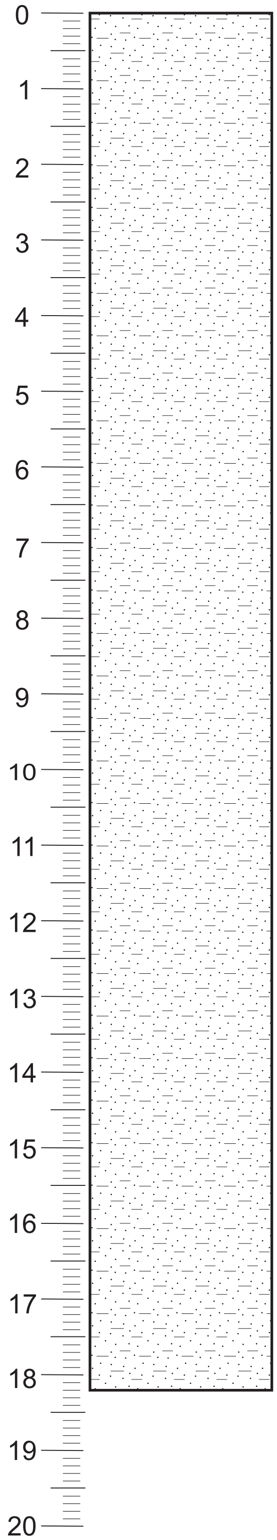
DGSID Yh41-01 DATE DESCR. 02/13/18 WATER DEPTH (FT) 57.48

LOCAL ID. VA-2017-02 DESCR. BY CRM

DEPTH (FT)

LITHOLOGIC DESCRIPTION

SAMPLE #



117273

117274

117275

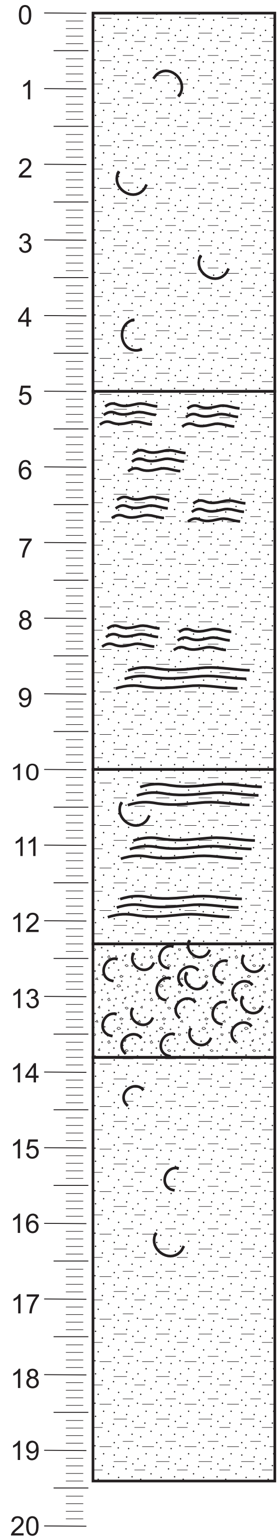
117276

SAND: f, slty slty, strless, abd mica & OHM, gry (1GLEY 5/5G), few scat shl frags (v sm); bioturb/ cly to sdy cly-fill Bur @ 0-0.7', abd lg shl frag (clam) @ 1.9-2', dwncre crsening to m sd (10-15’); v slty zn @ 13.8-14, shl frag (~1 cm)/bivalve @ 13.9-14', dwncre crsening to m/crs sd (15-18.2’).

DGSID Yh54-01 DATE DESCR. 02/14/18 WATER DEPTH (FT) 68.37

LOCAL ID. VA-2017-03 DESCR. BY CRM

SAMPLE # | DEPTH (FT) | LITHOLOGIC DESCRIPTION



117277

SAND: m-crs, slty, gry (1GLEY 5/10GY), abd sm scat shl frags, strless, abd OHM; bioturb, incr slt & cly dwncre; sdy cly zns @ 3.7-3.9' & 4-4.6'; abd shls/shl zn @ 0-0.3', 4.7-5'; lg shl frags *>1 cm) @ 0.9-1', 1.2', 2.3', 3.4-3.5', & 4.2'.

117278

SAND: AA w/ slty-clyey m-crs sd zn w/ abd shl frags (sm & l) & abd cly interbeds (blsh gry - 1GLEY 5/5G); abd shl frags/shlly zn @ 5.4-5.7' & 6.1-6.4'; cly interbeds @ 5-5.4', 5.7-6', 6.6-6.8', 7-7.3', 7.6-7.8', 8.4-8.7', & 8.6-9'.

SAND: AA (m, slty) w/ cly interbed (clr = AA); lg shl frag (~5 cm) @ 10.4-10.6'; shrp cntct @ 12.3'.

117279

SHELL HASH: sdy (matrix), abd sm shls & shl frags; few lg shl frags (clam); shrp cntct @ 13.8'.

117280

SAND: m-crs, slty slty, clr = 5Y 4/2 (grnsh gry), abd OHM, abd v sm scat shl frag (<<1 cm); strless; clay lam @ 15.5, 16.1, 16.3-16.4''; clam shl (~2 cm diam) @ 16.4', razor clam frag @ 15.4-15.5'.

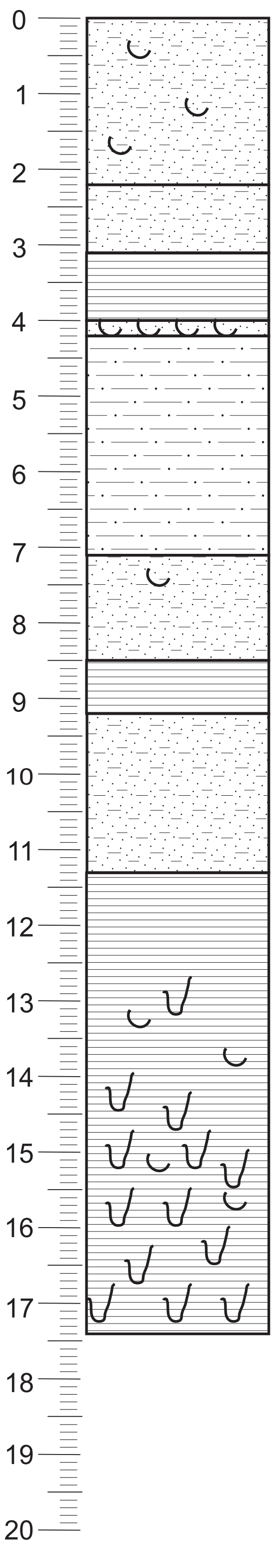
DGSID Yh22-01 DATE DESCR. 02/15/18 WATER DEPTH (FT) 49.77

LOCAL ID. VA-2017-04 DESCR. BY CRM

DEPTH (FT)

LITHOLOGIC DESCRIPTION

SAMPLE #



117281

117282

117283

117284

SAND: f, slty slty, dk ry (1GLEY 4/10GY), dwncre incr slt, sm scat shl frags, OHMs; cly lams (clr = AA) @ 1.2-1.6'.

SAND: AA, interbeds & interlams of cly - slty cly (dk blsh gry - 1GLEY 4/5G); shrp cntct @ 3.1'.

CLAY: dk blsh gry (1GLEY 4/.5G), f sd lam @ 3.4' & 3.8'; shrp cntct @ 4'.

SAND: f-m, abd sm shl frag, gry (1GLEY 4/10GY), strless; shrp cntct @ 4.2'.

CLAY: dk blsh gry (1GLEY 4/.5G), f sd lams abd; lg shl frags (>2 cm) @ 5.5-5.7' (oyster); shrp cntct @ 7.1'.

SAND: f, slty, abd OHM, strless (bioturb?), cly-fill Bur (clr = AA), sd clr = gry (1GLEY 5/5GY); shrp cntct @ 8.5'.

CLAY: ddk blsh gry (1GLEY 4/.5G); shrp cntct @ 9.2'.

SAND: f, v slty, dk gry (1GLEY 4/10GY), scat sm shl frags, strless; grad cntct @ 11.3'.

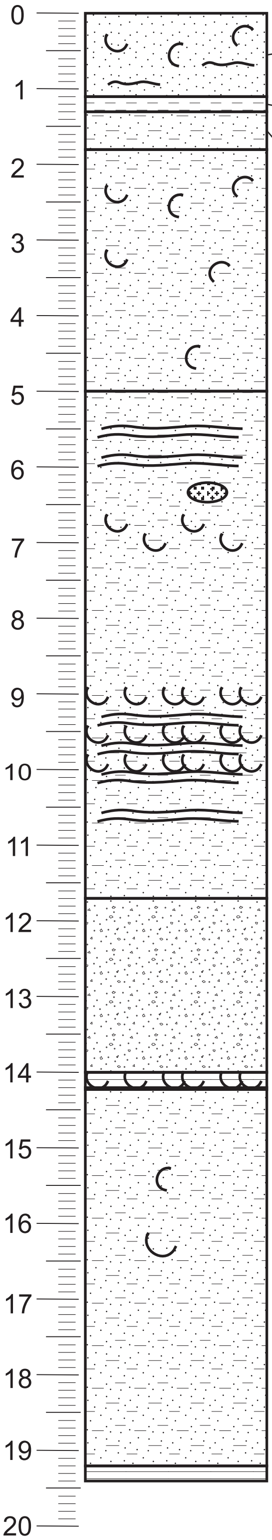
CLAY: dwncre chng from sdy cly to cly; bioturb, abd sd-fill Bur, few scat sm shl frags.

DGSID	Zz82-83	DATE DESCR.	02/05/18	WATER DEPTH (FT)	49.1
LOCAL ID.	VA-2017-05	DESCR. BY	CRM		

DEPTH (FT)

LITHOLOGIC DESCRIPTION

SAMPLE #



SAND: f, OHM & mica, dk gry (1GLEY 4/10GY), few sm scat shl frags, cly lams (clr AA) @ 0.8-1'; shrp cntct @ 1.1'.

CLAY: slty-sdy, lt brnsh gry (2.5Y 5/2), sd-fill Bur (dk gry - 1GLEY 4/10GY) @ 1.2'; shrp cntct @ 1.3'.

SAND: f-crs, strless, abd Q & OHMs & mica, slty, scat shl frags (sm), clr = AA (1GLEY 4/10GY); grad cntct @ 1.8-2'.

117285

SAND: f, slty, abd OHM, strless, dk brnsh gry clr zn @ 2-3.2 (2.5Y 5/2), or gry clr zn (2.5Y 5/4) @ 3.5-5', cly rip-ups (or - 2.5Y 5/4) @ 3.2-3.6', lg (~5 cm) shl frag (bivalve) @ 2-2.2', abd shll frags (sm) @ 3.2-3.4'.

117286

SAND: f, slty, org-gry (2.5Y 5/2), cly-slty cly interbeds (2.5Y 5/4) @ 5.5-5.6', 5.8-6', 10-10.2', 10.6-11.7'; cly rip-ups (clr = AA) @ 6.4-6.7', abd shl frags (sm) @ 6.7-7.2', shl lams @9', 9.5', & 9.8-9.9', cly lams @ 8.9-10'; shrp cntct @ 11.7'.

117287

SAND: f, slty, abd mica & OHM, strless, clr = tan-gry (2.5Y 5/2); shr cntct @ 14'.

SHELL HASH: clyey, abd f-crs shl & shl frags; shrp cntct @ 14.2'.14'.

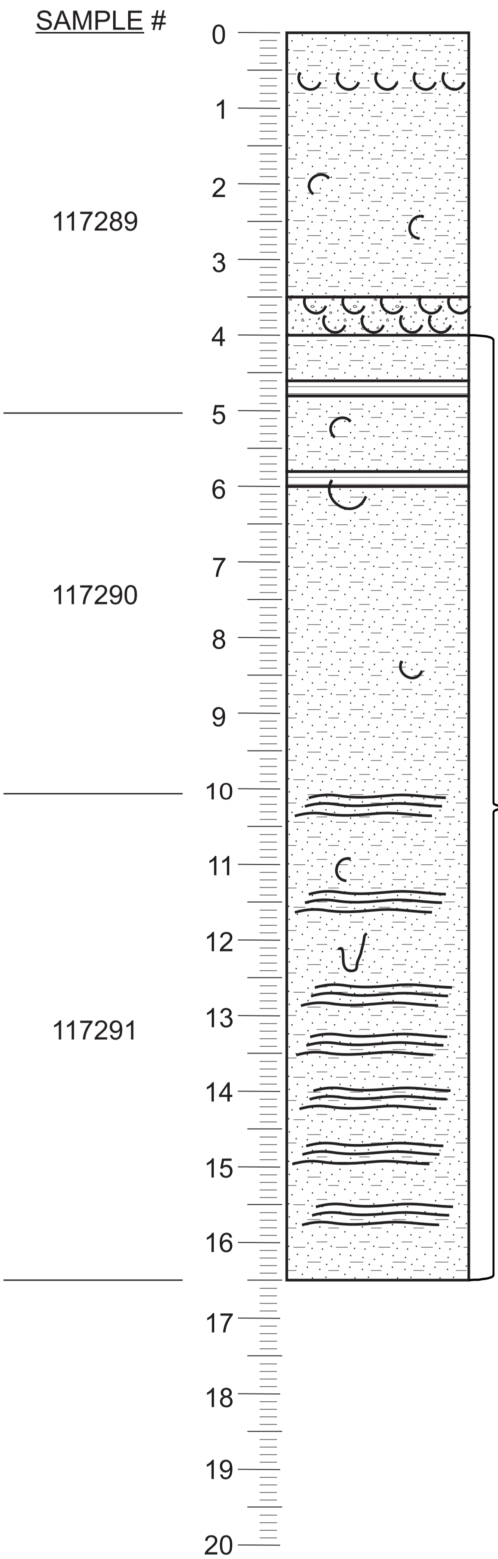
117288

SAND: f, cly-slty cly interbeds; clr = blsh gry (1GLEY 5/5G); gastropods @ 14.7', few scat shl frag (sm), shl lam @ 19.2', cly bed 19.2-19.4'.

DGSID Zz82-84 DATE DESCR. 02/13/18 WATER DEPTH (FT) 40.37

LOCAL ID. VA-2017-06 DESCR. BY CRM

DEPTH (FT) LITHOLOGIC DESCRIPTION



SAND: f, slty slty, abd OHM, abd mica, few sm scat shl frag, gry clr (1GLEY 4/10Y); shl zn @ 0.6-0.7' (lg frags > 1 cm diam), gastropod @ 1.2', lg shl frag (>1 cm) @ 2.1-2.2', 3.1'; shrp cntct @ 3.5'.

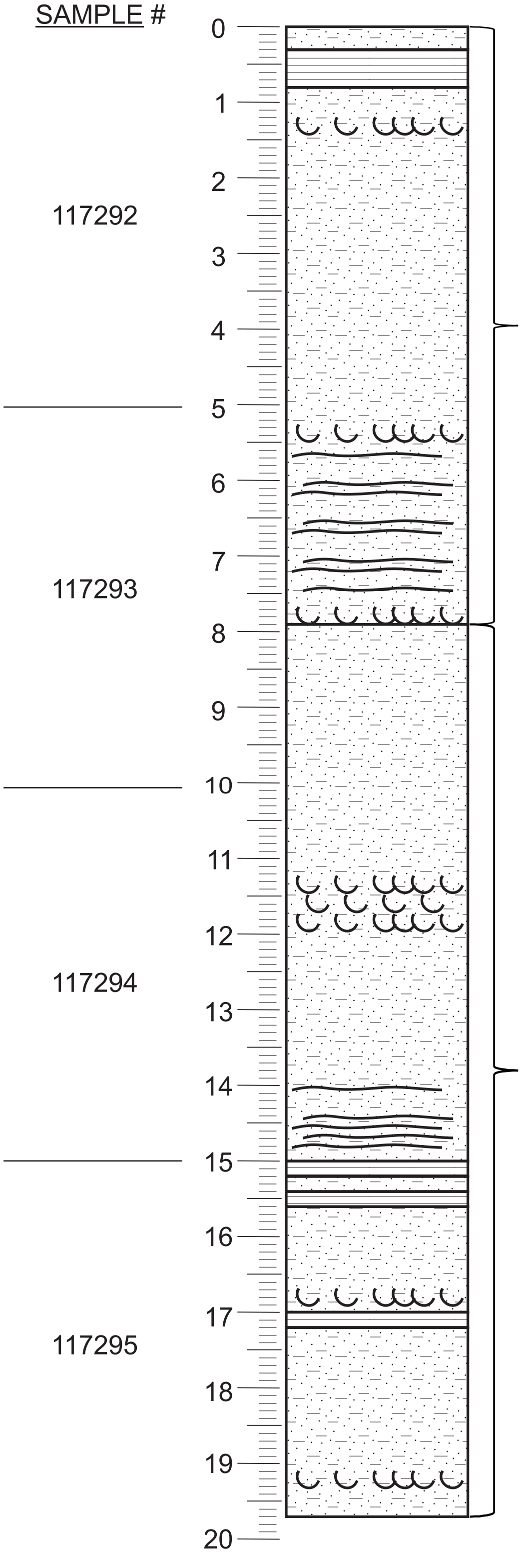
SAND: vcs, v shlly, clr = AA, dwncre incr shl & shl diam; shrp cntct @ 4'.

SAND: f, slty slty, abd OHM, abd mica, few sm scat shl frag, gry clr (1GLEY 4/10Y); blsh gry (1 GLEY 5/5G) cly interlams/interbeds @ 4-4.1' 4.6-4.8', 5.3-5.4', & 5.8-6', lg shl frag (~3 cm) @ 6.2-6.3'; abd cly interbeds @ 10-16.5' (clr = AA), sd-fill Bur @ 12.2-12.3', dwncre incr slt & cly (slt & cly dom below 14.7'.

DGSID Zz82-85 DATE DESCR. 02/14/18 WATER DEPTH (FT) 37.18

LOCAL ID. VA-2017-07 DESCR. BY CRM

SAMPLE # | DEPTH (FT) | LITHOLOGIC DESCRIPTION



SAND: f, gry (1GLEY 7/10GY), dwncre clr chng to yllsh gry (5Y6/3), abd OHM (incl lams), few sm scat shl frags @0-1.5', few mica; cly interlams/interbeds @ 0.3-0.7' (clr = dk olv gry/1GLEY 4/5GY), shl lam @ 1.3', few scat shl frags (sm) @ 3.6-5', abd OHM lams @ 5.4-7.9', shl zn @ 5.3-5.4' (abd shl frags up to 1 cm), sm shl lams @ 7.7-7.9', slty cly lams (clr = AA) @ 7.5'; dwncre incr slt.

SAND: f, slty to v slty, gry (1GLEY 5/5GY), abd OHMs & mica, few slty & cly lams; cly rip-up or cly-fill Bur (clr = 1GLEY 4/10Y) @ 9.3', dwncre clr chng to dk gry (1 GLEY 4/5GY) @ 10-19.7', abd OHM lams @ 14-14.7', 15.1 to EOC; cly (dk gry - 1GLEY 3/10Y) interbed @ 13-13.7', 15-15.2', 15.4-15.6', & 17-17.2'; shl zns (abd shl frags/hash) @ 11.2-11.9 & 16.8-16.9'; shl lam 19.2'.

DGSID Zz82-86 DATE DESCR. 02/14/18 WATER DEPTH (FT) 42.9

LOCAL ID. VA-2017-08 DESCR. BY CRM

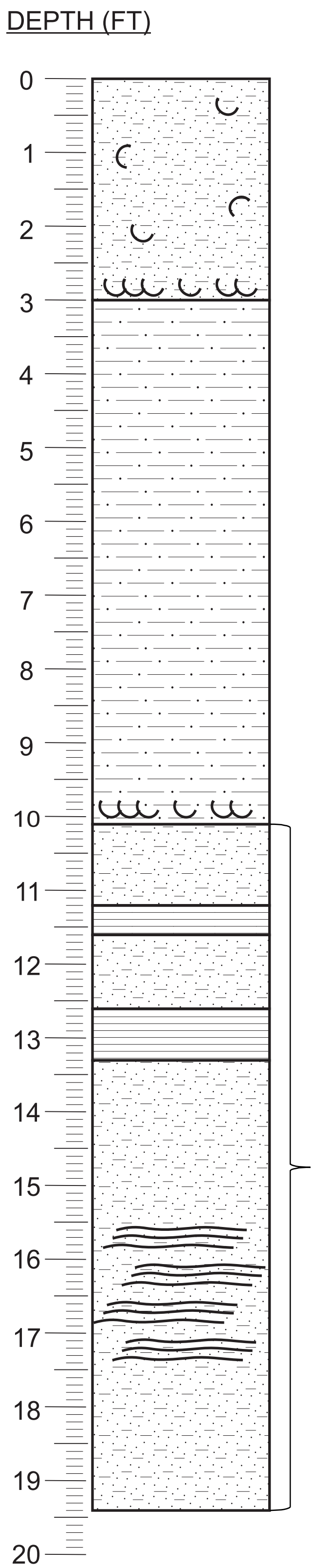
SAMPLE #

117296

117297

117298

117299



LITHOLOGIC DESCRIPTION

SAND: f-m (dwncre fining), slty, clr = lt gry (1GLEY 6/5GY), bioturb, abd OHM, strless, few sm scat shl frags; lg oyster frag (~3 cm) @ 1.4-1.6', gastropod @ 2.2-2.3', shl hash (abd lg shl frags) @ 2.9-3'; shrp cntct@ 3'.

SAND: Interbed f, slty sd & cly: sd clr = or-gry (2.5Y 5/4), mica, OHM, few scat shl frags, strless; cly clr = blsh gry (1GLEY 6/5G) to or-gry (2.5Y 5/4); sdy zns @ 4.5-7' & 9-10', interlam zns @ 3.8-4.5' & 7-7.5', abd shl frags @ 9.7-9.9'.

SAND: f, slty, abd OHM, few scat shl frag (sm), grnsh gry clr (2.5Y 4/3), cly interbeds (clr AA) @ 11.2-11.6', 12.6-13.3', & 17.3-17.4'; abd OHM lams @ 15.5-17.3'.

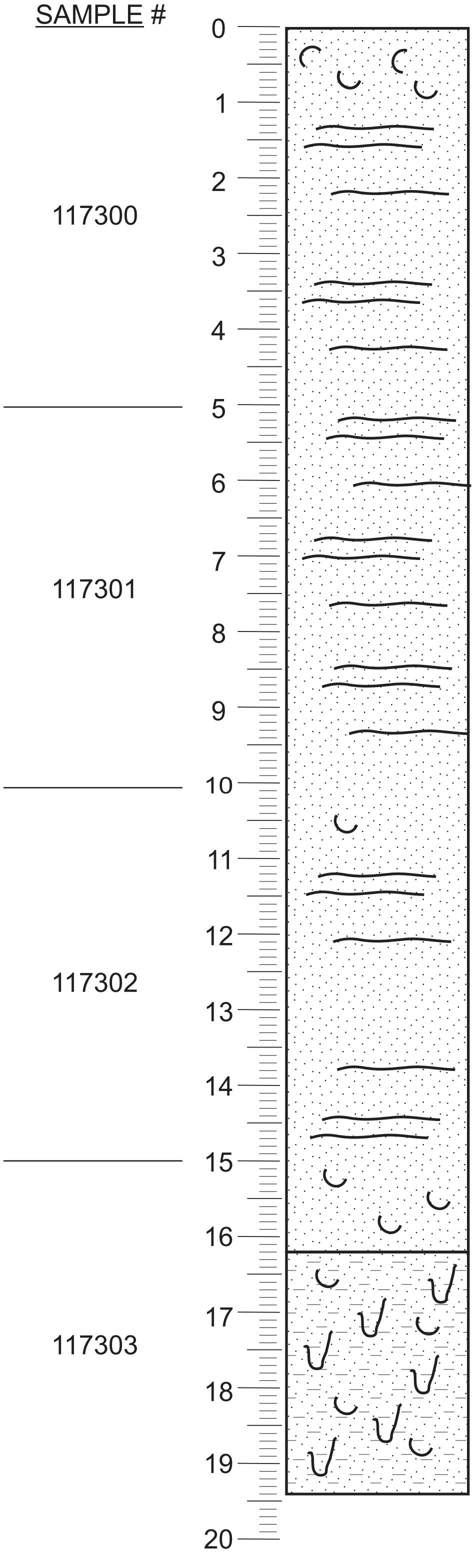
DGSID Zz82-87 DATE DESCR. 02/15/18 WATER DEPTH (FT) 29.88

LOCAL ID. VA-2017-09 DESCR. BY CRM

DEPTH (FT)

LITHOLOGIC DESCRIPTION

SAMPLE #



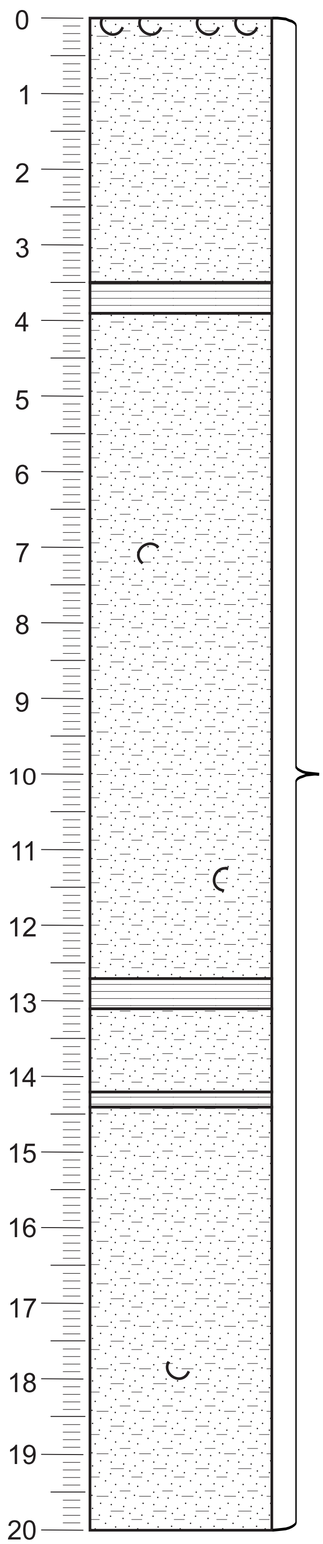
SAND: m-crs (m-dom), lt or gry (2.5Y 7/4) to gry (2.5Y 6/1), scat sm shl frag, abd OHM; OHM lams @ slt lams abd, abd shl frags @ 0-1.4', OHM abd zn @ 1.5-1.8', 2.2-2.9', 3-7.7', 8.3-13.7', & 14.3-14.6'; lg shl frag (~2 cm) @ 10.5'; m-crs sd zn @ 0.7-1.4' & 2.9-3'; shrp cntct @ 16.2'.

SAND: f-m, slty, dk gry (1GLEY 4/5GY), abd sm scat shl frags; bioturb, strless; lg bivalve (~2-3 cm diam) @ 16.7'.

DGSID Zz82-88 DATE DESCR. 02/20/18 WATER DEPTH (FT) 36.4

LOCAL ID. VA-2017-10 DESCR. BY CRM

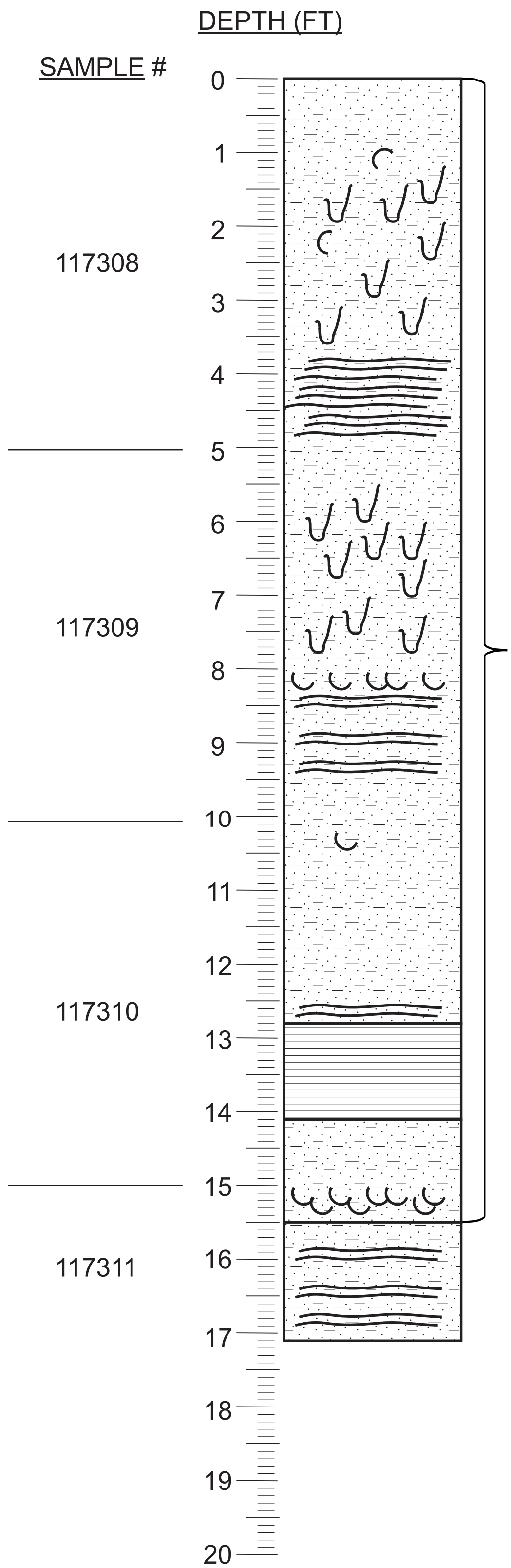
SAMPLE #	DEPTH (FT)	LITHOLOGIC DESCRIPTION
117304		
117305		
117306		
117307		



SAND: f, slty slty, lt tan (2.5Y 4/2), abd OHM, abd mica, v frew sm scat shl frag; org lams @ cly/slt lams 9dk brn - 2.5Y 5/2) @ 0.7-3.5' (x lams); abd sm shl frags (<1 cm) @ 0-0.1'; cly interbed (dk brn - 2.5Y 5/2) @ 3.5-3.9'; cly interbeds @ 12.7-13.1', 13.6-13.7', & 14.2-14.4' (clr = AA); bioturb zn @ 4-11'; strless zn @ 15-20'.

DGSID Zz82-89 DATE DESCR. 02/22/18 WATER DEPTH (FT) 32.99

LOCAL ID. VA-2017-11 DESCR. BY CRM



LITHOLOGIC DESCRIPTION

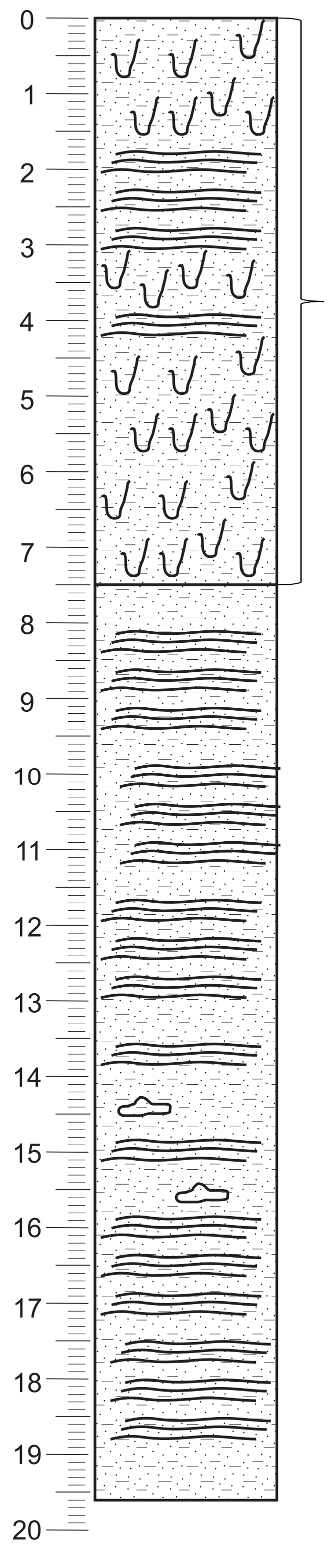
SAND: f, slty, bioturb, abd lg scat shl frags, abd OHM, few scat mica, few OHM & cly lams; sd clr = gry (1GLEY 6/5GY), cly clr = dk olv gry (1GLEY 4/10GY); abd cly-clyey sd-fill Bur (dk olv gry - AA) @ 1.3-3.7'; cly interlams @ 3.7-4.8', bioturb zn @ 5.8-8.3', lg shl frags (> 3 cm) @ 8.3', slt/cly lams @ 8.3-9.3', shl lam @ 9.4' (+ lg shl frag ~4 cm: Busycon), cly interlam @ 2.5-2.7', articulated razor clam (~3 cm) @ 10.4-10.5', shl lam @ 11', 12.5', cly lams @ 12.6-12.8', cly interbed (blsh gry - 1GLEY 5/5G) @ 12.9-14.1', abd lg shl frags (>2 cm) @ 15-15.3' (clam), m sd bed (clr & comp = AA) @ 15.4-15.5'; shrp cntct @ 15.5'.

SAND: f, clyey/slty; dk gry (1GLEY 4/10GY); abd cly interlams; few scat shl frags (sm).

DGSID Zz82-90 DATE DESCR. 02/22/18 WATER DEPTH (FT) 28.98

LOCAL ID. VA-2017-12 DESCR. BY CRM

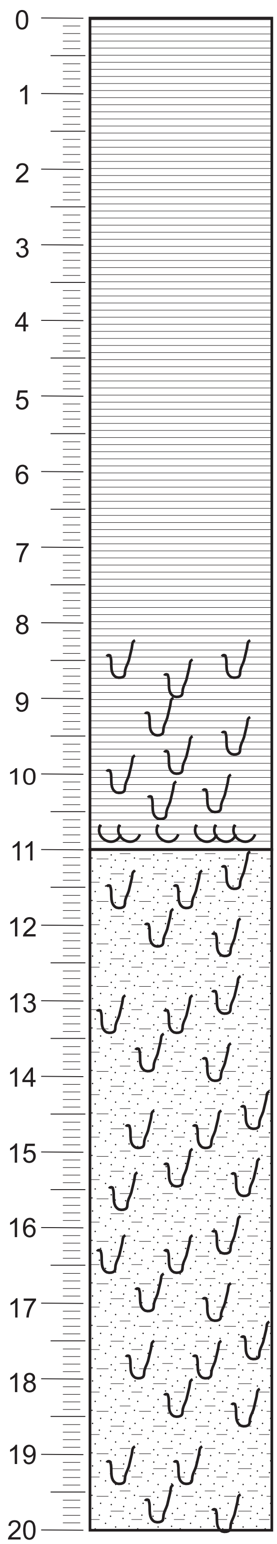
SAMPLE #	DEPTH (FT)	LITHOLOGIC DESCRIPTION
117312	0–7.5	SAND: f, v slty, abd OHMs, scat sm shl frags (<1 cm), abd cly interlams (dk olv gry - 1GLEY 4/10GY), bioturb zns @ 0-1.5', 3-3.9', & 4.3-7.5' (abd cly-sdy cly-fill Bur); lam zns @ 1.5-3', 3.9-4.3'; abd sm shl fags/shl lams @ 0.4-0.5', & 2.5-3'; lg shl frag (> 2cm) @ 6.4-6.5'; grad cntct @ 7.5-7.9'.
117313	7.5–19.6	SAND: clyey to v clyey, few mica, blsh-gry streak clr (1GLEY 5/5G), abd cly lams (clr = AA); dwncre incr cly; wood debris @ 15.5' (sampled for C-14) & 14.5'; incr bioturb below 12'.
117314		
117315		



DGSID Zz82-91 DATE DESCR. 02/26/18 WATER DEPTH (FT) 44.09

LOCAL ID. VA-2017-13 DESCR. BY CRM

SAMPLE # | DEPTH (FT) | LITHOLOGIC DESCRIPTION



117316

117317

117318

117319

CLAY: dk blsh gry (1GLEY 4/5G), strless, few sm scat shl frags, few sm scat wood frags; f sd & slt lams (lt gry - 1GL 7/10Y) @ 7-8.3' (or sd-fill Bur?), shl zn (abd lg shl frags) @ 7.2-7.3', lg shl frags (>1 cm) @ 7.6-7.8', f sd-fill Bur (clr = AA) @ 8.4-10.7'; abd shl frags @ 10.8-11'; shrp cntct @ 11'.

SAND: f, v slty-clyey, bioturb/abd cly & sdy cly-fill Bur (dk olv gry clr - 1GLEY 4/10Y), abd mica.

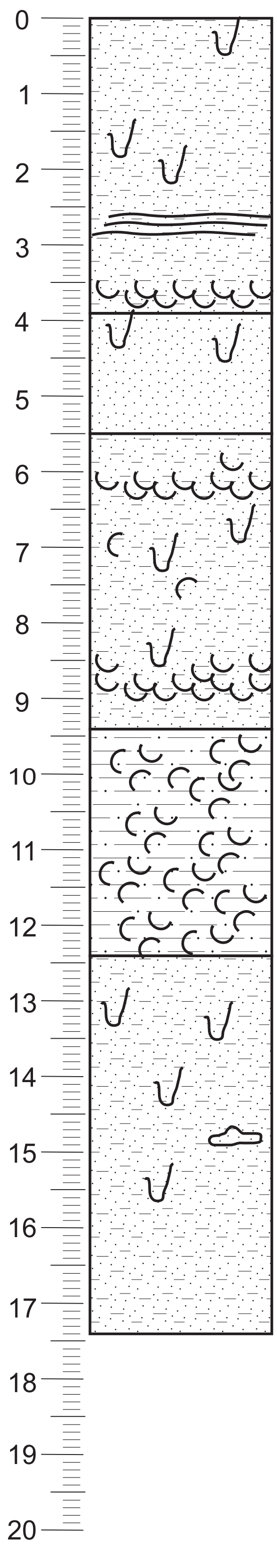
DGSID Zz82-92 DATE DESCR. 02/26/18 WATER DEPTH (FT) 43.09

LOCAL ID. VA-2017-14 DESCR. BY CRM

DEPTH (FT)

LITHOLOGIC DESCRIPTION

SAMPLE #



117320

117321

117322

117323

SAND: vf, slty, gry (1GLEY 4/10GY), abd OHM & mica, few OHM lams @ 2.6-3.1', shl lams @ 3.6-3.9', olv gry (1GLEY 4/10GY) clyey sd/slt-fill Bur @ 0-0.5', 1.6-1.7', 2.1-2.5', & 3.7-3.9'; shrp cntct @ 3.9'.

SAND: m, gry (1GLEY 7/10Y), Q, abd OHM, strless, few scat sm shl frags, sand dollar frag @ 5.2', dk olv gry (1GLEY 4/10GY) slty-clyey sd-fill Bur (f sd) @ 3.9-4.1' & 4.3-4.4'; shrp cntct @ 5.5'.

SAND: f-m, slty slty, dk gry (1GLEY 5/10Y), few sm scat shl frags, abd OHM, strless; few cly-fill Bur (dk olv gry - A) @ 6.7', 7-7.2', & 8.3-8.4', abd shl/shl zn @ 6-6.3', dwncre incr slt @ 8.5-9.4' (slty-clyey zn), abd shl frag (sm) @ 8.6-8.9'; shrp cntct @ 9.4'.

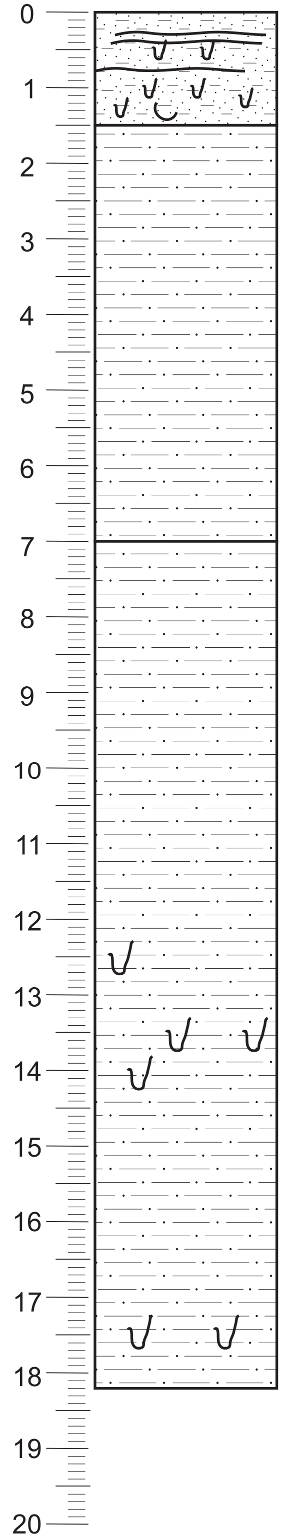
SHELL HASH: slty-sdy, abd sm (<1 cm) and lg shls & shl frags; strless; shrp cntct @ 12.4'.

SAND: m-crs, slty slty, lt gry (1GLEY 6/10Y), Q (rnded), abd OHM, dk olv gry (AA) cly- slty/sdy cly-fill Bur @ 13-13.1', 13.3-13.5' & 14-14.3'; wood frag @ 14.8'.

DGSID Zz82-93 DATE DESCR. 02/26/18 WATER DEPTH (FT) 35.82

LOCAL ID. VA-2017-15 DESCR. BY CRM

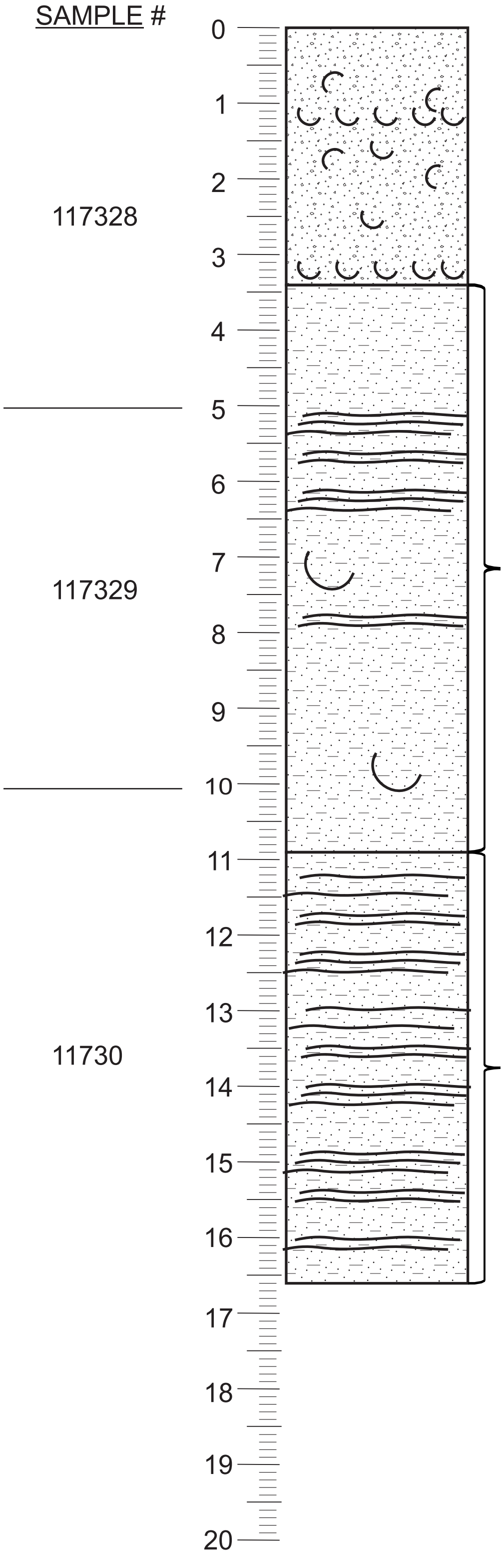
SAMPLE #	DEPTH (FT)	LITHOLOGIC DESCRIPTION
	0–1.5	SAND: f, slty, olv gry (1GLEY 5/10GY), few sm scat shl frags (<1 cm), grnsh gry cly interbeds/interlams (1GLEY 5/5G); abd bioturb; grad cntct @ 1.5'.
117324	1.5–7	CLAY: brn (2.5Y 4/3), abd f sd interlams/interbeds (yllsh-or/2.5Y 6/6), few scat sd-fill Bur (f, lt gry clr - 2.5Y 7/1); grad cntct @ 7'.
117325		
117326	7–18.3	CLAY: brnsh gry (2.5 4/1), abd f sd interbeds/lams (clr = lt gry - 2.5Y 7/1), few scat f sd-fill Bur (clr = AA), crs sd zn (Bur-fill?) @ 12.6', 13.4-13.6', 14-14.1', & 17.4-17.6'.
117327		



DGSID Zz82-94 DATE DESCR. 02/20/18 WATER DEPTH (FT) 31.48

LOCAL ID. VA-2017-16 DESCR. BY CRM

DEPTH (FT) LITHOLOGIC DESCRIPTION



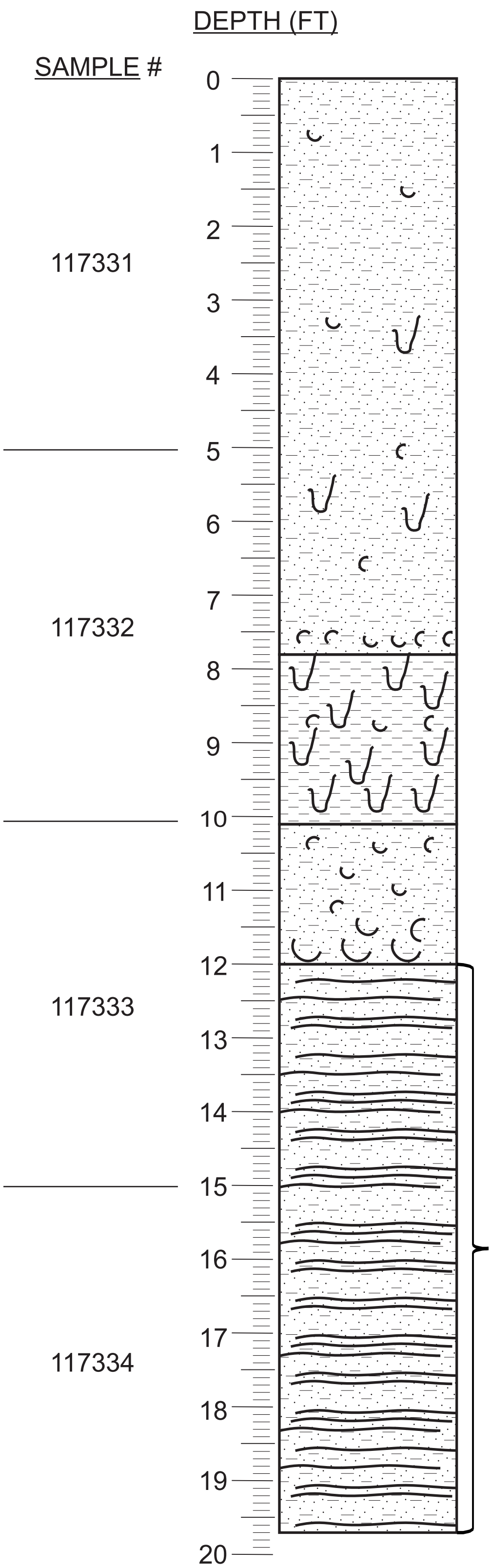
SAND: m, lt gry (1GLEY 7/10Y), abd sm scat shl frags (<1 cm), abd OHM, Q; strless, shl interbed (abd sm shl frags) @ 1.1-1.3' & 3.1-3.3'; shrp cntct @ 3.4'.

SAND: f-m, slty (dwncre incr slt), gry (1GLEY 6/5GY), abd sm scat shl frags, abd OHM, strless (bioturb?); abd shl zn/shl interbed (sdy) @ 5.2-5.4', 5.6-5.7', 6-6.5', 7.8-7.9'; few scat lg shl frags (>1 cm), lg shl frag (~3 cm) @6.2-6.4', lg shl frag (~2 cm) @ 7.3-7.4', v lg shl frag (conch) @ 9.8-10'; grad cntct @ 10.9-11.3'.

SAND: f-m, slty slty, lt gry (1GLEY 7/N), abd OHM lams & slty lams, A, abd cly lams/interlams (dk olv gry - 1GLEY 4/10GY); cly interlams @ 13.2', 14.7-14.9', 15.6'; lg oyster frag/valve (~5 cm) @ 11.9-12.2'.

DGSID Zz82-95 DATE DESCR. 02/20/18 WATER DEPTH (FT) 31.48

LOCAL ID. VA-2017-17 DESCR. BY CRM



LITHOLOGIC DESCRIPTION

SAND: m, slty slty, gry (1GLEY 6/10Y), abd Q, abd OHM, bioturb?, few scat clyey sd-fill Bur (dk olv gry - 1GLEY 4/10GY), few sm scat shl frags; abd shl frags (sm) @ 7.7-7.8'; shrp cntct @ 7.8'.

CLAY: slty slty/sdy, abd sd-fill Bur (AA) @ 7.8-8.9', cly clr = olv gry (1GLEY 4/10GY); sd-fill Bur @ 9', 9.6-9.7', 9.8'; lg oyster (~4 cm) @ 8.6-8.8', abd sm shl frags @ 8.6-8.8', bioturb zn @ 7.8-8.9'; shrp cntct @ 10.1'.

SAND: f, slty, gry (1 GLEY 6/10Y), abd sm scat shl frags, cly ripup or clay-fill Bur (clr = AA) @ 11.1-11.3', abd lg shl frags (oyster & clam) @ 11.5-12'; shrp cntct @ 12'.

SAND: f, slty slty, brn (2.5Y 6/4), abd OHM @ slt lams; shl lams @ 12.4-12.5' & 16.8-16.9'; cly lams @ 12.6' & 16.9-17.1'

APPENDIX B. Grain size scales and sieve sizes for sediment classification.

Phi (ϕ)	millimeters (mm)	inches (in)	ASTM No. (U.S. Standard)	Size Class (Wentworth, 1922)
≥ -8	>256	> 10.1		boulders
-6 to -8	64-256	2.5 – 10.1		cobbles
-5 to -6	32 – 64	1.26 – 2.5		very coarse pebbles
-4 to -5	16 - 32	0.63 – 1.26		coarse pebbles
-3 to -4	8 – 16	0.31 – 0.63		medium pebbles
-2 to -3	4 – 8	0.157 – 0.31 5		fine pebbles
-1 to -2	2 – 4	0.079 – 0.157	10	granules (gravel) very fine pebbles
0 to -1	1 – 2	0.039 – 0.079	18	very coarse sand
0.25	0.84	0.033	20	
1 to 0	0.5 – 1	0.020 – 0.039	35	coarse sand
1.25	0.42	0.017	40	
2 to 1	0.25 – 0.5	0.010 – 0.020	60	medium sand
2.75	0.149	0.0059	100	
3 to 2	0.125 – 0.25	0.0049 – 0.010	120	fine sand
4 to 3	0.0625 – 0.125	0.0025 – 0.0049	230	very fine sand
5 to 4	0.031 – 0.0625	0.0012 – 0.0025		coarse silt (mud)
6 to 5	0.0156 – 0.031	0.0006 – 0.0012		medium silt
7 to 6	0.0078 – 0.0156	0.0003 – 0.0006		fine silt
8 to 7	0.0039 – 0.0078	0.00015 – 0.0003		very fine silt
>8	<0.0039	<0.00015		clay