

HOBBS

Investigations of Offshore Beach Sands:
Virginia Beach and Sandbridge, Virginia

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FORWARD

This report reflects work accomplished during the performance of three separate yet intertwined research projects.

The cores were collected during 1994 as part of the Cooperative Agreement between the U. S. Department of the Interior's Minerals Management Service (MMS) and the Commonwealth of Virginia (Cooperative Agreement No. 14-35-0001-30740). The work was managed and, in the most part, performed by the Virginia Institute of Marine Science (VIMS), the College of William and Mary.

Funds for the analysis of the cores were provided as part of Cooperative Agreement between the Virginia Division of Mineral Resources (VDMR), worked performed by VIMS, and the Bureau of Economic Geology, University of Texas at Austin acting as agent for the Minerals Management Service (Cooperative Agreement 14-35-0001-30731).

Integration of data derived from the cores with seismic data drew upon and continued work performed on earlier VIMS-VDMR-Texas-MMS projects (Cooperative Agreement 14-35-0001-130643). Analysis also have been partially funded by the ongoing VIMS-MMS cooperative agreement.

Work on both the broader understanding of the geologic setting of southeastern Virginia's inner continental shelf continues and the specifics of sand resources continues

Investigations of Offshore Beach Sands:
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I. INTRODUCTION

Statement of the Problem

The City of Virginia Beach is faced with an ongoing problem of erosion along its ocean beaches. The "Resort Strip," the backbone of beach-going tourism in the Commonwealth, must be renourished annually. Steel bulkheads or seawalls have been constructed along most of the 7 km (4.5 mile) ocean shoreline of Sandbridge, a semi-private, ocean-side community. The City is looking for beach material to reestablish its sandy coast. Maintaining a protective and recreational beach is the primary goal in both locales.

Previous sources of sand for the "Resort Strip" have been upland borrow pits that either have closed or are located too far from the shore for economically feasible truck-haul. Most recent nourishment efforts have relied on a large dredge material stockpile at Lynnhaven Inlet. Although, this stockpile is adequate at present for beach nourishment, it must be transported by truck and its future as a sand resource is not certain.

Nearshore borrow areas have been utilized with success at several locations around the U.S. including the nearby sites of Ocean City, MD and Hampton, VA. Two projects were constructed at Ocean City, MD, in 1988 and 1990-91 with of $1.8 \times 10^6 \text{ m}^3$ ($2.4 \times 10^6 \text{ cy}$ (cubic yards)) and $2 \times 10^6 \text{ m}^3$ ($2.7 \times 10^6 \text{ cy}$) of suitable beach fill being mined and placed respectively. Hampton's Buckroe Beach was supplied with $210 \times 10^3 \text{ m}^3$ ($275 \times 10^3 \text{ cy}$) of offshore borrow material from Thimble Shoals, Chesapeake Bay in August 1990 (Hobbs and Kimball, 1990; Hobbs, 1993).

Since the installation of steel bulkheads in 1987, Sandbridge essentially has lost its subaerial beach. The site never has been nourished; however recent overtures by the City and the U.S. Army Corps of Engineers indicate a potential partnership. Truck hauling sand is feasible with very good upland source about 22 road km (14 miles) away in the Pungo Ridge. However, offshore sand reserves occur at "Sandbridge Shoal" less than 3 n mi offshore and likely are a viable, less expensive sand source for beach nourishment.

In the summer of 1995 the U. S. Navy began the paperwork process intended to lead to the eventual mining of $5.35 \times 10^5 \text{ m}^3$ ($7 \times 10^5 \text{ cy}$) for nourishment of 2,829 m (9,280 ft) of beach in front of the facility at Dam Neck, an area immediately north of Sandbridge. The discussion of potential reserves of sand for Sandbridge applies equally the Navy's to Dam Neck facility.

Indeed the Navy proposes to use one of the sources, "Sandbridge Shoal" addressed in this and previous reports.

Objectives

The objectives of this effort are to identify, locate, and describe sources of beach quality sand on the inner shelf that are within cost effective distances of the "Resort Strip" and Sandbridge. Previous research efforts have identified offshore sand sources off the both coastal areas (Williams, 1987; Kimball and Dame, 1989; Dame, 1990; Kimball et al., 1991). However, the identified sand sources off the "Resort Strip" are several miles offshore. The purpose of this report is to (1) identify a suitable sand source closer to the shoreline, (2) determine its lateral and vertical extent, and (3) recommend further courses of investigations. The cores taken in the shoal offshore of Sandbridge as part of this study were to verify and substantiate previous investigations. The cores obtained offshore of the resort strip were taken to develop potential resources suggested by earlier seismic profiles.

This report expands upon the earlier documents, Williams (1987), Kimball and Dame (1989), Dame (1990), and Kimball et al. (1991), by the inclusion of the 22 cores taken in 1994 and the various sub-bottom profiles collected in the interim.

II. GEOLOGIC SETTING

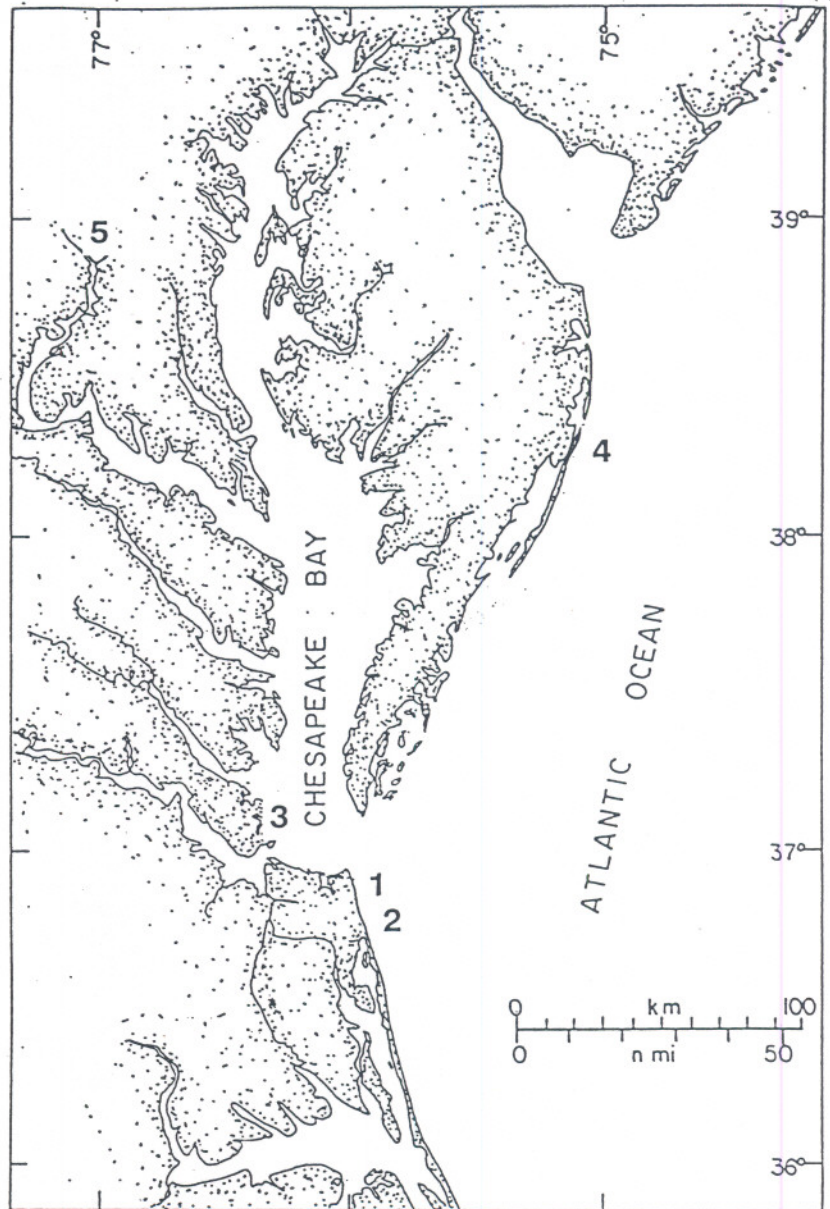
Limits of Study Areas

Although the entire Virginia inner shelf is the general area of interest, the two specific areas of study are off the "Resort Strip" and Sandbridge (Figure 1). Both are along the Atlantic coast within the limits of the City of Virginia Beach immediately south of the entrance to Chesapeake Bay.

Regional Stratigraphy

The inner continental shelf of the Commonwealth of Virginia is the subaqueous extension of the Coastal Plain Province. Several stratigraphic units that have been identified in outer coastal plain (Peebles et al., 1984). These units range from Pliocene to Late Pleistocene in age and are overlain by a veneer of modern Holocene sediments that have been transported into the area from shoreline sources and the Chesapeake Bay and have been reworked from the older, underlying strata.

Williams's (1987) analysis and interpretation of seismic data, which is based upon Shideler et al. (1972), indicates that the stratigraphy of the Virginia inner continental shelf to depth of about 45 m (150 ft) (MSL) consists of four primary and



- 1 Resort Strip, Virginia Beach, Virginia
- 2 Sandbridge, Virginia
- 3 Buckroe Beach, Hampton, Virginia
- 4 Ocean City, Maryland
- 5 Washington, DC

Figure 1: Map depicting the location of the study area and other sites mentioned in the report.

distinct sedimentary units separated by unconformities, indicated as sharp reflectors, of regional extent. Reflector 1, the top of the deepest and oldest unit, Unit A (Shideler *et al.*, 1972), is about -36 m (-120 ft) MSL. The depth and acoustic character suggest this surface to be the top of the Yorktown Formation (Unit A), a major erosional surface throughout the Virginia Coastal Plain. The Yorktown Formation was deposited during the Pliocene.

The next, younger sedimentary sequence, Unit B, is characterized by planar stratification and prominent channels showing considerable relief with thalweg depths to -30 m (-100 ft) MSL. According to Williams (1987), their structural nature and stratigraphic position suggest the channels were eroded during the late Pleistocene ocean-level lowstands when rivers, such as the ancestral Susquehanna and James, flowed eastward across the then subaerially exposed continental shelf. Vibracores from this unit contain yellowish-brown coarse sand and gravel that suggest a fluvial origin. These channel deposits were determined to offer the greatest potential for sand and gravel resources in the area (Williams, 1987).

Unit C, the next younger sedimentary unit, is characterized by a gray moist clay with high plasticity. The surface of Unit C is at depth of approximately -18 m (-60 ft) MSL with some cores recovering 6 m (20 ft) of clay. The fine grained size and uniform character of Unit C suggest a low-energy depositional environment such as an estuary or back-barrier lagoon (Williams, 1987). Shideler *et al.* (1972) obtained two radiocarbon dates from Unit C that put the stratum at 20.5 to 26.0 Ka that suggest deposition during the middle to late Wisconsinian highstand.

The youngest and shallowest sedimentary stratum is Unit D, which comprises much of the surficial sediments except in areas where Unit B and C outcrop on the seabed. Unit D is characterized by a gray to tan fine to medium sand or muddy sand with modern shell fauna. Unit D is the modern sand sheet that originated during the Holocene transgression.

The four major stratigraphic units are separated from one another by regional reflectors thought to be regional unconformities (Shideler *et al.*, 1972). For the interested reader Toscano and York (1992) attempt to put units A through D into the context of the middle Atlantic Coastal plain and shelf.

More recently Chen (199) and Chen *et al.* (1995) discuss filled channel systems in the inner continental shelf south of the Chesapeake Bay entrance. Foyle (1994) and Oertel and Foyle (1995) discuss the seismic stratigraphy of the inner shelf offshore from the Delmarva Peninsula.

Offshore Sand Resources

Williams (1987) studied high resolution sub-bottom profiles and 138 vibracores, mostly associated with the Chesapeake Bay access channel offshore of the "Resort Strip," and found minable sand for beach nourishment. He used the four criteria, from Waterways Surveys and Engineering, Ltd (1986) to identify potential sand reserves. These are

- 1) The quartzose sand should be clean, with little or no silt and clay and with a minimum median grain diameter of 0.20 mm (fine sand.) The optimum grain size to best match the native beach sediment appears to be 0.30 to 0.35 mm; however slightly finer sediment may apparently be used if the overfill ratios are increased.
- 2) the sand deposits should be shallower than 63 feet below sea level, the maximum depth of dredging for deepening the Atlantic Ocean Channel.
- 3) The sand stratum should be a minimum of two feet in thickness.
- 4) The sand should not have more than two feet of undesirable fine-grained overburden.

Williams (1987) analysis of cores and seismic records resulted in identifying two areas of potential sand reserves that are 7.8 km (4.2 n mi) and 13 km (7.0 n mi) from the "Resort Strip," referred to as Area A and Area B respectively. Area A is in 15- 18 m (50-60 ft) water depth with $17.2 \times 10^6 \text{ m}^3$ ($22.5 \times 10^6 \text{ cy}$) of potential sand. Area A sand reserves are associated with ancestral fluvial channels. Area B is in 9-13 m (31-45 ft) water depth with $57 \times 10^6 \text{ m}^3$ ($75 \times 10^6 \text{ cy}$) of potential sand and is associated with Holocene sand sheet.

Williams (1987) found that some of the channel fill was sand and gravel and some was clay. This emphasizes an obvious point; cores must be used to identify the stratigraphy in the seismic record.

The Sandbridge Shoal source has been well documented by Kimball and Dame (1989), Dame (1990), and Kimball et al.(1991). The shoal region lies about 5 km (3 n mi) off Sandbridge and might contain as much as $30 \times 10^6 \text{ m}^3$ ($40 \times 10^6 \text{ cy}$) of sand with very little overburden although more recent work by the Corps of Engineers (Swean, personal communication) suggests that the quantity is somewhat less than that.

III. METHODS

Core Acquisition

During April, 1994, cores were taken off the "Resort Strip" and Sandbridge. A total of 22 cores were taken, 18 off the "Resort Strip" and 4 off Sandbridge. The vibracores which were acquired working off a barge with tug support. In several cases it was necessary to take cores in segments, "jetting" to the depth of the preceding segment, in order to obtain a meaningful length of sample. The contract for the work was awarded to and work performed by Exmar of Virginia Beach with tug and barge support from Rebel Marine of Norfolk, Virginia.

The first 4 core locations at the "Resort Strip" were selected on the basis of a previous study (Berquist and Gomillion, 1993). That study indicated a dramatic change in the nature of surface sediments from generally fine or very-fine grained sands nearer shore to coarser grained sands farther offshore. The change was evident in the surficial grab-samples and appeared to correlate with the outcropping of a deeper (acoustic) stratum as seen on the sub-bottom profiles. Therefore, the first 4 cores were positioned to transect this interface.

Subsequent core locations were based on a combination of the potential inner shelf extension of onshore sand ridges, seismic features such as channels, previous reports and stratigraphic "dead reckoning" from the previous cores. This latter element was done by drilling small one inch cores into the side of the plastic core liners to sample the material in the field. This in-the-field examination of the cores helped provide guidance for the next day's sampling.

The cores taken at Sandbridge were located to expand the understanding of the previously studied shoal (Kimball and Dame, 1989; Dame, 1990; Kimball et al., 1991).

Sediment Analysis

The cores were brought back to laboratory where they were split, logged, and sampled. Only the sand strata were sampled for grain-size analysis. The samples were analyzed for percent gravel, sand, silt, and clay. The sand fraction was further analyzed on the VIMS Rapid Sand Analyzer to obtain statistical parameters including the mean and median grain sizes. Appendix A contains a table of grain-size data. The cores then were placed in plastic and stored.

The cores were logged as to changes in sediment composition and color. The nature of stratigraphic contacts, whether sharp or gradational were noted. The occurrence of and mode of deposition of shell fragments, whole shell, and wood were

recorded. Interbedding, gravel, clay lenses and clay balls were also given note. The rough core logs are included in Appendix B for both study areas.

Seismic Record Analysis

Seismic track lines from earlier studies run through the area of coring off the "Resort Strip." Core locations were plotted on the nearest seismic line in order to correlate subbottom reflectors (Figure 2). Several cores were taken on or near seismic lines. Lines 92-25 and 87-16 are east-west and north-south lines that transect the study area respectively.

IV. RESULTS

"Resort Strip" Offshore Characteristics

The 18 cores taken off the "Resort Strip" show a high degree of variability both laterally and vertically (Figure 3). There are 3 basic sedimentary units recognized by the authors. They range from a stiff clay unit to a very coarse sand and gravel unit. The top 0.6 m (2 ft) along the seaward side of the study area are probably contaminated with "early drop" dredge material bound for the nearby disposal site to the south. The 3 units are based on sediment composition, the occurrence of shells, shell fragments and wood debris that assist in determining depositional environments.

The three basic sedimentary environments represented in the "Resort Strip" cores are underlying 1) fluvial and 2) estuarine sequences and an overlying 3) shallow marine sand unit. The fluvial-estuarine sequences have two facies, an estuarine clay (clay unit) and a fluvial-estuarine sand and gravel. The fluvial-estuarine units are not necessarily associated with the same transgressive/regressive episodes.

The "basal" unit found across most of the study area is a estuarine blue/grey clay (blue unit). This unit is characterized as a moderate to very stiff slightly sandy clay. There are numerous occurrences of Rangia and Polynices especially in cores 10 and 16. Several oyster shells were found in the upper part of the blue unit in core 5. There are also numerous wood samples found throughout this unit whose species were not identified. The depositional environment for the blue unit is estuarine backbarrier tidal lagoon in accordance with the shell species and wood debris. This unit would seemingly correspond to Shideler et al.'s (1972) Unit C.

The blue clay unit is overlain unconformably by the shallow marine sand in cores 1, 3, 9, 10, 13, 15 and 18. In some cases the blue clay unit is overlain by fluvial sands and gravel that contains no shells and some wood. This occurs in cores 5, 8, 11,

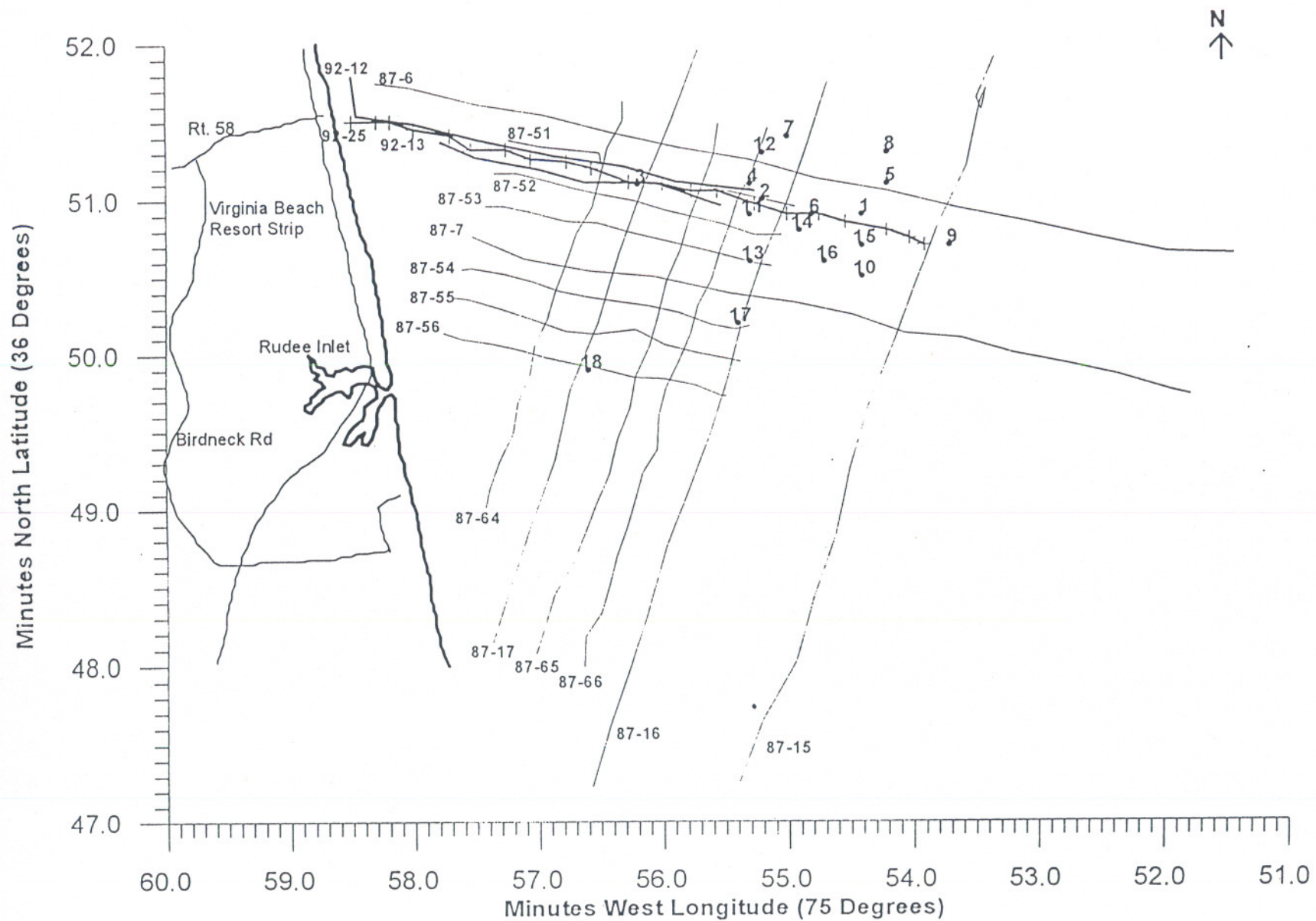


Figure 2: Map depicting locations of cores and sub-bottom profile lines offshore of the Resort Strip of Virginia Beach, Virginia.

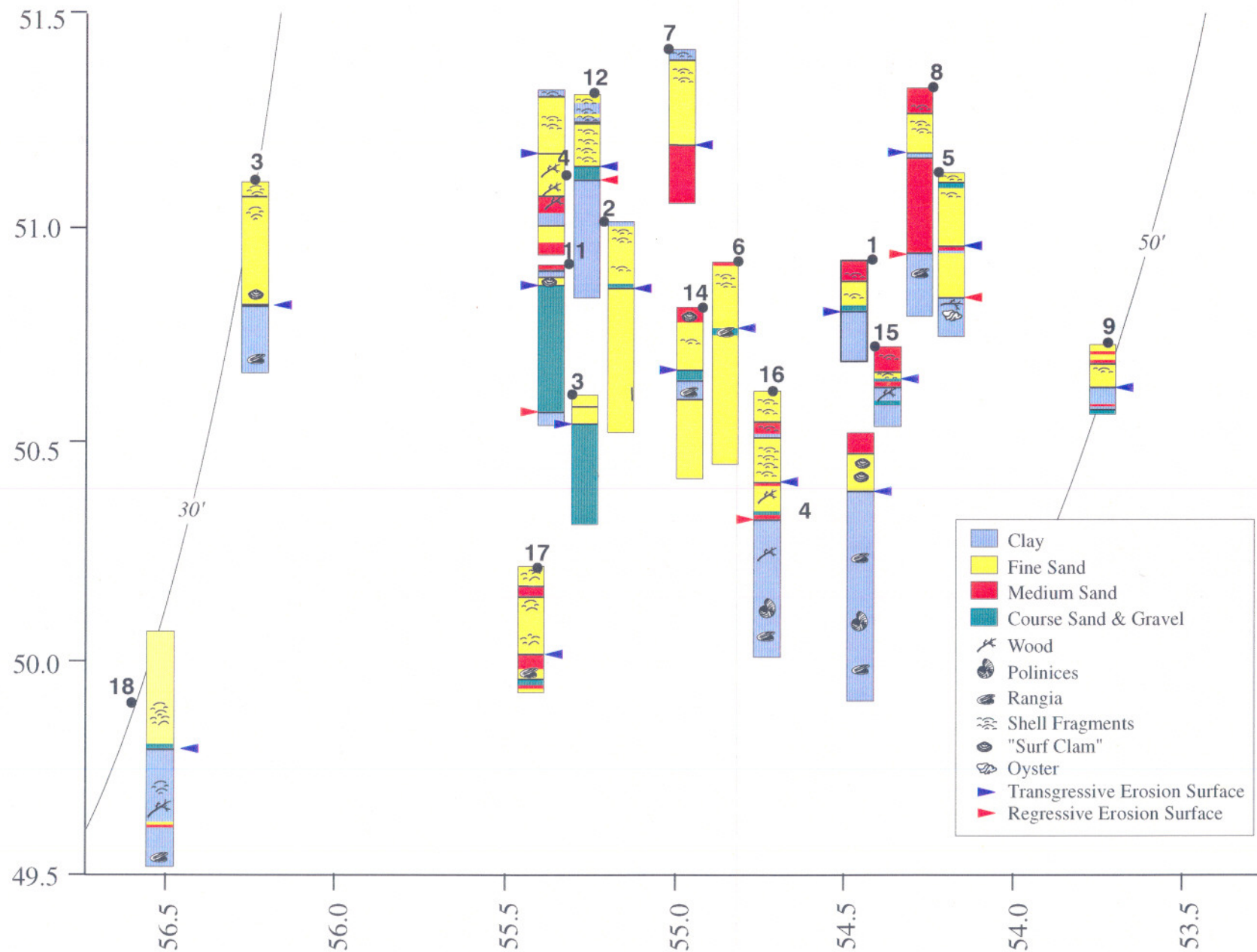


Figure 3: A schematic showing the core logs for the cores offshore of the "Resort Strip." See Figure 2 for specific locations.

12, and 16. These non-marine sand and gravel units represent different energy regimes related to fluvial and possibly estuarine environments and may correspond to Unit B.

The fluvial-estuarine sands and gravels are then overlain by the shallow marine sand unit and in some cases the blue clay unit is absent in the record. This occurs in cores 2, 4, 6, 7, and 17. The blue clay unit may have been eroded out by fluvial processes and/or the fluvial-estuarine fine sands are a facies deposited synchronously with the clay.

The shallow marine unit is composed primarily of very fine to fine sandy material with varying but generally minor amounts of silt and clay. The unit contains numerous shallow marine shells primarily clams. This unit corresponds to Unit D, a discontinuous Holocene transgressive sand sheet (Swift *et al.*, 1977).

Other notable trends include core 14 which shows a thin estuarine clay with and an underlying fluvial sand and an overlying shallow marine sand. This particular clay unit maybe related to the latest transgressive phase of this sequence.

Cores 11 and 13 have 3.4 and 4.3 m (11 ft and 14 ft) thick strata respectively of coarse sand and gravel that appear to be high energy channel fill, Unit B. This is further evidenced by occasional occurrence of pebble size material. These units also are potential beach sand sources.

A Carbon-14 date of 9440 yrs BP +/- 50 yrs was obtained from wood material was taken in core 4 about 3.7 m (12 ft) below the seabed in a fluvial sand unit. This indicates active fluvial processes at a time when sea level was 45 m (150 ft) below today's and the shoreline was about 55 km (30 n mi) east of the present shore. This date also places the fluvial system younger than the estuarine clay that was dated between 20 Ka and 26 Ka by Shideler *et al.* (1972). This apparent fluvial channel likely is part of the same system identified by Chen (1992) and Chen *et al.* (1995) extending approximately offshore from today's Rudee Inlet and Lake Rudee.

Seismic records that criss-cross the general study area show numerous episodes of cut and fill. Seismic line 92-25 transects the middle of the study area from core 3 to between cores 1 and 15 (Figure 4). At the core 1/15 location, the record depicts a flat trough with steep sides. The reflector between the seabed and the trough appears to be the contact of the blue clay unit overlain with the shallow marine unit. Core 6 is on seismic line 95-25 and shows what appears to be a reflector contact of the thin coarse sand and gravel stratum that separates underlying fluvial/estuarine sands and the overlying shallow marine unit.

Line 92-25 also passes between cores 2 and 11. Core 2 appears to be a continuation of core 6 but core 11 is thick

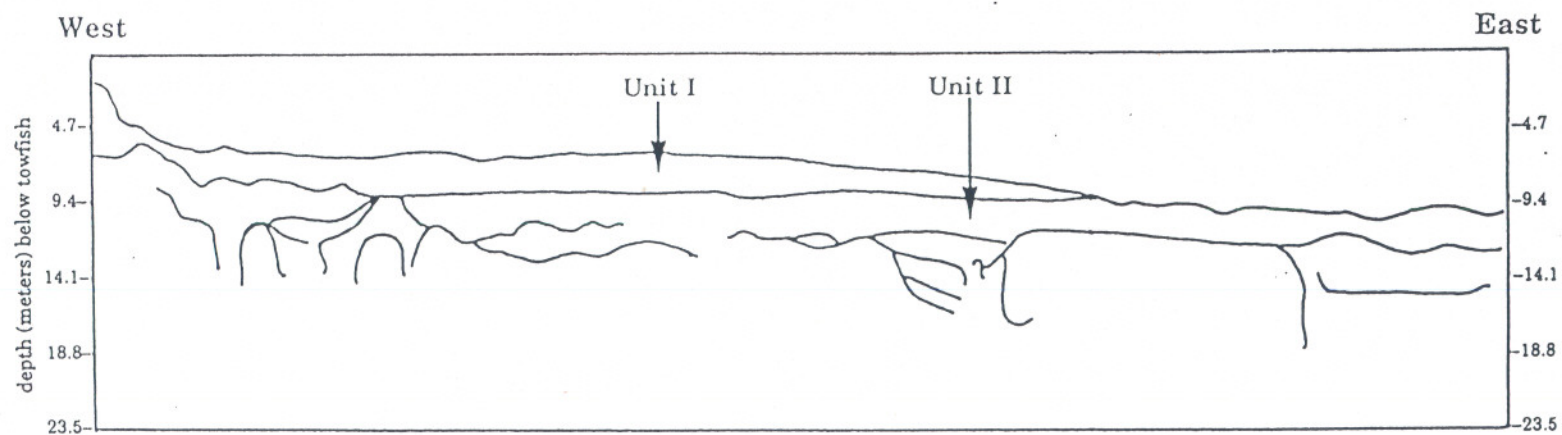
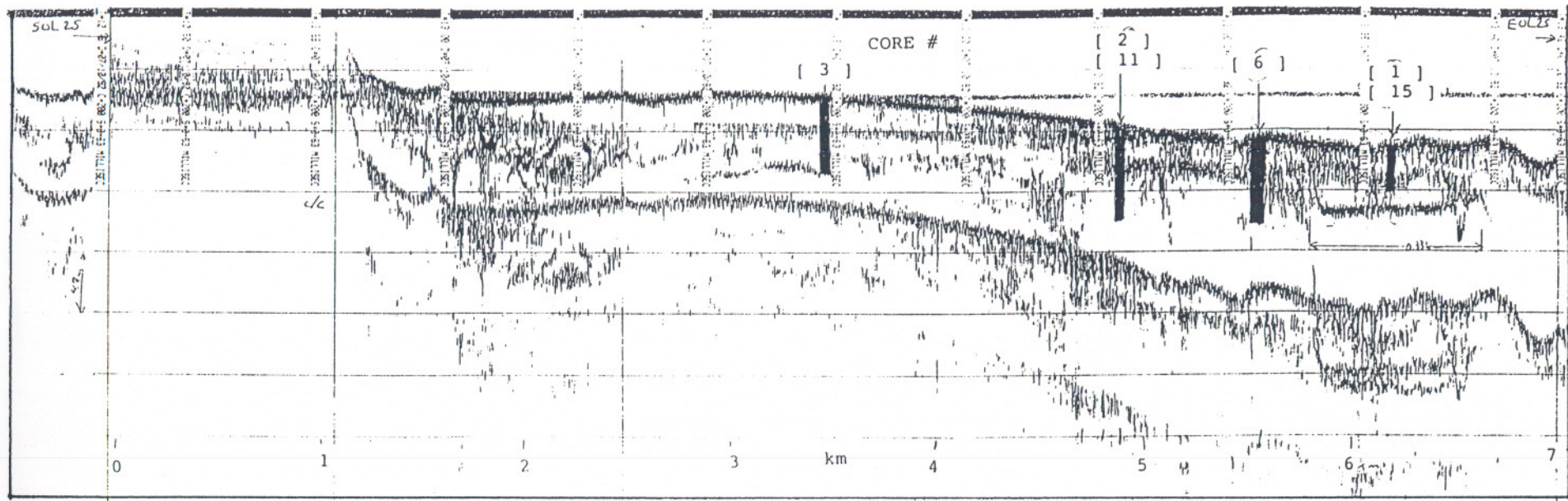


Figure 4: Above: Sub-bottom profile line 92-5 indicating the approximate locations of MMS-94-1, 2, 3, 6, 11, and 15 from April 1995. Below: A schematic interpretation of line 92-5 from Berquist and Gomillion (1993).

channel fill overlain by the shallow marine unit. Core 3 is on seismic line 92-25 and shows the shallow marine sand-blue clay contact about 1 m (3 ft) from the bottom of the core which corresponds to the lower reflector. However, the mid-core reflector is not established in the core. This reflector may represent differences in compaction of fine grained sands. This reflector may also separate two sand units as the very top unit may be a modern marine sand associated with the ebb shoal complex off the mouth of Chesapeake Bay.

Sandbridge Offshore Characteristics

The shoal offshore of the Sandbridge section of Virginia Beach has been described, as previously noted, by Kimball and Dame (1989), Dame (1990), and Kimball et al. (1991). The four vibracores collected in the shoal in April, 1994 (Figure 5) confirm the characterizations of sediments as "medium grained sands." The mean grain size of the sand fractions of the 14 analyzed samples being in area of 0.2 mm with many samples having over 10 percent by weight pebbles. The pebbles were not considered in the grain-size analysis of the sands.

The shoal itself is a discrete geomorphic body that is clearly evident on the nautical charts of the area. The aforementioned works depict it sitting atop an acoustically different substrate of silty to sandy clay. The shoal is as much as 6 m (20 ft) thick.

V. DISCUSSION

It is apparent from the core and seismic records that the offshore region of the "Resort Strip" is complex. This is due to the proximity to the Bay mouth and the fluvial influence across the underlying strata in the form of channel cut and fill sequences.

At the present level of knowledge, it appears that the blue clay unit is an estuarine sequence associated with the last sea level regression after the high stand peak at about 72,000 yrs BP. As sea level lowered and the shoreline moved across the continental shelf, back barrier, lagoonal, and estuarine sediments were deposited. Up until and beyond the low stand, about 18,000 yrs BP, those estuarine sediments were being incised by fluvial channels associated with coastal plain rivers. A regressive erosion surface was the result.

When sea level began to rise, fluvial processes were met by upcoming estuarine systems and then the coastline creating a transgressive erosion surface. This further distorts and complicates stratigraphic relationships. Even with good seismic data and core control it is difficult to unravel the stratigraphic history. The shallow marine units associated with

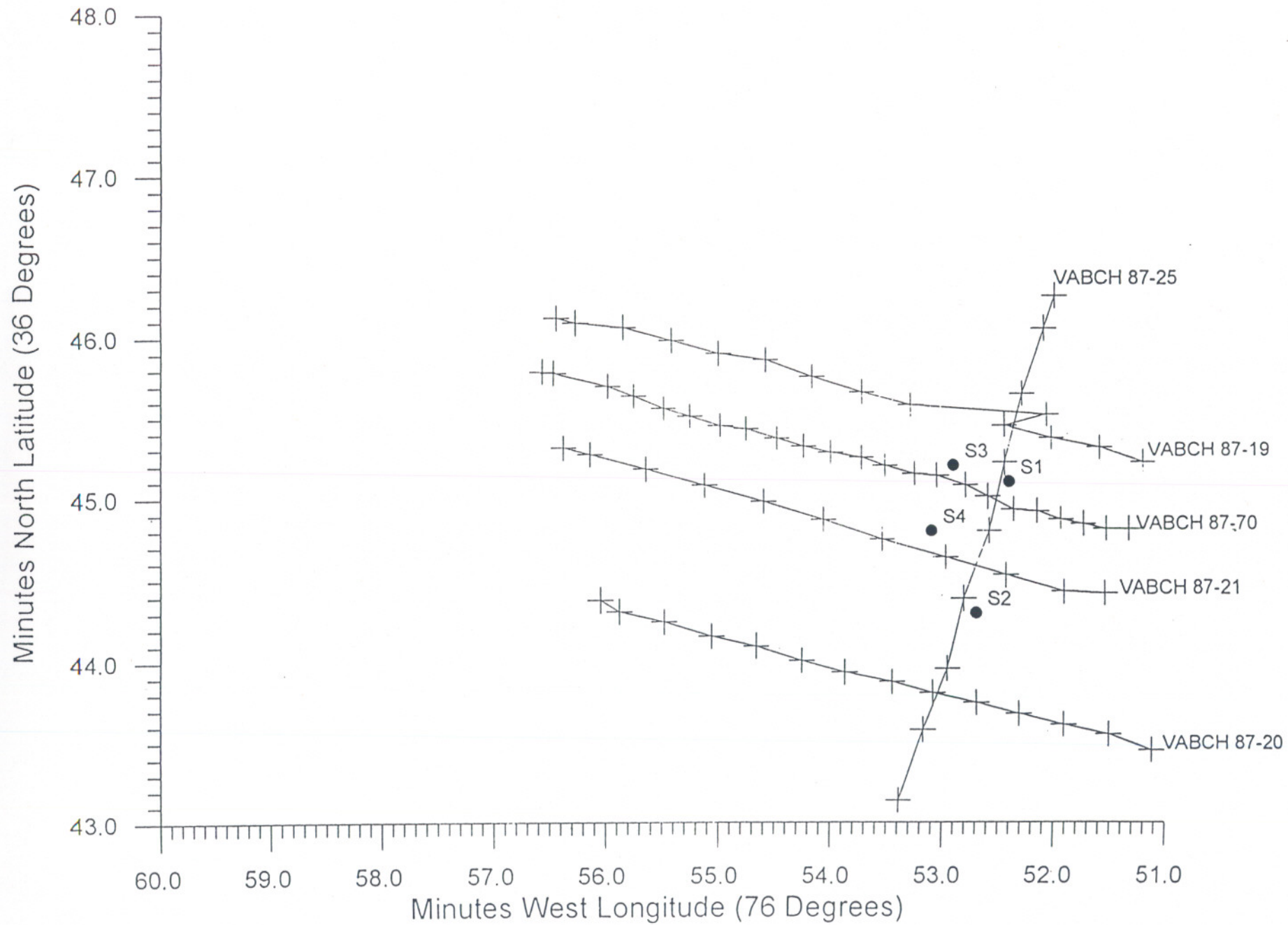


Figure 5: Map depicting locations of the 4 vibracores obtained in 1992 offshore of Sandbridge, Virginia.

the latest transgression show little internal stratification. According to Williams (1987), this stratum was formed as the result of a rising sea level over an eroding shoreface, with substantial redistribution of material by shelf currents.

Proving a large beach quality sand reserve in the nearshore off the "Resort Strip" is will require further investigations, both sub-bottom profiling and coring. This is due to the rapidly changes stratigraphic facies. Beach nourishment material may be fluvial sands such as appear to be contained in cores 11 and 13. These cores have the best potential and fit the criteria of being at least 0.6 m (2 ft) thick with less than 0.6 m (2 ft) of overburden, composed of sand that is consistently larger than D50 of 0.25 mm, and are in less than 18 m (60 ft) of water as well.

If the channel-fill is a continuous unit about 5 km (3 n mi) in length from core 11 to core 13 with a 150 m (500 ft) average channel width and an average thickness of 3.7 m (12 ft), the yield of beach sand would be about $3 \times 10^6 \text{ m}^3$ ($4 \times 10^6 \text{ cy}$). Mining this sand would require carefully controlled dredging. Additional cores would be required to define the limits of the channel. This area is acceptably close to the "Resort Strip."

There is a thick, continuous, fine marine sand sequence in the nearshore as seen in the upper portions of cores 3 and 18. Median grain size averages about 0.1 mm. Although potentially easy to mine and very close to shore, this shallow marine sand unit is simply too fine-grained for beach material unless a very large overflow ratio is imposed.

The Sandbridge shoal has been thoroughly assessed by numerous investigators including, Kimball and Dame (1989), Dame (1990), and the Corps (1992). Sand reserves, of perhaps as much as $30 \times 10^6 \text{ m}^3$ ($40 \times 10^6 \text{ cy}$) are available. The conclusions of these works is supported by the 4 cores taken for this project.

VI. CONCLUSIONS

If only cores 11 and 13 had been taken, one might think that an enormous sand reserve occurred offshore of the "Resort Strip." However, the relatively closely spaced array of 18 cores depicts just how complex this stratigraphic relationships are and, in fact, creates more questions than answers.

In order to provide a real picture of the sand reserves off the "Resort Strip," more cores will be required in and around the areas of greatest potential. It is our opinion that the area of cores 11 and 13 offer the highest potential for beach sand and should be evaluated further.

The sand in the shoal offshore of the Sandbridge area should be sufficient to satisfy that area's needs for the foreseeable future.

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APPENDIX A:

Grain Size Data

Gravel, Sand, Silt, Clay percents are weight percents of the entire sample.

Remaining data refer only to the sand portion of each sample as determined by the Rapid Sediment Analyzer (RSA) (settling tube).

M1, M2, M3, and M4 are the moment measures.

Mz is the Graphic Mean.

Md is the Median.

SI is the Inclusive Graphic Standard Deviation.

SKI is the Inclusive Graphic Skewness.

KG is the Graphic Kurtosis.

ID	GRV %	SAND %	SILT %	CLAY %
MMS-94-1-A	0.0	95.4	0.6	4.1
MMS-94-1-B	0.0	81.9	10.2	7.9
MMS-94-1-C	24.9	67.0	2.4	5.7
MMS-94-2-A	0.0	83.4	9.0	7.6
MMS-94-2-B	13.8	58.9	14.4	12.9
MMS-94-2-C	39.8	50.4	3.4	6.4
MMS-94-2-D	0.0	71.5	21.8	6.7
MMS-94-3-A	0.0	88.2	5.2	6.6
MMS-94-3-B	0.0	88.4	4.6	7.0
MMS-94-3-C	0.0	79.4	6.9	13.8
MMS-94-4-A	0.1	95.2	2.6	2.1
MMS-94-4-B	0.0	71.4	18.1	10.5
MMS-94-4-D	0.8	78.1	13.3	7.8
MMS-94-4-F	58.2	39.5	1.4	0.9
MMS-94-4-G	0.7	61.1	23.8	14.4
MMS-94-4-H	0.0	92.1	3.9	3.9
MMS-94-5-A	0.0	93.5	2.3	4.2
MMS-94-5-B	0.0	92.8	4.4	0.4
MMS-94-5-C	0.4	95.7	1.6	2.4
MMS-94-5-D	0.0	84.8	9.3	6.0
MMS-94-6-A	0.0	94.6	1.1	4.3
MMS-94-6-A				
MMS-94-6-B	0.0	84.7	8.0	7.3
MMS-94-6-B				
MMS-94-6-B				
MMS-94-6-C	0.0	75.3	15.0	9.7
MMS-94-6-C				
MMS-94-6-D	34.8	51.9	5.5	7.8
MMS-94-6-D				
MMS-94-6-E	1.0	63.1	19.9	16.1
MMS-94-6-E				
MMS-94-6-F	0.0	65.4	20.3	14.3
MMS-94-6-F				
MMS-94-7-A	0.4	95.8	1.1	2.7
MMS-94-7-B	0.0	81.1	10.5	8.4

ID	GRV %	SAND %	SILT %	CLAY %
MMS-94-7-C	1.4	90.9	7.1	0.6
MMS-94-8-A	0.0	94.6	1.1	4.3
MMS-94-8-B	0.0	78.6	9.8	11.7
MMS-94-8-C	0.0	71.5	17.3	11.2
MMS-94-8-D	0.8	93.9	0.6	4.8
MMS-94-8-E	3.4	89.7	1.6	5.2
MMS-94-9-A	0.0	96.1	1.9	2.0
MMS-94-9-B	0.2	94.3	2.4	3.1
MMS-94-10-A	0.7	93.9	2.8	2.6
MMS-94-10-B	0.0	82.2	11.7	6.1
MMS-94-11A-A	0.2	94.6	1.3	4.0
MMS-94-11A-B	0.0	88.8	4.4	6.8
MMS-94-11A-C	1.0	73.7	12.3	13.0
MMS-94-11A-D	0.2	80.2	8.9	10.7
MMS-94-11-B-A	0.0	91.5	5.9	2.6
MMS-94-11-B-B	0.0	81.0	13.4	5.6
MMS-94-11-B-C	4.9	87.7	4.4	3.0
MMS-94-11-B-D	18.5	75.3	3.4	2.8
MMS-94-11-C-A	0.1	94.6	3.1	2.2
MMS-94-11-C-B	0.0	94.2	3.8	1.9
MMS-94-11-C-C	0.0	94.4	3.1	2.5
MMS-94-11-C-D	5.0	89.8	3.7	1.5
MMS-94-11-C-E	2.4	92.6	3.3	1.7
MMS-94-12-A	0.0	93.1	3.9	3.0
MMS-94-12-B	0.4	85.6	9.2	4.8
MMS-94-12-C	0.2	89.4	5.9	4.5
MMS-94-12-D	0.0	93.5	3.5	3.0
MMS-94-13-A-A	0.0	84.1	7.2	8.7
MMS-94-13-A-B	12.8	77.0	2.9	7.3
MMS-94-13-A-C	19.8	73.6	0.8	5.8
MMS-94-13-B-A	10.3	83.5	1.0	5.2
MMS-94-14-A	0.5	89.6	4.3	5.6
MMS-94-14-B	0.0	79.3	10.6	10.0
MMS-94-14-C	3.9	87.3	2.5	6.3

ID	GRV %	SAND %	SILT %	CLAY %
MMS-94-14-D	20.6	60.0	7.3	12.1
MMS-94-14-E	0.0	68.0	17.4	14.6
MMS-94-14-F	0.1	63.1	21.6	15.1
MMS-94-15-A	0.0	97.2	0.5	2.4
MMS-94-15-B	0.0	88.9	4.5	6.6
MMS-94-15-C	0.0	86.1	6.4	7.6
MMS-94-15-D	11.6	81.7	2.5	4.2
MMS-94-15-E	4.4	88.8	2.6	4.3
MMS-94-16-A	0.0	94.2	2.6	3.2
MMS-94-16-B	0.0	91.4	3.6	5.0
MMS-94-16-C	0.0	74.0	16.2	9.8
MMS-94-16-D	0.7	79.0	10.3	10.1
MMS-94-17-A	0.0	86.4	8.5	5.1
MMS-94-17-B	0.4	92.0	3.9	3.7
MMS-94-17-C	0.2	86.8	6.7	6.4
MMS-94-17-D	0.4	87.5	7.9	4.2
MMS-94-17-E	0.0	83.2	10.5	6.3
MMS-94-17-F	0.9	81.9	9.4	7.8
MMS-94-17-G	0.6	82.0	10.1	7.3
MMS-94-17-H	1.4	95.2	2.9	0.5
MMS-94-18-A	0.0	90.3	5.6	4.1
MMS-94-18-B	0.0	89.2	7.3	3.5
MMS-94-18-C	0.0	88.1	7.3	4.6
MMS-94-18-D	3.4	91.0	2.2	3.4
MMS-94-18-E	25.0	63.3	6.9	4.8
S-94-1-A	1.5	95.5	1.2	1.8
S-94-1-B	1.1	96.1	0.9	1.9
S-94-1-C	0.0	95.8	2.0	2.3
S-94-1-D		84.6	7.7	7.3
S-94-1-E	0.2	96.7	1.3	1.8
S-94-2-A	12.5	83.1	0.8	3.6
S-94-2-B	15.5	80.2	0.9	3.3
S-94-2-C	1.0	94.3	1.1	3.6
S-94-2-D	1.6	93.6	0.9	3.9
S-94-2-E	0.4	92.6	1.9	5.1

ID	GRV %	SAND %	SILT %	CLAY %
S-94-3-A	5.0	89.0	1.5	4.5
S-94-3-B	0.1	86.7	4.9	8.2
S-94-3-C	0.7	88.6	6.0	4.7
S-94-4-A	10.5	86.6	2.1	0.7

ID	M1 PHI	M2 PHI	M3	M4	Mz PHI	Md PHI	SI PHI	SKI	KG
MMS-94-1-A	1.671	0.577	0.922	7.281	1.647	1.660	0.517	0.072	0.621
MMS-94-1-B	3.129	0.900	-2.545	9.850	3.346	3.353	0.573	-0.319	0.497
MMS-94-1-C	1.278	0.984	0.111	2.868	1.167	1.316	1.027	-0.083	0.819
MMS-94-2-A	3.366	0.697	-4.787	28.190	3.469	3.442	0.240	0.124	0.156
MMS-94-2-B	2.111	1.537	-0.366	1.664	2.062	2.252	1.502	-0.209	0.549
MMS-94-2-C	1.290	1.259	0.584	2.535	1.236	1.175	1.265	0.176	0.889
MMS-94-2-D	3.187	0.473	-2.453	19.776	3.208	3.172	0.322	0.254	0.244
MMS-94-3-A	3.086	0.918	-2.856	11.273	3.270	3.296	0.682	-0.039	0.611
MMS-94-3-B	3.294	0.833	-3.508	15.971	3.449	3.429	0.570	-0.256	0.539
MMS-94-3-C	2.471	1.050	-1.146	3.847	2.528	2.901	1.007	-0.572	0.583
MMS-94-4-A	1.393	0.733	1.132	5.993	1.305	1.385	0.661	-0.016	0.949
MMS-94-4-B	3.433	0.558	-3.711	20.522	3.520	3.489	0.314	-0.013	0.228
MMS-94-4-D	2.464	0.904	-0.956	4.024	2.486	2.653	0.899	-0.310	0.576
MMS-94-4-F	1.590	1.303	-0.170	1.770	1.588	1.875	1.319	-0.235	0.649
MMS-94-4-G	3.257	0.635	-1.872	10.407	3.309	3.299	0.529	-0.046	0.309
MMS-94-4-H	3.031	0.568	-4.260	26.613	3.094	3.105	0.289	-0.114	0.222
MMS-94-5-A	3.057	0.533	-2.763	17.063	3.104	3.151	0.377	-0.027	0.273
MMS-94-5-B	2.906	0.763	-1.838	8.246	2.959	3.064	0.644	-0.325	0.450
MMS-94-5-C	1.441	0.742	0.190	4.977	1.409	1.445	0.679	0.035	0.736
MMS-94-5-D	3.380	0.765	-4.503	26.646	3.497	3.474	0.256	0.098	0.167
MMS-94-6-A	1.435	0.740	0.492	5.368	1.383	1.468	0.675	-0.110	0.841
MMS-94-6-A	1.629	0.720	0.441	6.527	1.587	1.603	0.588	0.045	0.743
MMS-94-6-B	3.229	0.843	-2.905	11.643	3.413	3.398	0.569	-0.264	0.521
MMS-94-6-B	3.182	1.006	-3.229	13.225	3.418	3.405	0.641	-0.314	0.582
MMS-94-6-B	3.116	1.119	-2.695	9.616	3.412	3.396	0.737	-0.308	0.686
MMS-94-6-C	3.561	0.470	-4.866	36.699	3.606	3.582	0.240	0.167	0.148
MMS-94-6-C	3.462	0.814	-4.390	23.036	3.604	3.572	0.260	0.105	0.171
MMS-94-6-D	0.981	1.325	0.961	2.621	1.020	0.440	1.347	0.592	0.908
MMS-94-6-D	0.871	1.203	1.087	3.318	0.893	0.485	1.241	0.503	1.307
MMS-94-6-E	3.634	0.650	-4.901	31.921	3.717	3.709	0.276	0.007	0.170
MMS-94-6-E	3.271	1.077	-2.626	9.610	3.470	3.565	0.856	-0.506	0.686
MMS-94-6-F	3.651	0.514	-4.051	26.637	3.709	3.681	0.287	0.104	0.175
MMS-94-6-F	3.514	0.694	-3.385	17.195	3.649	3.634	0.555	-0.277	0.471
MMS-94-7-A	1.352	0.761	1.177	6.248	1.275	1.338	0.697	0.036	0.916
MMS-94-7-B	3.195	0.920	-2.951	12.237	3.407	3.386	0.586	-0.234	0.533

ID	M1 PHI	M2 PHI	M3	M4	Mz PHI	Md PHI	SI PHI	SKI	KG
S-94-3-A	1.228	0.780	1.139	5.259	1.177	1.124	0.708	0.244	0.970
S-94-3-B									
S-94-3-C									
S-94-4-A	1.255	0.724	0.645	6.693	1.218	1.282	0.631	-0.049	0.756

APPENDIX B:

Core Logs

CORE LOG

PAGE 1 OF 2CORE LABEL: MMS-941 PROJECT: MMS-94DATE OF CORE: 15 April 94 DRILLER: EMMARFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27143.0, 41226.5TYPE OF CORE: 3 in vibrocore WATER DEPTH FT: 40'PENETRATION: 15' RECOVERY: 11.7' JETTED: 0LOGGED BY: Angela DATE: 5-17-94

DEPTH	SAMP #	DESCRIPTION
0 ft		coarsening upwards
1 ft	A	coarse sand, brown, some shells some patches of medium sand present meds. - coarse sands, gray/brown some coarse sand present (dark gray) few shells present H ₂ O saturated
2 ft		sands at top of core section appears to have changed from sands at bottom of 1 st core section probably as function of drying (H ₂ O drained)
3 ft	B	fine - v. fine sand gray sands along edge of core (parallel) is more brown in color - drying difference? hardly any shells present v. small shells
4 ft		
5 ft	C	coarse sand - gravel/pebbles present (some med. sand) gray; brown gray - tends to be med. brown - coarse clay/mud. gray
6 ft		

CORE: MMS-94-1PAGE 2 OF 2

6 ft	clay/mud, gray
7 ft	↓
8 ft	
9 ft	
10 ft	
11 ft	11.3" plastic embedded in clay
12 ft	

CORE LOG

PAGE 1 OF 3CORE LABEL: MMS-94-2 PROJECT: MMS-94DATE OF CORE: 15 April 94 DRILLER: EjmanFIELD LOCATION DETERMINED BY: donamLAT: _____ LONG: _____ LORAN: 27146.5, 41226.7TYPE OF CORE: 3in Vibracore WATER DEPTH FT: 38'PENETRATION: 13.3' RECOVERY: 13.3 JETTED: 0LOGGED BY: ASF DATE: 17 May 94

DEPTH	SAMP #	DESCRIPTION
0 ft		coarse sand, brown no shells
7.5		dark gray - lt. black at top 5" gray - rest of it.
1	A	v. fine - silty sand some small shells present, not many
2		↓
3		
4		
5		
6		

CORE: MMS-94-2PAGE 2 OF 3

6'	6		v. fine - silty sand, some clay present pebbles present gray
7.15'	7	C	v. coarse - med sand large pebbles gray & brown, mostly gray v. poorly sorted
	8	φ	v. fine fine silty sand lt gray no shells
	9		↓
	10		
	11		
	12		
	13		
	14		
	15		

15		
16		
17		brown - 3" layers - almost like stripes
18	*	v fine sand lt. gray no shells
19		dark gray v. fine sands - fine no shells present
20	*	
21		
22		v. hard to cut through consolidated / hardened sand
23	*	gray fine sand

CORE LOG

PAGE 1 OF 3CORE LABEL: MMS-94-3 PROJECT: MMSDATE OF CORE: 15 April 94 DRILLER: EymannFIELD LOCATION DETERMINED BY: downLAT: _____ LONG: _____ LORAN: 27151.0, 41226.2TYPE OF CORE: 3 in vibracore WATER DEPTH FT: 30.0PENETRATION: 21.8' RECOVERY: 21.8' JETTED: 0LOGGED BY: A.S.J. DATE: 18 May 94

1" of extra
core w/ no
sed. went by
measurement
in tube
I started
measuring
at top of
sed.

DEPTH	SAMP #	DESCRIPTION
0 ft		
1 ft	A	(medium sand) - fine sand shells - small fragments v. dark gray
2 ft	B	layers of bigger, whole shells fine - medium sand dark gray - dark greenish gray shells - not as many as ↑ layer small fragments some whole pieces
3 ft		
4 ft		
5 ft		
6 ft		

CORE: MMS-94-3PAGE 2 OF 3

1 ft	compaction of sediments 4" from top
7 ft	
8	
9	
10	
11	large muscle shells present
12	compaction of sediments 3" from top
13	
136"	
14	clay / mud dark gray - dark greenish gray shells
15	

15-		clay/mud, interbedded with med. sands
16-	C	dark gray - dark greenish gray black, bottom 4"
17-		clay/mud dark gray - dark greenish gray (same as layers below ↑) shells present - mollusks w/ traces on shells wood fragments
18-		
19-		
20-		
21-		
22-		

around
corn
top of
diment

CORE LOG

PAGE 1 OF 3

CORE LABEL: MMS-94-4 PROJECT: MMS

DATE OF CORE: 15 April 94 DRILLER: Eymar

FIELD LOCATION DETERMINED BY: Loran

LAT: _____ LONG: _____ LORAN: 27146.7, 41227.1

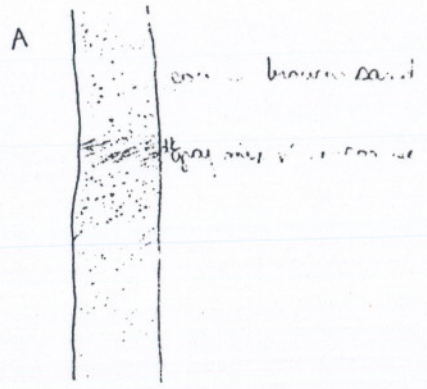
TYPE OF CORE: 3 in vibrocore WATER DEPTH FT: 38.0

PENETRATION: 18.0 RECOVERY: 18.0 JETTED: 0

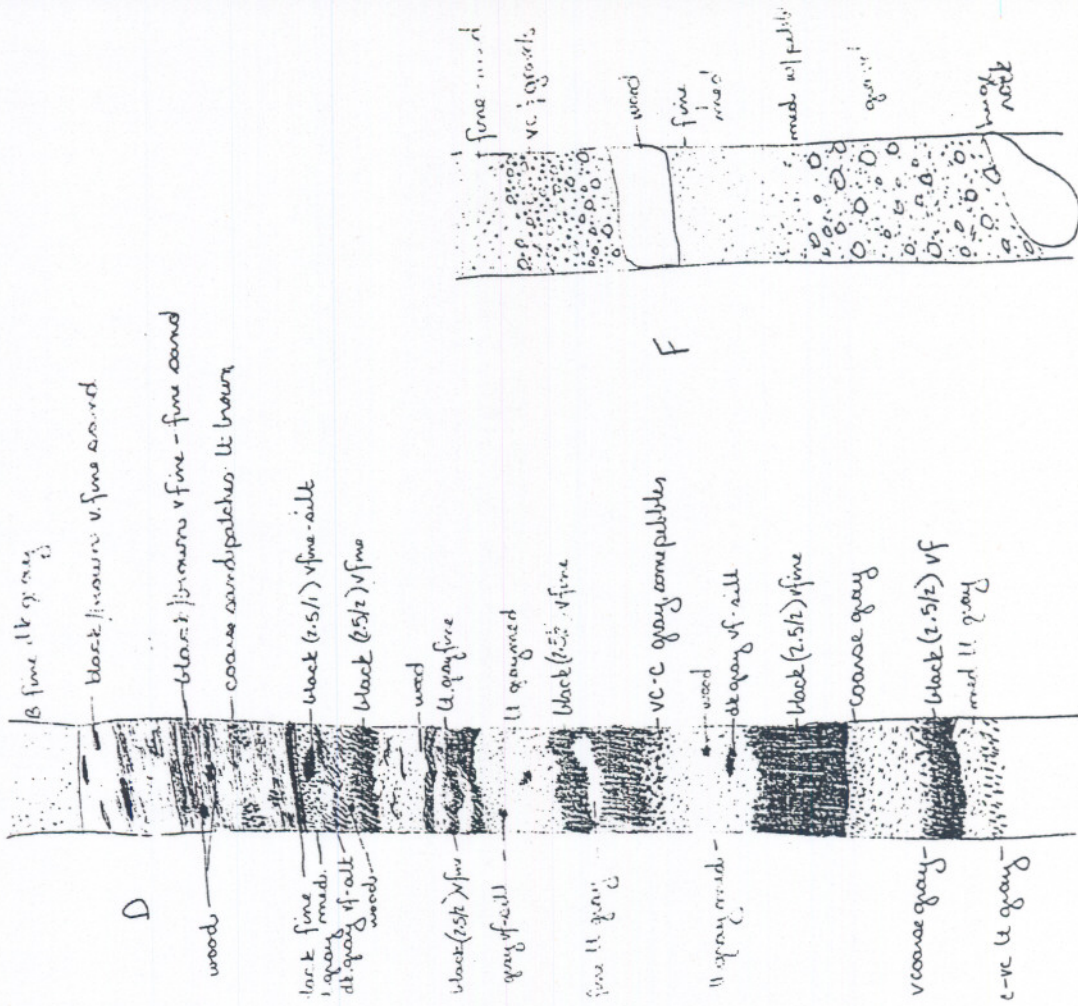
LOGGED BY: A.S.J. DATE: 19 May 94

DEPTH	SAMP #	DESCRIPTION
0 ft		
-	A	coarse sand grayish brown some organics, shell fragments
-		9" interbedded dark gray mix of v. fine sand; coarse sand interbedded
-		14" - one inch of same interbedded ↑
- 1 1/2"		
- 2	B	fine sand dark gray few shell fragments
- 3		
- 4		
- 5		
- 6		

sketch →



6		
7	alt. unconsolidated conce light brown with coarse blackish brown v fine - fine sand (core)	
8	light gray med. sands black (2.5/1) v fine - silt dark gray v fine - silt black (2.5/2) v fine	
9	coarse - v coarse gray sands lt. gray fine sands	D
10	many wood fragments. no shells (coarse 3" pieces)	
11	gravel present	
12	huge wood chunks (3" x 2" at least)	
13	generals fining up sequences fine-med lt. gray sands v coarse lt. gray sand - gravel pubbles gravel fine med. w/ pubbles med coarse v coarse w/ gravel	F
14		
15		



15		
16	G	fine sand. dark greenish gray (54# 411) some v fine-silt present in patches (towards bottom) a few small pebbles towards top.
17	H	fine-med. sand. dark greenish gray (54# 411)
18		

18/11

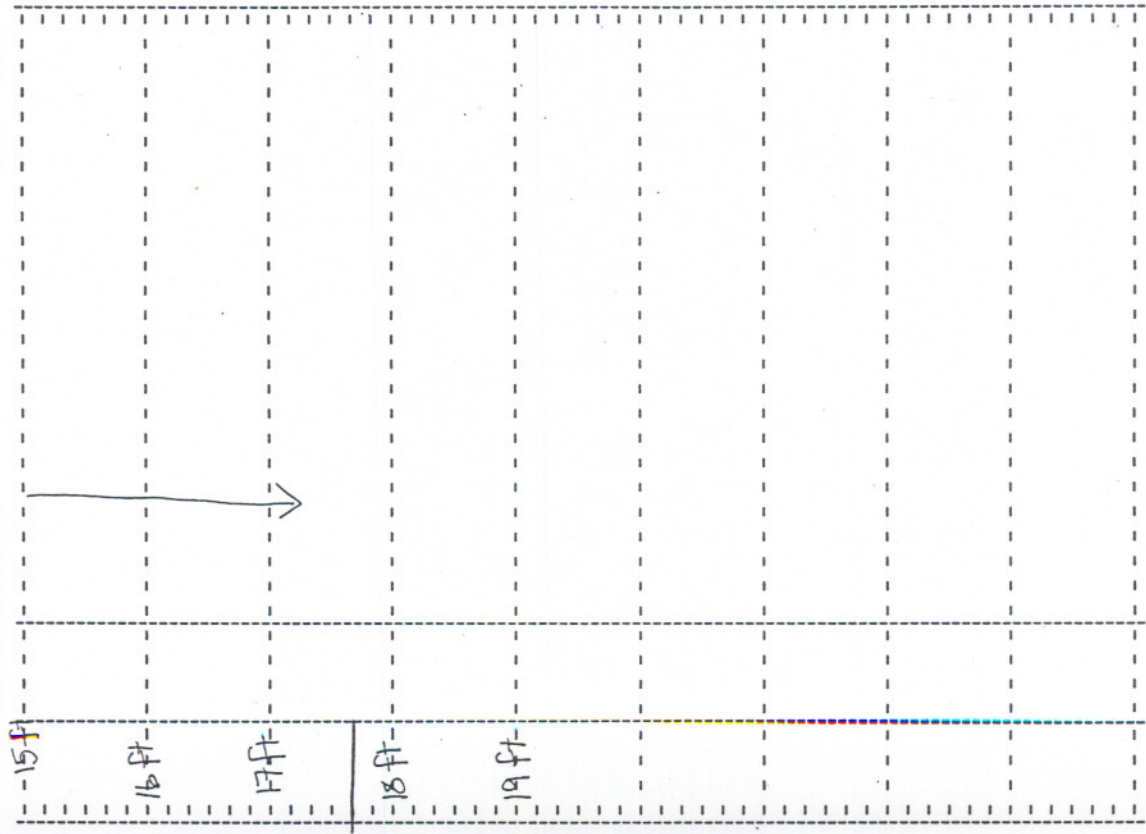
CORE LOG

PAGE 1 OF 3CORE LABEL: MMS-94-5 PROJECT: MMSDATE OF CORE: 17 April 94 DRILLER: ExmarFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27142.8, 41230.0TYPE OF CORE: 3 in vibrocore WATER DEPTH FT: 34.5PENETRATION: 19.0' RECOVERY: 17.6' JETTED: 0LOGGED BY: A.S.J. DATE: 20 May 94

DEPTH	SAMP #	DESCRIPTION
0 ft		1st 3 1/2" of sediment are missing
	A	fine sand olive gray / grayish brown small shell fragments 9% distinct color change - dark gray fine sand
1 1/2 ft		only a drying difference (1st next day gone) gray fine sand - med. sand organics - shell fragments
2 ft		
3 ft	B	
4 ft		some interbedded med-coarse sand
5 ft		
6 ft		

CORE: MMS-94-5PAGE 2 OF 3


6 ft		
7 ft		
8 ft	C	coarse sand organic shell fragments - top 2" grayish-brown
9 ft		dark gray med. sand some fine v. dark gray lenses
10 ft	D	dark gray clay with coarse fine sand lenses fine sand dark gray shell fragments - few pretty non-descript
11 ft		
12 ft		
13 ft		transitional - fine sand patches present clay
14 ft		v. dark clay whole shell - oyster? some small wood fragments shells a few small patches of fine sand
15 ft		



CORE LOG

PAGE 1 OF 3

CORE LABEL: MMS-94-6 PROJECT: MMSDATE OF CORE: 17 April 94 DRILLER: EpmarFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27145.0, 41226.2TYPE OF CORE: 3 in vibracore WATER DEPTH FT: 38.0 (fathoms x 3.6)PENETRATION: 22.4 RECOVERY: 22.4 JETTED: _____LOGGED BY: ASJ DATE: 10 May 94

DEPTH	SAMP #	DESCRIPTION
0 ft		
	A	med-coarse sand grayish brown lots of shells & shell fragments 
1		med-fine dark grayish brown shell fragments
2		fine sand - v. fine sand v. dark gray shell fragments
3	B	
4		+3.5" dark gray clay lens 1 inch
5		
6	C	gray fine sands interbedded with v. dark gray some v. dark gray silt also fine sand - also (from above)

additional
changedepth
correctionCORE: MMS-94-6

PAGE 2 OF 3

6		6.7" coarse sand, one inch thick layer shell fragments
7	D	v. poorly sorted v. coarse sand-clay v. shelly v. dark gray - v. dark gray v. dark gray shells (same as ↑ layer) clay
8		fine sand, gray some clay lenses, dark gray no shells, organics
9	E	
10		
11	F	fine sand - v. fine dark (olive) gray no shells ↑ layers interbedded in patches for 10"
12		
13		v. fine sand (no more fine sand)
14		some same color clay lenses
15		

15	v. fine sands	dark (olive) gray	no organics
16			
17			
18			
19			
20			
21			
22			
23			
24			

1MS-94-6

CORE LOG

PAGE 1 OF 3CORE LABEL: MMS-94-7 PROJECT: MMSDATE OF CORE: 25 April 94 DRILLER: CjmarFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27-146.5, 41232.6TYPE OF CORE: 3" vibrocore WATER DEPTH FT: 38.0 fathomsPENETRATION: 17.0' RECOVERY: 8'10" JETTED: to 9' gravity to 11' vibrated to 17'LOGGED BY: ASF DATE: 26 May 94

DEPTH	SAMP #	DESCRIPTION
0 ft		
1	A	coarse olive gray (5Y 4/2) shells; fragments
2	B	v. dk. gray (5Y 3/1) silty fine sand shells; fragments ↓ interbedded layers of medium sand
3		
4		a few sparse clay lenses
5		
6		

CORE: MMS-94-7PAGE 2 OF 3

6		a small patch of light olive gray med. sands (5Y 6/2)
7		
8	C	dk. gray med. sand transitions into light olive gray (5Y 6/2) medium sand some silty/sand gray (5Y 6/1) no shell fragments
9		
10		↓ transitions gradually to light brownish gray (2.5Y 6/2) still med. sand w/ a few patches of gray silty/sand
11		
12		
13		
14		
15		

2nd run
1st core1st run
2nd coregray
silty/sand

CORE LOG

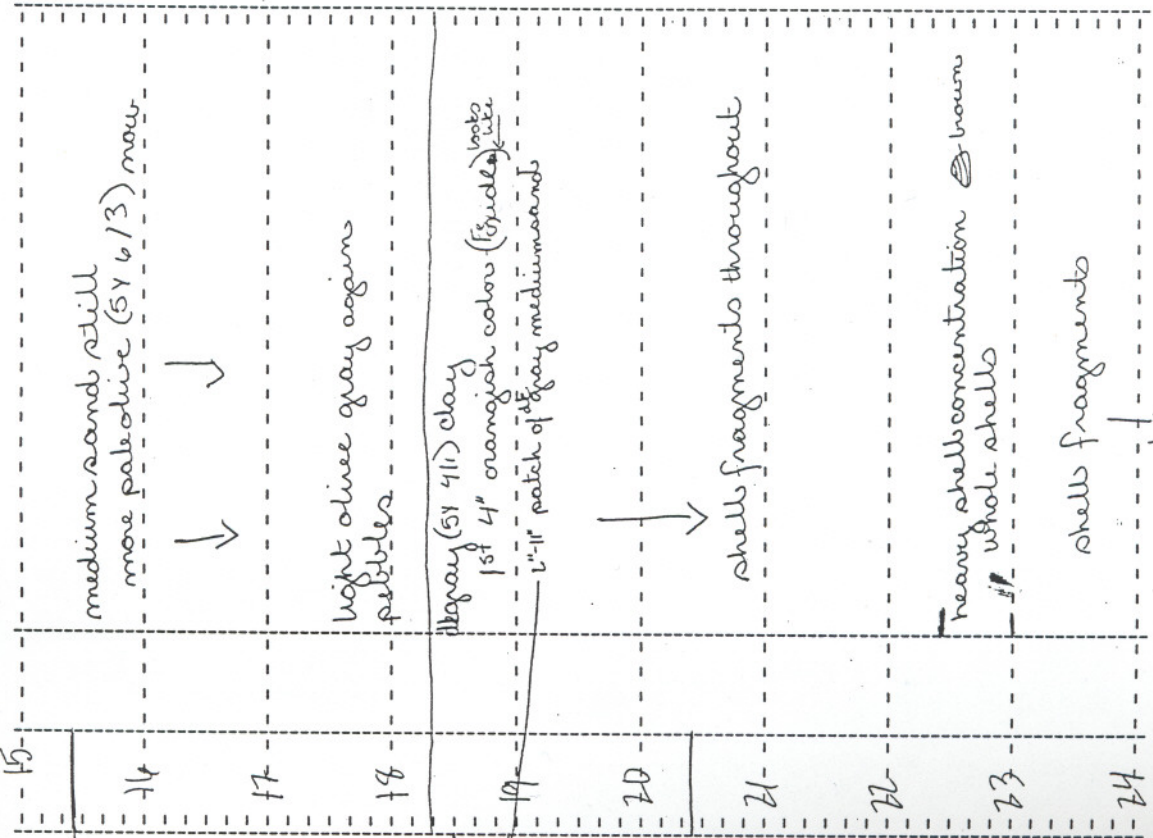
PAGE 1 OF 3

CORE LABEL: MMS-94-8 PROJECT: MMSDATE OF CORE: 25 April 94 DRILLER: EdmanFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27143.0, 41232.5TYPE OF CORE: 3 in vibrocore WATER DEPTH FT: 46.3PENETRATION: 11' / 24.5' RECOVERY: 7.5' / 11' JETTED: 0-15'LOGGED BY: ASF DATE: 31 May 94

DEPTH	SAMP #	DESCRIPTION
0 ft		
1	A	med. sand shells; fragments (54 5/2) olive gray
1.5		
2	B	mixture with seemingly no distinct layers black v. fine sand shells fragments black silt some olive gray med. sand
2.5		v. dark gray (54 3/1) med sand (2")
3	C	silty fine sand dark gray (54 4/1) shell fragments inches patch of med sand - 10
4		
5		
6		

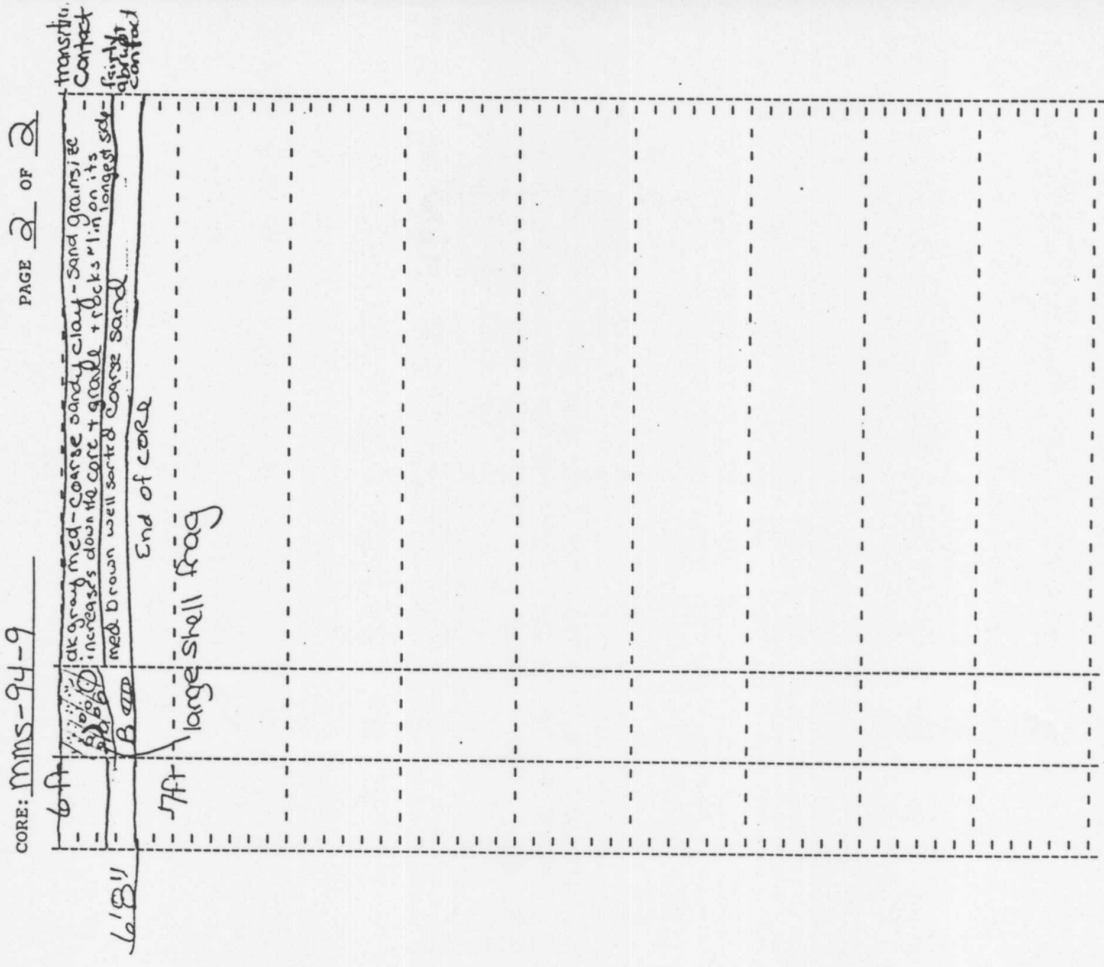
CORE: MMS-94-8PAGE 2 OF 3

6		
7	D	coarse ^{or} coarse lt. olive gray (54 6/2) pebbles - no shells
7.5		med. gray sand also
8		
9		
10		nothing
11		
12		
13	E	medium sand, coarse sand, as well some pebbles interspersed some as D? light olive gray (54 6/2)
14		some silty gray (54 4/1) patches silt no shells
15		



LAT: _____ LONG: 27140.1, 4226.2
 TYPE OF CORE: 3" vibrocore WATER DEPTH FT: 48.6
 PENETRATION: 10' RECOVERY: 6'8" JETTED: NO
 LOGGED BY: Donna Milligan DATE: 23 June 1994

DEPTH	SAMP	DESCRIPTION
0 ft		empty
1 ft		well sorted fine-med sized med brown sand med gray silty fine sand twinning a dk gray clay part fine brown sand surrounded by dk gray silty fine sand abrupt clay layer over a thin layer of brown fine sand
2 ft	A	med gray silty fine sand mottled w/ dk gray clayey fine sand abrupt contact
3 ft		dk brown med sand w/ small shell frags med gray silty fine-v. fine sand with small shell frags abrupt contact
4 ft		dk gray v. fine sandy silt mottled with a few areas of dk brown only slightly silty fine-v. fine sand trans. fine contact
5 ft		dk gray v. fine sandy clay a bit of clay present decreases somewhat down the core
6 ft		occasional small shell frags small wood frag contact of dk gray slightly clayey coarse sand trans. fine contact



CORE LOG

PAGE 1 OF 4

CORE LABEL: MMS-94-10 PROJECT: MMS
 DATE OF CORE: 21 April 94 DRILLER: Eymars
 FIELD LOCATION DETERMINED BY: Droran
 LAT: _____ LONG: _____ LORAN: 27143.0, 41223.8
 TYPE OF CORE: 3" vibrocone WATER DEPTH FT: 40.0
 PENETRATION: 29.0' RECOVERY: 29" JETTED: 0
 LOGGED BY: ASF DATE: 2 June 94

DEPTH	SAMP #	DESCRIPTION
0 ft		medium sands olive gray (SY 5/2) shells; fragments transitions to dk gray (SY 4/1) med. sands
1	A	
2		transitions to dk. gray (SY 4/1) med. sands
3		dark gray (SY 4/1) silt - fine sand (mostly fine sand w/ silt present) first 2" still have some dk. gray med. sand shells shells; shell fragments
4	B	↓ ↓
5		
6		

CORE: MMS-94-10PAGE 2 OF 4

6	no shells
7	dark gray (SY 4/1) clay a few patches of fine sand at facies boundary
8	some small v. dk. gray (SY 3/1) patches of fine sand fine sand clay
9	
10	
11	
12	
13	
14	
15	

15-		
16-		shell fragments brownish shell
17-		
18-		
19-		vd. gray (54 3/1) fine-med. sand
20-		
21-		shell @ (saved in a sample bag) 20' 11"
22-		
23-		
24-		

24-		same dk. gray clay ↓ whole shell (both halves together) sample bag
25-		
26-		shells - fragments whole shells
27-		
28-		another whole shell (both halves) sample bag w/ (smaller of the two)
29-		

CORE LOG

PAGE 1 OF 1CORE LABEL: MMS-94-11A PROJECT: MMSDATE OF CORE: 21 April 94 DRILLER: EdmanFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27146.6 , 41224.2TYPE OF CORE: 3 in vibracore WATER DEPTH FT: 37.0PENETRATION: 11.0' RECOVERY: 4.0' JETTED: 0LOGGED BY: ASF DATE: 3 June 94

DEPTH	SAMP #	DESCRIPTION
0 ft	A	medium sand lt. olive gray (SY 6/2) shell fragments
	B	medium sand dk. olive gray (SY 3/2) shell fragments
1	C	v. dk. gray (SY 2/1) shell fragments silty fine sand interspersed patches of medium sand (both v. dk. gray : dk. olive gray)
2	D	(SY 5/1) greenish gray fine - v fine sands shell fragments
3		
4		
5		

CORE LOG

PAGE 1 OF 3

CORE LABEL: Mms-94-11c PROJECT: mms 1994

DATE OF CORE: 21 April 1994 DRILLER: Exmar

FIELD LOCATION DETERMINED BY: Loran

LAT: _____ LONG: _____ LORAN: 27146.6, 41224.2

TYPE OF CORE: 3" Vibracore WATER DEPTH FT: 37.0

PENETRATION: 17.5 ft RECOVERY: 5 ft JETTED: 14 ft

LOGGED BY: Donna Milligan DATE: 17 June 1994

DEPTH	SAMP #	DESCRIPTION
0 ft		
1		
2		
3		
4		
5		
6		

↑
Jetted
↓

CORE: Mms-94-11c

PAGE 2 OF 3

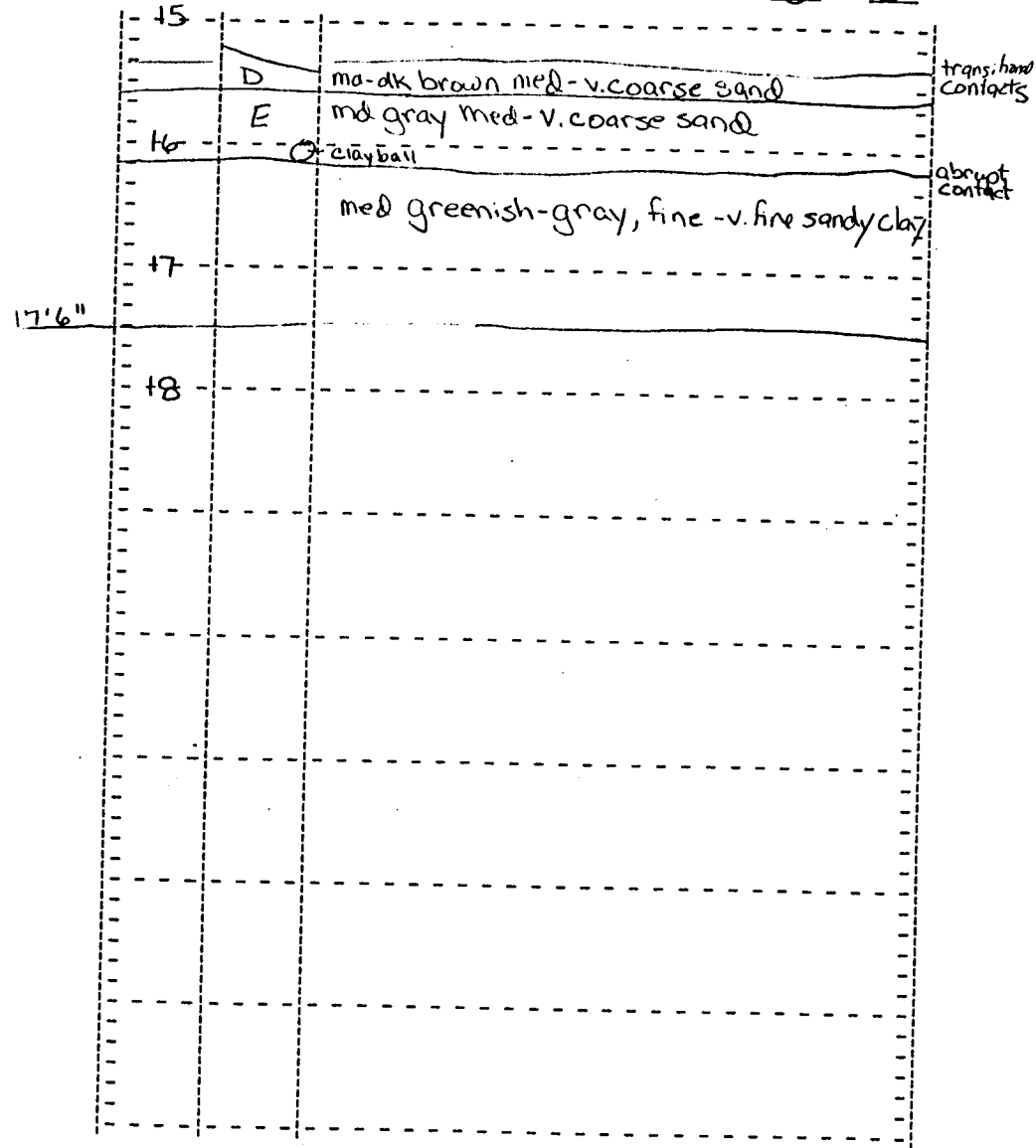
6			
7			
8			
9			
10			
11			
12			
12'6"			
	A	med brown fine-coarse sand	
13			
	B	med gray fine to coarse sand	
14		grain size appears to slightly decrease down the section	
15	C		

↑
Jetted
↓

trans. conta.

CORE: mms-94-11c

PAGE 3 OF 3



CORE LOG

PAGE 1 OF 3

CORE LABEL: Mms-94-11c PROJECT: mms 1994

DATE OF CORE: 21 April 1994 DRILLER: Exmar

FIELD LOCATION DETERMINED BY: Loran

LAT: _____ LONG: _____ LORAN: 27146.6, 41224.2

TYPE OF CORE: 3" Vibracore WATER DEPTH FT: 37.0

PENETRATION: 17.5 ft RECOVERY: 5 ft JETTED: 14 ft

LOGGED BY: Donna Milligan DATE: 17 June 1994

DEPTH	SAMP #	DESCRIPTION
0 ft		
1		
2		
3		
4		
5		
6		

↑
Jetted
↓

CORE: Mms-94-11c

PAGE 2 OF 3

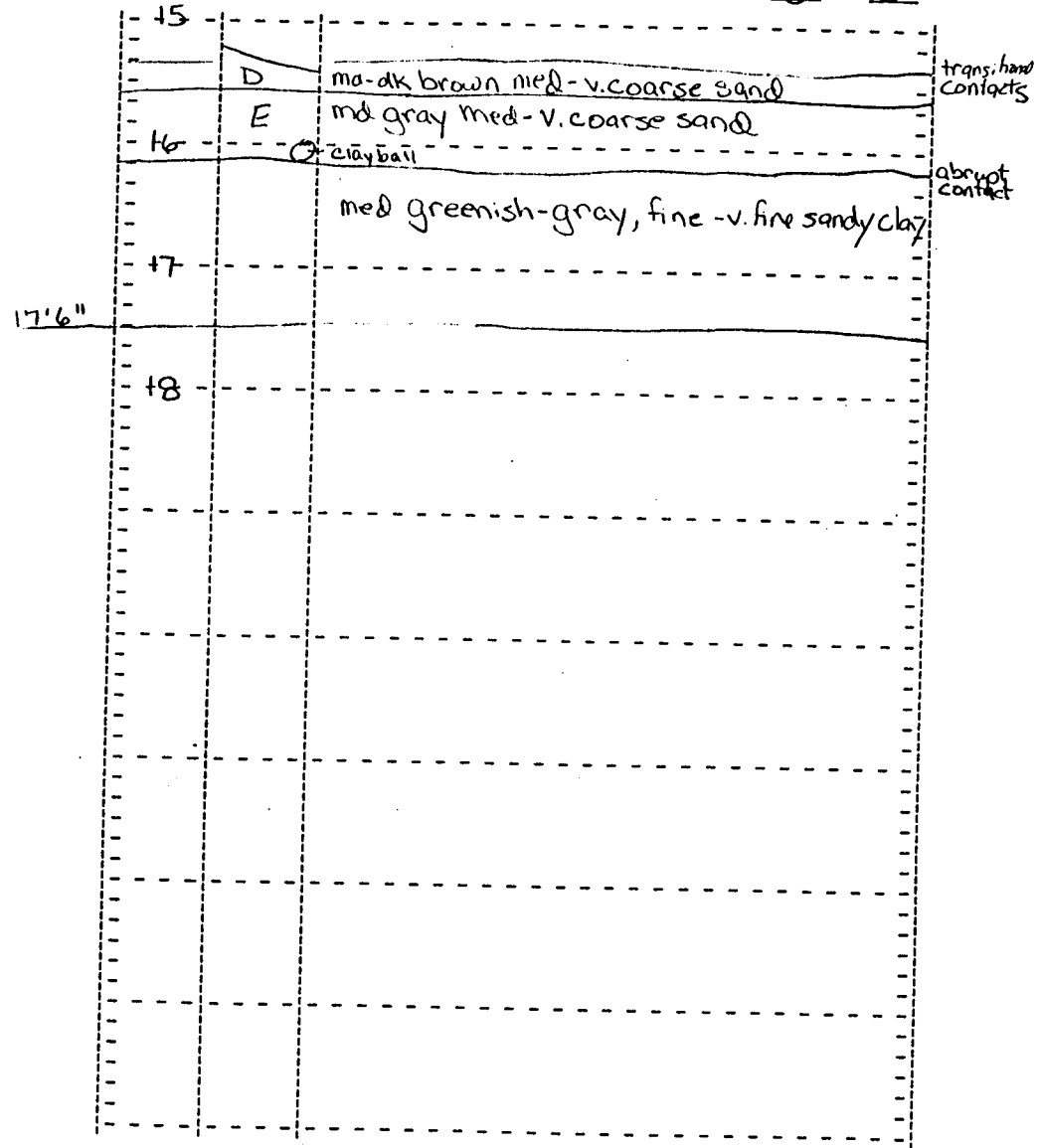
6			
7			
8			
9			
10			
11			
12			
12'6"			
	A	med brown fine-coarse sand	
13			
	B	med gray fine to coarse sand	
14		grain size appears to slightly decrease down the section	
15	C		

↑
Jetted
↓

trans. conta.

CORE: mms-94-11c

PAGE 3 OF 3



CORE LOG

PAGE 1 OF 3CORE LABEL: mms-94-12 PROJECT: mms 1994DATE OF CORE: 25 April 1994 DRILLER: ExmarFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27147.4, 41222.9TYPE OF CORE: 3" Vibracore WATER DEPTH FT: 32.0'PENETRATION: 23' RECOVERY: 22'6" JETTED: NOLOGGED BY: Donna Milligan DATE: 24 June 1994

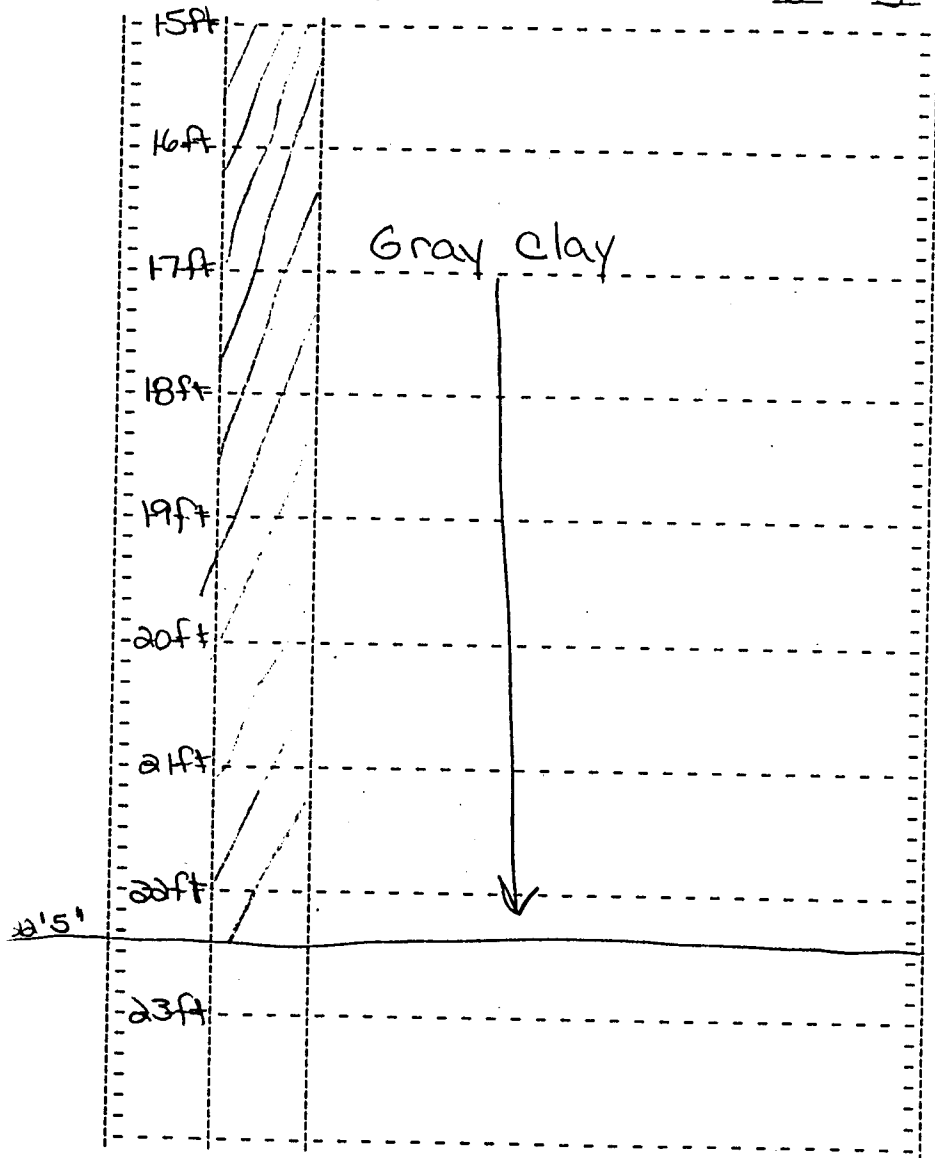
DEPTH	SAMP #	DESCRIPTION
0 ft		Empty
1 ft	A	med brown fine sand mottled with med gray slightly silty fine sand shell frags
1 ft		dk gray slightly sandy clay med brown slightly clayey fine - v. fine sand dk gray slightly sandy clay med brown v. fine - coarse sand shell frags in an
2 ft	B	med gray silty v. fine - fine sand, occ shell frags - brown layer, same material silt content appears to decrease down the core dk gray clay between brown coarse sand shells in sand layer (frags)
3 ft		brown layer same material as in section
4 ft	C	med gray silty fine - v. fine sand occ shell frags
4 ft		color is mottled with darker + lighter grays. Light colors appear to have less silt content
5 ft		in general, silt content appears to increase down the core
6 ft		

CORE: mms-94-12PAGE 2 OF 3

6 ft		grayish brown silty fine sand mottled with dk gray silty v. fine sand occ shell frags shell frag layer	trans. contact
7 ft		dk gray clayey v. fine sand occ pieces of gravel + shell frags	Fairly abrupt contact
8 ft		v. poorly sorted fine - v. coarse sand + gravel with some rocks over 1" on their longest side	Fairly abrupt contact
8 ft		brown slightly silty fine - coarse sand mottled with gray slightly silty fine - coarse sand	
9 ft		clay balls a few scattered pieces of gravel	abrupt contact
10 ft		med gray clay areas of black med sandy clay increasing down the core	
11 ft		fluid mud layer area of highest black sandy clay content shell frag	
12' 0"	12 ft	tiny shell frags, little sandy areas	
12' 5"		No sample	
13 ft		gray clay	
14 ft		liner + sample stuck in barrel; removed onshore	
14 ft		This section has many little cores inside it	
15 ft			

CORE: mms-94-1a

PAGE 3 OF 3



CORE LOG

PAGE 1 OF 1

CORE LABEL: mms-94-13A PROJECT: mms 1994DATE OF CORE: 25 April 1994 DRILLER: ExmarFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27146.5, 412230TYPE OF CORE: 3" vibracore WATER DEPTH FT: 35PENETRATION: 10 ft RECOVERY: 5'6" JETTED: NOLOGGED BY: Donna Milligan DATE: 21 June 1994

DEPTH	SAMP #	DESCRIPTION	
0 ft		med brown slightly silty v. fine - fine sand w/ thin mud layer on top	
		dk gray v. fine sandy clay mottled with med brown silty v. fine sand	abrupt contact
1 ft		med brown silty v. fine sand	abrupt contact
	A	color change to dk gray mottled with md gray silty v. fine sand whole shell found - a few small shell frags through section	
2 ft		slightly sandy clay ball	
		silt content appears to increase down the core	
3 ft		not well sorted fine to v. coarse brown sand with gravel (some ~ 1 inch on its longest side)	abrupt contact
		slightly sandy clay ball	
4 ft		color change to grayish brown	
	B	med gray fine - v. coarse sand mottled with dk gray silty fine - coarse sand	transition contact
		color change to grayish brown	
5 ft	C	brown med - v. coarse sand w/ gravel	fairly abrupt contact
5'6"		brownish gray silty fine - v. coarse sand w/ gravel	transition contact

CORE LOG

PAGE 1 OF 1

CORE LABEL: MMS-94-138 PROJECT: MMS 1994

DATE OF CORE: 25 April 1994 DRILLER: Exmar

FIELD LOCATION DETERMINED BY: Loran

LAT: _____ LONG: _____ LORAN: 26146.5, 41223.0

TYPE OF CORE: 3" vibrocore WATER DEPTH FT: 35 ft

PENETRATION: 14.5' RECOVERY: 3'6" JETTED: 10'6"

LOGGED BY: Donna Milligen DATE: 21 June 1994

DEPTH	SAMP #	DESCRIPTION
10 ft		
0'6"		Top of core
		empty
11ft	① ②	fine-coarse light brown sand with frequent clay balls Becomes coarse & contains core wr gravel + rocks ~ 1 inch on their longest side
12ft		med brown med-v. coarse sand occasional gravel + clay balls + clay layers?
13ft		
14ft		
14'0"		

transitional contact

CORE LOG

PAGE 1 OF 3

CORE LABEL: mms-94-14 PROJECT: mms-94DATE OF CORE: 25 April 1994 DRILLER: ExmarFIELD LOCATION DETERMINED BY: LoranLAT: _____ LONG: _____ LORAN: 27145.1, 41224.9TYPE OF CORE: 3 in vibracore WATER DEPTH FT: 39.0PENETRATION: 22.0 ft RECOVERY: 19.1 ft JETTED: 0LOGGED BY: Donna Milligan DATE: 13 June 1994

DEPTH	SAMP #	DESCRIPTION
0 ft		Top 6 inches empty
1 ft		tan/Brown coarse sand - poorly sorted transitional to below
1'4"		dark gray + brown silty sand poorly sorted fine - coarse sand some shells
2 ft		DK Brown silty sand / sand is fine - med shell frags
2 ft	B 2'4"	tan/bn. fine sand mottled with dk gray silty material dk gray increasing down core
3 ft		gray very fine sand + dk gray silt occasional shell frags
4 ft		
5 ft		
6 ft		

transitional contacts

CORE: mms94-14

PAGE 2 OF 3

6 ft			
7 ft		dk gray sandy silt sand is very fine	
7'8.5"	C	Poorly sorted fin. v. coarse lt. gray sand + shell frags	abrupt contact
8 ft	D	dk gray silty coarse sand whole shells + frags	
8 ft		dk gray clay several shells about every 2 inches	
9 ft			
10 ft		dk gray clay but many, many shells/a lot of frags	abrupt contact
10 ft		lt to dk gray v. fine sandy silt occasional mottled w/ brown	
11 ft		v. fine sandy silt	
12 ft	E		
12'8.5"			
13 ft		lt gray wet pattern dk grayish brown fine sandy silt	
14 ft		a little mottling with lt. brown silty sand	
15 ft	F		

CORE LOG

PAGE 1 OF 4

CORE LABEL: mms-94-18 PROJECT: mms-94
 DATE OF CORE: 27 April 1994 DRILLER: Exmar
 FIELD LOCATION DETERMINED BY: Loran
 LAT: _____ LONG: _____ LORAN: 27150.9, 41212.5
 TYPE OF CORE: 3" Vibra core WATER DEPTH FT: 30
 PENETRATION: 24 ft RECOVERY: 25' 10" JETTED: NO
 LOGGED BY: Donna M. Iligan DATE: 20 June 1994

DEPTH	SAMP #	DESCRIPTION
0 ft		Empty
1A		md brown fine sand one area of md gray fine sand clump of shell frags
2A		occ. shell frags throughout
3A		md gray, slightly silty, fine-v. fine sand shell frag layer
4A		occ small clay balls
5A		empty
6A		dk gray, silty v. fine sand ↓

CORE: mms-94-18

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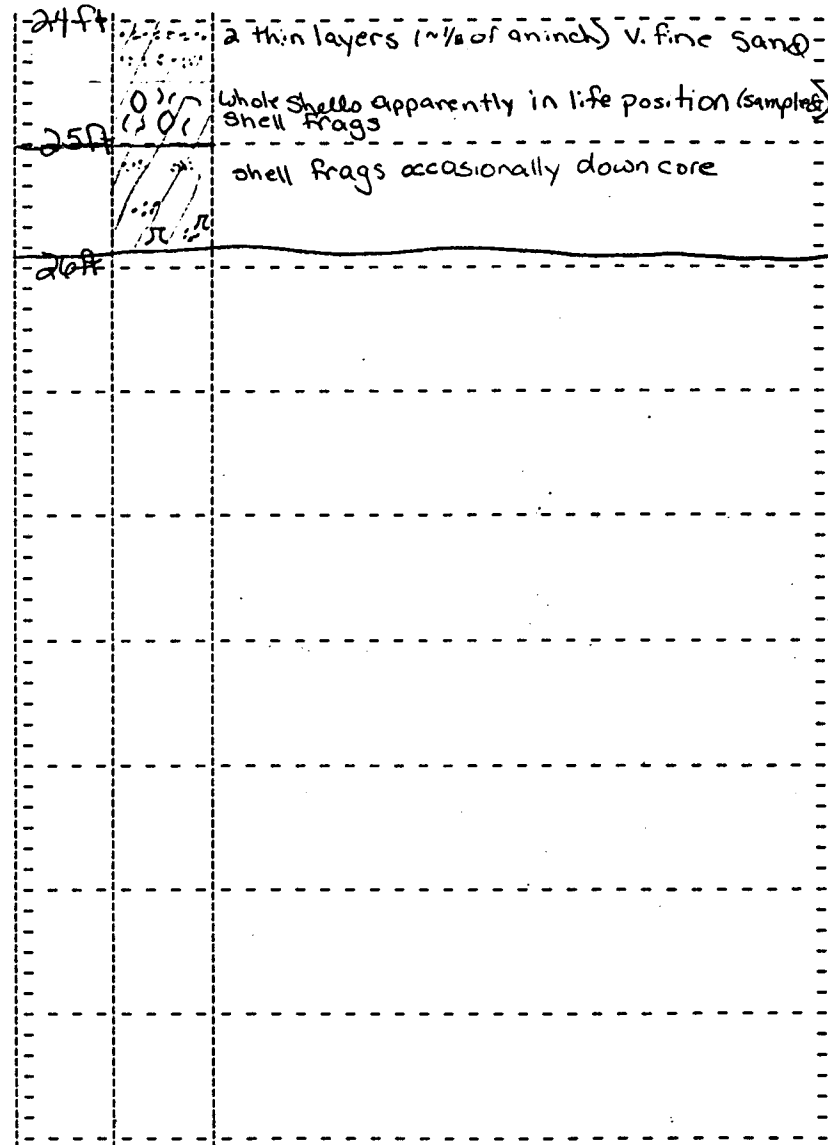
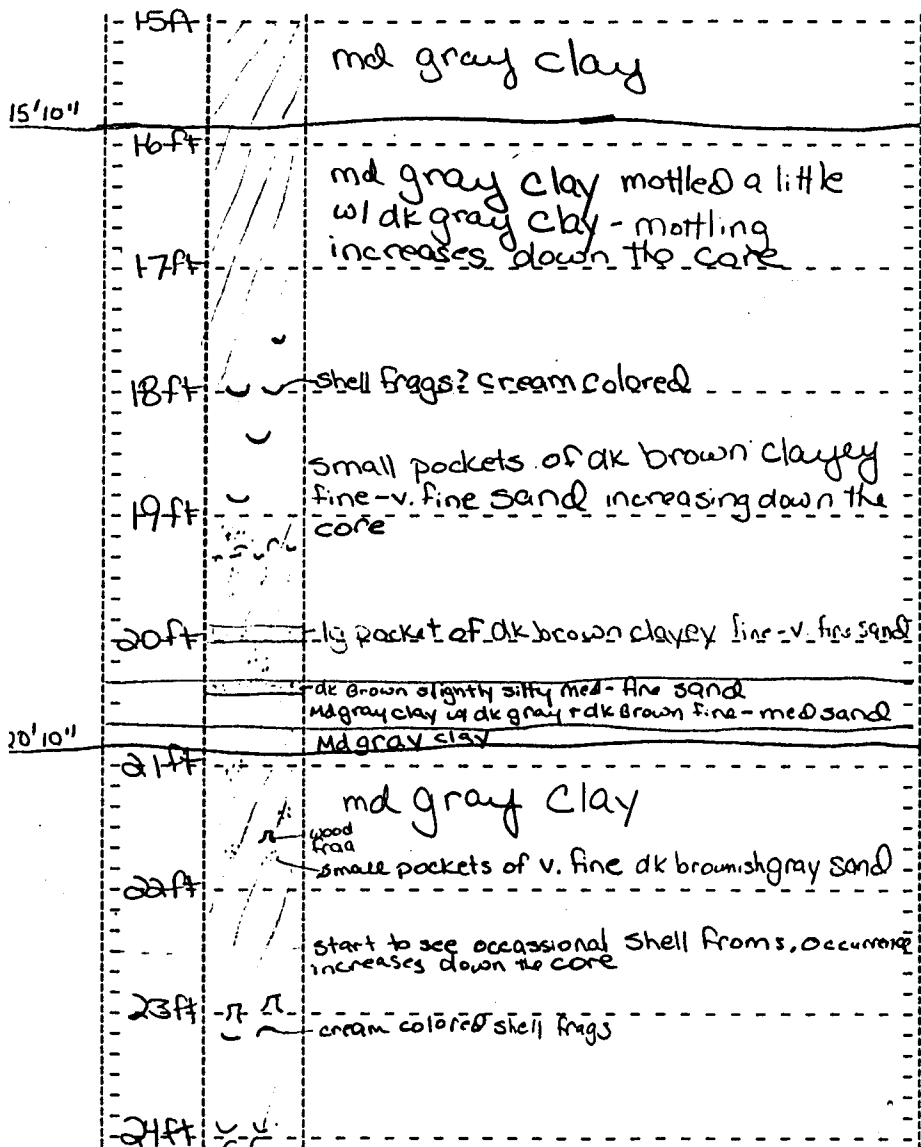
6A		dk gray silty v. fine sand
7A		occ shell frags
8A		
9A		
10.0A	D	dk gray slightly silty fine-coarse sand shell frags + 1 piece of gravel
11A		dk gray fine sandy silt occ shell frags a few pieces of gravel throughout section + increasing down section
12A		gravel
13A	E	poorly sorted dk gray clayey fine-v. coarse sand clay increases down section gravel size + occurrence increases down section coarse sandy + gravelly clay
14A		md gray clay ↓
15A		

transitions
contact

transit
contac

transit
contac

abrupt
contac



CORE LOG

PAGE 1 OF 3

CORE LABEL: S-94-1 PROJECT: mms 1994

DATE OF CORE: 26 April 1994 DRILLER: Exmar

FIELD LOCATION DETERMINED BY: Loran

LAT: _____ LONG: _____ LORAN: 27125.1, 41165.1

TYPE OF CORE: 3" vibrocore WATER DEPTH FT: 37.5'

PENETRATION: 20.0' RECOVERY: 13.0' JETTED: 7 ft

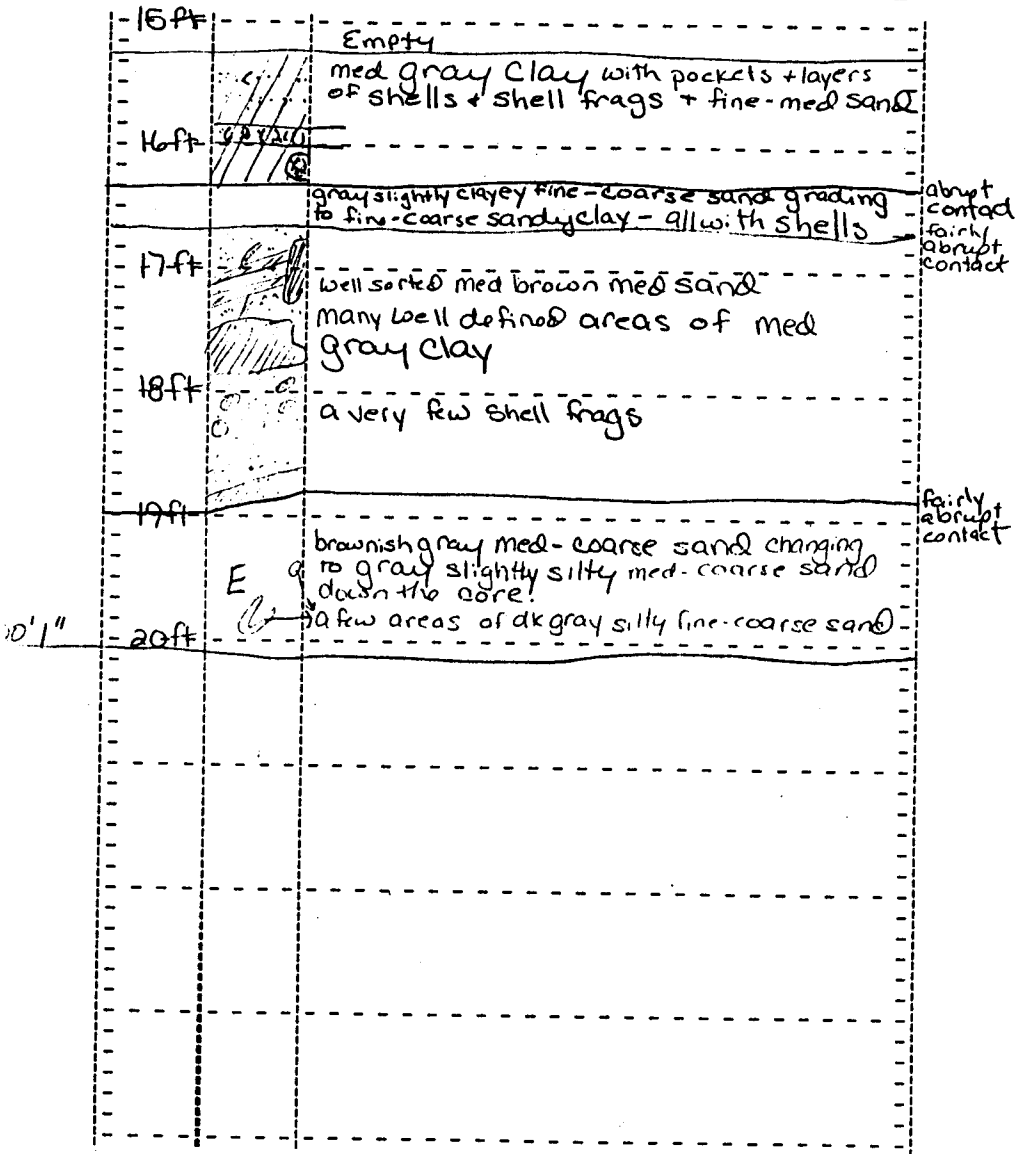
LOGGED BY: Donna Milligan DATE: 28 June 1994

DEPTH	SAMP #	DESCRIPTION
0 ft		
1 ft		
2 ft		Jetted
3 ft		
4 ft		
5 ft		
6 ft		

CORE: S-94-1

PAGE 2 OF 3

6 ft			
7 ft	A	med brown fine-med sand mottled with grayish brown slightly silty fine-med sand. A few small shell frags	transition contact
8 ft	B	med gray fine-med sand shell frags + whole shells (sampled)	
9 ft			
10.0'	C	partly sorted fine-coarse sand (brown) shell frags med gray fine-v. fine sand shell frags	transition contact
11 ft		brownish gray fine-med sand mottled with gray fine sand whole shell + many shell frags	transition contact
12 ft	D	many large + small shell frags dk gray silty fine-v. fine sand many small shell frags scattered throughout	
13 ft		pocket of fine-med sand surrounded by clayey sand + whole shells (sampled)	
14 ft		transitional area dk gray sandy clay whole shells + shell frags	transition contact
15.0'		med gray clay with a few shell frags	
		2 similar sequences: clay contains a little bit of very fine sand. AT the top of each sequence clay with a few whole shells + shell frags. Near the bottom many shells + shell frags mixed in the clay. (whole shells sampled) clay in shells of second sequence has a greater water content.	
		med gray clay	



CORE LOG PAGE 1 OF 3
 CORE LABEL: 5-94-2 PROJECT: MMS 1994
 DATE OF CORE: 26 April 1994 DRILLER: Exmar
 FIELD LOCATION DETERMINED BY: Loran
 LAT: _____ LONG: _____ LORAN: 27125.0, 41155.0
 TYPE OF CORE: 3" vibracore WATER DEPTH FT: 38.0
 PENETRATION: 14.0 RECOVERY: 7'8" JETTED: 7'8"
 LOGGED BY: Donna Milligan DATE: 5 July 1994

DEPTH	SAMP #	DESCRIPTION
0 ft		
1 ft		
2 ft		
3 ft		
4 ft		
5 ft		
6 ft		

Jetted

CORE: 5-94-2

PAGE 2 OF 3

6 ft			
7 ft			
8 ft	A	1 ft. brown med-coarse sand - occ gravel shell frags + small whole shells	transitional contacts
9 ft	B	1 ft brown coarse - v. coarse sand + gravel lg + small shell frags + whole shells (sampled) a few larger rocks ~ 1/2 in exits longest side	
10 ft	C	1 ft. brown med-coarse sand occ small shell frags	
11 ft	D	Poorly sorted fine-coarse sand, 1 ft brown many shell frags + a few small whole shells - (sampled) occ gravel	
11'3"		transitional area from above to below	
12 ft	E	dk gray fine-coarse sand possibly slightly silty a few shell frags, but increases down the core pocket of coarse sand	
12 ft		fine-coarse sand w/ many shell frags	transitional contact
		med-coarse sand w/ a few shell frags	} all arr dk grayish brown
		fine-coarse sand w/ a lot of shell frags some large	
13 ft		med-coarse sand w/ only a few shell frags	abrupt contact
		dk gray clayey coarse sand - a thin layer of clay at the top. Two pockets of many shell frags + whole shells mixed with clayey coarse sand	transitional contact
		dk gray clay with a few whole shells + a pocket of med-coarse clayey coarse sand + gravel - shell frags	
14 ft		dk gray clayey clay with many whole shells + shell frags dk gray clay with a shell layer at the bottom (frags)	abrupt contact
		med gray clay	abrupt contact
		watery clay + coarse - v. coarse sand mixed together with many, many whole shells + shell frags dk gray	transitional contact
15 ft			

CORE LOG PAGE 1 OF 3
 CORE LABEL: S-94-3 PROJECT: MMS-1994
 DATE OF CORE: 26 April 1994 DRILLER: Exmar
 FIELD LOCATION DETERMINED BY: Loran
 LAT: _____ LONG: _____ LORAN: 27127.5, 41165.0
 TYPE OF CORE: 3" Vibracore WATER DEPTH FT: 34.5
 PENETRATION: 19.0 ft RECOVERY: 10 ft JETTED: 10 ft
 LOGGED BY: Donna Milligan DATE: 5 July 1994

DEPTH	SAMP #	DESCRIPTION
0 ft		
1 ft		
2 ft		
3 ft		
4 ft		
5 ft		
6 ft		

↑
Jetted
↓

CORE: S-94-3

PAGE 2 OF 3

6 ft		
7 ft		
8 ft		
9'0"		
9 ft		dk gray clay
		med-coarse sandy clay w/ some gravel
10 ft		dk gray clay with small shell frags
		dk gray clay
		clayey med-coarse sand
		dk gray slightly clayey coarse sand w/ many sm. shell frags
11 ft		Many small shell frags mixed with dk gray clay
		dk gray clay
		many small shell frags
12 ft		dk gray clay quite a few scattered whole shells + shell frags
13 ft		dk gray clay, v. few shell frags - only one whole shell
		small whole shells changing to mostly shell frags with little clay
14'0"		small whole shells mixed w/ shell frags + clay (sampled)
14 ft		same as above
		dk gray clay grading down to coarse sandy clay with many shell frags + occ whole shells
15 ft		md gray clay

abrupt contact

