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New York District

A GEOMORPHOLOGICAL AND ARCHAEOLOGICAL STUDY IN CONNECTION WITH THE NEW YORK AND NEW JERSEY HARBOR NAVIGATION STUDY, UPPER AND LOWER BAY, PORT OF NEW YORK AND NEW JERSEY

HUDSON, ESSEX, AND UNION, COUNTIES, NEW JERSEY, KINGS, RICHMOND, AND NEW YORK COUNTIES, NEW YORK

FINAL REPORT

October 2000

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Riverdale, New York 10471

Prepared under subcontract to and prepared in conjunction with:

PANAMERICAN CONSULTANTS, INC.
Buffalo Branch Office
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UNDER CONTRACT TO:

U.S. Army Corps of Engineers
New York District
CENAN-PL-EA
26 Federal Plaza
New York, New York 10278-0090

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October 2000

Management Summary

Geoarcheology Research Associates (GRA) was subcontracted by Panamerican Consultants, Inc. (Buffalo, New York) under contract to Barry Vittor & Associates to perform a systematic assessment of the potential for preservation of submerged prehistoric cultural resources within the vicinity of ten navigation channels in the Upper New York and New Jersey Harbor. This geomorphological and archaeological study was undertaken on behalf of the U.S. Army Corps of Engineers, New York District. The report was prepared with the assistance of Panamerican Consultants, Inc.

The geomorphological and archaeological study of the New York Bight incorporated an interdisciplinary approach to examine the potential for cultural resource preservation in buried contexts flanking ten navigation channels. Field work stressed the inspection of samples and cores undertaken over the course of geotechnical investigations that produced a total of 114 borings, including 24 conducted in the field for this project. An additional 21 borings were selected for analysis from the collection curated at the USACE Caven Point facility. The 46 borings were examined—samples were studied stratigraphically and sedimentologically. They were then subjected to a variety of specialist analysis including radiocarbon dating; foram analysis; pollen analysis; and macrobotanic identifications. Limited paleoenvironmental reconstructions were produced that helped to determine the landscape implications of the stratigraphic columns that were retrieved.

A result of these investigations was the generation of a working model of cultural resource sensitivity that ranked the channels and various segments according to "High," "Moderate-High," and "Low" preservation categories. The rankings referred not only to the sensitivity of the navigation channels themselves, but also to the subaqueous terrain immediately flanking the channel; the latter were more likely to preserve intact deposits and were highly likely to sustain destructive impacts. Two principal factors were pivotal in producing these rankings. The first was stratigraphic observation. Sequences were typically documented that extended to depths (>30 ft) and intact sediment types of an age equivalent to known cultural periods of the Middle Atlantic and New York state prehistoric chronologies. The second major factor for sensitivity assessment was the depth of dredging associated with each channel. Depth and extent of dredging eliminated preservation potential for later prehistoric deposits in many channels. A series of maps zoning the sensitivity of channels by bands corresponding to elevations and subsurface stratigraphy was produced for this study.

In general, it was concluded that the navigation channels had moderate to high potential for preserving intact deposits pre-dating 6000 B.P. This is critical, since sites of such periods (Late Archaic or earlier) are scarce and poorly documented in the metropolitan New York area. One of the few locations that has preserved deposits of such antiquity is northern Staten Island, immediately flanking the study area. Sites post-dating the Late Archaic, while generally better known outside the study area in terrestrial environments, are less likely to be preserved in the channel environments because they are higher in elevation and thus more exposed to the destructive long-term effects of dredging and shipping activities.

In sum, this study concludes that the oldest and most rarely documented prehistoric site types are most likely to be impacted and encountered by channel widening activities for select channels. Later and more widely distributed prehistoric sites are less likely to be impacted since they have either been eroded in the prehistoric past or have been destroyed by contemporary dredging activities.

The most sensitive channels for cultural resources were Newark Bay, Anchorage, Claremont, and Port Jersey and should therefore be the focus of additional geomorphological and archaeological studies. Ambrose Channel and Stapleton Channel may be somewhat sensitive but were not extensively investigated in this study.

Copies of this report are on file at the U.S. Army Corps of Engineers, New York District Office, the New York State Historic Preservation Office, Peebles Island, New York, the New Jersey Historic Preservation Office, Trenton, and the New York City Landmarks Preservation Commission, New York, New York.

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Acknowledgments

A large, multidisciplinary team was involved in the geomorphological and archaeological study of New York and New Jersey Harbor. We thank Lynn Rakos, archaeologist for the U.S. Army Corps of Engineers (USACE), New York District, who designed much of the project, reviewed interim progress reports, and provided helpful comments on the present report. Ben Baker, geologist for USACE, assisted with access to archived borings and boring logs. John Wilson, shop foreman, and other staff members at the USACE facility on Caven Point provided additional assistance in finding and inspecting archived borings.

During the field investigations in November and December of 1998, logistics were facilitated by Dr. Al Hirsch and his geotechnical staff at URS Greiner, Inc. and by drilling crews from Warren George, Inc. Laboratory analyses of foraminifera were ably performed by Dr. Ellen Thomas of Wesleyan University. Analyses of plant microfossils were performed by Dr. Lucinda McWeeney of Yale University. Dr. Michael Cinquino, Dr. Michele H. Hayward, Mr. Mark Steinback, Dr. Frank Schieppati, Mr. Carl Thiel, and Mr. Martin Lewars of Panamerican Consultants, Inc. (Buffalo Office), compiled draft and final versions of the present report and showed commendable patience in assisting with innumerable revisions.

1.0 Introduction

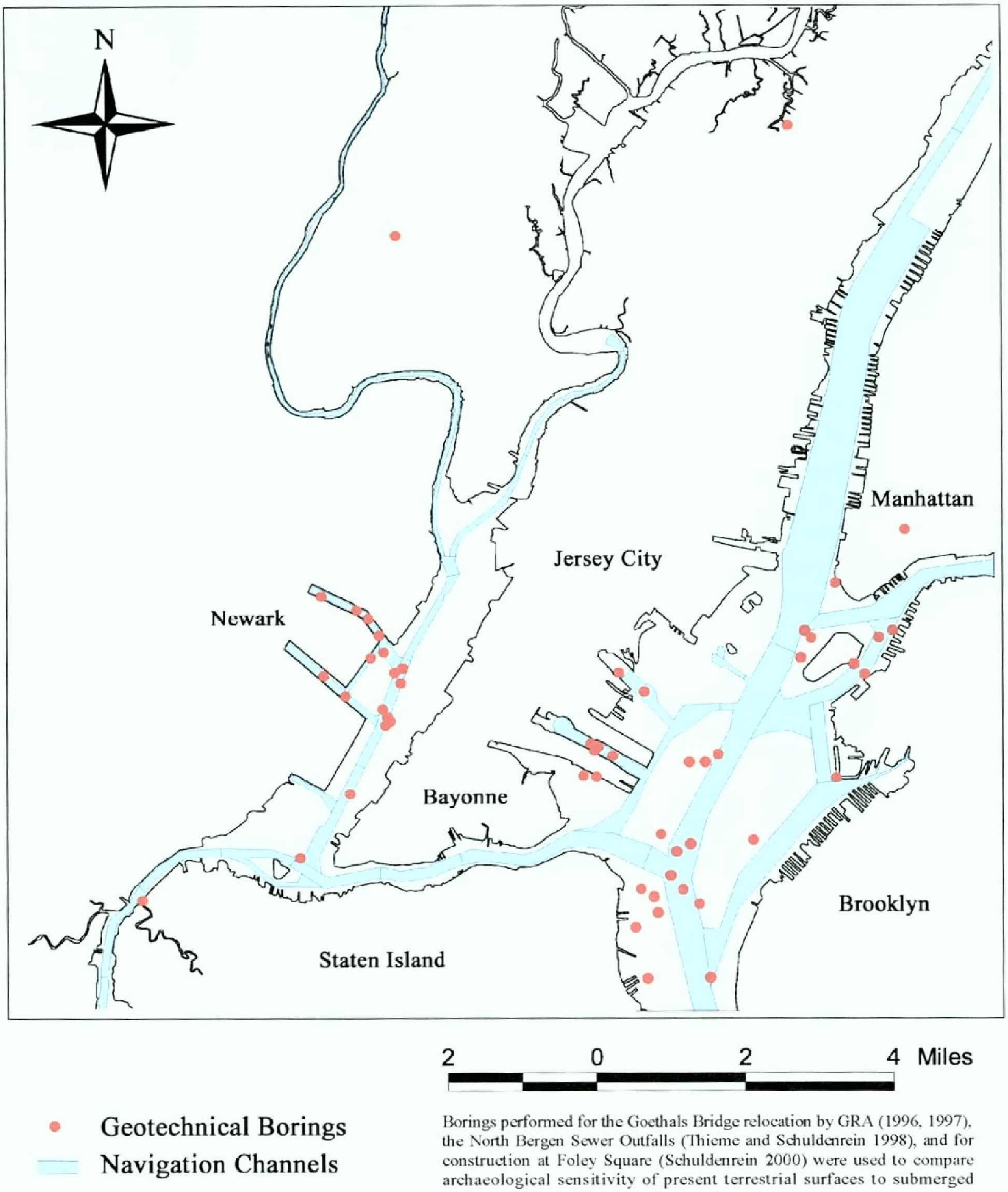
Geoarcheology Research Associates (GRA) was subcontracted by Panamerican Consultants, Inc. (Buffalo, New York) under contract to Barry Vittor & Associates to perform a systematic assessment of the potential for preservation of submerged prehistoric cultural resources within the vicinity of ten navigation channels in the Upper New York and New Jersey Harbor. This geomorphological and archaeological study was undertaken on behalf of the U.S. Army Corps of Engineers, New York District (USACE) and with the report production assistance of Panamerican Consultants. Geoarchaeological investigations described in this report were performed in advance of proposed deepening of existing navigation channels in the New York and New Jersey Harbor. The purpose of these investigations was to assess the potential for prehistoric cultural resources within the study area by evaluating pertinent geophysical and paleoenvironmental data with respect to deglaciation, sea level rise, paleogeography, and the effects of marine erosion. The results of these investigations will make it possible for USACE to systematically assess locations that are potentially sensitive for prehistoric cultural resources.

The contact person for the U.S. Army Corps of Engineers (USACE), New York District is archaeologist Ms. Lynn Rakos; Mr. Ben Baker served as geologist for USACE. John Wilson, shop foreman, and other staff members at the USACE facility on Caven Point provided additional assistance in finding and inspecting archived borings. During the field investigations in November and December of 1998, logistics were facilitated by Dr. Al Hirsch and his geotechnical staff at URS Greiner, Inc. and by drilling crews from Warren George, Inc. Botanical analyses were performed by Dr. Ellen Thomas of Wesleyan University and by Dr. Lucinda McWeeney of Yale University.

Dr. Joseph Schuldenrein served as principal investigator. Mr. Donald M. Thieme, Dr. Terrence Epperson, and Mr. Mark Smith assisted in writing the report. The final report was technically edited and produced by personnel at Panamerican Consultants, Inc., Buffalo Branch Office, including Dr. Michael Cinquino, project director, Dr. Michele Hayward, Mr. Mark Steinback, Dr. Frank Schieppati. Mr. Carl W. Thiel, and Mr. Martin Lewars.

The study area is part of a jurisdictional region currently designated as the New York-New Jersey Port District. This district encompasses over 1,500 square miles within a 25-mile radius of the Statue of Liberty, including 17 counties and 234 municipalities, with a population of over 12 million. The eight separate bays and associated waterways of the harbor itself provide a total of 755 miles of frontage (460 miles in New York and 295 miles in New Jersey). The harbor is divided into the Upper Bay and the Lower Bay, which are connected by the two-mile long passage between Staten Island and Brooklyn known as the Narrows. Detailed archaeological assessments are presented below for the navigation channels in the Upper Bay or Upper New York and New Jersey Harbor Region (Figure 1). Assessments for the much deeper channels in the Lower Bay are more tentative and based on less complete stratigraphic and paleoenvironmental records.

Deepening of channels in the New York and New Jersey Harbor is very likely to be required for economically efficient and environmentally sound navigation to meet current and future needs. The U.S. Army Corps of Engineers, New York District was authorized to conduct a comprehensive



Borings performed for the Goethals Bridge relocation by GRA (1996, 1997), the North Bergen Sewer Outfalls (Thieme and Schuldenrein 1998), and for construction at Foley Square (Schuldenrein 2000) were used to compare archaeological sensitivity of present terrestrial surfaces to submerged surfaces within the Harbor navigation channels.

Figure 1. New York and New Jersey Harbor Region showing the navigation channel study areas and the geotechnical borings used for analysis of archaeological sensitivity. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*

study of such navigation needs under Section 435, Water Resources Development Act of 1996. As a Federal agency, USACE is required to identify cultural resources within its study areas and evaluate their eligibility for listing in the National Register of Historic Places (NRHP). The Federal statutes and regulations mandating these responsibilities include Section 106 of the National Historic Preservation Act, as amended through 1992, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800).

The specific objective of the present geomorphological and archaeological study is to assess the archaeological sensitivity of areas that may be dredged to deepen or widen the existing navigation channels. Prior geotechnical borings, performed for USACE by URS Greiner (1999), provided the primary data used for reconstructing depositional environments and modeling archaeological sensitivity. Figures 2 and 3 show the locations of the borings used on topographic maps (Port Jersey Quadrangle and Elizabeth Quadrangle).

Findings of the present study are presented as a series of maps of archaeological sensitivity as well as a generic flowchart specifying implications of geomorphological and paleo-environmental data for sensitivity assessment. In addition to the primary stratigraphic and paleo-environmental data from the geotechnical borings, the assessments of archaeological sensitivity draw upon a broad synthesis of extant archaeological and geological literature as well as historic maps which document previous dredging and other modifications in the areas studied. The most sensitive areas are those which have relatively thick accumulations of Holocene sediments and which, on the strength of the chronology and stratigraphy, have some likelihood of preserving cultural materials. Specifically, locations in Newark Bay (NB), the Claremont Channel (CC), the Port Jersey Channel (PJ), the Anchorage Channel (ANC), the Stapleton Channel (STA), and the Ambrose Channel (AMB) are considered to have at least a moderate potential for submerged cultural resources while only low potential characterizes the other navigation channel study areas.

Figure 2. Locations of geotechnical borings in the Upper Bay region. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(USGS 7.5 Minute Series, Port Jersey Quadrangle, 1999).*

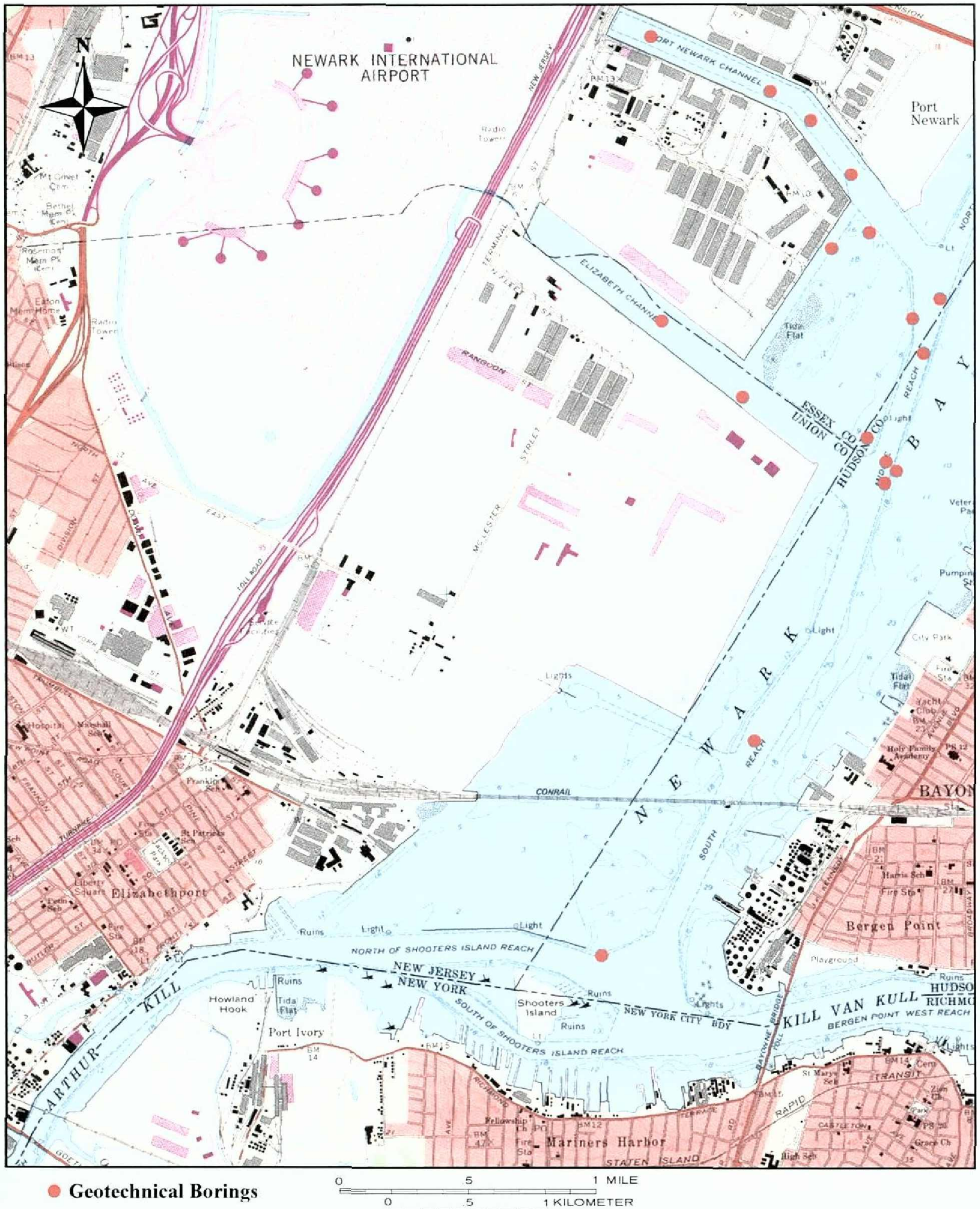


Figure 3. Locations of geotechnical borings in the Newark Bay region. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(USGS 7.5 Minute Series, Elizabeth, NJ Quadrangle, 1999).*

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2.0 Geological and Environmental Setting

Many of the conclusions of the present study are based on the geology of the project area, particularly its history of glaciation and deglaciation as well as submergence and emergence as ice sheets formed and global (eustatic) sea level changed during the past million years. The New York and New Jersey Harbor is an estuary formed within valleys deepened and widened by the advance and retreat of the great continental (Laurentide) ice sheet of the last ice age. The valleys occupy rifts which developed as the North American and African continents began to separate about 200 million years ago (Isachsen *et al.* 1991:50-51). The Atlantic Ocean formed within the largest of these rifts while lesser rifts sliced through Paleozoic continental land masses and left isolated remnants such as the Manhattan Prong east of the Hudson River Valley. The Newark Group rocks underlying most of the Harbor Region formed from primarily alluvial sediments which filled the rifts as they opened.

The Quaternary deposits of the Harbor Region rest unconformably on the Newark Group sedimentary rocks from upper Newark Bay east to the Hudson River. The Stockton, Lockatong, and Brunswick formations of the Newark Group consist of redbed sediments deposited in a Triassic basin which was subsequently faulted and intruded by igneous magma. The most significant intrusion occurred on the eastern edge of the basin at the Palisades sill, adjacent to the Hudson River of today.

East of the Hudson River, the Manhattan Prong consists of outcropping Cambrian to Ordovician igneous and metamorphic lithologies of the New York City Group. Rare outcrops of gneiss or schist occur on Governors Island (Herbster *et al.* 1997; Schuberth 1968:82) and in Queens and Brooklyn, but these land masses consist primarily of Quaternary sediments or older marine units of the Atlantic Coastal Plain. A northeast trending axial ridge of gneiss and serpentinite comprises the core of Staten Island against which tens of meters of glacial till were lodged by the Laurentide ice sheet.

Several contributing drainages to Newark Bay follow channels inherited from the great southwest-trending Pensauken River system of probable Pliocene age (Stanford 1997). Diversion of the Pensauken River into the Hudson Canyon between the Pliocene and the Pleistocene refocused continental shelf deposition from the Baltimore Canyon area (Poag and Sevon 1989; Stanford 1997) but the Pensauken deposits have been long since scoured away from the Harbor Region. Cretaceous and possible interglacial (oxygen isotope Stage 5e) sediments occur at the Narrows, but sediments older than the Wisconsinan glaciation are otherwise missing from the lower Hudson as a result of erosion following base-level fall (Weiss 1974:1567).

Glaciers advanced across the region at least twice during the Pleistocene (Stanford 1997; Sirkin 1986). Both Illinoian (ca. 128,000-300,000 B.P.) and pre-Illinoian (> 300,000 B.P.) terminal moraines are mapped in northern New Jersey, and these ice advances may be represented by lower tills on Long Island such as the Montauk (Rampino and Sanders 1981; Merguerian and Sanders 1994). An abundance of gneiss clasts gives the older tills a "dirty" appearance which distinguish them from late Wisconsinan deposits by the presence of unweathered mudstone, sandstone, and igneous rock clasts in the latter (Stanford 1997).

The Hudson-Mohawk Lobe of the latest or Wisconsinan ice sheet advanced to its Harbor Hill terminal moraine by 20,000 years B.P. based on the evidence obtained from Port Washington on Long Island by Les Sirkin (Sirkin 1986:14; Sirkin and Stuckenrath 1980). Some organic sediments from the preceding, warmer, interstadial period (oxygen isotope Stage 3) appear to have survived beneath or within the till and outwash, and some possible examples of this were encountered from the geotechnical borings examined for the present study.

In addition to the oxygen isotope geochronology (Richmond and Fullerton 1986) and the data from Port Washington on Long Island (Sirkin 1986:14; Sirkin and Stuckenrath 1980) the age of the terminal Wisconsinan Harbor Hill moraine is constrained by basal postglacial radiocarbon dates from northwestern New Jersey of 19,340 ± 695 B.P. in a bog on Jenny Jump Mountain (Witte 1997) and 18,570 ± 250 B.P. in Francis Lake (Cotter 1983). Thieme and Schuldenrein (1998) recently obtained a date of 19,400 ± 60 B.P. from a loamy sediment overlying glacial till along Penhorn Creek in the Hackensack Meadowlands. A pollen core from Budd Lake in northwestern New Jersey (Harmon 1968) also provides supporting evidence for Sirkin's chronology of the Hudson-Mohawk Lobe. A sample of clay from 37 feet below surface was dated to 22,870 ± 720 B.P. and contained a pollen assemblage dominated by pine (50 to 60 percent) and spruce (10 to 20 percent) with some oak (5 to 10 percent) and Ambrosiae dominant in the non-arboreal pollen. A boreal forest or park-like vegetation community is further indicated by pollen assemblages dated to 22,310 ± 2070 B.P. and 22,040 ± 550 B.P. from varved silt and clay in the Hackensack Meadowlands (Schuldenrein 1992; Rue and Traverse 1997) although reworked Cretaceous spores and pollen were also present. Pollen records of postglacial vegetation change are discussed in greater detail in Section 6 with reference to samples analyzed from borings in the harbor.

At the last glacial maximum, approximately the time of deposition of the Harbor Hill moraine, nearly one percent of the Earth's water was transformed into glacial ice (Strahler 1971). Eustatic sea level consequently plummeted, and a terrestrial coastal plain extended from 24 to 60 miles onto the present continental shelf along the Atlantic coast (Bloom 1983a:220-222; Emery and Edwards 1966; Stright 1986:347-350). Sea level rise was extremely rapid in the period immediately following the retreat of the ice (Figure 4) as glacial meltwater was delivered to the oceans from basins impounded at a series of recessional margins. Locally, the lower Hudson and Hackensack River Valleys were sequentially scoured and flooded (Reeds 1925, 1926; Stanford 1997; Stanford and Harper 1991), forming much of the present-day topography surrounding New York and New Jersey Harbor. The basins left behind after the proglacial lakes drained were initially incised by meandering channels and then transformed into tidal marsh in the mid- to late-Holocene (Widmer and Parillo 1959; Thieme and Schuldenrein 1996; Carmichael 1980; Heusser 1949, 1963).

In addition to the rapid delivery of glacial meltwater to the Atlantic Ocean, the rapid rate of sea level rise in the period immediately following retreat of the Laurentide ice sheet (ca. 18,000 –7000 B.P.) was also affected by the fact that the ice sheet had itself depressed the continental land mass (Bloom 1983b; Clark *et al.* 1978; Fairbridge and Newman 1968). As the continent

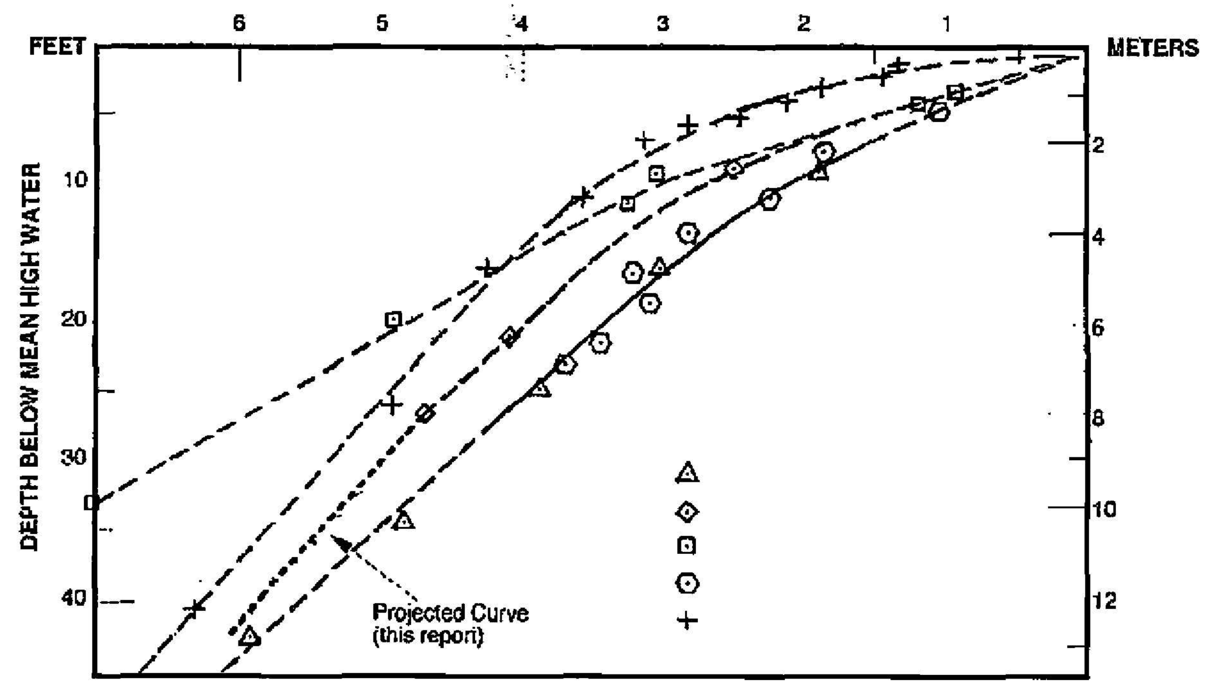
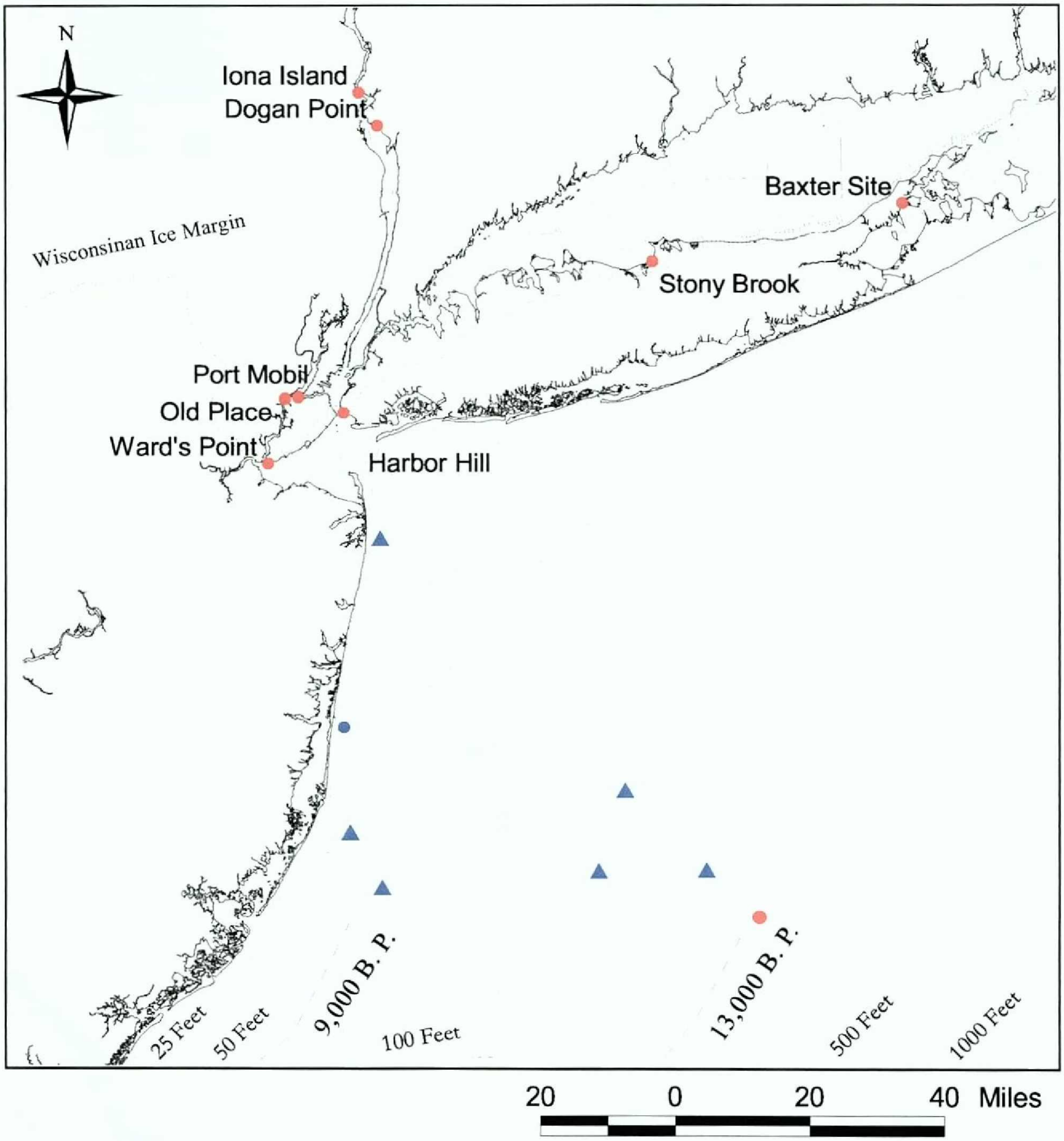


Figure 4. Relative sea level rise curves for the Lower Hudson Valley and other areas on the Atlantic seaboard. (Base curves modified from Newman et al. 1969.) A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*

deglaciated, isostatic rebound slowed the rate of sea level rise during a period (ca. 7000-4000 B.P.) when coastal occupations became particularly prevalent in the northeastern United States (Funk and Pfeiffer 1988; Pretola and Little 1988; Ritchie 1969, 1980; Salwen 1962). Figure 5 shows how the bathymetric contours within the harbor and seaward onto the continental shelf can be projected to represent lower sea level positions at 11,000 (-100 ft), 7000 (-30 ft), and 4000 (-15 ft) years B.P. This reconstruction of the submerged postglacial shorelines is crucial to the assessments of archaeological sensitivity in the present study and generally conforms to previous paleoshoreline reconstructions for the mid-Atlantic region (Kraft *et al.* 1983, 1985; Newman *et al.* 1969). It suggests that there was still an additional 212 miles of Coastal Plain at 7000 B.P.

Recent studies on Staten Island (GRA 1996a, 1996b), Ellis Island (Pousson 1986), and Governors Island (Herbster *et al.* 1997; Thieme and Schuldenrein 1999) suggest some of the complexity of Quaternary depositional environments in the lower Hudson River valley as well as the variable preservation of archaeologically sensitive deposits. While the generic stratigraphy can be said to consist of Wisconsinan ice-contact and meltwater deposits capped by quartzose sheet sands, granulometric analyses of basal sands on Governors Island indicated a combination of glaciofluvial, ice-contact, and fluviomarine deposition (Thieme and Schuldenrein 1999).

There is little evidence of soil formation or stability of Holocene shorelines until after 4000 years B.P., although some submerged contexts may in fact be present within the harbor itself. As proposed for the northeastern United States in general by Nicholas (1988, 1998), Mid-Holocene terrestrial sediment packages have occasionally been identified in the project vicinity at the margins



● **Mammoth teeth finds (after Whitmore et al. 1967: Figure 2)**

▲ **Mastodon teeth finds (after Whitmore et al. 1967: Figure 2)**

– – **Reconstructed shoreline (after Newman et al. 1969 and Kraft et al. 1985)**

Figure 5. The New York Bight showing bathymetric contours projected to represent lower sea level positions of the late Quaternary. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000)*.

of freshwater ponds or marshes (e.g., Thieme and Schuldenrein 1996). The most recent example of this is at Collect Pond in lower Manhattan (Schuldenrein 2000). Early- to mid-Holocene sediments are virtually absent in the estuarine valley fills, however, and this may result in part from erosion during the kink or "highstand" in the regional sea level curve (see Figure 4; also *cf.* Newman *et al.* 1969). Fairbridge and Newman (1968) interpret this kink feature in their curve as the result of postglacial crustal subsidence following late glacial crustal rebound.

In Newark Bay and the lower reaches of the Hackensack and Passaic River valleys there is a somewhat different and more uniform sequence beginning with deeper and more extensive varved proglacial lake beds (Antes 1925; Love green 1974; Reeds 1925, 1926; Salisbury 1902; Salisbury and Kummel, 1893; Stanford 1997; Stanford and Harper 1991; Widmer 1964). Reddish brown muds derived from Newark Group rocks typify the thicker winter varved while the more heterolithic sandy varved were deposited as the ice melted during the summer.

The top of the glaciolacustrine facies is typically an unconformable contact from 12-30 feet below the present land surface in the Hackensack Meadowlands (Love green 1974). Relatively late Holocene peat often overlies the contact except for where sediment was stored by one of the pre-estuarine river systems. In the North Bergen Sewer Outfalls project area previously investigated by Thieme and Schuldenrein (1998), the stratigraphic column fines upward from sandy loam to fine silt, indicating deposition on the natural levee of a meandering stream (Brown 1997:70-81; Waters 1992:134-135). A buried soil within this Holocene floodplain facies was dated to 3650 ± 70 B.P. while plant stem fragments from overlying tidal marsh were dated to 1130 ± 60 B.P. (Thieme and Schuldenrein 1998).

Because they represent intervals of landform stability, buried soils are the most sensitive elements in a generic stratigraphy from the perspective of prehistoric cultural resources (Holliday 1992:101-104; Rapp 1998:34-36; Waters 1992:74-77). Buried soils have been identified primarily within the interval 4000 to 2000 B.P. for terrestrial settings in the project vicinity (GRA 1996a, 1996b; Herbster *et al.* 1997; Schuldenrein 1995a, 1995b, 1995c; Thieme and Schuldenrein 1998, 1999). In some locations, such as on Governors Island and the north shore of Staten Island, the buried soils are at or even slightly below mean sea level. Earlier as yet undocumented soil forming intervals may be represented by stratigraphy which has been submerged, although no buried soils were definitively identified from geotechnical borings during the present study.

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3.0 Prehistoric Culture History

Human occupation probably occurred within the area of the present New York and New Jersey Harbor navigation channels beginning with the Paleoindian cultural period, ca. 11,500-8000 years B.P. Sea level was at least 30 feet below present throughout the period and the habitable Coastal Plain land surface extended from 24 to 60 miles onto the present continental shelf (Bloom 1983a:220-222; Emery and Edwards 1966; Stright 1986:347-350). Mammoth and mastodon finds on the continental shelf and within the Hudson River channel show that both of these large mammals were plentiful enough to have permitted focal hunting adaptations (see Figure 5) (Fisher 1955; Whitmore *et al.* 1967). Recent Paleoindian site excavations in the Northeast suggest a more varied subsistence, however (Adovasio *et al.* 1977, 1978; Gardner 1977, 1983; Funk and Steadman 1994; McNett *et al.* 1985). Exploitation of marine fish and shellfish in settings now submerged beneath the harbor would not be surprising given the broad spectrum diet of plants, birds, small mammals, and freshwater fish now suggested for Paleoindians in the Northeast.

Several sites with diagnostic artifacts attributed to either the Late Paleoindian or Early Archaic (10,000-8000 B.P.) cultural periods have been found on the western shore of Staten Island (Kraft 1977a, 1977b; Ritchie and Funk 1971). At Port Mobil, fluted points, end and side scrapers, and unifacial tools were among over 51 lithic artifacts recovered from a sandy slope between 20 and 40 feet above sea level. Fluted points are also among the artifacts which have been found on Charlestown Beach south of Port Mobil. Projectile points classified as Kirk, Kanawha, LeCroy, and Stanley have been recovered from the Hollowell and Ward's Point sites at the island's southwestern tip. The Old Place site near the crossing of the Goethals Bridge appears to be primarily a Middle Archaic (8000-6000 B.P.) through Late Archaic (6000-3000 B.P.) encampment, although a radiocarbon date of 7260 ± 140 B.P. (I-4070) was obtained on hearth charcoal associated with Stanley, LeCroy, and Kirk points.

It is very likely that the sites with Paleoindian, Early Archaic, or Middle Archaic artifacts discovered to date represent only a very small portion of settlement networks which extended across surfaces within the Harbor Region which have since been inundated by rising sea level. The rate of sea level rise slowed at approximately 5000 B.P., due in part to postglacial crustal rebound (Bloom 1971; Bloom and Stuiver 1963; Fairbridge and Newman 1968). This may explain the abundance of Late Archaic sites in settings that are now at or slightly below present shoreline positions. Of five inundated sites along shores or tidal stream banks on Long Island reported by Stright (1990), for example, all are Late Archaic or Woodland period encampments.

Exploitation of shellfish and other marine resources was a definite specialization among Late Archaic hunter-gatherers of coastal New York and New Jersey (Brennan 1974; Kraft and Mounier 1982; Ritchie 1980:165-167). Although Brennan (1977) argued for antecedents extending back to the Early Archaic, his only evidence was the date of 6950 ± 100 B.P. (L-1381) from the deepest level of the Dogan Point shell midden (Little 1995). Dogan Point did have a small Middle Archaic component, as evidenced by both the radiocarbon chronology and presence of Neville, Stark, and other large side-notched projectile points (Claassen 1995a). The main shellfish gathering period, however, dates from 5900-4400 B.P. (Claassen 1995b:131) and thus correlates with other shell midden sites in the Lower Hudson such as the Twombly Landing site below the Palisades near Edgewater, New Jersey (Brennan 1968).

As noted by Funk (1991:51), shell matrix and shell-bearing sites on Martha's Vineyard (Ritchie 1969), Nantucket (Pretola and Little 1988), Fishers Island (Funk and Pfeiffer 1988), and Long Island (Ritchie 1980:164-178; Stright 1990:442-443) are all less than 4,000 years old. Older shell middens may once have existed, however, along coastlines that are now beneath the sea. In addition to the more ephemeral hunting camps of the earlier cultural periods, this type of prehistoric culture resource is likely to be present within the harbor navigation channels.

The transition between the Archaic and Woodland periods in the Northeast is marked by the presence of ceramics and, in many areas, by the first evidence of cultivated plants. The Woodland period is generally divided into three stages, Early (3000-2000 B.P.), Middle (2000-1000 B.P.), and Late (1000 B.P. to European contact). In coastal New York, however, the Windsor and East River "traditions" were defined by Smith (1950, 1980) as distinct ethnic groups manifested in several contemporaneous phases. The Windsor tradition originates earlier, and its North Beach phase is contemporaneous with shell-bearing Terminal Archaic sites of the Orient phase. In several sites on Long Island, Windsor ceramics have been found associated with steatite vessels and Orient fishtail points.

The Clearview phase of the Windsor tradition is Middle Woodland in age and is followed by the Late Woodland Sebonac phase. Sebonac phase sites are most common in Connecticut, although the phase is named for a site on eastern Long Island excavated by Harrington (1924). These later phases of the Windsor tradition were suggested by Smith (1950, 1980) to coincide with the earliest, Bowmans Brook phase sites of the East River tradition on Staten Island. Bowmans Brook begins ca. A.D. 1000 and its geographic range eventually included western Long Island, Manhattan, and the lower Hudson River Valley (Ritchie 1980:268-270). The type site on the northwestern shore of Staten Island was investigated by Skinner in 1906 (Skinner 1909:5-9; Smith 1950:176-177). Pits filled with shell and other refuse ranged from four to six feet in diameter and from three to six feet in depth. The pottery is either stamped or incised and tempered with grit or occasionally shell.

The Clasons Point phase of the East River tradition begins ca. A.D. 1300. The type site on the north side of the East River in the Bronx was excavated by Skinner in 1918 (Skinner 1919:75-124; Smith 1950:168-169). The few known village sites are approximately an acre in size and located on higher landforms well above any tidal submergence (Ritchie 1980:270-272). The pottery is typically shell tempered but there is a wide range of both vessel forms and surface decoration. European trade goods have been found in the upper levels of some Clasons Point phase sites.

4.0 Historical Background of the Harbor Navigation Channels

In A.D. 1524 the Florentine navigator Giovanni da Verrazano sailed between the straits that now bear his name, beginning the European exploration and eventual colonization of Upper New York Harbor. Trade goods from this period have been found in the upper levels of some Clasons Point phase sites (Ritchie 1980:270-272) and the native inhabitants are known to have been Algonquin relatives of the Delaware (Homberger 1994:16). They sold the island they called 'Manahatta' to the Dutch for trinkets in 1626 and moved west of the Bronx River.

The initial Dutch settlement was concentrated near the tip of Manhattan island, commanding naval access to both the Hudson River and the East River (Homberger 1994:20). By 1639, Dutch plantations thinly lined the East River and three small villages on Long Island were combined to form Breukelen in 1642 (Homberger 1994:30). Buildings on the East River waterfront faced a muddy shoreline until after Peter Stuyvesant became Director-General in 1647 (Homberger 1994: 32); hence considerable potential exists for early historic as well as prehistoric archaeological contexts beneath the present piers and seawalls.

One stimulus to Dutch settlement in the Upper Bay was the virtually land-locked harborage, well protected from ocean gales, afforded by the Narrows between Brooklyn and Staten Island. At its most constricted point, this passage is less than three-quarters of a mile wide, where it is now spanned by the Verrazano-Narrows Bridge (Water Resources Support Center 1988). The natural geography of the New York and New Jersey Harbor region nonetheless posed certain challenges for early maritime commerce. Unlike the naturally deep harbors of Boston, Quebec and Norfolk which could accommodate any vessel afloat during the eighteenth and early nineteenth centuries, the lower portion of New York Harbor had a controlling depth of 21 feet at low tide and the upper bay contained numerous areas of shoals and treacherous currents. Prior to the first dredging of the harbor, larger vessels could approach New York only through the Main Ship Channel, which required navigation of a narrow passage between Sandy Hook and a series of shoals that blocked most of the Lower Bay (Albion 1939; Newberry 1978). Smaller vessels could utilize the Swash, "Fourteen Feet," or East (later known as Ambrose, see below) channels (Figure 6). In 1837, Lieutenant R. T. Gedney conducted a Coast Survey study that charted an outer alternative channel that still bears his name.

The first publicly-funded attempt to improve the harbor resulted from a New York City municipal appropriation of $13,861 in 1851 to remove rocks and reefs located in the Hells Gate entrance to the East River. This effort was supplemented two years later by a federal appropriation of $20,000 (Albion 1939:28). However, most efforts at harbor improvement during this period were privately funded and poorly coordinated. The dredging of underwater property was under the jurisdiction of the New York City Street Commissioner and the unregulated construction of piers and wharfs was found to be stifling the economic potential of the harbor (Homans 1859; New York State Harbor Encroachment Commission 1864). In 1870 the city and state legislature established the New York City Department of Docks, appointing General George McClellan of Civil War fame to serve as engineer-in-chief. Since all of the new wharves and piers would ultimately be owned by the municipality, the Department of Docks represents the first sustained attempt at municipal

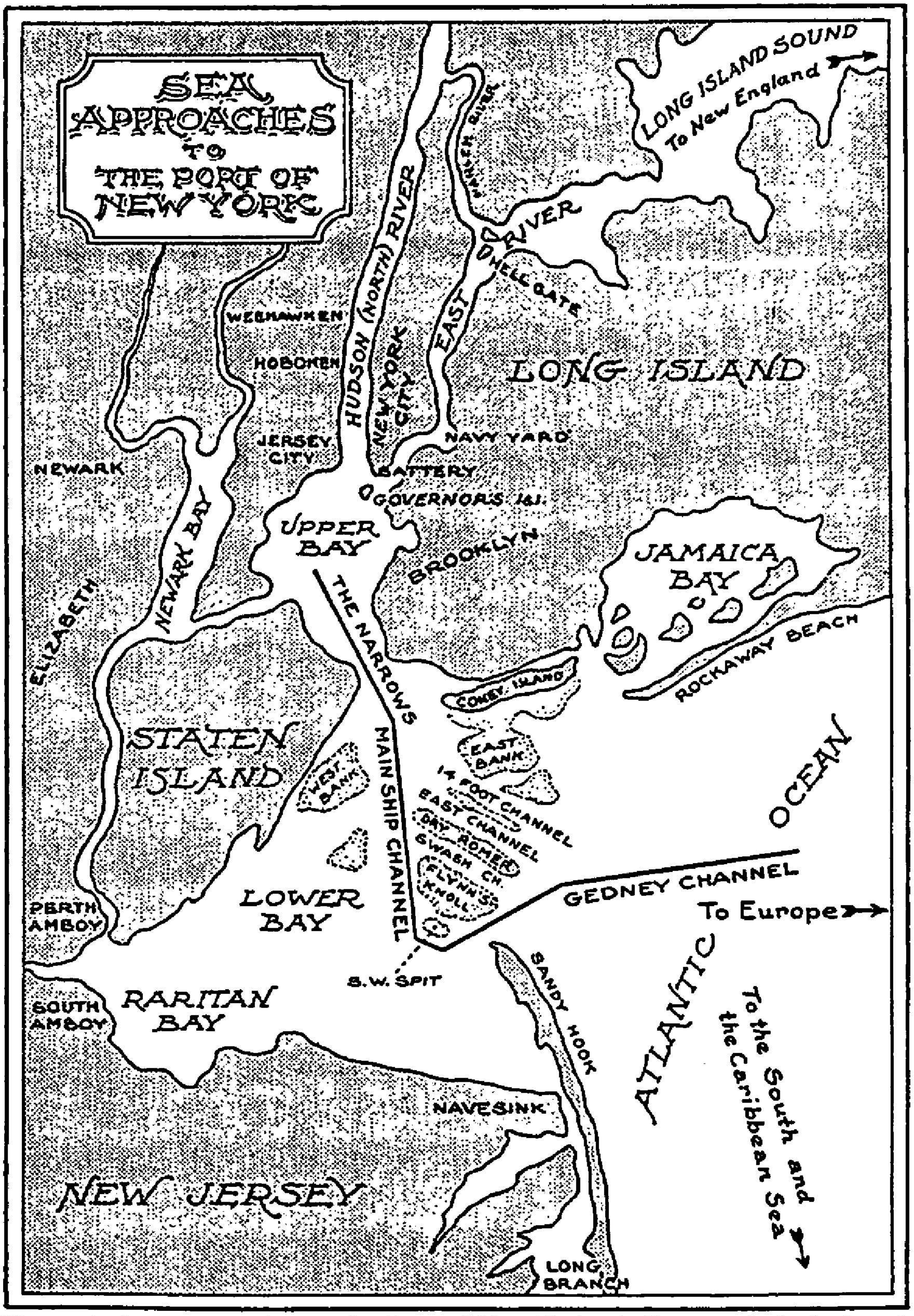

Figure 6. Sea approaches to the Port of New York. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(Albion 1939).*

ownership and administration of port facilities in the United States. In 1921 this agency was renamed the Division of Surveys and Dredging. McClellan's first task was to invite public proposals and comment with a view to developing a master plan for piers, wharfs and seawalls around the island of Manhattan. The subsequent processes of seawall construction and landfilling have resulted in a Manhattan Island that is thirty percent larger than the landform initially encountered by the first Dutch settlers.

Development of McClellan's Master Plan included the excavation of some six hundred soil borings around the entire perimeter of Manhattan. As described in the 1871 Annual Report, these borings were performed by various techniques, including: handrod, Woodcock, and artesian-well boring machine (Betts 1997; New York City Department of Docks 1872). At least some of the logs from these borings are apparently still held in the New York City Municipal Archives, representing an untapped resource for examining the landscape transformation of Manhattan.

Federal projects to enhance New York Harbor proceeded in conjunction with the municipal efforts. In 1872 Congress commissioned a survey of Buttermilk Channel, the narrow passage between Governor's Island and the City of Brooklyn (Figures 7 and 8). The survey located a large shoal with a minimum depth of 9.5 feet at the junction with the East River. This shoal was in the track of navigation, making it unsafe to maneuver large vessels in the vicinity of the Brooklyn wharves. The proposed dredging was conducted from October 1 through November 3, 1884 (U.S. Engineer Bureau 1885). The shoal was removed to a depth of 24 to 26 feet below mean low water in a zone extending 850 feet from the wharves. The estimated cost of this work was $210,000. By 1976 Buttermilk Channel had been enlarged to a width of 1,000 feet and a depth of 34 to 40 feet below mean low water (Hammon 1976).

New York City's harbor improvement program was substantially enhanced on July 5, 1884 by an unanticipated congressional appropriation of $200,000 to conduct a survey for deepening Gedney's Channel, marking the first attempt to improve a navigation channel in the lower bay (Edwards 1893; U.S. Engineer Bureau 1886). Since this project resulted in the first large-scale dredging project in New York Harbor, it will be examined in some detail. The appropriation included a detailed survey of the lower New York Bay, including current and tide observations, borings to a depth of three feet below bottom, and detailed bathymetric maps showing the location of the -24 foot contour in 1835, 1855, 1881, and 1884. Despite dramatic changes in the configuration and location of the Sandy Hook peninsula, the bottom profile had changed very little between 1835 and 1884. The survey also found that in 1884 the minimum depth in Gedney's Channel at mean low tide was 22.3 feet. The mean high tide rose to 4.8 feet, giving a controlling depth at high tide of 27.1 feet. The report noted that the largest steamships running out of New York drew 28 feet when fully loaded, but few vessels were loaded to capacity. The 1886 Engineers Report also discussed options for creating a safe navigable channel along or near Spuyten Duyvil Creek between Manhattan and the Bronx. This project would not come to fruition until the completion of the Harlem River Ship Canal in 1923.

The lowest acceptable bid for the Gedney's Channel dredging contract was submitted by Elijah Brainard at a cost of 54 cents per cubic yard. The dredging work commenced on September

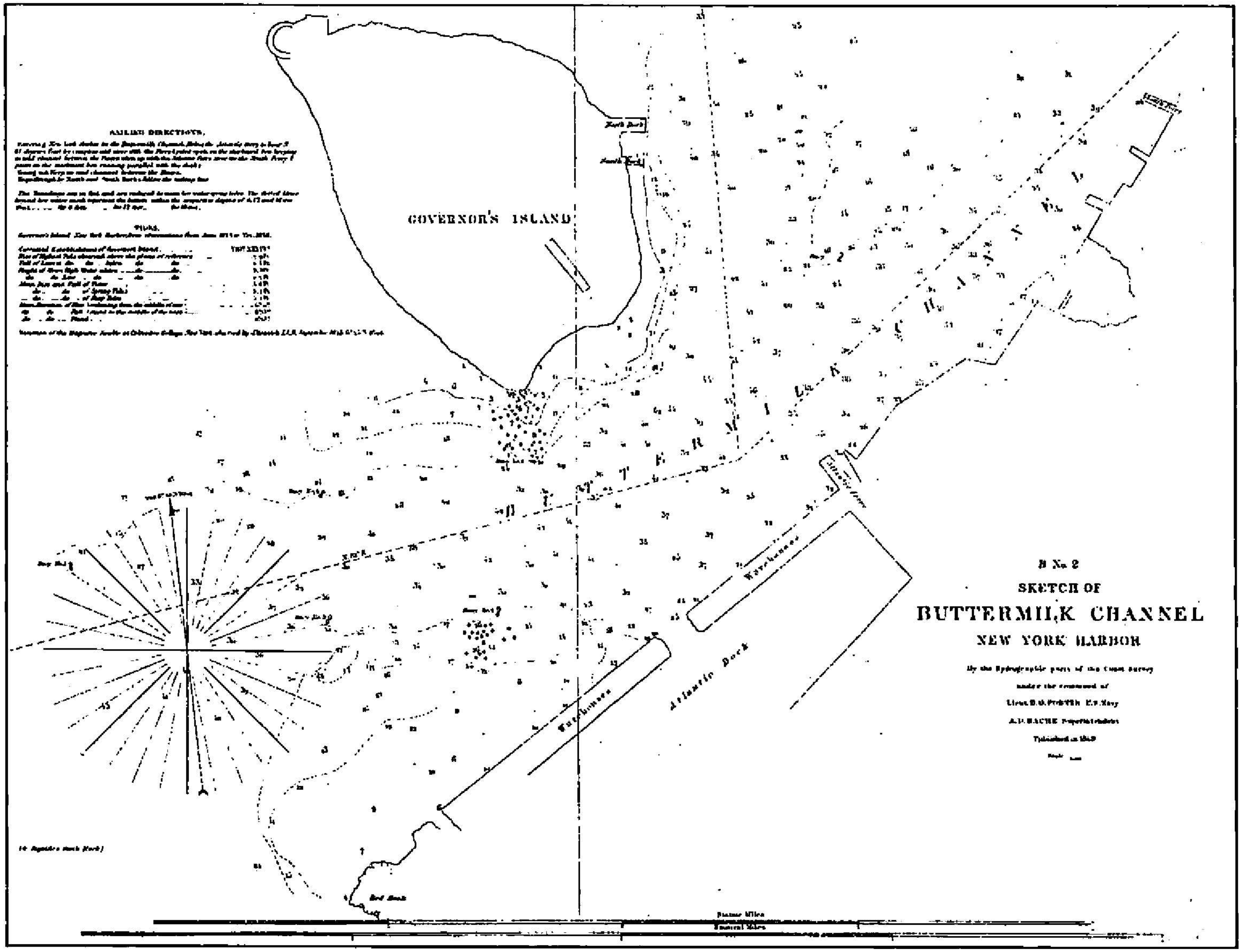

Figure 7. Sketch of Buttermilk Channel, New York Harbor in 1849, prior to passage of 1872 legislation. A Geomorphological and Archaeological Study of New York and New Jersey Harbor. *(Map CP28C from the Image Archives of the Historical Map & Chart Collection Office of Coast Survey/ National Ocean Service/NOAA).*

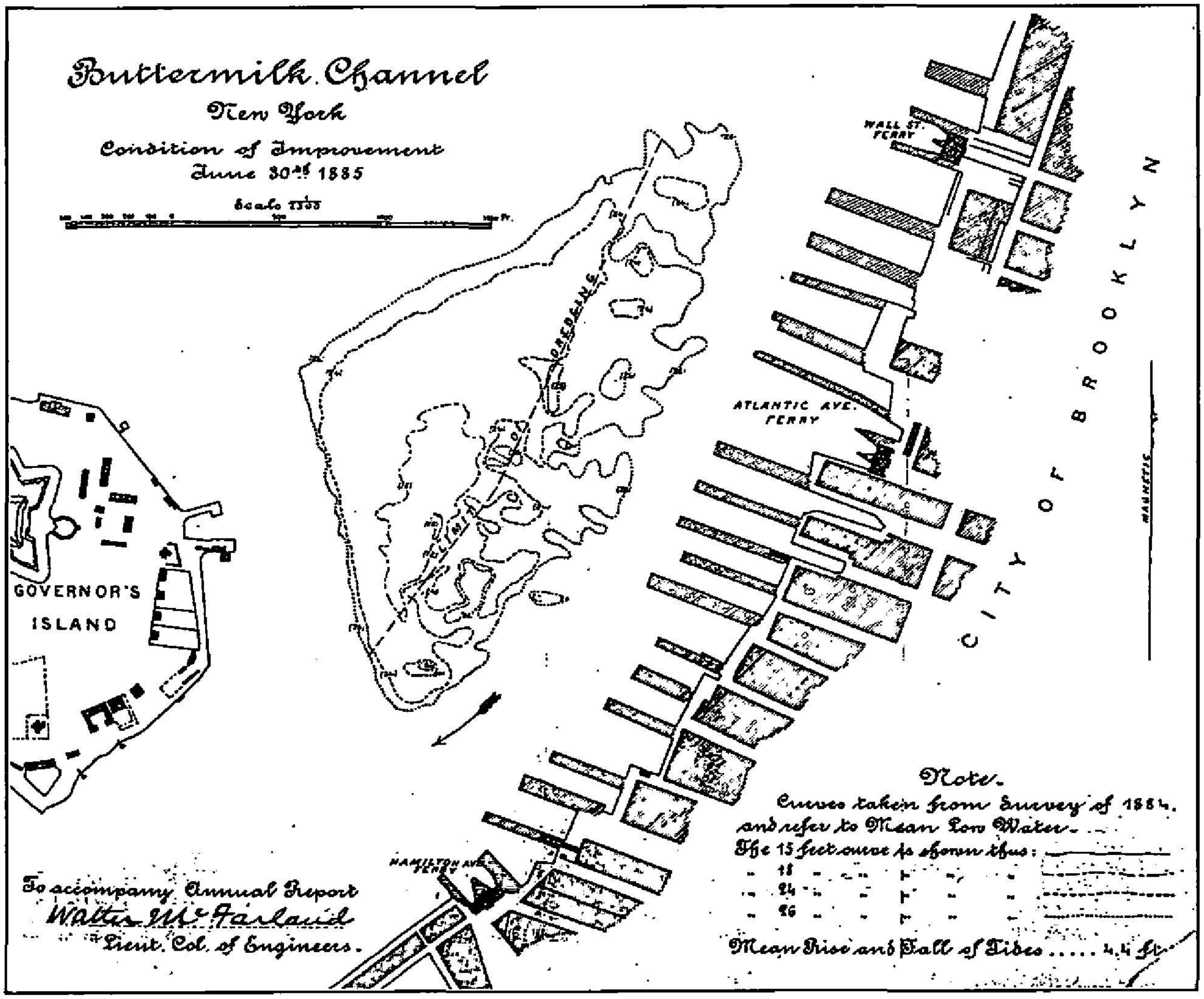

Figure 8. Buttermilk Channel, New York, Condition of Improvement, June 30th 1885. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(U.S. Engineer Bureau 1885).*

26th, 1885, and by the beginning of November 1886, 303,869 cubic yards had been dredged from the channel (Edwards 1893). On the basis of the Engineer's Report (U.S. Engineer Bureau 1886: 737-739) it is possible to reconstruct the stratigraphic sequence encountered during the dredging. The dredging first encountered a bed of live mussels ranging from six to ten inches thick. Some of the mussels were quite large and large quantities of dead shells and a very fine powder of pulverized mussel shells was also encountered. The mussel layer was underlain by a stratum of "pea gravel" to which the mussels often adhered. Beneath the upper stratum of pea gravel the dredging encountered interbedded layers of fine sand and water-worn quartz gravel. The gravel ranged in size from "the size of a pea to the size of a goose egg." About 70 percent of the gravel was classified as "pea gravel." The dredging also encountered a few large pieces of water-worn sandstone, the largest of which measured 13 by 8 by 5 inches. Finally, at the western end of the channel the dredging encountered a stratum of very compact "blue clay" at 33 to 35 feet beneath mean low water. The report notes that this clay is "evidently a very old formation." By 1889 the dredging program had resulted in an unobstructed navigable channel with a 30-foot controlling depth at mean low water and a depth of 34.8 feet at high tide.

Continuing increases in the volume of harbor traffic and the size of vessels fueled additional harbor development. On June 3, 1896 Congress authorized a survey with a view to providing a 35-foot channel at mean low water from the Narrows to the sea. This survey resulted in a recommendation to dredge the East Channel to 40-foot depth and 2,000-foot width. The funds for this project were appropriated by the River and Harbor act of 1899. The East Channel was renamed by an Act of Congress in 1900 to "Ambrose Channel," in honor of Mr. John Wolf Ambrose, who had worked diligently for the improvement of New York Harbor. The channel continues officially to be known by this name (U.S. Engineer Bureau 1939). This project was completed in 1914, providing a mean low water controlling depth of 40 feet and a width of 2,000 feet. A total of approximately 66,000,000 cubic yards of material was removed under the project.

Passage in 1888 of the Federal Rivers and Harbors Act gave the U.S. Engineer Bureau (now the U.S. Army Corps of Engineers) control over all navigable waters in the United States, including sole power to establish bulkhead and pierhead lines. With the 1898 consolidation of Greater New York under a single municipal government, the Department of Docks also became responsible for city-owned ferries and ferry terminals and was renamed the Department of Docks and Ferries (Betts 1997; Hoag 1911). Meanwhile, the development of the New Jersey portion of the harbor lagged, in part because of the lack of a comprehensive, cooperative approach to waterfront use. A 1914 report by the New Jersey Harbor Commission, entitled "New Jersey's Relation to the Port of New York" noted that New York City's waterfront development had cost more than $100 million and that waterfront development annual revenue in excess of $4½ million. The commission contrasted this situation with conditions on the New Jersey side of the harbor:

> It is only necessary to glance at the two sides of the Hudson River (below Weehawken) to see how much benefit New York has gained from its docks, for forty years under one central control, as compared with the development of the New Jersey side, which, with the exception of the steamship terminal at Hoboken, is practically nothing but a series of railroad yards. New Jersey's waterfront within the limits of the Port of New York is under the control of many separate municipalities and the limit of this control has usually been the building department's supervision of the proposed structures (New Jersey Harbor Commission 1914:6).

The report recommended creation of a permanent New Jersey Harbor Commission with statutory authority to regulate all waterfront development in the state. After World War I, the long-standing New York-New Jersey animosity was considered as hindering unified development of New York Harbor. Therefore, the Port of New York Authority was created on April 30, 1921. Adapted from the Port of London governance model, the Port of New York Authority was the first interstate agency created under a clause of the Constitution permitting compacts between states. It was also the first agency of its type in the Western Hemisphere. In 1972 the name of the agency was changed to the Port Authority of New York and New Jersey (Port of New York Authority 1946; Port Authority of New York and New Jersey 1996).

As dredging of the recently-renamed Ambrose Channel was nearing completion, the River and Harbor Act of March 4, 1913, authorized a survey for a channel 40 feet deep and 2,000 feet wide as an extension of Ambrose Channel through Upper Bay. Funded by the Act of August 8, 1917, the project was commonly known as the Anchorage Channel and was completed in 1929. A similar large-scale project was initiated in the Stapleton vicinity, located above the Narrows on the northeast shore of Staten Island. This area offered a substantially undeveloped stretch of waterfront approximately 6,300 feet in length (U.S. Engineer Bureau 1939). Piers over 1,000 feet long could be constructed in this area, where the natural water depth at the pierhead line exceeded 40 feet. A composite map compiled in 1939 depicted a complex network of Federal projects throughout the harbor (Figure 9). However, the Port Elizabeth, Port Newark, and Port Jersey areas remained relatively undeveloped.

The most recent major project has been the removal of drift and debris from shorelines of the entire New York Harbor (Hammon 1976; USACE 1971). The New York Harbor Collection and Removal of Drift Project ultimately recommended the removal or repair of 2,230 timber and steel vessels, 100 dilapidated piers, wharves, and miscellaneous shore structures, and 23.6 million cubic feet of timber drift and debris (Hammons 1976:32). One of the highest concentrations of derelict vessels was located in the Port Jersey Channel. The drift removal project was initiated in 1976, in conjunction with development of Liberty State Park in Jersey City. Table 1 presents various data concerning federal dredging projects discussed in the present study, abstracted from a summary of such projects supplied by URS Greiner (1988).

Table 1. Details of federal dredging projects within the New York and New Jersey Harbor navigation channels.

Channel	Project Depth (feet)	Controlling Depth (feet)	Date of Survey
Ambrose Channel	55-45	45	1986
Newark Bay, including branch channels at Port Newark and Port Elizabeth	35-45	31-35	1986
Anchorage Channel	45-55	43	1975
Buttermilk Channel	45-50	35-40	1986

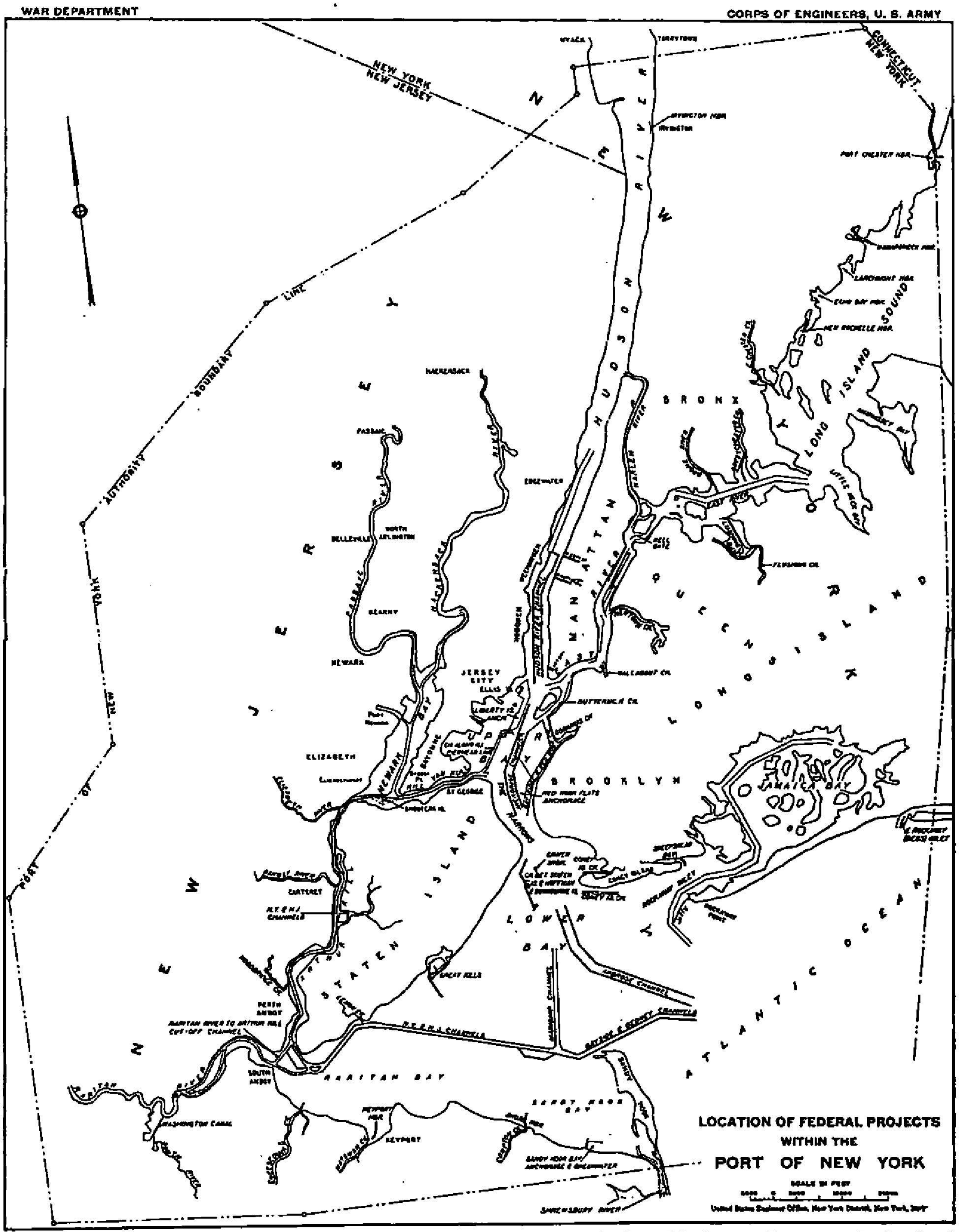

Figure 9. Location of federal projects within the Port of New York. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(U.S. Engineer Bureau 1939).*

Based on the paleoshorelines reconstructed in Section 2 (see Figure 5), all of these active navigation channels appear to have been dredged below the elevation of any terrestrial surfaces younger than 7,000 years old and most can be presumed to preserve no Holocene surfaces whatsoever. It is not necessarily the case that all sediments beneath the channel floors are Pleistocene or older, however, since thick estuarine packages of Holocene age have been reported throughout the harbor (Carmichael 1980; Heusser 1949; LaPorta *et al.* 1999; Lovegreen 1974; Newman *et al.* 1969; Weiss 1967, 1974; Wagner and Siegel 1997). Assessments of archaeological sensitivity presented in Section 8 further assume that the edges of the navigation channels may need to be carved back and this could impact more shallow sediments which have not been dredged previously. Review of dredging and other modifications to the sediments in shoreline environments is an essential component in the evaluation of their archaeological potential. This type of data has therefore been incorporated into the present sensitivity assessments along with geomorphological and paleoenvironmental data.

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5.0 Methodology for Geoarchaeological Investigations

In order to develop meaningful and accurate assessments of archaeological sensitivity, the following methodological objectives were established for the present geoarchaeological investigations in connection with the New York and New Jersey Harbor navigation study:

(1) Development of a paleoenvironmental time line based on radiocarbon chronology;

(2) Identification of variability in shore and near shore landscape history by documenting sediment and facies changes in the suite of geotechnical borings;

(3) Tracking of late Pleistocene and Holocene paleoenvironmental trends through specialized analyses of samples from a selection of the borings performed;

(4) Synthesis of geomorphological, paleoenvironmental and historical data sets to develop a generic model for sensitivity assessment.

The project methodology emphasized stratigraphic and sedimentological analysis of borings with reference to the regional relative sea level rise curve (Newman *et al.* 1969) because archaeological sensitivity on the Atlantic Seaboard is generally keyed to changing shoreline margins that are a function of sea level change. Baseline stratigraphic analyses were in turn indexed with a suite of radiocarbon determinations. Because the boring locations are georeferenced to the bathymetry of the harbor itself, it has been possible to project the types of surfaces which were available for prehistoric groups to settle at given points in time. Paleogeographic reconstructions were refined through specialized analyses including foraminifera, pollen, and plant macrofossils.

As demonstrated by the preceding review of the history of the harbor navigation channels, previous dredging and landfilling have impacted much of the stratigraphy within the present day harbor. The active navigation channels all appear to have been dredged below the elevation of any terrestrial surfaces younger than 7,000 years old. Nonetheless, sediment packages of Holocene age do appear to have been preserved below the current floor in several of the navigation channels, as demonstrated by results presented in the following chapter. This was anticipated in the project methodology, which specified the use of radiocarbon dating and other specialized analyses to recover geomorphological and paleoenvironmental information from these sediment packages.

Data for reconstructing depositional environments and modeling archaeological sensitivity in the vicinity of the harbor navigation channels were obtained from borings performed for geotechnical assessment. A total of 114 borings were performed in 1998 under the supervision of URS Greiner (formerly Woodward-Clyde), a subcontractor to the U.S. Army Corps of Engineers, New York District. GRA project geoarchaeologists accompanied URS Greiner geotechnical inspectors and drilling crews from Warren George, Inc. during the borings and also examined previous borings curated by USACE at their facility in Caven Point, New Jersey.

Borings were performed both from a barge towed to the drill site and from a larger ship, the *Catherine G* (Figure 10). Geoarchaeological field work began November 9, 1998 and involved inspection and sampling of borings from one or both of the two available drilling platforms. Typically, two geoarchaeologists went out on a single rig. One member of the team recorded the stratigraphy of the cores, while a second provided oral descriptions of the sedimentology. The standard geotechnical procedure was to recover two-foot-long split-spoon samples at every five feet in the uppermost sediments (Figure 11). This procedure was generally modified when geoarchaeologists were present so that a continuous series of two-foot spoons was taken until the sediments appeared to be of Pleistocene age (see description of lithologies below). Samples of bulk organic sediment were collected as well as any plant macrofossils observed. Latex gloves had to be worn to inspect and sample many of the uppermost sediments due to contamination with hydrocarbons and other hazardous material.

Following a day of field work, team members transferred observations to a spreadsheet data base which had been developed using the logs from previous borings. Field visits continued until all of the geotechnical borings were completed on December 18, 1998. Twenty-five of the 114 borings were described and sampled by GRA project geoarchaeologists in the field (Table 2). Seven of these borings were in the vicinity of the Newark Bay (NB) navigation channel work area, five borings were in the vicinity of the Port Newark (PN) work area, one boring was in the Port Newark Point (PNP) work area, and two (2) borings were in the Elizabeth Channel (E) work area. Two borings were described and sampled during fieldwork in the Claremont channel (CC) work area, as well as three borings in the Port Jersey (PJ) work area and five borings in the Buttermilk Channel (BC) work area.

GRA also selected for description and specialized study samples an additional 21 borings which had been obtained from the remaining navigation channel work areas prior to the start of the present fieldwork. Thirteen borings in the Anchorage Channel (ANC) work area, seven borings from the Stapleton (STA) work area, and one boring from the Ambrose (AMB) work area were chosen. This brought the total number of borings sampled by GRA to 46 out of the total of 114 performed for the New York and New Jersey Harbor navigation study.

The borings were numbered sequentially by the subcontractor within each of the navigation channel study areas and are prefixed by the year ("98") and the channel abbreviation (e.g., "NB"). Thus, a typical boring designation would be "98-NB-22" or "NB-98-22." Split-spoon samples were also numbered sequentially downhole for each boring (e.g., samples "S1" or "S2" from boring 98-NB-22). These standard abbreviations were used as provenience designations in the specialized analyses presented in Appendices 5 and 6.

Lithostratigraphic description of the borings was based primarily on sediment texture and Munsell color as well as on more subtle bedding characteristics, sorting, and the distribution of whole shells, shell fragments, stones, and other inclusions (Birkeland 1999:347-359; Folk 1974; Reineck and Singh 1973; Soil Survey Staff 1951, 1994). Observation of the split-spoons in the field was invaluable for noting the nature of the contacts between strata as well as the occurrence of varving and other features characteristic of particular depositional environments (Antevs 1925;

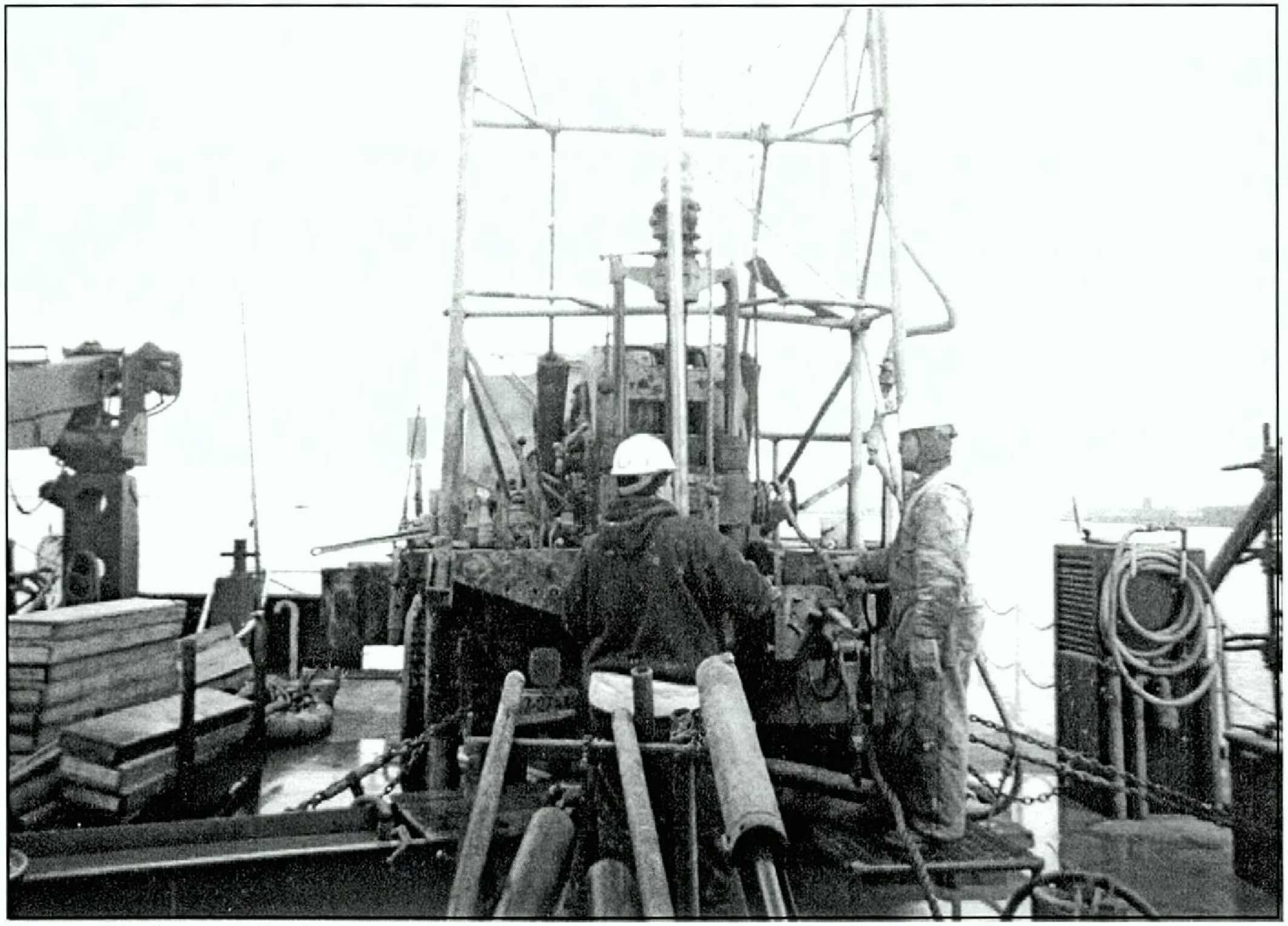


Figure 10. Geotechnical crew with drilling rig on board the ship *Catherine G.* A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 1998)*.

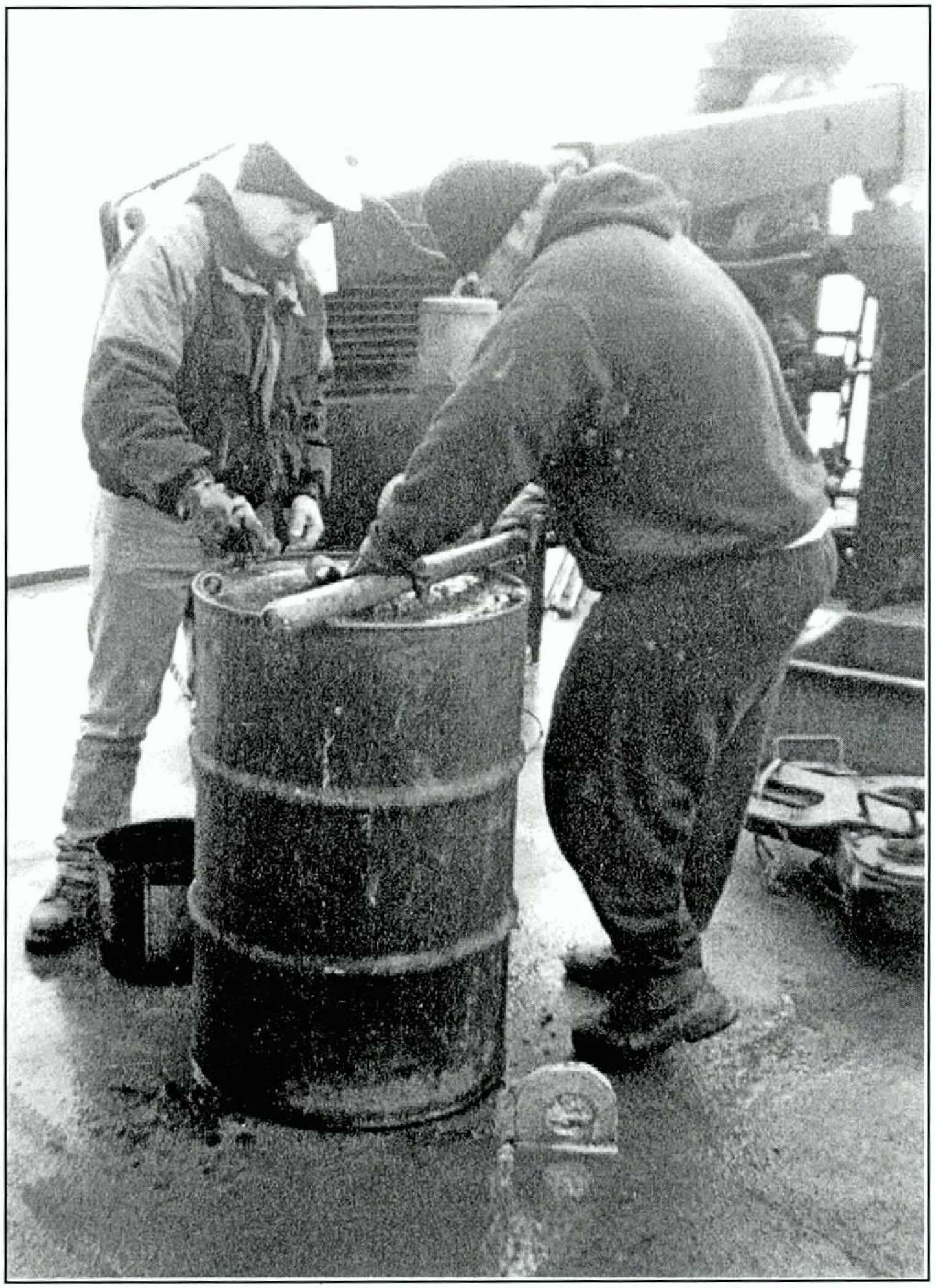


Figure 11. Geologist and driller's assistant opening a two-foot split spoon on board the ship *Catherine G.* A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 1998).*

Table 2. Summary of geoarcheological investigations of New York and New Jersey Harbor navigation channels.

Segment	USACE Work Area	Borings	C14	Forams	Pollen	Plant	Sensitivity
NB	Newark Bay	12, 22, 23, 24, 27, 28, 29	1	7	7	X	Moderate-High
PN	Port Newark	4, 6, 8, 10, 15	X	X	2	X	Low
PNP	Port Newark Point	16	X	X	X	X	Low
E	Elizabeth Channel	13, 15	X	X	X	X	Low
ANC	Anchorage Channel	13 samples * - 12, 25, 29, 33, 39, 41, 44, 63, 64, 65, 98, 103, 104	1	14	14	2	Moderate-High
CC	Claremont Channel	17, 21	X	X	X	X	Moderate-High
PJ	Port Jersey	4, 6, 7	X	X	X	X	Moderate-High
BC	Buttermilk Channel	20A, 24A, 27, 29A, 31	1	X	3	X	Low
STA	Stapleton Channel	7 samples * - 9, 17, 18R1, 18R2, 23R1, 23R2, 25	X	2	X	X	Moderate-High
AMB	Ambrose Channel	1 sample * - 10	X	X	X	X	Moderate-High

Notes: "X" indicates analyses were not performed for the borings from this work area.

* from Caven Point

Sensitivity column assessments are discussed in Section 7.

Brackenridge 1988; Leopold *et al.* 1964; Reineck and Singh 1973; Smith 1985). Possible terrestrial soils were noted in several of the borings based on the size, shape, and structural development of aggregates or "peds" within the sedimentary materials (Birkeland 1984; Soil Survey Staff 1951, 1994).

Specialized analyses were undertaken as appropriate and are listed by Segment in Table 2. Radiocarbon determinations (n=3) were obtained on samples from the Newark Bay (NB), Anchorage Channel (ANC), and Buttermilk Channel (BC) work areas. The limited number of samples reflected results of preliminary sample sorting and interpretations of stratigraphy that indicated that many of the specimens retrieved were either contaminated or provided contexts unsuitable for dating (i.e., minimal organic materials).

Samples from the Newark Bay (NB), Port Newark (PN), Anchorage Channel (ANC), Buttermilk Channel (BC), and Stapleton Channel (STA) work areas were submitted for specialized analyses of foraminifera, pollen, and plant macrofossils. Foram results proved to be productive, as it was possible to document changing biomes and migrations of the estuaries during the Holocene. During a preliminary selection process, samples were grouped by diagnostic potential, resulting in the submittal of 23 specimens. Screening of preliminary pollen samples (n=26) suggested minimal productivity for this analysis and only four specimens were comprehensively analyzed. Plant macrofossils (n=2) isolated freshwater and saltwater biomes and were a productive avenue of investigation. Over the course of the study, it was recognized that the most critical data set for a baseline study of this type was intensive sedimentological examination and mapping. Collectively these observations and the supplementary specialized analysis were key to reconstructing local depositional environments and their potential to preserve cultural resources.

6.0 Results and Stratigraphic Interpretations

The results obtained from the present geoarchaeological investigations establish a regional paleoenvironmental baseline for the Upper New York and New Jersey Harbor and identify a number of discrete settings and stratigraphic packages which merit additional field and laboratory study. An interdisciplinary approach was taken, along the lines suggested by Butzer (1982). Bathymetric, lithostratigraphic, paleobotanical, and foraminiferal analyses contribute a context for interpreting the archaeological materials recovered to date and for projecting where significant materials may remain, both within the harbor and on the present continental land surface.

Chronologies of paleoenvironmental and geomorphological change typically sequence longer and less precisely bounded periods than those obtained from cultural materials (Birkeland 1999: 307-337; Butzer 1982:162-170; Rapp and Hill 1998:153-174). This is as true for the Holocene in the northeastern United States as it is for other periods and places of human occupation. The strong imprint of late Pleistocene glaciation on regional landscapes (Sirkin 1986; Stanford 1997) does facilitate development of generic sequences, however, and postglacial sea level rise can be correlated with estuarine valley fills containing fossil and microfossil evidence of changing salinity and water depth (Newman *et al.* 1969; Weiss 1974).

Radiocarbon dates reviewed in Section 2 bracket the retreat of the Laurentide ice sheet between 21,000 and 18,000 B.P. in conventional radiocarbon years (Taylor 1987:4-6). The calibration of Stuiver *et al.* (1999) currently extends back only to 19,000 B.P. but it does suggest that true "calendar years" for these events may be as much as 4,000 years earlier than the radiocarbon years. Lacustrine sediments in both the lower Hudson River valley and the Hackensack Meadowlands have traditionally been interpreted as evidence for very large, contemporaneous meltwater impoundments behind the terminal Harbor Hill moraine (Antevs 1925; Lovegreen 1974; Reeds 1925, 1926; Salisbury 1902; Salisbury and Kummel 1893; Schuberth 1968).

Two samples of organic sediment from the borings obtained for the present study were dated to the late Pleistocene. A sample from 17 to 19 feet below the floor of the Newark Bay channel (–53 feet MSL) dated to 29,600 ± 360 B.P. (Beta-127020) and a sample from 13 to 15 feet below the floor of the Buttermilk Channel (approximately -59 feet MSL) dated to 26,000 ± 300 B.P. (Beta-127022). These dates are both surprisingly early and appear to index organic materials from the interstadial oxygen isotope Stage 3 preserved within or beneath sediments deposited during deglaciation. Anomalously old radiocarbon dates could also result from the presence of petroleum and other hydrocarbons in the estuarine sediments (Taylor 1987:42). Each of the samples dated was from a deposit which typifies late Pleistocene substrates, however. At least ten feet of the uppermost estuarine sediments capping these substrates were probably removed in each of these channels by dredging activities detailed in Section 4.

Synthesis of the stratigraphic details for the 46 borings examined in this study indicates one generic sequence for the lower Hudson River valley (Buttermilk, Anchorage, Claremont, Port Jersey, Stapleton, and Ambrose navigation channels) and another, slightly different sequence for the lower Hackensack and Passaic drainages (Newark Bay, Port Newark, Port Newark Point, and

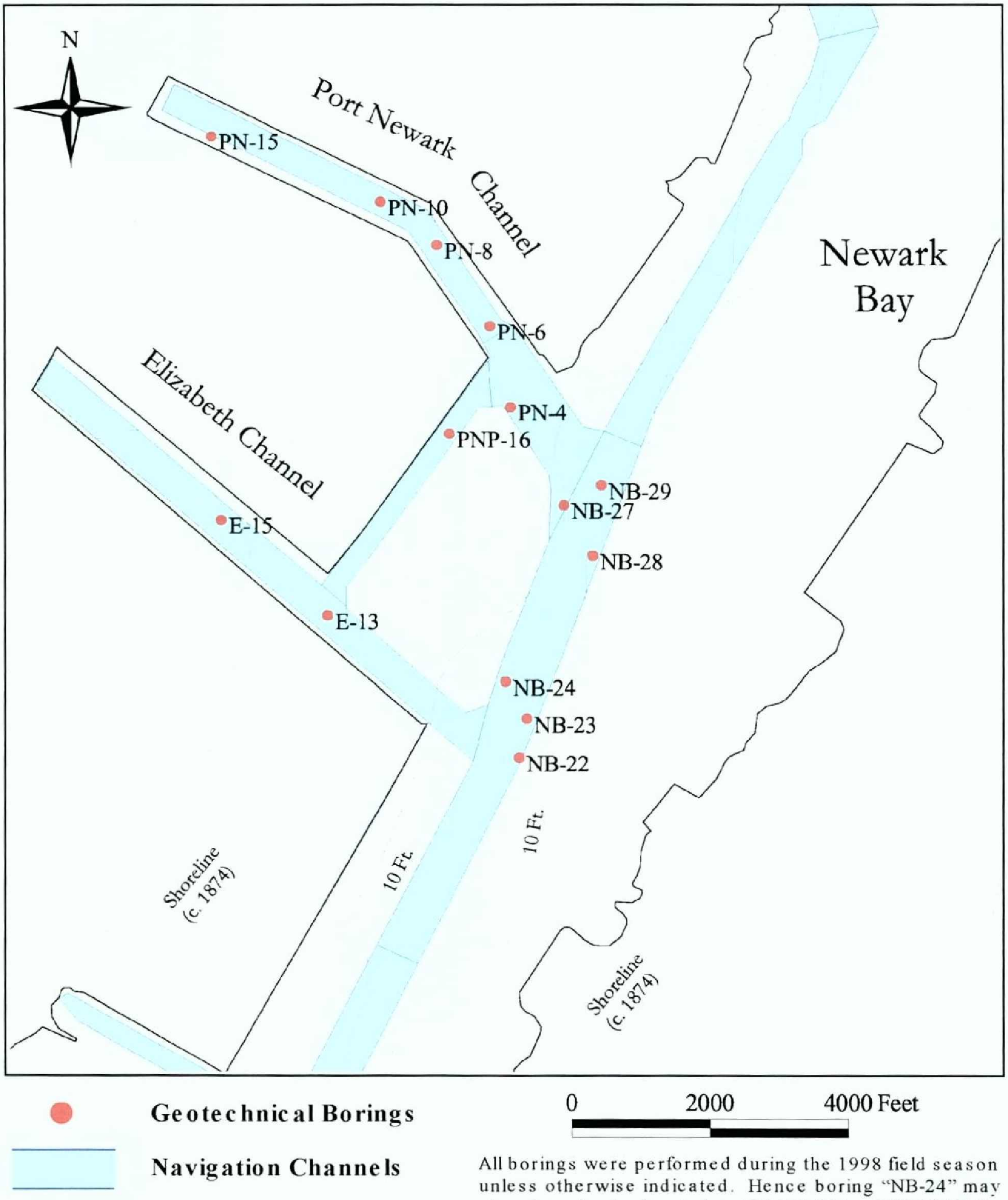
Elizabeth navigation channels). The former sequence consists of Wisconsinan ice-contact and meltwater deposits capped by quartzose sheet sands. The uppermost estuarine silts in the lower Hudson River valley are typically much younger than these sands, with dates more recent than 2000 B.P. reported by both Newman *et al.* (1969) and Weiss (1974).

Evidence of soil formation and shoreline stability from terrestrial records in the lower Hudson River valley dates after 4000 years B.P. (GRA 1996a, 1996b; Herbster *et al.* 1997; Schuldenrein 1995; Thieme and Schuldenrein 1999c). Submerged contexts within the harbor, however, may conceivably provide a more detailed picture of the intervening window. Contexts identified in the present study include flood-plain facies deposits buried over 20 feet below the harbor floor in the Anchorage Channel work area. A radiocarbon date of 9400 ± 150 B.P. (Beta-127019) was obtained on wood from a reduced clay at one of these boring locations (98-ANC-44), indexing the Holocene flood plain prior to the onset of tidal inundation. Mid-Holocene sediment packages appear to be more common than early Holocene ones in terrestrial settings and are particularly associated with the margins of freshwater ponds or marshes (Nicholas 1988, 1998; Schuldenrein 2000; Thieme and Schuldenrein 1996).

The generic sequence for Newark Bay and the lower reaches of the Hackensack and Passaic River valleys is somewhat different from the lower Hudson sequence summarized above. Brunswick shale or intrusive igneous bedrock are encountered at variable depths, overlain by very dense reddish brown glacial till and then by massive reddish brown clay or lacustrine clay with thin sand varves. These lacustrine sediments are tentatively correlated with the glaciolacustrine facies encountered at an unconformable contact from 12 to 30 feet below the present land surface in the Hackensack Meadowlands (Lovegreen 1974). For many of the borings described in the following stratigraphic summaries dredging activities appear to have removed all naturally deposited sediment down to these late Pleistocene deposits. Borings depicted on the accompanying maps (Figures 12, 13 and 14) include all 44 locations listed in Table 2 as well as borings in the vicinity of the navigation channel areas performed for previous studies by GRA (1996, 1997), La Porta et al. (1999), Schuldenrein (2000), Thieme and Schuldenrein (1996, 1998), and Wagner and Siegel (1997).

Newark Bay (NB)

Seven borings were examined in this work area (Figure 12) and all of them were monitored in the field. Six of these borings (NB-98-12, NB-98-23, NB-98-24, NB-98-27, NB-98-28, and NB-98-29) penetrated over 50 feet below the harbor floor, and Newark Group sedimentary bedrock was reached in all but NB-98-28. The borings had a remarkably consistent stratigraphy with at least 10 feet of till over bedrock capped by as much as 30 feet of lacustrine or glaciolacustrine clay. Varves were noted in borings NB-98-24 and NB-98-27, gray or gray-green sandy "summer" varves alternating with brown "winter" muds. The remaining lacustrine muds were reddish brown, characteristic of their derivation from Brunswick shale outcropping upstream within the Hackensack basin.



All borings were performed during the 1998 field season unless otherwise indicated. Hence boring "NB-24" may elsewhere be designated as "98-NB-24" or "NB-98-24."

Figure 12. Newark Bay, Port Newark, Port Newark Point, and Elizabeth Navigation Channel study areas. (Note that bathymetric contours are circa 1874.) A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*

A sample from 17 to 19 feet below the harbor floor (53.5-55.5') in boring NB-98-28 had a radiocarbon date of 29,600 ± 360 B.P. (Beta-127020); this suggests that some of the massively bedded late Pleistocene clays are not of proglacial origin and instead represent interstadial freshwater or brackish impoundments. Barite crystal aggregates ("desert rose") inherited from the Newark Group lithologies were identified from this same depth by E. Thomas in both NB-98-24 and NB-98-28 (see Appendix 5). These evaporite grains weather rapidly and indicate the sediments were probably eroded and redeposited rapidly in a glacial environment with little or no chemical erosion. Samples from 43.5-45.5 ft and 48.5-50.5 ft in boring NB-98-28 also contained calcareous benthic foraminifera common in intertidal to shallow subtidal settings. The suggested interpretation is a late Pleistocene meltwater lake which was then flooded gradually by the sea at some point, probably also in the Pleistocene and possibly as early as oxygen isotope Stage 3. Only four of the seven borings examined contained capping sediments which can be considered to be Holocene in age. Brown clayey silt or silty clay in the upper five feet of borings NB-98-23 and NB-98-27 probably represents Hackensack River alluvium. Borings NB-98-24 and NB-98-28 contained more organic silty capping sediments characteristic of relatively late Holocene tidal inundation. The remaining borings were in locations which appear to have been dredged down to the late Pleistocene clayey substrate.

Port Newark (PN)

Five (5) borings were examined in this work area, all of which were monitored in the field (Figure 12). Three of these borings (PN-98-4, PN-98-10 and PN-98-15) encountered Newark Group sedimentary bedrock at less than 20 feet below the harbor floor. Overlying sediment in boring PN-98-6 resembled the massively bedded glaciolacustrine clay described above for the Newark Bay work area. The more landward borings, PN-98-10 and PN-98-15, encountered up to 10 feet of stiffer clayey till with common faceted stones. Till was also encountered at the bottom of boring PN-98-6, capped by the massively bedded glaciolacustrine clay. Boring PN-98-8 had a more complex stratigraphy indicating high energy deposition. Abundant angular rock fragments implicate colluvial as well as alluvial depositional environments.

Port Newark Point (PNP)

One boring (PNP-98-16) was monitored from this work area during the 1998 field season (Figure 12). This is a ship passage along the point of land between the Port Newark and Elizabeth channels. Newark Group sedimentary bedrock was encountered just over 20 feet below the harbor floor, capped by stiff clayey till with faceted angular cobble clasts of metamorphic lithologies. Approximately 10 feet of massively bedded glaciolacustrine clay capped the till and continued to the top of the boring. This work area consequently appears to have been dredged down to this late Pleistocene clayey substrate.

Elizabeth Channel (E)

Two (2) borings were examined from this work area, both of which were monitored in the field (Figure 12). Argillite bedrock was encountered at 31 feet below the harbor floor in boring E-

98-13 while boring E-98-15 bottomed out in sandy till at slightly over 30 feet. Both borings exhibited complex upper stratigraphy suggestive of ice-contact or "flow till" deposition. Clayey units had sandy laminae of inconsistent thickness and alternated with gravelly or sandy units less than five feet thick. While the boring E-98-15 location has been dredged down to a late Pleistocene clayey substrate, boring E-98-13 was capped by massive micaceous sand and a thin lense of silty alluvium. The sand may be artificial spoil and the alluvium is clearly a modern harbor sediment.

Anchorage Channel (ANC)

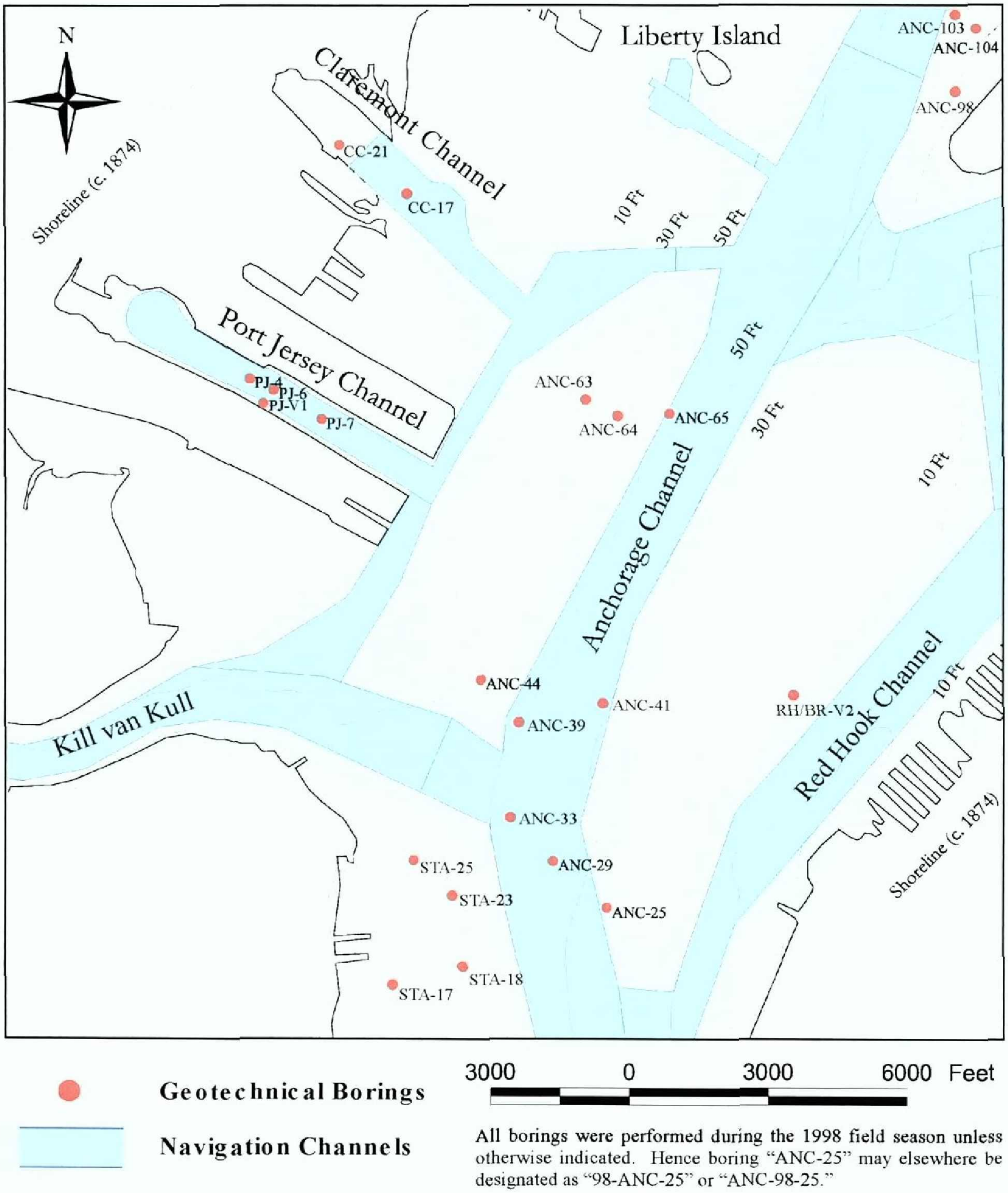
Thirteen (13) borings from this work area (Figure 13) were described and selected from the Caven Point facility's samples. The borings were designated ("98-ANC-") 12, 25, 29, 33, 39, 41, 44, 63, 64, 65, 98, 103, and 104. None of these borings reached bedrock, although 98-ANC-63 and 98-ANC-104 both extended over 50 feet below the harbor floor. Massively bedded, quartzose, glaciolacustrine or fluviolacustrine sands represent from 5 to 15 feet at or near the base of the stratigraphic column in all of the borings examined with the exception of 98-ANC-44 and 98-ANC-65. These latter two borings exhibited fine textured sediment rich in plant material or shell hash throughout their extent.

Specialized analyses of foraminifera or pollen and plant macrofossils were performed on samples from borings 98-ANC-25, 98-ANC-29, 98-ANC-44, 98-ANC-65, and 98-ANC-104. Figure 13 plots the location of these borings while 98-ANC-104 was adjacent to Governors Island and is also plotted on Figure 14. The stratigraphy for boring 98-ANC-44 was indexed with a radiocarbon date of 9400 ± 150 B.P. (Beta-127019) on wood from a reduced clay 30 to 32 feet below the harbor floor. Evidence of oxidation and possibly soil formation was observed in sample S14 (28-30 ft) from the same boring, a silt loam with no shell material but abundant small plant fragments. No foraminifera were found in this sample by E. Thomas in her analyses (see Appendix 5), corroborating the inferred fluvial deposition. Benthic foraminifera and centric diatoms were found in samples S11 (20-22 ft), S12 (22-24 ft), and S13 (24-26 ft), indicating an intertidal depositional environment not too different from present water depths. Agglutinated foraminifera found in S12 (22-24 ft), however, suggest a salt marsh setting.

A similar but somewhat more complex sequence of environmental changes is recorded by the analyses for samples from boring 98-ANC-65. The lower two samples analyzed, S9 (16-18 ft) and S12 (22-24 ft), contained common plant fragments and agglutinated foraminifera, typical of middle to high marsh settings within the intertidal zone. Overlying assemblages suggest a deepening of the water column either due to rising sea level or to the migration of the channel toward the boring location.

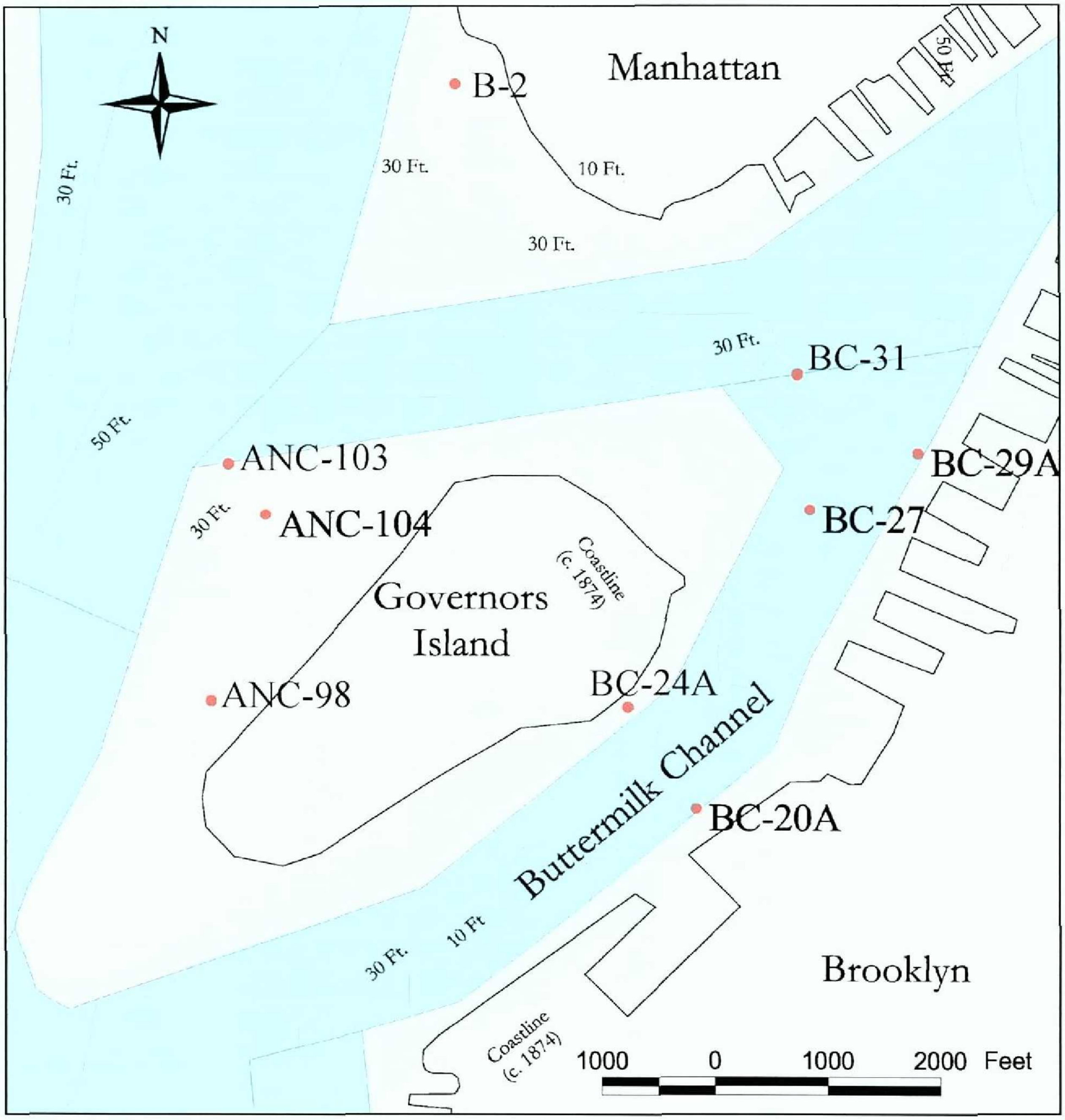
Claremont Channel (CC)

Two (2) borings in this work area, CC-98-17 and CC-98-21, were monitored in the field (Figure 13). Both extended over 30 feet without reaching bedrock. A late Pleistocene glaciolacustrine deposit was observed at the base of CC-98-17 (61-66 ft), with reddish brown "winter" muds and grayish brown sandy "summer" varves. Overlying massively bedded brown



All borings were performed during the 1998 field season unless otherwise indicated. Hence boring "ANC-25" may elsewhere be designated as "98-ANC-25" or "ANC-98-25."

Figure 13. Anchorage, Claremont, and Port Jersey Navigation Channel Study Areas. (Note that bathymetric contours are circa 1874.) A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*



● **Geotechnical Borings**

🟦 **Navigation Channels**

All borings were performed during the 1998 field season unless otherwise indicated. Hence boring "BC-27" may elsewhere be designated as "98-BC-27" or "BC-98-27."

Figure 14. The Buttermilk Channel Study Area between Brooklyn and Governors Island. (Note that bathymetric contours are circa 1874.) A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*

sandy clay is more typical of the lower Hudson River valley sequence and correlates with reddish brown clay at equivalent depths (40-60 ft) in boring CC-98-21. From 6 to 7 feet of finer-textured, probable Holocene sediment were encountered at the top of both of the borings examined in the Claremont Channel work area. Although a 20th century age is indicated by a petroleum odor in some of these sediments, deposits buried over five feet below the harbor floor are of uncertain age and may be equivalent to regional periods of prehistoric settlement. A coarse, poorly sorted sand deposit from 6 to 10 feet below the harbor floor in boring CC-98-17 clearly represents some natural high-energy flood event either from the Hudson River itself or the creek which originally incised this channel.

Port Jersey Channel (PJ)

Three borings were examined from this work area (PJ-98-4, -6 and -7), all of which were monitored in the field (Figure 13). Boring PJ-98-7 reached bedrock at nine feet below the harbor floor, a saprolitized schist which changed to gneiss with depth. All three borings encountered from six to ten feet of glacial till with a reddish brown clayey matrix, as previously described for boring PJ-V1 by LaPorta *et al.* (1999). However, coarse, poorly sorted, heterolithic sand was found beneath the clayey till at 15 to 17 feet below the harbor floor in borings PJ-98-4 and PJ-98-6. Reddish brown clay with gray laminations in the upper 5 to 9 feet of the navigation channel work area is a probable Holocene deposit resulting from fluvial or estuarine reworking of the till. Although a 20th century age is indicated by a petroleum odor in the upper muds at PJ-98-7, deposits in the other two borings are probably equivalent in age to periods of prehistoric settlement. There appears to have been relatively little disturbance by dredging at these locations.

Buttermilk Channel

Buttermilk Channel is a body of water approximately 1500 feet wide and 30 feet deep separating Governors Island from Brooklyn (Figure 14). Five borings were examined in this work area, all of which were monitored in the field. The stratigraphy of borings BC-98-20A, BC-98-24A, and BC-98-27 featured massively bedded, coarse, poorly sorted sand, variably micaceous, in beds from 12 to 15 feet thick. A late Pleistocene age is inferred for these high-energy sands based on the radiocarbon date of 26,000 ± 300 B.P. (Beta-127022) on a sample from the brown clayey silt at the base of boring BC-98-27. Similar fine-textured sediment was observed between 58 and 63 feet below the harbor floor in BC-98-20A, while beds of till with large angular and faceted pebble clasts were observed in borings BC-98-24A and BC-98-29A. Boring BC-98-29A also featured varved silt and clay with gray-green, sandy "summer" varves beginning approximately seven feet below the harbor floor. The stratigraphic results (discussed in Section 7) suggest a high-energy depositional environment some of which may predate the last glacial advance as indicated by the radiocarbon date. The absence of Holocene deposits may also in part reflect the previous dredging within areas shown in Figures 7 and 8.

Stapleton Channel (STA)

Seven borings from this work area were described and selected from the Caven Point curation facility. The borings were designated 98-STA-9, 98-STA-17, 98-STA-18-R1, 98-STA-18-R2, 98-

STA-23-R1, 98-STA-23-R2, and 98-STA-25 (only the last is depicted on a map, Figure 13). All of these were performed with a vibracore apparatus to depths of less than 20 feet below the harbor floor and none of the borings reached bedrock. The "R1" and "R2" segments of borings 98-STA-18 and 98-STA-23 signify that these borings had to be performed in two separate pushes due to the resistance of the sediments. Both of these borings bottomed out in gray to olive brown massively bedded, quartzose, fine sand similar to deposits previously examined in this work area by Louis Berger and Associates (1985) and inferred to represent deposits from a "post-glacial freshwater lake." Finer-textured sediments at equivalent depths at the base of borings 98-STA-9, 98-STA-17, and 98-STA-25 typify Holocene estuarine sediments. The sample from 6 feet below the harbor floor in 98-STA-25 that was analyzed by Ellen Thomas (see Appendix 5) contained both agglutinated and calcareous benthic foraminifera as well as ostracodes, indicating deposition on mud flats just below the intertidal zone.

Ambrose Channel (AMB)

A single boring from this work area, AMB-98-10, was described and selected from the Caven Point curation facility. The boring extended for 30.5 feet below the harbor floor without penetrating bedrock. A sample of preserved plant fragments was recovered from 23 feet for possible radiocarbon dating. Sediments are generally fine sand with occasional lenses of shell hash or plant material and appear to be Holocene in age.

Stratigraphic and Paleoenvironmental Baseline for Sensitivity Assessment. The preceding data from 46 geotechnical borings in the New York and New Jersey Harbor navigation channel work areas provide a stratigraphic and paleoenvironmental baseline for assessing the archaeological potential of submerged settings within the lower Hackensack and Hudson River valleys. Table 3 summarizes the data for each of the navigation channel work areas, showing that areas of moderate-high sensitivity are generally those which have relatively thick accumulations of Holocene sediments. Locations in the Newark Bay (NB), Claremont Channel (CC), Port Jersey (PJ), Anchorage Channel (ANC), Stapleton Channel (STA), and Ambrose Channel (AMB) work areas are considered to have a moderate-high potential for submerged cultural resources while only low potential characterizes the other navigation channel study areas. (This is discussed in more detail in Section 7.)

Table 3. Summary of stratigraphic and paleoenvironmental data from the New York and New Jersey Harbor Navigation work areas.

Work Area	Depth to Bedrock	Late Pleistocene Deposits	Holocene Package(s)	Biostratigraphy	Archaeological Sensitivity
Newark Bay (NB)	<50 feet	Reddish brown, massively bedded or varved, glacio-lacustrine sandy clay (approx. 30 feet)	Brown clayey silt (< 5 feet)	Benthic forams with glaciolacustrine seds	Moderate-High
Port Newark (PN)	<20 feet	Clayey till with faceted stones	Deeply dredged, possible high energy colluvium (< 5 feet)	NA	Low
Port Newark Point (PNP)	20-25 feet	Clayey till with faceted angular metamorphic cobbles	Dredged to Pleistocene	NA	Low
Elizabeth Channel (E)	30-35 feet	Clayey till or massively bedded glaciolacustrine sandy clay	Massive micaceous sand and silty alluvium (< 5 feet)	NA	Low
Anchorage Channel (ANC)	>50 feet	Massively bedded, quartzose sands (5-15 feet)	Brown silt and clay rich in plant materials and/or shell hash (> 30 feet)	Benthic and agglutinated forams, centric diatoms, pollen of oak zone	Moderate-High
Claremont Channel (CC)	>30 feet	Reddish brown, varved, glaciolacustrine sandy clay (approx. 20 feet)	Brown silt and clay (< 5 feet)	NA	Moderate-High
Port Jersey (PJ)	9-20 feet	Clayey till with faceted stones	Reddish brown clay with gray laminations (<10 feet)	NA	Moderate-High
Buttermilk Channel (BC)	>50 feet	Massively bedded, coarse quartzose sands (> 30 feet)	Dredged to Pleistocene	NA	Low
Stapleton Channel (STA)	>20 feet	Gray to olive brown, massively bedded, quartzose fine sand (5-10 feet)	Grayish brown fine sand and silt	Ostracodes, agglutinated and calcareous benthic forams	Moderate-High
Ambrose Channel (AMB)	>30 feet	Probably found deeper than 30 feet below the harbor floor	Grayish brown fine sand and silt	Plant material	Moderate-High

7.0 General Model for Cultural Resource Sensitivity

In order to synthesize observations on the relationships between cultural resource potential, dynamic landscapes of the past 20,000 years, and the impacts of dredging on former human landscapes it is necessary to draw on several bodies of information from the geological and archaeological records. In general the geological record offers a wider range of data because several disciplines—geography, marine science, palynology, and sedimentology—have contributed variously to the data base. In contrast, the archaeological information is considerably more uneven, since most investigations prior to the implementation of the National Historic Preservation Act (NHPA) were not systematic and the thirty years of subsequent research have produced limited results because of the complex logistics of both subaqueous archaeological exploration and access to cultural deposits in urban and "made" landscapes. "Made" landscapes are especially resistant to large scale archaeological exploration in the New York metropolitan environment because of the extent and depth of landfilling and because coastline engineering has permanently modified the shore environments and the patterns of near shore sedimentation.

Formulating the Model: Baseline Information. Given the general limitations on linking the buried landscape and archaeological records, the present research facilitates development of a model of cultural resource sensitivity based on three general sets of factors. These may be grouped as follows:

(1) Geomorphic and paleoenvironmental trends
(2) Archaeological site geography
(3) Historic impacts on the channel settings

Each set of factors is summarized in turn. The comprehensive sensitivity model must also consider the integration of these factors on a channel-by-channel basis. Thus, for example, if a particular channel setting had a broad coastline during Woodland times, but shoreline dredging in the early 20th century effectively removed the sediments dating to that period, cultural resource sensitivity for Woodland sites would be minimal.

The balance of this discussion analyzes the sets of factors contributing to cultural resource sensitivity, utilizing the data compiled from this report. It then synthesizes the factors to produce a ranking of sensitivity for the individual channel impact areas. The presentation concludes with strategies for near and long term management of the cultural resources for New York Harbor.

Geomorphic and Paleoenvironmental Trends. As developed in Sections 2 and 3 of this report, the most critical barometers of landscape and Late Quaternary environmental change include these factors:

- the patterned rise of Holocene sea level
- the shape, extent, and biotic potential of the former coastline during particular periods
- distinct sedimentation modes during phases of sea level rise
- age of Holocene sediments

Patterned rise in sea level is perhaps the most important of the factors since it is the most widely accepted barometer of landscape modification and is the baseline for projecting the shape of the former coastline through time. Postglacial sea level rise (after 12,000-10,000 B.P.) resulted in drowning of surfaces that may have been occupied prehistorically. The widely accepted curve for relative sea level when projected onto bathymetric contours in the New York Bight allows for projection shorelines, and thus prehistoric surfaces, beginning at 12,000 B.P. (-100 feet) and continuing in millennial increments. As the continent deglaciated, isostatic rebound slowed the rate of sea level rise during a period (ca. 8000-3000 B.P.) when coastal occupations apparently became prevalent in the northeastern United States (Funk and Pfeiffer 1988; Pretola and Little 1988; Ritchie 1969, 1980; Salwen 1962) (see also Figure 4). Between 5000 and 3000 B.P. sea level had risen to within 13 feet of present heights. After 3000 B.P. sea level rise slowed appreciably and the transgressions of the 3000 years are within a 10 ft vertical band. Significantly, however, the impacts of industrial age erosion and contemporary ocean circulation systems have produced unique depositional patterns in the "made" landscapes of New York Harbor.

Once the buried levels of former shorelines were established it was possible to project time-transgressive shorelines based on bathymetric models (i.e., contours of submerged topography). As shown in Figure 5, the habitable Coastal Plain land surface extended at least 60 miles onto the present continental shelf during the Paleoindian period (Bloom 1983a:220-222; Emery and Edwards 1966; Stright 1986:347-350). Kraft's (*et al.* 1985) paleoshoreline reconstruction for the mid-Atlantic region suggests that there was still an additional ten miles of Coastal Plain ca. 9000 B.P. Succeeding shorelines rapidly approach the present contours. All other factors considered, stratified shoreline occupations would be expected to have existed within the ten-mile belt of the Middle Atlantic shore.

The third factor in this data set—distinct modes of sedimentation during sea level rise—is reasonably well understood regionally, but poorly documented locally. The chronology of late glacial to post-glacial sedimentation was initially explored by Newman *et al.* (1969) who identified the preponderance of glacial lakes in the Hudson Valley and their signature alternating clay and silt beds. After 12,500 B.P. these beds were overridden by glacial meltwater sands whose distributions remain incompletely mapped. What is currently clear is that estuarine fines—finer sands, organic silts, and clays—typically cap sand deposits in many differentiated shoreline settings after 5000 B.P. Thus the sands may date to between 10,000 and 5000 B.P. but the absence of complete chronologies is complicated in the near channel settings by the ongoing dredging activities that have tended to redistribute the sands in various harbor settings.

Ages of the Holocene sediments remain poorly understood for the harbor area, in part because of the extensive historic reworking of shore facies. A relatively complete record of radiocarbon dates for the harbor and environs is compiled in Table 4. Samples include specimens examined for a variety of projects in the New York Harbor vicinity by the present group of investigators and several other teams. Dated materials were taken from surface and near surface contexts at elevations extending to 60 ft below mean sea level. The data show that radiocarbon determinations document nearshore transformations for the late Pleistocene and peak glacial environments. Dated materials, however, are rare for terminal deglaciation (especially on the coast); there is a gap in the

Table 4. Radiocarbon dates for paleoenvironmental and archaeological contexts in the New York and New Jersey Harbor region.

Location	Elevation				Lithofacies/ Biofacies	Material	C14 yr B.P.	Calibrated 2-sigma (Calendar yr)	Lab Numbe
	m bls	ft bls	m MSL	ft MSL					
Anchorage Channel - 98-ANC-44*	9.50	31.00	-20.12	-66.00	Fluvial lag?	wood	9400±150	BC 9216 (8717, 8713, 8689, 8663, 9646, 8642, 8633) 8286	Beta-127019
Buttermilk Channel - BC-98-27*	4.30	14.00	-17.98	-59.00	Interglacial lacustrine	Bulk sediment	26,000±300	NA	Beta-127022
Newark Bay - 98-NB-28*	5.50	18.00	-16.61	-54.50	Interglacial lacustrine	Bulk sediment	29,600±360	NA	Beta-127020
Arthur Kill (off Shooters Island)	2.00	6.56	-2.30	-7.55	Fluvial lag	wood	3040±120	BC 1530 (1300) 930	Beta-137984
Arthur Kill (off Shooters Island)	3.66	12.00	-4.60	-15.09	Estuarine silt	Bulk sediment	4340±80	BC 3325 (2915) 2770	Beta-137986
Arthur Kill (off Shooters Island)	1.68	5.50	-2.56	-8.40	Estuarine silt	Bulk sediment	6100±60	BC 5225 (5005) 4830	Beta-137985
Arthur Kill (off Wards Point)	8.38	27.49	-20.73	-68.00	Fluvial lag?	wood	7950±70	BC 7064 (6980, 6970, 6946, 6938, 6901, 6883, 6826) 6642	Beta-?
Carlstadt 90-5	1.68	5.50	-0.70	-2.30	Brackish marsh		2160±80	BC 396 (199, 186, 184) AD 17	Beta-39925
Carlstadt 91-2	0.58	1.90	0.50	1.64	Brackish marsh	Plant macrofossils	2140±90	BC 396 (195, 173) AD 54	Beta-47271
Carlstadt 91-3	6.00	19.69	-5.00	-16.40	Glaciolacustrine?	Bulk sediment	22,040±550	NA	Beta-53001
Carlstadt 91-3	8.00	26.25	-7.00	-22.97	Glaciolacustrine?	Bulk sediment	22,310±1070	NA	Beta-55265
Carlstadt 91-4	0.90	2.95	0.30	0.98	Brackish marsh	Plant macrofossils	1130±70	AD 694 (897, 922, 942) 1023	Beta-47272
Collect Pond	7.60	24.93	-1.50	-4.92	Freshwater marsh	Peat	1220±60	AD 664 (779) 977	Beta-130393
Collect Pond	8.20	26.90	-2.10	-6.89	Freshwater marsh	Peat	2490±60	BC 800 (759, 682, 665, 636, 590, 579, 554) 402	Beta-130394
Collect Pond	8.80	28.87	-2.70	-8.86	Freshwater marsh	Peat	3500±50	BC 1944 (1876, 1842, 1812, 1799, 1778) 1688	Beta-130395
Collect Pond	9.40	30.84	-3.30	-10.83	Interior paleosol	Bulk sediment	4590±40	BC 3500 (3360) 3121	Beta-130396
Goethals Bridge AT-4	4.00	13.12	-3.50	-11.48	Salt marsh	Peat	770±60	AD 1161 (1271) 1379	Beta-95083
Goethals Bridge B-305	3.95	12.96	-3.45	-11.32	Freshwater marsh	Peat	2250±80	BC 410 (363, 269, 262) 93	Beta-92924
Goethals Bridge G-1	3.66	12.00	-2.13	-7.00	Freshwater marsh	Peat	2540±60	BC 815 (779) 441	Beta-100256
Goethals Bridge G-1	4.27	14.00	-2.75	-9.00	Fluviomarine sand	Bulk sediment	2770±60	BC 1048 (904) 805	Beta-100252
Goethals Bridge G-1	4.88	16.00	-3.35	-11.00	Eroded diamicton	Plant macrofossils	3230±50	BC 1676 (1516) 1408	Beta-100254
Goethals Bridge G-2	3.66	12.00	-2.13	-7.00	Eroded diamicton	Plant macrofossils	2100±50	BC 350 (146, 142, 113) AD 17	Beta-100255
Goethals Bridge G-2	3.05	10.00	-1.52	-5.00	Fluviomarine sand	Bulk sediment	2550±60	BC 825 (786) 412	Beta-100253
Goethals Bridge G-4	3.05	10.00	-1.52	-5.00	Brackish marsh	Peat	830±60	AD 1036 (1218) 1288	Beta-100257
Governors Island MT-12	2.80	9.19	3.30	10.83	Cultural sediment?	Bulk sediment	590±60	AD 1286 (1329, 1343, 1395) 1437	Beta-117732
Governors Island MT-16	1.90	6.23	2.70	8.86	Cultural sediment?	Bulk sediment	660±70	AD 1244 (1299, 1375) 1418	Beta-117733
Governors Island MT-6	2.10	6.89	4.00	13.12	Cultural sediment?	Bulk sediment	1130±110	AD 663 (897, 922, 942) 1158	Beta-107658
Governors Island MT-9	0.85	2.79	1.15	3.77	Shoreline paleosol	Bulk sediment	2610±50	BC 833 (799) 598	Beta-107659
Hackensack/Rt 3 core	0.90	2.95	0.10	0.33	Brackish marsh	Plant macrofossils	240±110	AD 1438 (1656) 1954	RL-1030
Hackensack/Rt 3 core	1.70	5.58	-0.70	-2.30	Brackish marsh	Plant macrofossils	810±110	AD 1003 (1224, 1231, 1239) 1396	RL-1031
Hackensack/Rt 3 core	2.80	9.19	-1.80	-5.91	Brackish marsh	Plant macrofossils	2060±120	BC 390 (50) AD 225	RL-1032
Hackensack/Rt 3 core	3.80	12.47	-2.80	-9.19	Freshwater marsh	Plant macrofossils	2610±130	BC 1014 (799) 400	RL-1033
HBLRT NC-04	3.70	12.14	-1.70	-5.58	Brackish marsh	Plant macrofossils	930±50	AD 1002 (1043, 1091, 1119, 1140, 1155) 1219	Beta-82795
Heusser	3.30	10.83	-2.30	-7.55	Brackish marsh	Plant macrofossils	2025±300	BC 801 (39, 28, 23, 9, 2) AD 642	I-510
Hollowell	0.90	2.95			Cultural sediment	wood charcoal	3110±90	BC 1597 (1401) 1127	I-3965
North Arlington B-1	3.00	9.84	-1.00	-3.28	Freshwater marsh	Peat	5030±160	BC 4223 (3888, 3883, 3797) 3384	Beta-80726
North Bergen Sewer B-10	2.40	7.87	0.40	1.31	Brackish marsh	Peat	1130±60	AD 732 (897, 922, 942) 1020	Beta-112239
North Bergen Sewer B-10	6.00	19.69	-4.00	-13.12	Ice-contact diamicton	Bulk sediment	19,450±60	BC 21,919 (21,112) 20,404	Beta-112240
North Bergen Sewer B-11	3.00	9.84	-1.00	-3.28	Floodplain paleosol	Bulk sediment	3650±50	BC 2265 (2027, 1992, 1982) 1780	Beta-112241
Old Place	1.40	4.59			Cultural hearth	wood charcoal	7260±140	BC 6417 (6150, 6143, 6082) 5813	I-4070
Richmond Hill					Cultural sediment	wood charcoal	9360±120	BC 9136 (8627, 8621, 8612) 8288	I-4929
Wards Point	1.25	4.10			Cultural sediment	wood charcoal	7260±125	BC 6398 (6158, 6143, 6082) 5843	I-4512
Wards Point	1.40	4.59			Cultural sediment	wood charcoal	8250±140	BC 7580 (7314, 7218, 7203) 6831	I-5331

Key: bls = below (submerged) land surface m = meters MSL = mean sea level

* Borings from present investigation.

sequence of dates between 19,000 and 9500 B.P. Early Holocene dates (ca. 10,000-6000 B.P.) are present but not abundant (n=7), while Middle and Late Holocene determinations proliferate (n=34). These data confirm the trend, discussed subsequently, that after 6000 B.P. regional and local landscape configurations begins to approximate those of the present.

Archaeological Site Geography. As developed in earlier sections of this report, the most critical barometers of landscape and Late Quaternary environmental change include these factors:

- Documentation of regional site types and distributions
- Documentation of local site types and distributions
- Post-occupation site histories
- Preservation contexts of sites

Archaeological models of site geography are most widely developed for the Middle Atlantic region but remain poorly known for New York City. This is because archaeological investigation within the city environs has been impeded by the urban constraints discussed earlier. If the regional models are projected, the germane are those for the Hudson and neighboring river valleys (i.e., Delaware and Susquehanna; see Funk 1976, 1993: Ritchie 1980). These constructs suggest that the potential to model settlement location are reflected in the modifications of landscape caused by changing stream valley morphologies for terrestrial habitats and by the exponentially-based rises in Holocene sea level for near shore locations. In both situations, "available land" for occupation shifts in response to sedimentation patterns. That tendency was most dynamic and pronounced during the Early Holocene (10,000-6000 B.P.) when rates of sea level rise were higher. After the magnitude of transgressions leveled off during the Middle Holocene, the newly exposed and lower gradient nearshore surfaces opened up for colonization. A corollary to this effect of nearshore stabilization is the increasing stasis of river systems whose channels became firmly entrenched by 6000 B.P. and whose flood plains subsequently mirror present configurations.

In archaeological terms, progressive quiescence of later Holocene environments is reflected in settlement patterns that are increasingly modeled after contemporary environmental zonations. Thus, for example, the infrequent occurrences of Early Archaic sites everywhere in the Northeast are largely explained by their preservation in sediments and river fills that are deeply buried and not accessible by typical survey strategies. In contrast, Late Archaic sites are considerably more (Ritchie 1980), due in no small measure to their alignment with contemporary flood plains; the geography of such flood plains has not changed dramatically in the past 3000 years. It has also been widely recognized that population densities for later prehistoric periods are higher as well. While there are often gaps cited for a population reduction during the Middle Woodland and generally more dispersed settlement during Woodland times in general, the dispersal of the later sites across composite landscapes increases with time (Funk 1993).

Review of the archaeological record for metropolitan New York verifies that the limited findings and interpretations generated are typically based on non-systematic surveys. Projecting the Hudson Valley data onto the lower estuary it is noteworthy that for the Paleoindian period mammoth and mastodon remains were found on the continental shelf and within the Hudson River channel (Fisher 1955; Whitmore *et al.* 1967). Indications are that both of these large mammals were plentiful in valley flats that have since been drowned by sea-level rise. The only known Paleoindian archaeological contexts, however, are in what were formerly upland locations at Port Mobil and Ward's Point on western Staten Island along the Arthur Kill (see Figure 5).

Subsequently, the general trend for sites was to "migrate landward" or to the interior (north and west) in response to sea level rise. After 7000 B.P, the bathymetric band between 10 and 30 feet below present mean sea level should be particularly rich in inundated archaeological sites. Such sites of Early to Middle Archaic age (and later) could have extended across a broad band that would have attracted humans for periods of up to a thousand years prior to their submergence. It has been suggested that humans were frequenting northwestern Staten Island at least by the ninth millennium B.C., when spruce was beginning to decline relative to pine in the boreal forest (Kraft 1977a, 1977b; Ritchie and Funk 1971). Early Archaic sites which are today in shoreline or salt marsh settings represent the vestiges of campsites in the boreal forest alongside small freshwater rivers or ponds. Their apparent low density and isolated distribution suggests that people were visiting them seasonally as part of an annual round which also included more substantial base camps at locations now submerged within the harbor or on the continental shelf.

Detailed, location-specific reconstructions of salinity, water depth, and other factors affecting shellfish habitat within the early- to mid-Holocene estuarine waters are still needed to assess the apparently sudden appearance of shell-bearing sites such as Dogan Point during the sixth millennium B.C. (Brennan 1974, 1977; Claassen 1995b). Without a comprehensive archaeological survey of the continental shelf and sensitive settings within the Harbor Region it is not certain that this was in fact the earliest intensive harvesting of shellfish by prehistoric people (e.g., Claassen 1995b:137-138; Schaper 1993). Another possibility is that environmental conditions changed at this point to permit the combined procurement of faunal and floral resources whose previously disjunct distribution in coastal and interior settings required more "scheduling" of the annual round (Flannery 1968). Continuation of residential mobility , however, at least through the Middle Archaic, is supported by Claassen (1995b), with an annual round which included both the shellfish, seeds, meat, and hides available at Dogan Point and other unspecified resources available from interior locations such as the Goldkrest site northeast of Albany.

Travel by canoes and other water craft was common throughout the Northeast at least as early as the fourth millennium B.C., and this is further substantiated by Woodland culture assemblages found on Ellis Island and Liberty Island (Boesch 1994; Pousson 1986) as well as the original portion of Governors Island (Herbster *et al.* 1997) within New York Harbor. More systematic examination of Woodland period contexts is precluded by the diffuse distribution of such sites and their limited documented presence within the project area.

The third factor in this data set—post-occupation site histories—can be somewhat assessed within the contexts of sea level rise and the data obtained for sedimentation modes. As implicated earlier, drowning of terminal Pleistocene valleys, realignments of landscapes, and the establishment of new drainage lines during the early Holocene would have buried or severely reworked the limited sites of Paleoindian and Early Archaic age. Locations within Upper New York and New Jersey

Harbor of Middle Archaic age might have suffered the same fate. It is possible that during the Late Archaic (post-6000 B.P.) sites submerged 20 ft below mean sea level might represent more discrete and intact loci than expectedly mixed Paleoindian through Late Archaic assemblages of the type recovered from the sites on northwestern Staten Island. Many of the latter artifacts and ecofacts may have been eroded and redeposited far from their original context, however, particularly from sites which were surface scatters at the time of initial transgression. Transgression of the sea generally does not preserve archaeological sites with undisturbed systemic context (Rapp and Hill 1998:78-79; Waters 1992:270-275).

The initial rapid rate of sea level rise suggests that disturbance due to wave action would have been minimal until the shorelines began to stabilize after 4000 B.P. Rapid submergence of sites followed quickly by burial in sediment should actually preserve artifacts and their spatial patterning better than gradual inundation (Stewart 1999:571-574; Waters 1992:275-280). This hypothesis would apply for all sites from upper Late Archaic, Transitional and Woodland to historic periods. An overriding exception applies to subaerial and even currently subaqueous landscapes which have been extensively modified by historic erosion, recontouring and development.

The preservation contexts of all sites are therefore subject to post-depositional modifications generated by quantum rises and stabilizations of the Holocene transgressions and by the irregular imbalances generated by historic activities along the shoreline margins. The nature of the latter activities is discussed below.

Historic Impacts. Historic impacts may be further subdivided on the basis of scale as follows:

- Comprehensive modifications to the harbor shoreline
- Impacts to the channel complexes by depth and extent

It is instructive to compare the overall differences between contemporary shore morphology and that of the previous century in order to understand how historic modifications and land use patterns have affected the geography of the harbor. Figures 12, 13, and 14 superimpose the present navigation channels onto the positions of both the 1874 and present shoreline for the individual channel segments. For Newark Bay, Port Newark, Port Newark Point and Elizabeth Channels the eastern shore is approximately at the same location as that of the present, but the western shoreline is considerably modified. First, "made land" and docking slips have cut into the old land surface in three separate locations. Next, the shoreline itself has been built out (eastward) on the order of 2000 feet (see Figure 12). The segments encompassing Anchorage, Claremont, and Port Jersey Channels reveal similar changes, with the eastern shorelines remaining essentially the same as in 1874, but the western shoreline has been even more intensively landscaped and effectively moved nearly one mile (approximately 5100 feet) to the west (see Figure 13). Finally, for the limited segment investigated along the Buttermilk Channel the eastern shore remains effectively the same, although Governors Island has been built out significantly, extending its area by nearly one half (see Figure 14).

There is considerable variability in the impacts to the individual channels by extent and depth (as reported in Table 2). Channel deepening typically extended to depths of 45 feet, although depths up to 55 feet are projected for Ambrose and Anchorage Channels. It is stressed, however, that project impacts are critical not only for surfaces immediately underlying the channels (which would eliminate deposits younger than 7000 years) but also for those adjacent tracts that may preserve intact buried surfaces and whose integrity would be compromised over the course of laterally extensive disturbances.

Formulating the Model: Data Synthesis. When assimilating the actual data collected for preparation of a working sensitivity model the most critical considerations that emerged were the following:

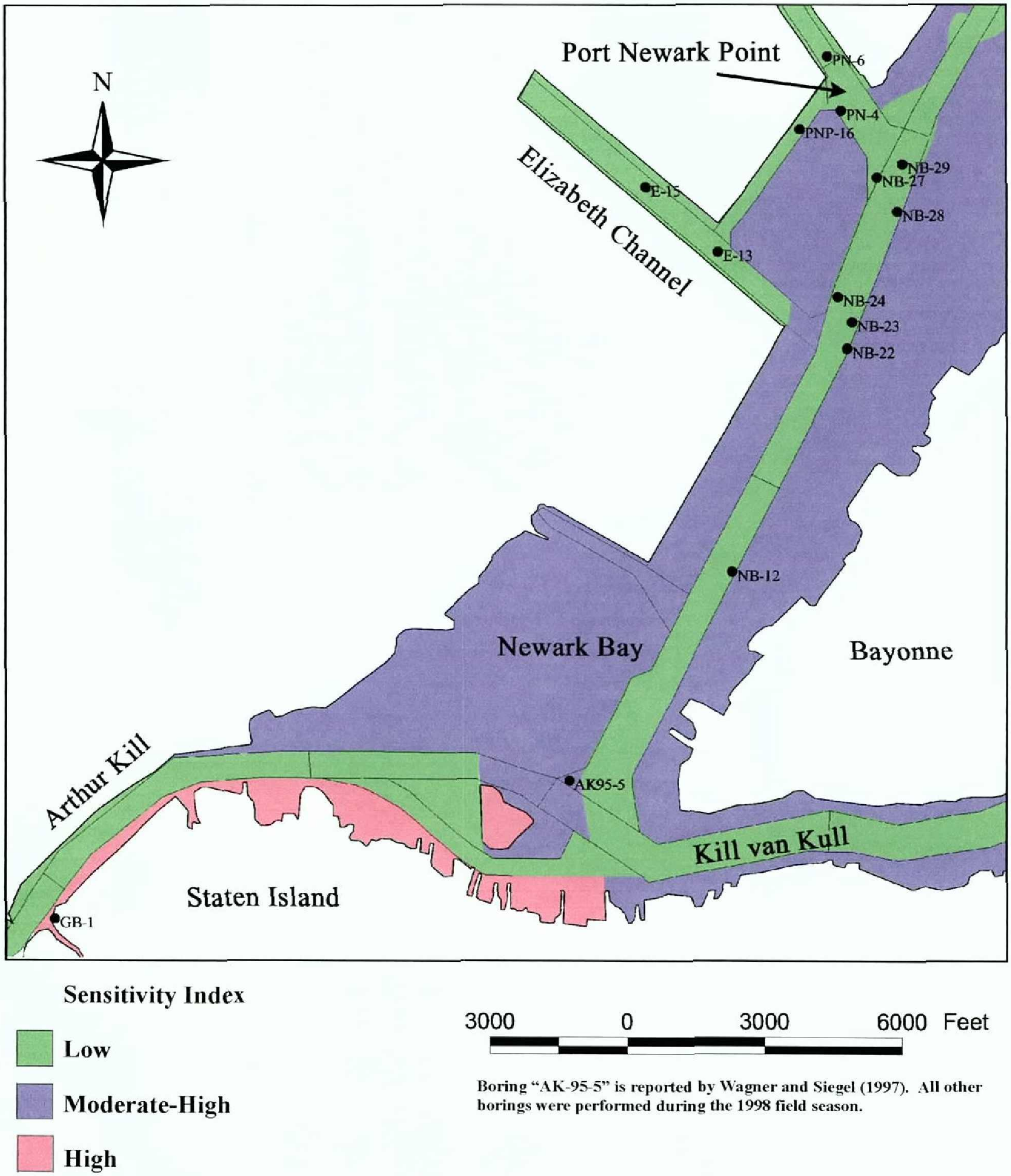
(1.) Paleoenvironmental data recovered from specific borings for channels; such data included sedimentology, radiocarbon dates, forams, and shoreline stratigraphies
(2.) Archaeological data bearing directly on a particular channel reach
(3.) Dredging histories and channel depth data obtained for channels

Critical for the archaeological assessments was the shoreline history and projected depth of particular surfaces for given occupations. For this reason an inordinate emphasis is placed on potential for encountering earlier prehistoric sites, since later prehistoric components would have been destroyed by historic dredging activities.

Figures 15 through 18 are sensitivity plots for the impact areas associated with the individual channel segments. Figures 15, 16, and 17 superimpose the boring locations onto the sensitivity plot for locations in which the most intensive study was undertaken. Figure 18 is the composite plot for the New York Bight. Included in the latter are Stapleton and Claremont Channels which are outside the areas which received intensive study. The Ambrose Channel is not depicted because of its location outside the general study perimeter. Very limited work was undertaken for this segment.

Sensitivity rankings are presented in terms of "Low," "Moderate-High," and "High" potential, again based on the conflation, by channel, of the data collected in the paleoenvironmental, archaeological, and channel impact histories outlined above. Table 5 summarizes the key paleoenvironmental relationships justifying the ranking of the channels. Table 6 presents more specific rankings of sensitivity by archaeological component; these rankings note the depth (below mean sea level) of expected occurrence of particular components as per the shoreline histories discussed earlier.

It is re-emphasized that impact areas refer not only to the navigation channels per se but to the channel margins which are likely to be excavated or disturbed by channel widening activities and future ship traffic. Finally, it is noted that the primary data obtained in this study (Category 1 above) was procured from intermittent geotechnical borings and that sedimentological observations were obtained from select exposures and proveniences. The discussion below presents the justification for the rankings emphasizing the key geoarchaeological supporting data for the particular segments or channel reaches.



Boring "AK-95-5" is reported by Wagner and Siegel (1997). All other borings were performed during the 1998 field season.

Figure 15. Archaeological sensitivity model for the New Jersey Harbor and lower Newark Bay. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*

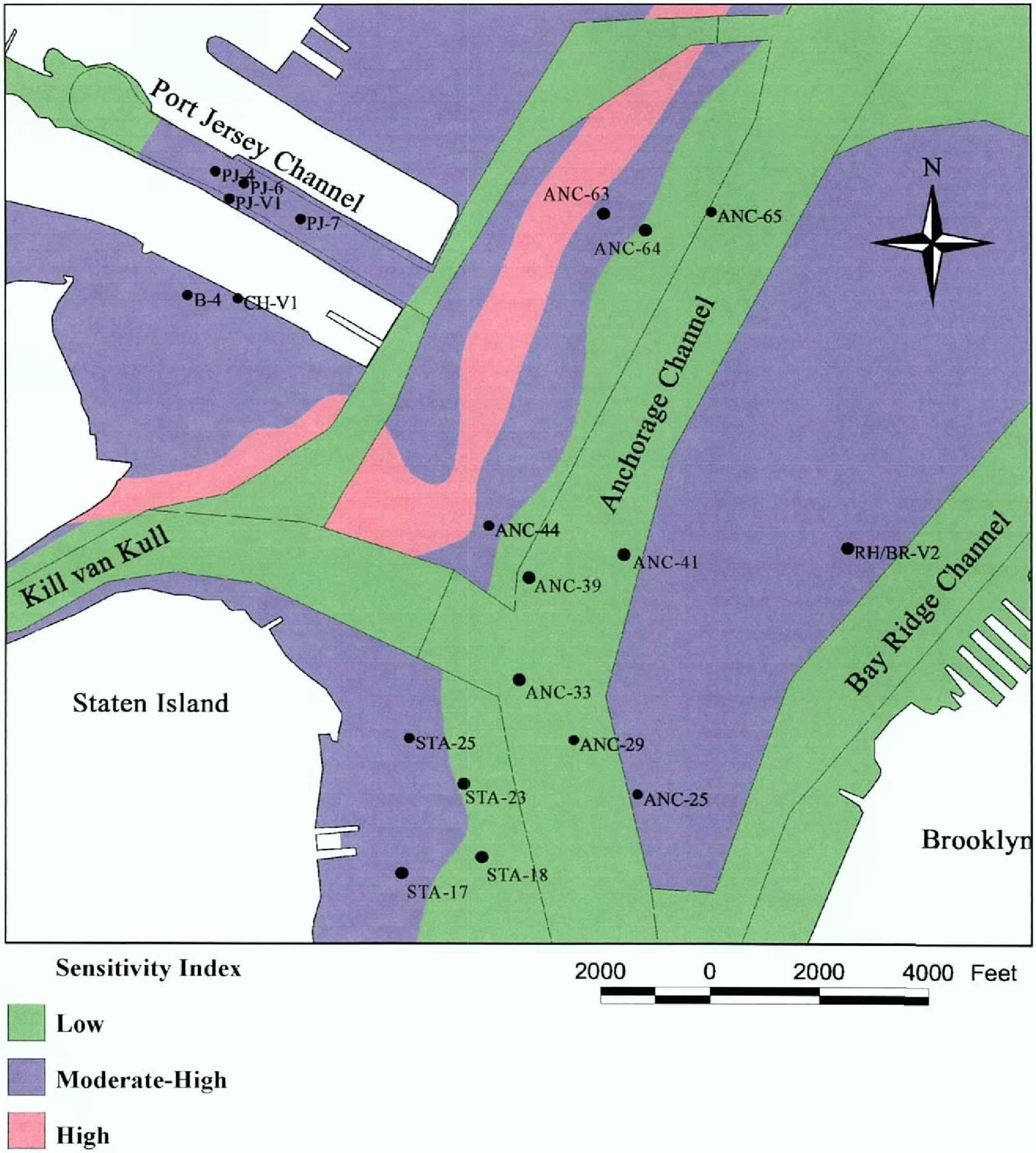


Figure 16. Archaeological sensitivity model for the Upper New York Harbor at the mouth of the Kill van Kull. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*

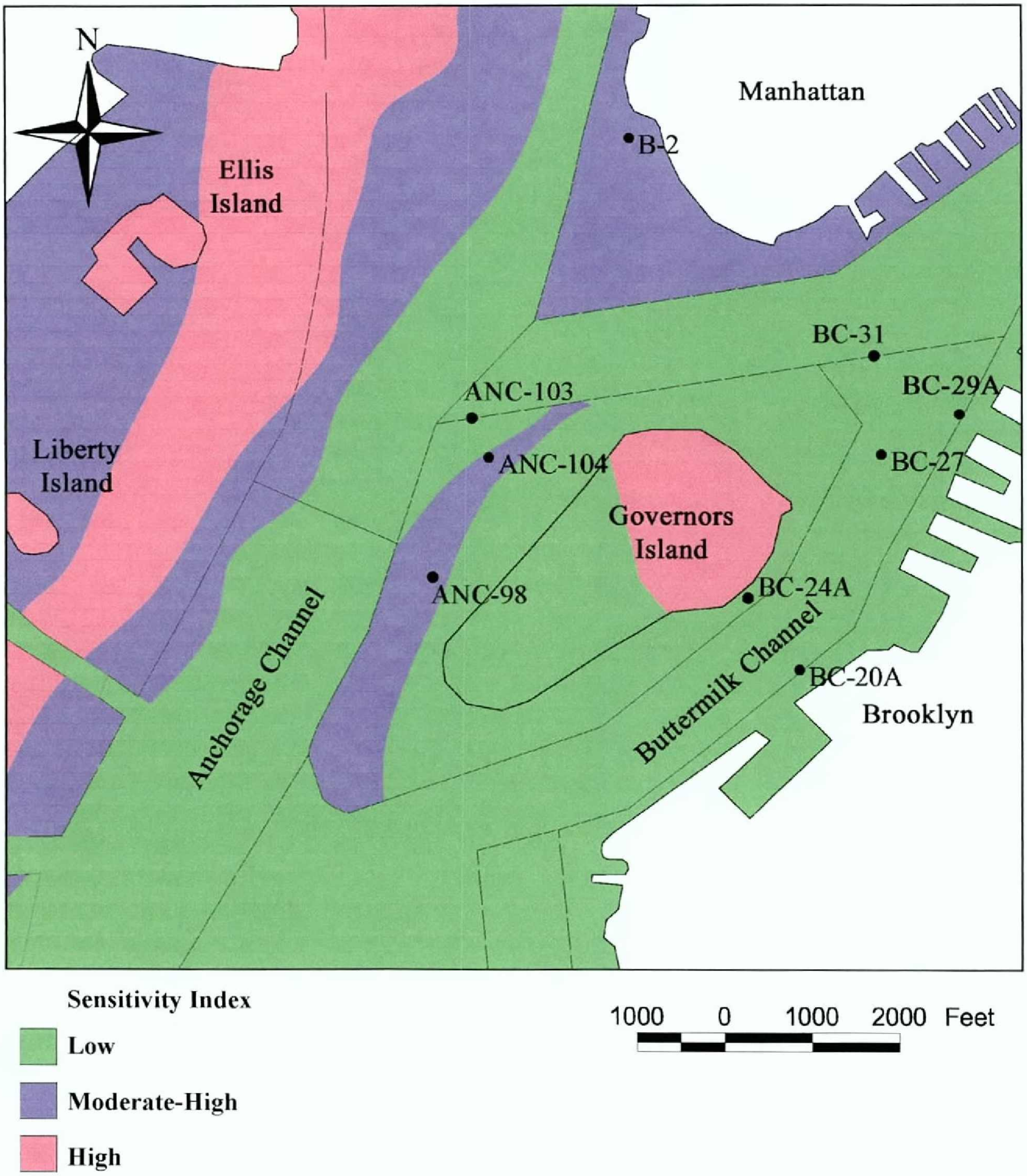


Figure 17. Archaeological sensitivity model for the Upper New York Harbor in the vicinity of Ellis Island, Liberty Island and Governors Island. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*

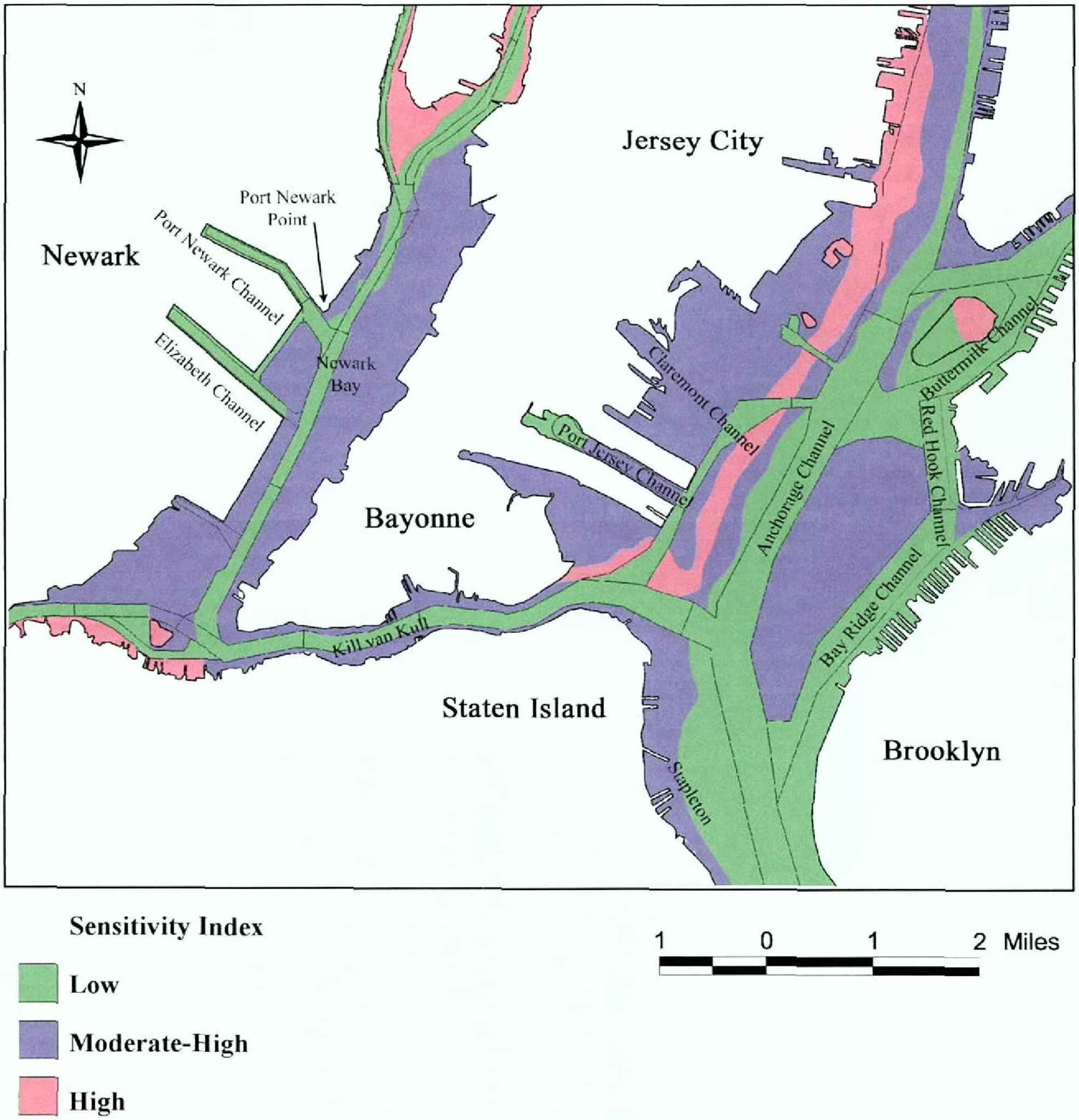


Figure 18. Composite archaeological sensitivity model for Upper New York and New Jersey Harbor. A Geomorphological and Archaeological Study of New York and New Jersey Harbor *(GRA 2000).*

Table 5.
Sensitivity assessments for navigation channel work areas, New York and New Jersey Harbor.

Area	Assessment	Rationale	Recommendations
Kill van Kull (KVK)	Moderate-High	Known prehistoric archaeological sites such as Bowmans Brook as well as the probable archaeological significance of many historic buildings, shipwrecks, and features associated with shipbuilding and other harborfront industries.	
Newark Bay (NB)	Moderate-High	Work area flanks lower reaches of Hackensack River valley. Navigation channel artificially straight alignment of valley axis. Channel excavated to depths of up to 35 feet below mean sea level through late Pleistocene glaciolacustrine facies. Bay generally shallow with depths of less than 10 feet below mean sea level. Remnants of old river cutbanks and floodplain landforms may be preserved beneath tidal flats. Stratigraphy downstream of Elizabeth channel suggests lower (i.e. moderate) potential. Area probably tidally inundated early in Holocene and did not accumulate Late Holocene alluvium.	Five (5) to ten (10) additonal cores on channel margins.
Port Newark (PN)	Low	Deepened below any pre-existing Holocene drainage. Bedrock dips toward Newark bay from 10 to 30 ft below channel floor. Overlying sediments predominantly reddish brown clay with massive bedding suggesting late Pleistocene age.	No further work recommended.
Port Newark Point (PNP)	Low	Deepened below any pre-existing Holocene drainage. Bedrock less than 20 ft below channel floor. Overlying sediments predominantly reddish brown clay with massive bedding suggesting late Pleistocene age.	No further work recommended.
Elizabeth Channel (E)	Low	Deepened below any pre-existing Holocene drainage. Bedrock 30 ft. below channel floor. Overlying sediments predominantly reddish brown clay with massive bedding suggesting late Pleistocene age.	No further work recommended.
Anchorage Channel (ANC)	Moderate-High	Relatively high potential for cultural resources, particularly on shallow flats and interfluves where tributaries join Hudson River from west. Samples obtained from curated borings at Caven Point. Boring 98-ANC-44 near the interfluve where the Kill Van Kull meets the Hudson River is particularly informative. Early Holocene radiocarbon date indexes profile from which foraminifera indicate progressive change from salt marsh to mud flat to shallow neritic environment.	Five (5) additional borings in the upper10 feet.
Claremont Channel (CC)	Moderate-High	Likelihood for cultural resources since channel not entirely dredged or deepened below pre-existing Holocene drainage. Borings extended beyond 30 ft without encountering bedrock. Lacustrine or glaciolacustrine clays not varved. Uppermost muds below the historic organic silt may be of Holocene floodplain facies which would preserve prehistoric cultural materials.	Two (2) additional borings in upper 10 feet.
Port Jersey (PJ)	Moderate-High	In lower reaches, channel has not been dredged below pre-existing Holocene drainage. Borings went deeper than 15 ft. without encountering bedrock. Uppermost muds below historic organic silt may be of Holocene floodplain facies which could preserve prehistoric cultural materials.	Two (2) additional borings in upper 10 feet.
Buttermilk Channel (BC)	Low	Deepened below any pre-existing Holocene drainage. Over 50 feet of sediment representing several cycles of channel incision and tidally influenced sedimentation. Radiocarbon dating indicates that most sediments predate last glacial advance.	No further work recommended.
Stapleton Channel (STA)	Moderate-High	Relatively thick packages of organic silt alongside Staten Island where bathymetric contours suggest presence of early- to mid-Holocene shorelines. Uncertain depositional origin. No radiocarbon dates obtained nor any analyses of foraminifera, pollen, or plant macrofossils.	Re-analyses of samples curated at Caven Point.
Ambrose Channel (AMB)	Moderate-High	Borings not monitored. Relatively thick packages of estuarine mud and plant material noted as deep as 25 ft below the channel floor. Channel floor approximately 45 ft below mean sea level, thus relict surfaces more than 8,000 years old.	Re-examination and radio-carbon, foram, and macro-botanical analysis of Caven Point samples. Two (2) additional borings in upper 30 feet.

Table 6. Potential for encountering cultural resources by channel impact area.

Period	Years Before Present	Depth of Surface (ft. bmsl)	Newark Bay	Port Newark	Port Newark Point	Elizabeth Channel	Anchorage Channel	Claremont Channel	Port Jersey	Buttermilk Channel
Historic	400-Present	±1	M-H	L-M	L-M	L-M	H	H	H	L-M
Late Woodland	1000-400	2	M	L	L	L	L	L	L	L
Middle Woodland	2300-1000	7	M	L	L	L	L	L	L	L
Transitional/Early Woodland	3500-2300	13	M	L	L	L	L	L	L	L
Late Archaic	6000-3500	20	M	L-M	L	L	M	M	M	L
Middle Archaic	9500-6000	40	L	L	L	L	H-M	M	M	L
Early Archaic	11,500-9500	55	L	L	L	L	H-M	M	M	L
Paleoindian	13,000-11,500	100	L	L	L	L	M	L-M	L-M	L

Key: bmsl = below mean sea level H = High M = Medium L = Low

Kill van Kull, Newark Bay, Port Newark, Port Newark Point, and Elizabeth Channel (Figures 15, 18)

This is the channel reach with the most extensive documentation of early prehistoric locations in the metropolitan New York City area (see location of GB-1). Borings in the active channel of the Kill van Kull show a bedrock floor with sparse accumulations of very recent estuarine mud. The shoreline areas extending approximately 500 feet into the present channel from either bank are assigned moderate to high potential. This is based on the presence of known prehistoric archaeological sites such as Bowmans Brook (Skinner 1909:5-9; Smith 1950:176-177) as well as the probable archaeological significance of many historic buildings, shipwrecks, and features associated with shipbuilding and other harborfront industries.

The area on the northern shore of Staten Island known as Mariner's Harbor was noted by Skinner (1909:5) to have "traces of prolonged occupation, fire-cracked stones, flint chips, potsherds, and the like ... in every field." Known prehistoric sites include the Archaic B.F. Goodrich site (Anderson 1970) and the Arlington Place, Arlington Avenue, Arlington Station, and Gertie's Knoll sites. Several of these sites may extend beneath the coastal salt marshes and modern fill and should be mapped in more detail within the area designated as having moderate to high potential. Further east along the Staten Island shore, the Old Place site near the Goethals Bridge appears to be primarily Middle Archaic through Late Archaic in age (Ritchie 1980:140; Ritchie and Funk 1971). Dates of 2540 ± 60 B.P., 2770 ± 60 B.P., and 3230 ± 60 B.P. were obtained from borings in the lower reaches of Old Place Creek by GRA (1996b). Rhizomes of *Spartina* sp. were found in the material from boring GB-1 (see Appendix 6) suggesting the presence of salt marsh at this location by this general time period.

Shooters Island probably did not become an island until around 3,000 to 4,000 years ago, prior to which it would have been a knoll adjoining a sharp bend in the Hackensack River (Kardas and Larrabee 1978:18-19). Rockman and Rothschild (1979) were unable to penetrate up to 13 feet of landfill on the island by hand excavation and suggested the need for additional investigations to identify prehistoric archaeological contexts or buried surfaces with which such contexts may be associated. The island is assigned high potential for cultural resources in the present preliminary model although such resources have yet to be found and will probably be deeply buried.

Areas immediately east and west of Shooters Island were considered to be archaeologically sensitive by Kardas and Larrabee (1978:48). However, data from borings reported by Wagner and Siegel (1997:23) indicate truncation by widespread dredging within the harbor. Interstratified deposits described as "mixed loamy to fine-textured or gravelly" were encountered less than 30 feet below mean low water and interpreted to be "pre-estuarine" at AK-95-5. No radiocarbon dates were obtained and no specialized analyses were used to identify environments of deposition. Detailed stratigraphic and geomorphic relationships for identifying potential alluvial landform sequences could not be generated owing to the great distances between core borings (Wagner and Siegel 1997:21).

The radiocarbon date of 29,600 ± 360 B.P. on a sample of bulk sediment from 17 to 19 feet down the sediment column in boring NB-98-28 lends some support to the possibility of truncation by widespread dredging within Newark Bay. Additional radiocarbon and paleoenvironmental analyses are needed, however, in order to further assess archaeological potential. Most of Newark Bay between the shoreline and the active channel is consequently assigned "moderate to high" archaeological sensitivity. The Elizabeth and Port Newark channels have been deepened below any pre-existing drainage and these are mapped as having low potential.

Although intact prehistoric archaeological contexts have yet to be discovered in the lower reaches of the Hackensack River, about two miles north of Port Newark, the area is considered to be archaeologically sensitive based on paleoenvironmental reconstructions (see Figure 18). Grossman and Associates (1995:37) proposed that a freshwater riverine environment existed as recently as 2,000 years ago. If this area were indeed a "well watered valley with low ridges sloping to the flood plain" it should have been an important regional focus of prehistoric settlement prior to the emergence of tidal environments. Prehistoric materials have been recovered along Penhorn Creek (Artemel 1979:30; Rutsch 1978:13) although these were apparently redeposited. A high potential area for submerged cultural resources is mapped for the upper portion of New Jersey Harbor, where the Hackensack is joined by the Passaic River.

Anchorage, Port Jersey, Claremont and Stapleton Channels (Figures 16, 18)

Results from borings 98-ANC-104, 98-ANC-65 and 98-ANC-44 indicate intact Holocene sediments at depths greater than 30 feet within the active Anchorage Channel. No foraminifera or plant macrofossils were found in the 98-ANC-104 samples while those from 98-ANC-44 and 98-ANC-65 suggest a shallow subtidal or tidal marsh environment of deposition. These would not be compatible with human occupation although many Archaic camps are found flanking tidal marshes in coastal New York and New Jersey (Brennan 1974; Kraft and Mounier 1982; Ritchie 1980).

The area flanking the upper Anchorage Channel on the west, upstream of the Kill van Kull, is known as the "Jersey Flats." The gradually sloping harbor floor is stepped off toward the river on what appear to be submerged alluvial terraces. There are also several interfluves where the Hudson was formerly joined by small Piedmont streams. These areas warrant additional investigations to identify locations favorable for prehistoric human habitation. The upper reaches of the Port Jersey channel have low potential because historic maps do not show this feature to have been part of the drainage and it is of recent origin. This agrees with the previous assessment by LaPorta *et al.* (1999), but the lower reaches of both the Claremont and Port Jersey channels are here assigned moderate to high potential since they do not appear to have been entirely dredged or deepened below the pre-existing Holocene drainages.

The previous assessment of the Stapleton Channel (Louis Berger and Associates 1985) proposed that the lower harbor region was submerged beneath the waters of a "post-glacial freshwater lake" until ca. 6500-7000 B.P. The proposed lacustrine sediments appear to resemble those analyzed from six- and eight-foot depths in boring 98-STA-25 for the present study (see Appendix 5). Strata O-1 to O-3 of Louis Berger and Associates (1985:6; Mueser *et al.* 1967) designate organic silty clays which represent up to 80 feet of deposition over sandy clay and gravel presumed to be Pleistocene in age.

The silt fraction in the 98-STA-25 samples and other borings examined at Caven Point was predominated by quartz with occasional mica and fragments of metamorphic rock. Foraminifera were found only in the uppermost sample analyzed and indicate deposition on mud flats just below the intertidal zone, close to a salt marsh. The Staten Island shoreline as well as the bathymetric band between 10 and 30 feet below mean sea level are assigned moderate to high potential. More detailed sedimentological and paleoenvironmental analyses as well as radiocarbon dating are needed to confirm the suggested submergence in this portion of the harbor throughout the Holocene. As discussed, many Archaic camps have been found flanking tidal marshes elsewhere in coastal New York and New Jersey (Brennan 1974; Ritchie 1980).

No detailed sensitivity assessments have been made for the remainder of the Stapleton and Anchorage channels or for the Ambrose Channel since very little data were obtained in the present study (see Figure 18). If the upper Stapleton Channel was in fact submerged throughout the Holocene then the same would be true of locations seaward to the hypothesized "dam" feature at the Narrows. Areas below the proposed dam would presumably have been deeply scoured or filled with ripped-up lake mud and other detritus at the time that the proposed lake drained (Louis Berger and Associates 1985:9-10). The Ambrose Channel begins at the Verazzano Narrows and was excavated to an average depth of 40 feet beginning in 1907 (Pickman 1990:35; Rattray 1973:11). It was subsequently deepened to 45 feet, which the bathymetry suggests to have been submerged by at least 8000 years B.P.

Buttermilk Channel, Anchorage Channel (Figures 17, 18)

Ellis Island, Liberty Island, and the original portion of Governors Island are all known to contain intact prehistoric archaeological contexts (Boesch 1994; Herbster *et al.* 1997; Pousson 1986). Each of these islands has a core of bedrock capped by Pleistocene till of variable thickness. For much of the Holocene, Ellis and Liberty Islands would have been parts of a larger Piedmont surface flanking Hudson River alluvial terraces, all of which have since been submerged. According to Pousson (1986:13), Ellis Island only became an island some 3,000 to 4,000 years ago. Both islands and the adjoining bathymetric band where the terraces should be found are designated as high potential.

Governors Island may have been connected to Brooklyn until sea level rose to at least 30 feet below present. The Buttermilk Channel between Brooklyn and Governors Island is a very high energy channel which has been depositing coarse massive sand during the Holocene. It was also dredged on its eastern side around the turn of the twentieth century (see Appendix 4) and appears to have scoured rather than uniformly buried any sediments above the Pleistocene clays. The prehistoric archaeological contexts known from the intact portion of the island are all younger than 2,000 years old, however, by which point there would have been perennial discharge through the channel (Herbster *et al.* 1997).

Aside from the aforementioned islands, only the bathymetric band between 10 and 30 feet below mean sea level has been assigned high potential within the Anchorage navigation channel. This is because of relatively limited disturbance to the near shore by ship traffic in this segment of the project area.

Geoarchaeological Background for the Model

Table 5 summarizes the primary geoarchaeological justifications for the sensitivity model. The critical data in support of the recommendations draw chiefly from the stratigraphic interpretations that were generated by sedimentological observation, radiocarbon dates, foram analysis, and to a lesser degree, the macrobotanic analysis.

In general, rankings for High and Moderate probability were determined by the recognition of facies below impact levels that correlated with shore, nearshore, estuarine, or flood plain surfaces. These are the range of buried surfaces that would have sustained human occupation during prehistoric times. As noted, for the earlier time frames (i.e., Paleoindian through Middle Archaic) rates of sea transgression were rapid and would have resulted in rapid burial of archaeological deposits. Accordingly, recognition of facies likely to house such deposits resulted in Moderate to High determinations, as detailed in the next section on a channel by channel basis. Low rankings were generally assigned to channel segments in which investigations disclosed the presence of a lake facies or till, both of which are unlikely to contain archaeological materials because of their subaqueous contexts or Pleistocene antiquity. Radiocarbon dates and the foram data, which index chronology and patterns of environmental change respectively, bolster the baseline assumptions. Low rankings are also assigned to segments in which bedrock was reached (i.e., Port Newark Point, Elizabeth Channel).

For the later time frames (Late Archaic through historic), recognition of estuarine or fluvial, alluvial and near shore facies was critical. These sediments document the presence of a stable surface or a potentially rich resource biome. The foram data indicated that shifts in resource zones might be tracked by assessing changes in foram types and frequencies.

The final column of Table 5 presents recommendations for each channel in which a moderate or higher ranking for cultural resource probability was identified. These recommendations (see Section 8) represent near term or immediate objectives that have emerged from the present study. Key stratigraphic observations are pivotal to the discussion on modeling sensitivity by component.

Modeling by Prehistoric Component

Table 6 shows the potential for channels by prehistoric component. As discussed earlier, regional and local paleoenvironmental data, settlement archaeology, and known historic impacts to the channels facilitate projection of cultural resource potential on a relative scale. The first two columns of Table 6 bracket the principal culture chronological divisions for New York State as currently recognized (Funk 1993). Column 3 identifies the depth below sea level of the shoreline during the mid-point of the given cultural period (i.e., shoreline during the Late Woodland is projected at 2 ft below sea level at ca. 700 B.P.). Sea level data are as per the curve presented in Figure 4. Site probability rankings for cultural period for the ten channels are presented in the remaining columns.

When examining the rankings, several trends are readily identified. The rankings are largely conditioned by sea level position and extent of disturbance by dredging. Both of these factors have been discussed earlier. Two additional concerns include site expectation by period and post-depositional modification. In this study, while site expectation might be considered highest for late prehistoric components, integrity is likely compromised by their presumed location in nearshore settings most susceptible to disturbance by dredging and by earlier reworking by nearshore geomorphic process during the long intervals of shore stabilization. Conversely, older sites, traditionally thought to be less dense and less likely to be preserved are more likely to be sealed at depths beneath dredging impact areas. Along similar lines, during the Early Holocene relatively rapid burial of earlier prehistoric components would have resulted in their optimal preservation contexts. The following preservation and site expectation trends elaborate on these points.

First, there is a relatively high expectation for historic finds, even along channel reaches that are acknowledged to have low overall cultural resource potential. This is because historic sites include contexts that may have been partially modified, but retain some integrity. Accordingly, even century old edifices constructed on "made land" are considered potentially eligible for the National Register of Historic Places (NRHP), as may tanning yards, for example, that are only partially preserved in settings that have been largely destroyed and buried. Obviously longer term sea level changes have minimal effect on many of these complexes, since they have been built on landscaped surfaces and are themselves responsible for local hydrographic changes.

Second, with the exception of Newark Bay, Claremont, and Port Jersey channels, and to a lesser degree the Anchorage Channel, all segments have Low expectations for later prehistoric remains. Reference is made specifically to post-Late Archaic site potential and specifically locations above the 20- to 40-ft bathymetric levels. The Low ranking reflects dredging disturbance to these channels and the probability of mixing of assemblages (i.e., Late Archaic and Woodland) on penecontemporaneous nearshore surfaces during the Late Holocene and as sea level rise was stabilizing. In this connection it is critical to consider the effects of wave cutting activity and the effects of changing margins of the estuaries on the broader expanses of the shore. Smaller sites would most probably have been swept away well before historic times when the differentiated surfaces were buried. Low-Moderate and Moderate rankings are preserved for those locations flanking the channels where minimal dredging occurred (see Table 6) and where there may be some likelihood for Late Archaic and Woodland sites to have survived.

Third, the Late Archaic is a threshold period when Moderate site expectations are projected for half of the channel segments. It is at approximately 5000 B.P. that rates of sea level rise diminished and shorelines stabilized. This marks a geomorphic threshold where many sites could have been rapidly buried, thus resulting in retention of site integrity. Next, sites of this period were known to be abundant, since in addition to the fact that landscapes began to approximate contemporary configurations, the oscillating coastlines marked the transitions to estuarine and highly differentiated micro-environments. These would have been excellent as well as prolific settlement loci. Finally, this is the "vertical belt" in the present aggradational regime that offsets the level beneath which impacts by dredging were minimal. Accordingly, the potential for site preservation rises proportionately with increasing depth.

Fourth, Paleoindian to Middle Archaic site expectations are Moderate or Moderate-High in six of the channel segments. Only Port Newark, Port Newark Point, and Buttermilk Channel have Low site potential rankings. The Low ranking was determined because elevations below 30 feet in these channels either encounter Late Pleistocene lake beds or bedrock. Moderate to High rankings are the product of stratigraphic exploration that either revealed a pristine glacio-fluvial facies (possible stream side location at Newark Bay), or Early Holocene nearshore facies (Anchorage Channel; dated) or flood plain (Claremont, Port Jersey) contexts. Stapleton and Ambrose Channels, while not examined in detail, provide limited records of analogous Early Holocene sedimentation regimes. In all locations, with the possible exception of Ambrose, the depth of deposits are below vertical limits of dredging.

Towards an Interdisciplinary Model of Cultural Resource Sensitivity

The above model has presented the results of an initial round of sensitivity assessments for the New York Bight. Based on these findings, it is possible to structure a generic flowchart (Figure 19) presenting linkages of geomorphological and paleoenvironmental data of the sorts that have been obtained to infer the potential of particular settings for preserving cultural resources. This is done for particular periods in the regional prehistoric sequence. Key geographic factors which serve as "red flags" indicating higher sensitivity for submerged cultural resources are the proximity of settings to islands within the harbor and to known prehistoric sites on the shore. In addition, the bathymetric contours in some settings appear to mimic pre-estuarine topography which has yet to be smoothed over by estuarine sedimentation, scoured away by tidal channels, or dredged away by previous navigation channel improvements.

Indications of cultural resource sensitivity within the harbor sediments themselves proved more subtle and difficult to incorporate into model design. Buried soils are commonly targeted in prospecting for deeply buried sites in terrestrial settings, and submerged soils and soils buried by estuarine sedimentation would be key markers of surfaces suitable for prehistoric habitation in the stratigraphy of the harbor. These proved difficult to recognize using pedological criteria, however, particularly in samples from the geotechnical borings we worked with in the present study. Abundance of plant macrofossils was a more useful indicator of possible buried soils, particularly where they represented terrestrial species or freshwater marsh plants and were found in rooting positions. Pollen results were incorporated into the flowchart because pollen spectra can be compared regionally and used to assign a Holocene age to sediments. Pollen will not differentiate terrestrial from estuarine settings, however.

Other factors can be used as "green flags" to assign areas low sensitivity for cultural resources. In the present study, historic maps provided key information on areas which havealready been dredged below the elevation of any Holocene terrestrial surfaces. The energy of stream and wave currents, as reflected in sediment grain size, also affects site preservation potential. Areas

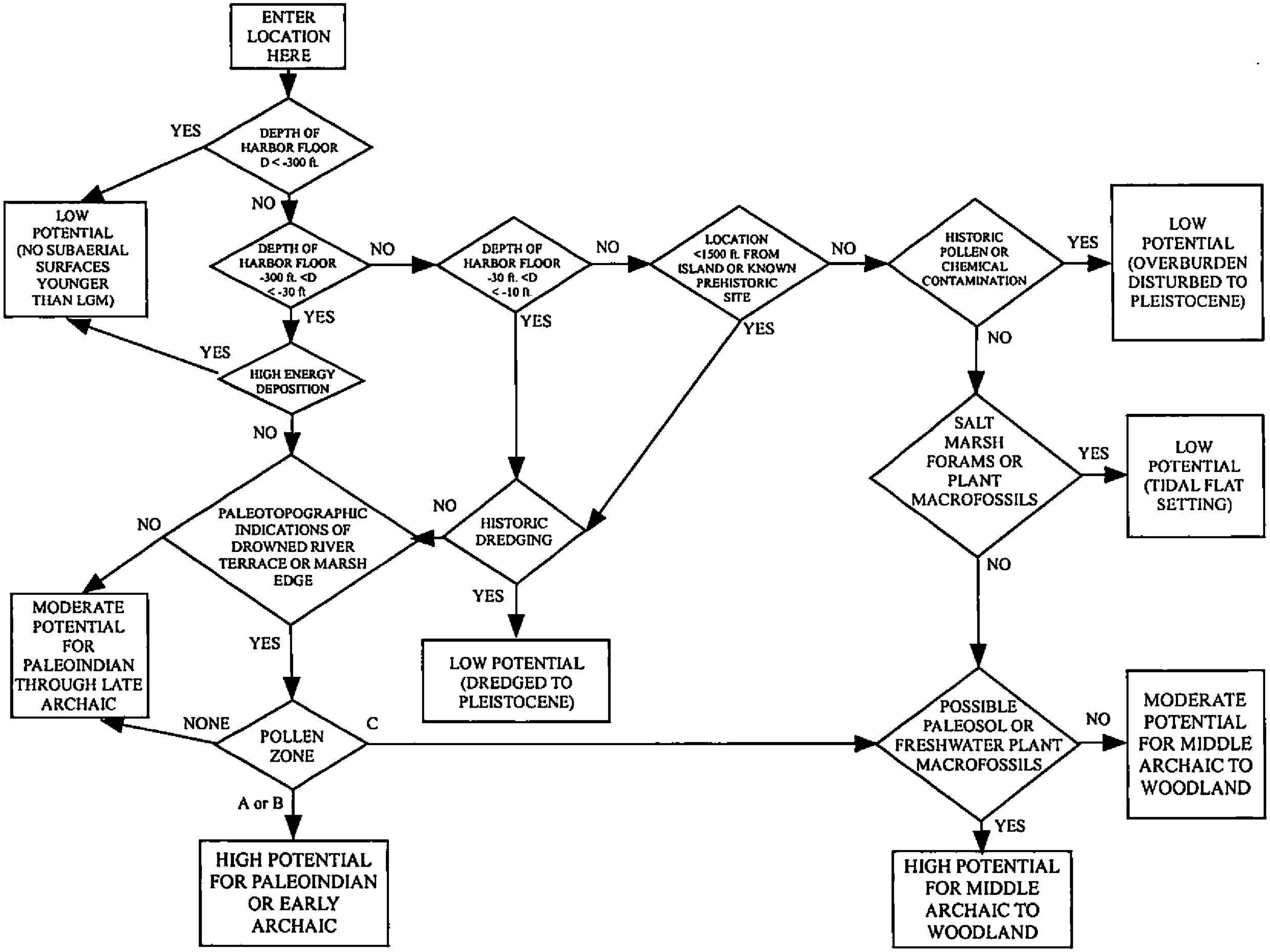


Figure 19. Working theoretical model of prehistoric site preservation potential for New York and New Jersey Harbor. A Geomorphological and Archaeological Study of New York and New Jersey Harbor.

where the sediments are characteristically coarse-textured, such as the Buttermilk Channel, would not be expected to preserve buried sites even if these sediments turned out to be Holocene in age.

Certain taxa in organic macrofossil and microfossil assemblages can be used to rule out the presence of habitable land surfaces within the sediments analyzed. Sediments which contain foraminifera or salt marsh plant macrofossils can be assigned low potential for cultural resources, for example. Rapid changes from salt marsh to deeper water microenvironments appear to occur within the estuary, however, signaling environmental conditions which would have affected but not determined human settlement of the project area. We therefore need to understand more about the spatial and temporal variation in settings which evidently ranged from the flood plains of meandering streams to tidal channels with water depths greater than 30 feet during the course of the Holocene. While the expenditure of time and money necessary to evaluate the entire stratigraphic column may be prohibitive, even for an individual work area, Anchorage Channel and Newark Bay appear to be productive "natural laboratories" within which to explore these relationships while at the same time prospecting for submerged archaeological sites.

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8.0 Summary and Recommendations

The geomorphological and archaeological study of the New York Bight incorporated an interdisciplinary approach to examine the potential for cultural resource preservation in buried contexts flanking ten (10) navigation channels. Field work stressed the inspection of samples and cores undertaken over the course of geotechnical investigations. These investigations have produced a total of 114 borings, including the 24 conducted in the field for this project. An additional 21 borings were selected for analysis from this collection curated at the USACE Caven Point facility. The forty-six (46) borings were physically examined—samples were studied stratigraphically and sedimentologically. They were then subjected to a variety of specialist analysis including radiocarbon dating; foram analysis; pollen analysis; and macrobotanic identifications. Limited paleoenvironmental reconstructions were produced that helped to determine the landscape implications of the stratigraphic columns that were retrieved.

Results of these investigations was the generation of a working model of cultural resource sensitivity that ranked the channels and various segments according to "High," "Moderate-High," and "Low" preservation categories. The rankings referred not only to the sensitivity of the navigation channels themselves, but also to the subaqueous terrain immediately flanking the channel; the latter were more likely to preserve intact deposits and were highly likely to sustain destructive impacts. Two principal factors were pivotal in producing these rankings. The first was stratigraphic observation. Sequences were typically documented that extended to depths (>30 ft.) and intact sediment types of an age equivalent to known cultural periods of the Middle Atlantic and New York state prehistoric chronologies. The second major factor for sensitivity assessment was the depth of dredging associated with each channel. Depth and extent of dredging eliminated preservation potential for later prehistoric deposits in many channels. A series of maps zoning the sensitivity of channels by bands corresponding to elevations and subsurface stratigraphy was produced for this study.

In general, it was concluded that the navigation channels had moderate to high potential for preserving intact deposits pre-dating 6000 B.P. This is critical, since sites of such periods (Late Archaic or earlier) are scarce and poorly documented in the metropolitan New York area. One of the few locations that has preserved deposits of such antiquity is northern Staten Island, immediately flanking the project area. Sites post-dating the Late Archaic, while generally better known outside the project area in terrestrial environments, are less likely to be preserved in the channel environments because they are higher in elevation and thus more exposed to the destructive long-term effects of dredging and shipping activities.

In sum, this study concludes that the oldest and most rarely documented prehistoric site types are most likely to be impacted and encountered by channel widening activities for select channels. Later and more widely distributed prehistoric sites are less likely to be impacted since they have either been eroded in the prehistoric past or have been destroyed by contemporary dredging activities.

The most sensitive channels for cultural resources were Newark Bay, Anchorage, Claremont, and Port Jersey. Ambrose Channel and Stapleton Channel may be somewhat sensitive but were not extensively investigated in this study.

The present document serves as a baseline study for systematizing observations about the cultural resource distributions buried along the channel environments of New York Harbor. It is based on a sensitivity model that was largely constructed from limited field work and from an uneven archaeological data base. As such the document provides guidelines for follow up testing based on the sensitivity zonations identified for the channel alignments. These guidelines form the basis of recommendations as discussed below.

Near Term Recommendations

The cultural resource sensitivity maps should be utilized to assess the sensitivity of areas scheduled for impacts by USACE projects in the near term. In practical terms it is proposed that USACE planners refer to the maps (Figures 15-18) when designing a project. Table 7 proposes investigative strategies appropriate for each navigation channel deemed to have a sensitivity ranking of Moderate and Higher. Implementation of these recommendations would cover immediate concerns and enrich the data base necessary for designing a more comprehensive research strategy.

Table 7. Near term recommendations for New York and New Jersey Harbor.

Area	Assessment	Recommendations
Newark Bay (NB)	Moderate-High	Five (5) to ten (10) additional cores on channel margins.
Port Newark (PN)	Low	No further work recommended.
Port Newark Point (PNP)	Low	No further work recommended.
Elizabeth Channel (E)	Low	No further work recommended.
Anchorage Channel (ANC)	Moderate-High	Five (5) additional borings in upper 10 feet.
Claremont Channel (CC)	Moderate-High	Two (2) additional borings in upper 10 feet.
Port Jersey (PJ)	Moderate-High	Two (2) additional borings in upper 10 feet.
Buttermilk Channel (BC)	Low	No further work recommended.
Stapleton Channel (STA)	Moderate-High	Re-analyses of samples curated at Caven Point.
Ambrose Channel (AMB)	Moderate-High	Re-examination and radiocarbon, foram, and macro-botanical analysis of Caven Point samples. Two (2) additional borings in upper 30 feet.

Long Term Recommendations

Reference is made to charting a model that the Corps can use for the next few years for protracted project design and planning. A first step in this regard is the development of a regional geoarchaeological synthesis to precede longer range field work. In practical terms it is necessary to formulate a synthesis project that will involve integrating all work done to date in the New York Bight. Extensive archival resources will be assembled and supplemented by Landsaat and satellite imagery to develop a "Model of Shoreline Sensitivity" in and around New York Harbor.

Tasks for this project will include:

- Utilization of this document as an initial framework
- Summary of all CRM shore investigations done to date
- Assembly of related archival (paleoenvironmental) and photographic info
- Refinement of an "interim" sensitivity model
- Identification of sensitive areas for further testing based on model
- Performance of testing to refine the sensitivity model
- Production a working model/document

The present document represents a first step in this process and should serve as a baseline for modeling after additional studies and resources are synthesized. This working model for sensitivity should be a document that the Corps should be able to apply for planning purposes for the next few years. It should contain a series of relatively detailed maps on a fine scale. This strategy is the most cost-effective as well as scientifically sound approach for addressing the Corps' CRM needs. It would avoid re-assessing initial sensitivity of a particular area every time a new impact zone is identified.

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APPENDIX 1

Final Scope of Work for the Geomorphological and Archeological Study

Scope of Work
and
Request for Proposal
For a
Geomorphological/Archaeological Study
In Connection with the
New York and New Jersey Harbor Navigation Study
Upper and Lower Bay
Port of New York and New Jersey

I. Introduction

The U.S. Army Corps of Engineers, New York District (Corps), has been authorized by Section 435, Water Resources Development Act of 1996, to conduct a comprehensive study of navigation needs at the Port of New York - New Jersey (the Port) to address improvements required to provide economically efficient and environmentally sound navigation to meet current and future requirements.

The Corps, as Federal agency is required to identify cultural resources within its study areas and evaluate their eligibility for listing on the National Register of Historic Places (NRHP). The Federal statutes and regulations authorizing the Corps to undertake these responsibilities include Section 106 of the National Historic Preservation Act, as amended through 1992 and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800).

Proposed deepening of existing navigation channels may impact stratigraphy containing significant data on the paleoenvironment of the region. The purpose of the investigations outlined in this scope is to assess the potential for prehistoric resources within the project areas by evaluating pertinent geophysical and paleoenvironmental data with respect to deglaciation, relative sea level rise, paleogeography, and the effects of marine erosion. This study is not designed to specifically locate cultural material. The overall goal of this cultural resource work will be to determine those locations within the study areas that are potentially sensitive for prehistoric resources. The resulting report will include recommendations for avoidance or mitigation of any potentially significant resources encountered.

The assessment will be based on, though not limited to, previous geological and cultural resource studies, both published and in the "gray literature," the history of dredging activities in the areas, an overview of existing boring logs for the area and on borings that have been, and will be, excavated for geotechnical purposes as part of the Port Study. The excavation of the proposed borings will be conducted under a separate contract but their collection will be monitored under this contract by an individual qualified in both fields of geomorphology and archaeology. Over 400 vibracores and borings have already been taken for the Port study in Ambrose and Anchorage Channels, parts of Brooklyn, Claremont and Port Jersey and the side slopes of the Kill Van Kull. Borings will be taken for the main channel of the Kill Van Kull, the Arthur Kill, and additional locations in Claremont, Port Jersey and Brooklyn (including the Buttermilk Channel). Approximately 115 borings are scheduled be taken. A map of boring locations is attached.

The Principal Investigator will determine which borings, and which soils within the profile, will require detailed physical and geochemical analysis. Palynological analysis will be undertaken on all pertinent strata (not to exceed 125 samples). Foraminifera analysis (not to exceed 150 samples), and radiocarbon dating (not exceed 20 samples), of selected samples will be undertaken as deemed necessary by the Principal Investigator. Grain size analysis will be conducted as part of the geotechnical study and the results will be made available for the work to be conducted under this scope. A limited number of soil samples from the 200 borings recently excavated for the Port Study will also be available for cultural resource specific testing. The Principal Investigator will determine which of these sediments should be tested. The quantity of samples to be tested are included in the total number of tests discussed above.

There has been some discussion between the Corps archaeologist, engineering and geotechnical staff as well as the geomorphologist currently working on the Corps' DMMP project regarding the borings already collected, as well as those proposed, for the Port study. It was agreed that the boring logs will be made available for this contract and selected soil samples will be retained for cultural resource specific studies. Borings proposed in more sensitive areas, such as Port Jersey and the Arthur Kill at the northeast end of Shooters Island, will be taken later in the geotechnical study schedule which will allow for the geomorphologist retained for cultural resource studies to be on board the vessel. Ideally, all excavation of the borings should be monitored by a qualified archaeologist/geomorphologist and the cores should be archived for further study. Scheduling difficulties did not allow for this to occur.

It is very probable that any prehistoric resources identified off-shore would be found to be eligible for listing in the NRHP under Criterion D of 36 CFR Part 60, due to their contribution in the study of the life and culture of indigenous peoples before the advent of written records. The documentation of the presence or absence of such sites and spatial distribution relative to landforms and resource bases would be important to the interpretation of prehistoric regional settlement patterns, demography and ecology. These sites may contain information on prehistoric environmental adaptations and subsistence strategies for environments not represented by terrestrial sites (e.g., Paleoindian coastal adaptations). Therefore, actions by the Port Deepening study could potentially impact NRHP eligible prehistoric cultural resources.

II. Project Background

A. Project Location

The New York and New Jersey Harbor study area has been divided into the following "paths", which have the Ambrose and Anchorage channels as common elements (see Figures 1,2 and 3):

Kill Van Kull and Newark Bay channels to include the Elizabeth Channel

Kill Van Kull and Arthur Kill channels to Howland Hook Marine Terminal

Arthur Kill Channel from Howland Hook to Gulfport and Petroport facilities

Bay Ridge, Red Hook, and Buttermilk channels

The Port Jersey Channel and Claremont Terminal Channels

Red Hook, Stapleton, and Gravesend anchorages.

The Ambrose and Anchorage channels are the main entrance channels to the Port of New York and New Jersey, extending from the Atlantic Ocean through Lower Bay. Ambrose Channel is maintained at a depth of -45 ft (MLW). Sandy Hook Channel is the second Harbor entrance channel extending from the Atlantic Ocean around Sandy Hook and connecting to the Raritan Bay channels and anchorages. Sandy Hook Channel is maintained at –35 ft (MLW).

The Upper Bay channels extending along the western shore of Brooklyn – Bay Ridge, Red Hook, and Buttermilk – permit ship access to Brooklyn Marine Terminal, Red Hook Container Terminal, and the South Brooklyn Marine Terminal. The three Upper Bay channels are maintained at –40 ft (MLW).

Kill Van Kull/Newark Bay channels are maintained at –40 ft (MLW). These two channels have been approved for deepening to a depth of –45 ft (MLW). Arthur Kill Channel is maintained at a nominal depth of –35 ft (MLW), and, with-project approval, will be deepened to –41 ft (MLW) to Howland Hook and to –40 ft (MLW) from Howland Hook to the Gulfport Reach.

The Arthur Kill Channel from Howland Hook to Gulfport and Petroport facilities has previously been surveyed for cultural resources (Wagner and Siegel 1997). This study indicated that the area north of Shooters Island remains sensitive for resources although the deposits along most of the reach as a whole lack integrity.

B. Project Description

One of the initial goals of the Feasibility Phase of the New York and New Jersey Harbor Navigation Study will be to identify the project's Area of Potential Effect. The array of alternatives to be examined in the Feasibility study includes structural and non-structural improvements to the above listed channels. For each of these channels, alternative combinations of channel depth, width and alignment will be examined, and the optimal combination will be identified in light of relevant current and future environmental, engineering and economic considerations. A program of blasting may be necessary in certain reaches to loosen hard materials for removal. Disposal sites, both upland and aquatic, may also be considered during these studies. The expansion of exiting Port facilities and/or creation of new infrastructure may also be evaluated as part of the Port Deepening Study if proposed facilities are directly related to Port Deepening. The outcome of these efforts will amount to a master plan for the location and timing of navigation related infrastructure investments Port-wide.

Portions of the Port have been subject to extensive study for prehistoric and historic cultural resources. These studies have documented that there is a very high potential for the Port to contain many significant resources including important data on the paleoenvironment of the region.

III. Previous Research

The first entry of peoples into the Greater New York Harbor region is believed to have been circa 12,000 years before the present era. This coincides with the retreat of the last glacial advance and the transgression of sea water across the continental shelf and into what is now the Lower New York Bay area. The precise timing of the retreat of the glacial ice and the rise of sea level is not known. Present evidence suggests that 12,000 years ago the modern-day Lower New York Bay may have been a relatively dry coastal plain, dissected by the ancestral Hudson and Raritan Rivers, and perhaps meltwater streams as well (Ferguson 1986).

The maximum extent of the Wisconsin ice sheet was along the south shore of Long Island at approximately 18,000 B.P. At that time sea level was approximately 100 meters (330 feet) below present level. The -30m contour line, "minus areas of post-inundation sand ridges, has been adopted as the lower limit for medium and high-probability areas of prehistoric site occurrence" on the now submerged continental shelf (Heritage Studies 1985:3-26). "At 12,000 B.P. the sea level was approximately 30 meters below the present level. At 8,000 B.P. the level was approximately -20 meters, and at 6,000 B.P. the level was about 10 meters below the present level" (Heritage Studies 1985:6-4). The potential for Archaic period sites in the New York area lies is between the present shoreline and the -20m isobath (Stright 1995). Paleo Indian sites may be found at greater depths.

Prehistoric archaeological sites on present-day dry land are generally located near certain key physiographic resources such as fresh water and ecologically rich habitats. The same, it is believed, holds true for sites now submerged where "although the physical and cultural remains of prehistoric man may occur anywhere along these extensive former land surfaces, the factors essential to human settlement, such as fresh water, plant and animal food resources, material source areas for tool manufacture, sheltered areas, and, in coastal areas, well-drained topographic highs, were often determinant in site selection" (Stright 1986:350). Site types that are likely to occur include semi-permanent, seasonally-occupied camp sites, temporary camps, processing stations, and shell middens.

The preservation of continental shelf sites is effected by many factors. Erosion associated with rising sea levels is expected to be a "major factor" in site destruction and "in general, sites buried by sediments in low-energy environments (i.e., flood plains, river terraces, bays, lagoons, lakes, ponds, sinkholes, and subsiding deltas) prior to marine transgression will be preserved" (Stright 1986:350). The potential for sites to have survived marine transgression can be estimated using such factors as the rate of relative sea level rise, the slope of the shelf, sediment budget, and shelf morphology (Stright 1995:132). The basal layers of deep archaeological deposits may remain even though upper surfaces may have been eroded by marine transgression (Stright 1995).

The potential for intact in-channel deposits will be dependent not only upon the geological history of the location but also on the area's dredging history. There is a significant chance that any relevant stratigraphy may have been removed by dredging activities. A recent study in the Arthur Kill indicated that "the almost complete absence of these Pleistocene or Holocene deposits throughout much of the channel corridor suggests that earlier dredging efforts have resulted in their removal; even where the deposits are still present the prospects of finding intact formerly inhabitable land surfaces are remote" (Wagner and Siegel 1997:21). The Arthur Kill Channel was dredged historically to approximately 40 feet below mean low water. Wagner and Siegel have identified an area north of Shooters Island as having a high potential for surviving Pleistocene/Holocene deposits.

Cores in the near-shore area of south Brooklyn suggest that prehistoric archaeological sites may exist there but in most locations would probably be buried under thick accumulations of sediment or fill. Cores in Erie Basin indicate the presence of organic silt deposits at approximately 30 to 55 feet below today's mean high water. These deposits reflect marine transgression in the area thereby representing "an approximate cap on possible earlier land surfaces available to humans" (Raber Associates 1984a:10).

To date, nine of the approximately 20 sites identified on the North American continental shelf containing Native American archaeological materials have been recovered from the Connecticut and Long Island coastline within the New York Bight region. These sites were for the most part found to underlie current marsh deposits along the Long Island Sound. The Cedar Creek Site was identified on the south shore of Long Island at Seaford. This site, located beneath marsh deposits, consisted primarily of shell mounds, with some evidence of burning and a small quantity of debitage. This submerged site is eligible for the NRHP (Stright 1990, Cammisa 1995).

Currently, work is on-going within the Port in connection with the DMMP. The results of this study indicate that even in existing navigation channels, deeply buried deposits may preserve prehistoric sites. However, most of the pertinent deposits are within the uppermost 30 feet of sediments (LaPorta, Sohl, and Brewer 1998).

The reports cited in the text above and those included in the attached bibliography contain much of the background data and interpretation that will be utilized for this project.

Research into boring logs held by the Army Corps of Engineers, New York District, the Port Authority of New York and New Jersey and other agencies and institutions may yield additional stratigraphic information. An inventory of Corps borings is available from the Corps' Engineering Division.

IV. Contractor Services and Required Investigations

A. The general services to be provided under this contract are those required to conduct research and prepare a report on the prehistoric environment of the Ambrose and Anchorage Channels, Brooklyn, Claremont and Port Jersey, Newark Bay and Elizabeth Channels, the Kill Van Kull, Arthur Kill, and the Red Hook, Stapleton and Gravesend Anchorages.

B. The Contractor shall be responsible for conducting, in the manner prescribed, the work detailed below. Failure to fully meet the requirements of this scope of work may be cause for termination of work for default of the contract, or for an evaluation of unsatisfactory upon completion of the project.

C. This scope of work requires the completion of the following tasks:

Task 1 - Review Previous Research and Background Research

a. The Contractor shall review the documents cited in Section III, "Previous Research" above, as well as other texts included in the attached bibliography. Many of the cultural resource reports cited are available at the New York District.

b. The Contractor shall also conduct additional research to:

1. determine the prehistory of the project area and vicinity.

2. identify previously known cultural resources within the project area and vicinity.

3. outline pertinent research issues associated with this study.

4. research the geology, hydrology, sea level rise, etc. of the project area.

5. research the dredging history of the project areas to determine areas and depths of disturbance. Inventories of core samples from the New York Bight have been compiled by WES and by the Engineering Division of the New York District. These inventories should be reviewed although the WES data seems to consist primarily of surficial deposits and may not be relevant to this study. The Port Authority of New York and New Jersey should also be contacted regarding any offshore subsurface information they may have. Dredging information can be obtained from the Operations Division of the New York District. A list of contacts will be provided by the Corps study archaeologist. Other pertinent federal, state and local agencies and academic institutions should also be contacted for information on the geology and sediments of the area.

6. Research was conducted at the New York and New Jersey State Historic Preservation Offices (NYSHPO, NJHPO) in the summer of 1996 for the DMMP project. These offices should be contacted again for more recent material. The New York State Museum and the New Jersey State Museum should be consulted.

Task 2 - Monitor Excavation of Borings

Borings will be excavated for the Corps' under a separate contract. However, under this contract, a geomorphologist familiar with shelf deposits will be periodically on board the vessel as borings are taken and will determine the depths to which continuous borings must be collected. A continuous profile should be obtained through Holocene deposits and into the terminal Pleistocene deposits, if present. The geomorphologist will provide guidance to the boring contractor for the borings that will be excavated when the geomorphologist is not on board the vessel. The geomorphologist and an assistant will monitor the data collection thereafter by periodically spending time on the vessel, particularly when borings are collected from areas determined, by the geomorphologist, to be sensitive for cultural resource data. The schedule will be determined in consultation with the Corps project archaeologist, Engineering Division and the boring contractor but will not be more than 20 days.

Task 3 - Sediment Testing

Samples will be taken from the cores and examined for evidence of cultural resources and paleoenvironmental data. All samples selected for further analysis will undergo palynological testing (not to exceed 125 samples). Foraminiferal and Carbon-14 analyses will be undertaken for only those sediments determined by the geomorphologist as likely to yield significant information. The number of samples to be tested for foraminifera by the geomorphologist will not exceed 150. Carbon-14 testing will not exceed 20 samples. The total number of samples include those obtained from the initial geotechnical investigation for the Port study as well as those monitored under this contract.

Task 4 - Data Analysis

The Contractor will assemble and interpret all data collected for this study with the purpose of collating it in the preparation of the draft and final reports. The report requirements are outlined in Section V, below.

Task 5 - Report Preparation

The Contractor shall prepare interim, draft and final reports. The final report will incorporate all comments received from the Corps and other reviewing agencies.

The reports produced by a cultural resource investigation is of potential value not only for its specific recommendations but also as a reference document. To this end, the report must be a scholarly statement that can be used as a basis for any future cultural resources work. It must meet both the requirements for cultural resource protection and scientific standards of current research as defined in 36 CFR Part 800 and the Councils Handbook.

To facilitate the preparation of input to the Corps' New York and New Jersey Harbor Navigation Study documents a section must be included within the report that breaks down the discussion of potential resources and recommendations by area (ie., Port Jersey, Bay Ridge, Red Hook, Buttermilk Channels, etc.), and must include a map of each zone on which the areas of sensitivity are depicted.

1. One copy of each interim report will be submitted to the Corps, according to the time schedule established in Section VI "Project Schedule", below. Each interim report will provide a brief summary of the work conducted to date and the work yet to be completed. It shall present any preliminary results of the research and field effort.

2. Four copies of the draft report will be prepared and submitted to the Contracting Office according to the schedule established in Section VI "Project Schedule", below. The draft report will be reviewed by the Corps, the NJHPO, the NYSHPO and the New York City Landmarks Preservation Commission. All comments of the reviewing

agencies and will be transmitted to the Contractor prior to the submission of the final report.

3. Six copies of the final report shall be submitted to the Contracting Office according to the schedule established below in Section VI "Project Schedule". The final report shall address all comments made on the draft report.

Task 6 – Public and Agency Coordination

The contractor will assist the Corps in organizing public and agency meetings (not to exceed 6 meetings within the time allotted for this delivery order). Posters may be required for the meetings (not to exceed three (3), 24x36" poster boards developed from materials in the Port Deepening Study cultural resource reports). The contractor will also assist in coordinating the results of the Port Deepening cultural resource studies with the public. This task will include maintaining a mailing list of interested parties (a preliminary list has been compiled by the Corps [approximately 60 parties are on the list]), and generating relevant correspondence and documents, but will not include the cost of mailing documents to the interested parties. The mailing list will be provided to the Corps, as needed. A Programmatic Agreement (PA) outlining the Corps' Section 106 responsibilities will be developed. The contractor shall assist in the development of this document. A Draft PA has been developed for the Port's Dredged Material Management Plan which may serve as a model for the Port Deepening PA.

Task 7 - Project Management

The Contractor will be responsible for ensuring that all deliverables are provided on schedule and that all terms of this scope of work are satisfied.

V. Report Format and Content

A. The draft and final reports shall have the following characteristics:

1. The draft and final copies of the cultural resources report shall reflect and report on the work outlined in Section IV (Required Investigations) above. They shall be suitable for publication and be prepared in a format reflecting contemporary organizational and illustrative standards of professional archaeological journals. The draft report will be revised to address all review comments.

2. The report produced by a cultural resources investigation is of potential value not only for its specific recommendations, but also as a reference document. To this end, the report must be a scholarly statement that can be used as a basis for

any future cultural resources evaluation. It must meet both job requirements for cultural resources protection and scientific standards as defined in 36 CFR Part 800 and in the "The Treatment of Archeological Properties: A Handbook" (1980) published by the Advisory Council on Historic Preservation.

3. All interim, draft and final copies of the report shall reflect and report on the work required by this scope.

B. **PAGE SIZE AND FORMAT.** Each report shall be produced on 8 1/2" x 11" archivally stable paper, single spaced with double spacing between paragraphs. The printing of the text should be letter quality. All text pages, including figures, tables, plates and appendices must be consecutively numbered.

C. Three final copies of the report, with original photographs, shall be submitted in a hard-covered binder suitable for shelving (see VI:B:2, below).

D. The **TITLE PAGE** of the report shall include the municipalities and counties incorporated by the project area, the author(s) including any contributor(s) The Principal Investigator should be identified and is required to sign the original copies of the report. If the report has been written by someone other than the contract Principal Investigator, then the cover of the publishable report must bear the inscription *"Prepared Under the Supervision of (NAME), Principal Investigator"*. The Principal Investigator in this case must also sign the original copies of the report.

E. A **MANAGEMENT SUMMARY** or **ABSTRACT** shall appear before the **TABLE OF CONTENTS** and **LIST OF FIGURES**. It should include a brief project description including the location and size of the project area, the methods of data collection, the results of the study, evaluations and identification of impacts and recommendations. It should also include the location of where copies of the report are on file.

F. The **TABLE OF CONTENTS** will include a list of all figures, plates and tables presented in the report.

G. The **INTRODUCTION** will state the project's purpose and goals as defined by the scope of work and will include the applicable regulations for conducting this work and will contain a general statement of the work conducted and the recommendations proposed.

H. The **BACKGROUND RESEARCH** must be sufficient to provide a detailed description and evaluation of the prehistoric research of the project area. This section should include a summary of the existence of sites and a description of previous work conducted in the area. The following information should be presented and discussed:

1. the **ENVIRONMENTAL SETTING**, including bathymetry, soils, and geology.

2. an **ANALYSIS** of paleoenvironment, present climate and current vegetation.

3. **PAST AND PRESENT LAND USES** and current conditions.

4. a **DISCUSSION** of prehistoric and historic cultural history of project locale. This section should provide contexts for research questions, survey methods, etc.

5. a **REVIEW** of known sites, previous investigations and research in the project area and vicinity.

I. A **RESEARCH DESIGN** will outline the purpose of the investigation, basic assumptions about the location and type of cultural resources within the project area. The following shall also be included:

1. **RESEARCH OBJECTIVES** and **THEORETICAL CONTEXT**

2. specific **RESEARCH PROBLEMS** or questions.

3. **METHODS** to be employed to address the research objectives and questions.

4. a **DISCUSSION** of the expected results, including hypotheses to be tested.

J. A **METHODS** section, if applicable, shall include:

1. a **DESCRIPTION OF FIELD METHODS** employed, including rationale, discussion of biases and problems or obstacles encountered.

2. a **DEFINITION** of site used in the survey.

K. **RESULTS, INTERPRETATIONS AND RECOMMENDATIONS.** A discussion of the results in terms of the background cultural context, research design, goals, research problems, and potential research questions.

L. A **REFERENCES CITED** section will list all references and citations located within the text, including all figures, plates or maps, and within any appendices. All sources (persons consulted, maps, archival documentation, etc.) maybe listed together. This list must be in a format used by professional archaeological journals, such as *American Antiquity.*

M. **APPENDICES** shall include, but not be limited to:

1. a copy of relevant boring/subsurface exploration data used in the report.

2. the **QUALIFICATIONS** of the Principal Investigator and any other key personnel used.

3. the final **SCOPE OF WORK.**

O. **PHOTOGRAPHS** will be glossy black and white prints no smaller than 5" x 7". Photographic illustrations should be securely mounted by use of an archivally stable mounting medium. Photograph captions for site overviews must include direction or orientation. At a minimum, captions should identify feature or location, direction, photographer and date of exposure. **All photographs should be fully captioned on the reverse of the photograph in case they should be removed from the report.** Photographs should be counted as "Figures" in a single running series of illustrations, plates, etc.

P. **GRAPHIC PRESENTATION OF THE RESULTS.**

1. All pages, including graphic presentations, will be numbered sequentially.

2. All graphic presentations, including maps, charts and diagrams, shall be referred to as "Figures". All figures must be sequentially numbered and cited by number within the body of the text.

3. All figures, plates and tables should be incorporated into the text on the page following their citation. They should not be appended.

4. All tables shall have a number, title, appropriate explanatory notes and a source note.

5. All figures shall have a title block containing the name of the project, county and state.

6. All maps, including reproductions of historic maps, must include a north arrow, accurate bar scale, delineation of the project area, legend, map title and year of publication.

7. The report must include the project area(s) accurately delineated on a U.S.G.S. 7.5' topographic map and a county soils survey map, if available for that area. A NOAA chart may also be submitted on which the project area(s) is delimited.

VI. Project Schedule

A. All reports should be submitted in a timely manner as stipulated below:

1. An interim report will be submitted to the Corps monthly with each invoice. The interim report shall discuss what work has been accomplished and what work has yet to be completed. It shall also state any problems the Contractor has encountered in conducting the work or contain requests for information.

2. the draft report will be submitted to the Corps not later than eight (8) months after notice to proceed. The draft report will be reviewed by the Corps, the NYSHPO, the NJHPO and New York City Landmarks Preservation Commission. One copy of the draft report will be returned to the Contractor with comments. The final report will address all comments provided with the draft report.

3. The final report will be submitted to the Corps four (4) weeks after the Contractor receives the draft report with comments.

B. The number of copies for the interim, draft, and final reports will be submitted, according to the above schedule, as follows:

1. One copy of each interim report.

2. Four copies of the draft report.

3. Six copies of the final report; one of which will be unbound and will contain original photographs and drawings, if applicable. Three bound copies, suitable for shelving, which will also contain original photographs. Two bound copies will also be submitted but photocopies of the photographs are acceptable.

C. Scheduled completion date for the work specified in this scope is one year from date of award.

VII. Additional Contract Requirements

A. Agencies, institutions, corporations, associations or individuals will be considered qualified when they meet the minimum criteria given below. As part of the supplemental documentation, a contract proposal and appendices to the draft and final report must include vitae for the **PRINCIPAL INVESTIGATOR** and **MAIN SUPERVISORY PERSONNEL** in support of their academic and experiential qualifications for the research, if these individuals were not included in the original contract proposal. The Principal Investigator must also be a qualified geomorphologist. Additional personnel should consist of an archaeologist that meets the qualifications presented below. Personnel must meet the minimum professional standards stated below:

1. Archaeological Project Director or Principal Investigator (PI). Persons in charge of an archaeological project or research investigation contract, in addition to meeting the appropriate standards for archaeologist, must have a doctorate or equivalent level of professional experience as evidenced by a publication record that demonstrates experience in project formulation, execution, and technical monograph reporting. Suitable professional references may also be made available to obtain estimates regarding the adequacy of prior work. If prior projects were of a sort not ordinarily resulting in a publishable report, a narrative should be included detailing the proposed project director's previous experience along with references suitable for to obtain opinions regarding the adequacy of this earlier work.

2. Geomorphologist. Personnel hired for their special knowledge and expertise in geomorphology should have a Master's degree or better and experience and a publication record demonstrating a substantial contribution to the field through research. For this project, the individual must have experience in the interpretation of sediments on the Continental Shelf, particularly with regard to the potential for archaeological resources. The individual should also ideally be able to interpret seismic data.

3. Archaeologist. The minimum formal qualifications or individuals practicing archaeology as a profession area a B.A. or B.S. degree from an accredited college or university, followed by two years of graduate study with concentration in anthropology and specialization in archaeology during one of these programs, and at least two summer field schools or their equivalent under the supervision of an archaeologist of recognized competence. A Master's thesis or its equivalent in research and publications is highly recommended, as is the PhD degree. Individuals lacking such formal qualifications may present evidence of a publication record and references from archaeologists who do meet these references. In addition, the archaeologist should also have experience in the prehistoric archaeology of the southern New York - northern New Jersey area.

4. Standards for Consultants. Personnel hired or subcontracted for their special knowledge and expertise must carry academic and experiential qualifications in their own fields of competence. Such qualifications are to be documented by means of vitae attachments to the proposal or at a later time if the consultant has not been retained at the time of proposal.

B. Principal Investigators shall be responsible for the validity of the material presented in their reports. In the event of a controversy or court challenge, Principal Investigators shall be required to testify on behalf of the government in support of findings presented in their reports.

C. Neither the Contractor nor his representatives shall release any sketch, photograph, report or other data, or material of any nature obtained or prepared under this contract without the specific written approval of the Contracting Officer prior to the time of final acceptance by the government.

D. The Contractor shall furnish all labor, transportation, instruments, survey equipment, boats and other associated materials to perform the work required by this Scope of Work.

E. The Contractor shall return all copies of reports provided by the Corps when the final report is submitted.

VIII. Fiscal Arrangements

A. Partial payments of the total amount allocated will be dispersed upon the receipt of invoices. Invoices will be submitted with the interim reports and with the draft report and will reflect the amount expended. The total amount of all monthly invoices shall not total more than 90% of the agreed work order amount. The remaining 10% of the agreed work order amount shall be paid upon the receipt and acceptance of the final report, all reports provided by the Corps, etc. and receipt of the final invoice. **No invoice payments will be made if it is does not include an accompanying interim or draft report.**

B. Invoice payments will be made pursuant to the "Prompt Payment" clause of the contract.

APPENDIX 2

Graphic Log Depictions of Geotechnical Borings

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Newark Bay

BORING: NB-98-22

DATE OF BORING: 11-19-98

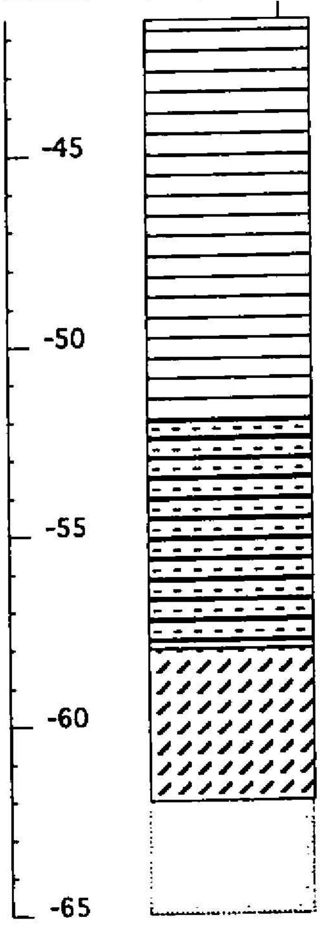
TOTAL DEPTH: 24.5 ft.

TOTAL DEPTH MLW: 65 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees

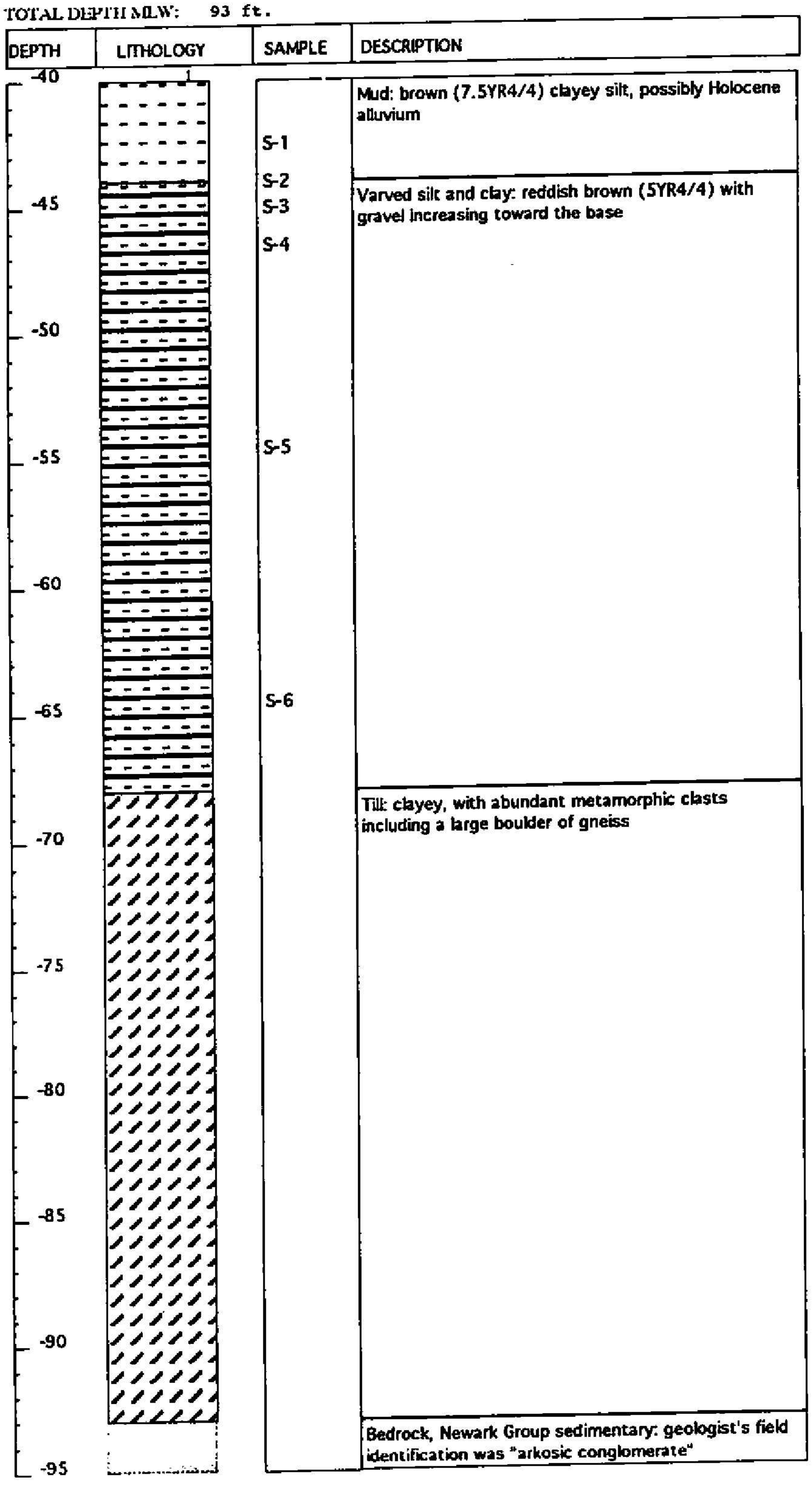
DEPTH	LITHOLOGY	SAMPLE	DESCRIPTION



SAMPLE	DESCRIPTION
S-1 S-2 S-3	Massive clay: brown (7.5YR4/4) but becomes reddish brown (5YR4/4) with depth, silty with some lamination but not regularly varved
S-4	Varved silt and clay: reddish brown (5YR4/4) and grading smoothly to the overlying more massive clay
S-5	Till: clayey, with gravel clasts of Newark Group sedimentary rocks
	Bedrock, Newark Group sedimentary: brown sandstone

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA:	Newark Bay		
BORING:	NB-98-23	LATITUDE:	40 degrees
DATE OF BORING:	11-19-98	LONGITUDE:	74 degrees
TOTAL DEPTH:	50 ft.		
TOTAL DEPTH MLW:	93 ft.		



Mud: brown (7.5YR4/4) clayey silt, possibly Holocene alluvium

Varved silt and clay: reddish brown (5YR4/4) with gravel increasing toward the base

Till: clayey, with abundant metamorphic clasts including a large boulder of gneiss

Bedrock, Newark Group sedimentary: geologist's field identification was "arkosic conglomerate"

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Newark Bay

BORING: NB-98-24

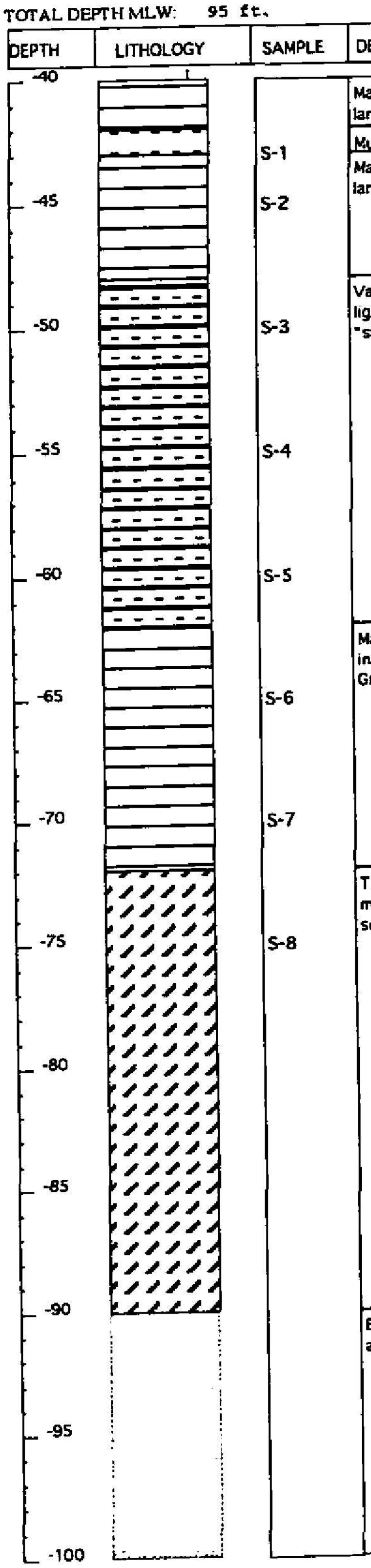
DATE OF BORING: 11-24-98

TOTAL DEPTH: 60 ft.

TOTAL DEPTH MLW: 95 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



DESCRIPTION

Massive clay: reddish brown (5YR4/4) with darker silty laminations

Mud: organic silt

Massive clay: reddish brown (5YR4/4), with sandy laminations increasing toward base

Varved silt and clay: reddish brown (5YR4/4), with light yellowish brown (2.5Y6/4) find sandy to silty "summer" varves

Massive clay: reddish brown (5YR4/4) with interbedded gravelly sand and pebble clasts of Newark Group sedimentary rocks

Till: more compact reddish brown (5YR4/4) clayey matrix with faceted clasts of Newark Group sedimentary rocks

Bedrock, Newark Group sedimentary: Brunswick shale and sandstone

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Newark Bay

BORING: NB-98-27

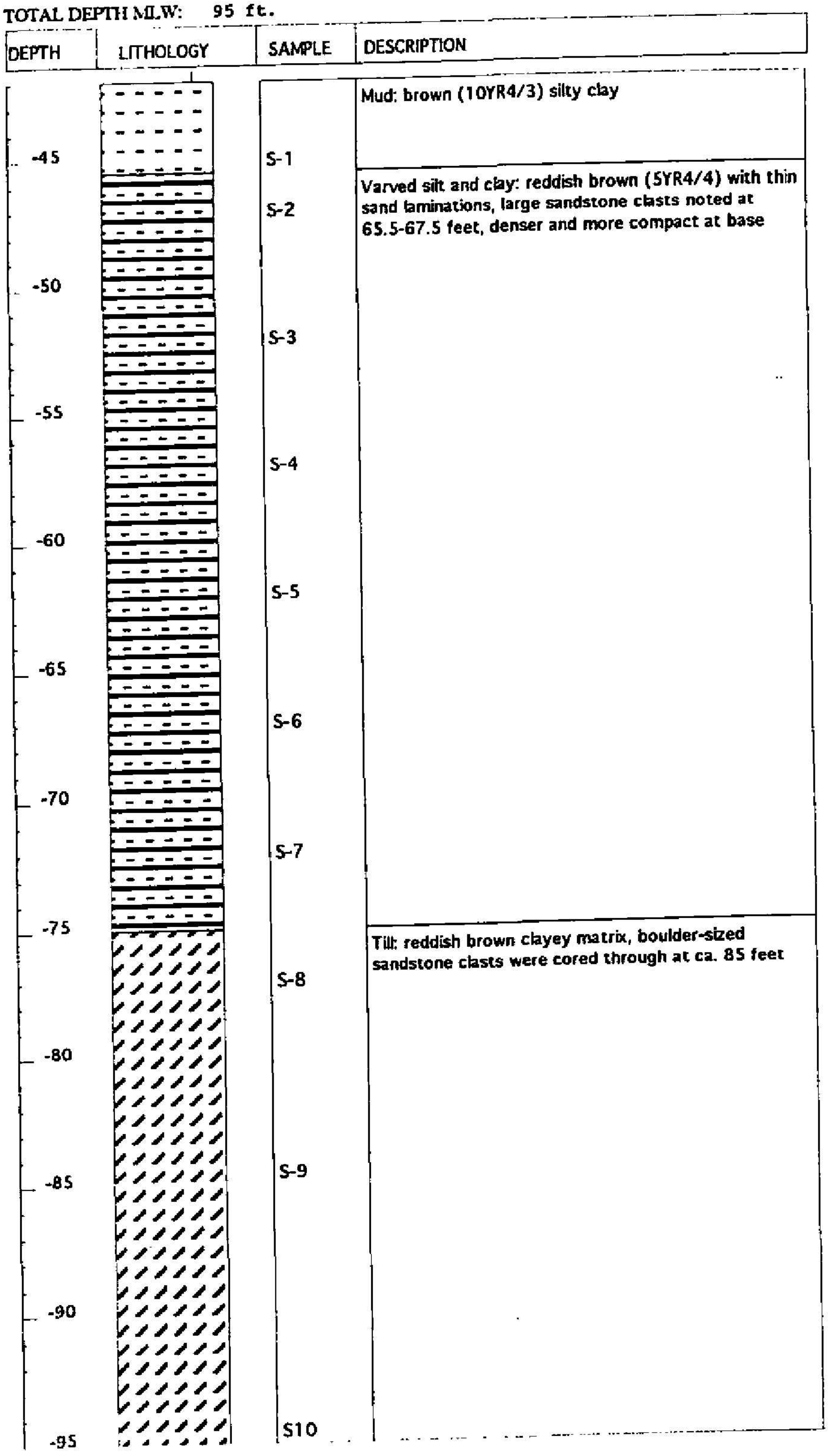
DATE OF BORING: 11-30-98

TOTAL DEPTH: 51.5 ft.

TOTAL DEPTH MLW: 95 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



Mud: brown (10YR4/3) silty clay

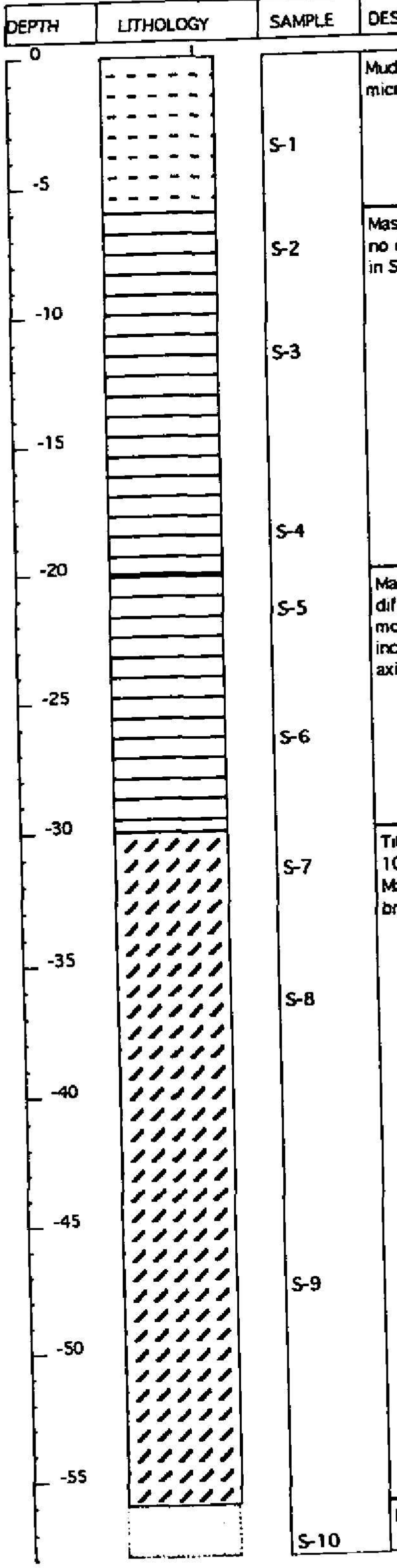
Varved silt and clay: reddish brown (5YR4/4) with thin sand laminations, large sandstone clasts noted at 65.5-67.5 feet, denser and more compact at base

Till: reddish brown clayey matrix, boulder-sized sandstone clasts were cored through at ca. 85 feet

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Newark Bay
BORING: NB-98-28
DATE OF BORING: 11-19-98
TOTAL DEPTH: 58 ft.
TOTAL DEPTH MLW: 93 ft.

LATITUDE 40 degrees
LONGITUDE 74 degrees



DESCRIPTION

Mud: loose peaty silts with abundant macro- and micro-organics. No clear upper boundary

Massive clay: reddish brown (5YR4/4), homogeneous, no discernible clasts. Sandy, silty organics were noted in S-4, radiocarbon dated to 29,600±360 B.P.

Massive clay: reddish brown (5YR4/4) with some diffuse organics, extremely stiff, faint limonitic mottling, S-6 had diffuse distributions of larger clasts including sandstone fragments up to 30 mm on long axis in a variety of shapes

Till: abundant large subangular clasts, 35% by volume, 10-30 mm on long axis with size diminishing in S-8. Matrix grades from reddish brown (5YR4/4) in S-7 to brown (10YR4/4) in S-9 with increasing organic matter

Bedrock, Newark Group sedimentary: Brunswick shale

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Newark Bay

BORING: NB-98-29

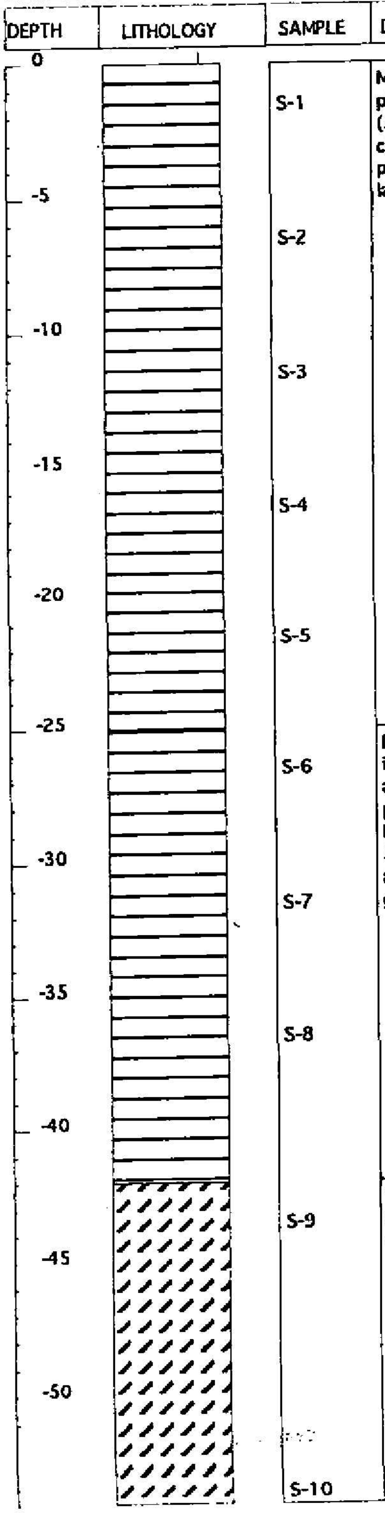
DATE OF BORING: 11-19-98

TOTAL DEPTH: 54 ft.

TOTAL DEPTH MLW: 95.3 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



DESCRIPTION

Massive clay: reddish brown (5YR4/4), extremely plastic, matrix interspersed with subrounded pebbles (2-5 mm on long axis, ca. 5-10% by volume). Detrital clasts diminish to less than 1% volume at S-4, progressive increase in plasticity beginning at S-5, no laminar planes

Massive clay: reddish brown (5YR4/4), slight increase in detrital component (1%-2%) at S-6 but plasticity and stickiness at maximum levels, subrounded pegmatite pebbles noted in detritus, lag at S-8 noted by further increase in detrital material to greater than 5% of matrix, chiefly subrounded pebbles (5 mm on average), serpentinite (weathered), detrital material grades coarser with depth

Till: reddish brown clayey matrix, 20% subrounded to subangular pebbles by volume, large diameter serpentinite clasts continue

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Port Newark

BORING: PN-98-4

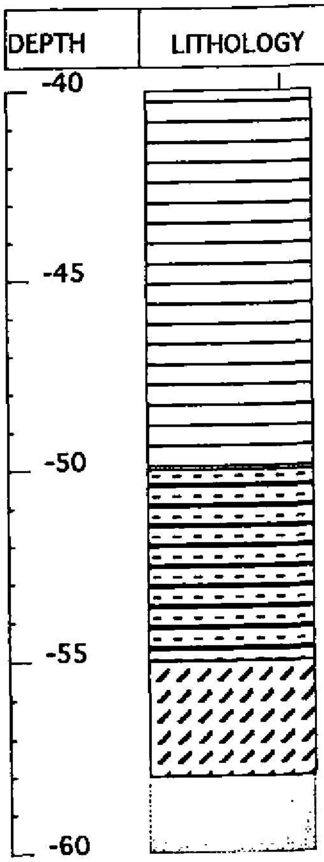
DATE OF BORING: 11-10-98

TOTAL DEPTH: 18 ft.

TOTAL DEPTH MLW: 58 ft.

LATITUDE: 40 degrees

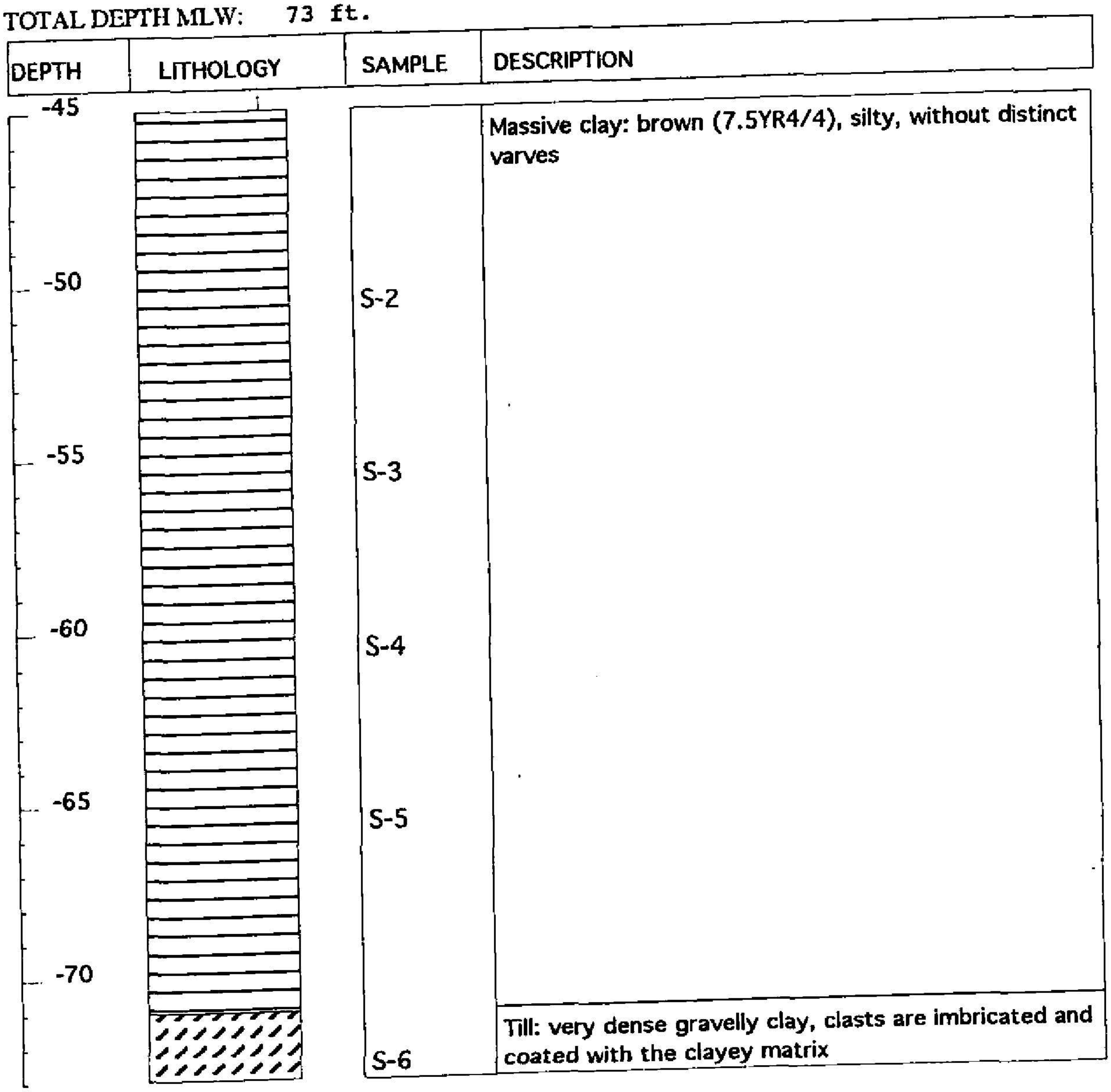
LONGITUDE: 74 degrees



SAMPLE	DESCRIPTION
S-1	Massive clay: reddish brown (5YR4/4) with some medium to coarse sand
S-2	
S-3	Varved silt and clay: glaciolacustrine facies
S-4	Till: clayey, very compact, with quartz filling a crack, possibly Illinoian
	Bedrock, Newark Group sedimentary: probably Brunswick shale

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA:	Port Newark		
BORING:	PN-98-6	LATITUDE:	40 degrees
DATE OF BORING:	11-30-98	LONGITUDE:	74 degrees
TOTAL DEPTH:	22 ft.		
TOTAL DEPTH MLW:	73 ft.		



Massive clay: brown (7.5YR4/4), silty, without distinct varves

Till: very dense gravelly clay, clasts are imbricated and coated with the clayey matrix

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Port Newark

BORING: PN-98-8

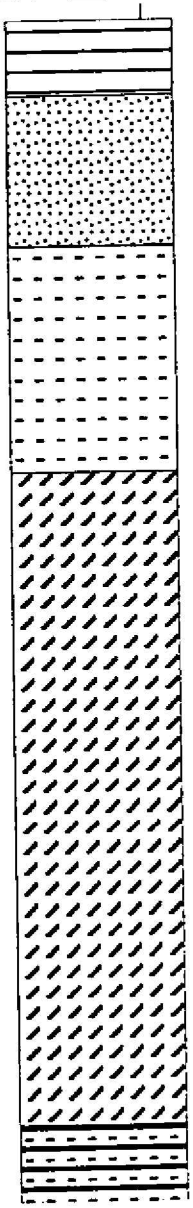
DATE OF BORING: 11-10-98

TOTAL DEPTH: 31 ft.

TOTAL DEPTH MLW: 75 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees

DEPTH	LITHOLOGY	SAMPLE	DESCRIPTION
-45		S-1	Massive clay: gravelly, with plastic and other modern refuse
		S-2	Massive sand: reddish brown (5YR4/4), medium to coarse, grades to massive clay with some sand at the base of the split spoon
-50 -55		S-3	Mud: brown (7.5YR4/4) silt with many large subangular to angular rock fragments (colluvium or till, possibly Holocene)
-60 -65 -70		S-4 S-5 S-6	Till: brown (7.5YR4/4), stiff, dense clay interbedded with coarse sand and gravel lenses (possibly flow-till), clasts of serpentinite noted at 66-68'
-75		S-7	Varved silt and clay: some well-sorted fine to medium sand

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Port Newark

BORING: PN-98-10

DATE OF BORING: 11-17-98

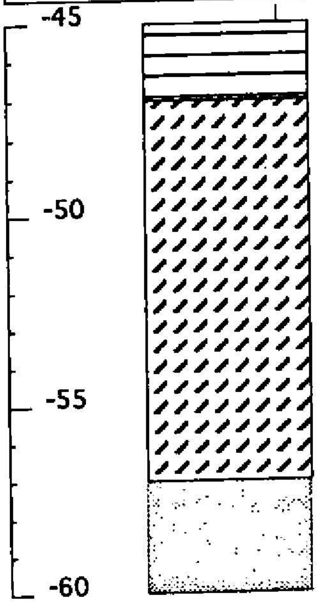
TOTAL DEPTH: 12 ft.

TOTAL DEPTH MLW: 60 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees

DEPTH | LITHOLOGY



SAMPLE	DESCRIPTION
S-1	Massive clay: reddish brown (5YR4/4), silty
S-2 S-3	Till: clayey, with faceted stones, becoming stiffer with depth
	Bedrock, Newark Group sedimentary: grey shale, possibly Stockton or Lockatong

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Port Newark

BORING: PN-98-15

DATE OF BORING: 11-17-98

TOTAL DEPTH: 11 ft.

TOTAL DEPTH MLW: 60 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees

DEPTH	LITHOLOGY	SAMPLE	DESCRIPTION
-45	☰	S-1	Massive clay: brown (7.5YR4/4), silty, probably reworked till
	▨		Till: sandy, with common faceted stones of Newark Group sedimentary rocks
-50 -55			Bedrock, Newark Group sedimentary: sandstone over gray shale, possibly Stockton or Lockatong

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Port Newark Point

BORING: PNP-98-16

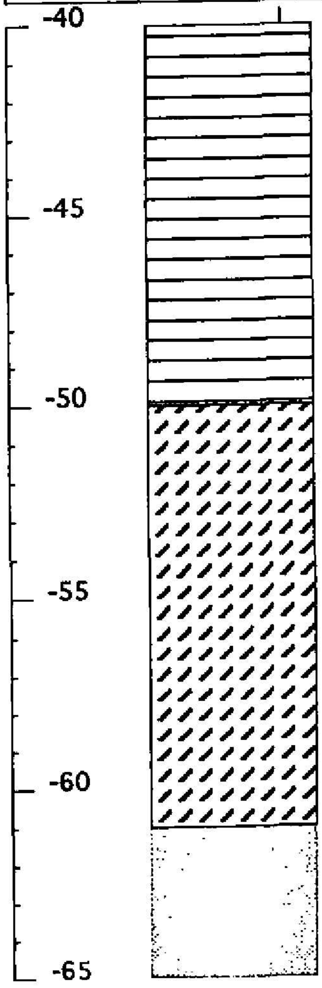
LATITUDE: 40 degrees

DATE OF BORING: 11-09-98

LONGITUDE: 74 degrees

TOTAL DEPTH: 18.5 ft.

TOTAL DEPTH MLW: 65 ft.



DEPTH	LITHOLOGY	SAMPLE	DESCRIPTION
		S-1 S-2	Massive clay: reddish brown (5YR4/4), sandy but compact, with common subrounded pebble and cobble clasts of Newark Group sedimentary rocks
		S-3	Till: finer-grained matrix with faceted angular cobble clasts of metamorphic lithologies
			Bedrock, Newark Group sedimentary: probably Brunswick shale

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Elizabeth Channel

BORING: E-98-13

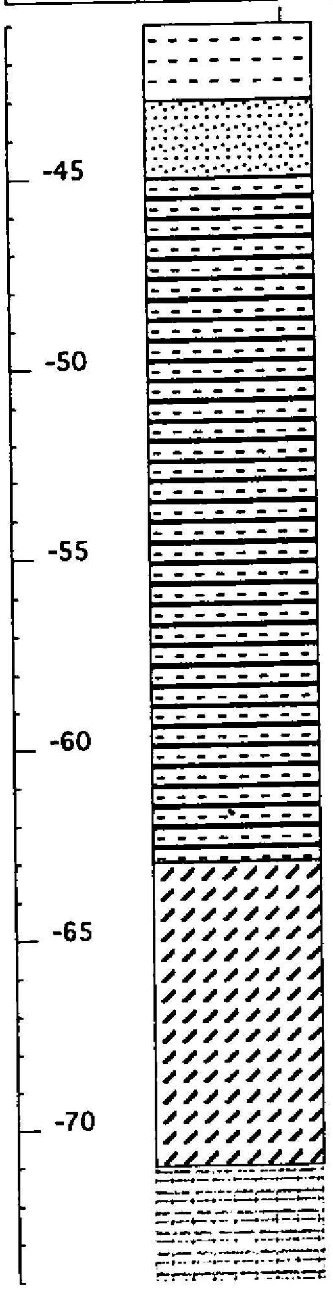
DATE OF BORING: 11-10-98

TOTAL DEPTH: 33 ft.

TOTAL DEPTH MLW: 74 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



DEPTH	LITHOLOGY	SAMPLE	DESCRIPTION
		S-1	Mud: brown (10YR4/3) Holocene silty alluvium
		S-2	Massive sand: micaceous with some weak laminations
		S-3	Varved silt and clay: glaciolacustrine facies capping a basal lag of cobbles
		S-4	Till: gravelly sand with faceted clasts
			Bedrock, argillite

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Elizabeth Channel

BORING: E-98-15

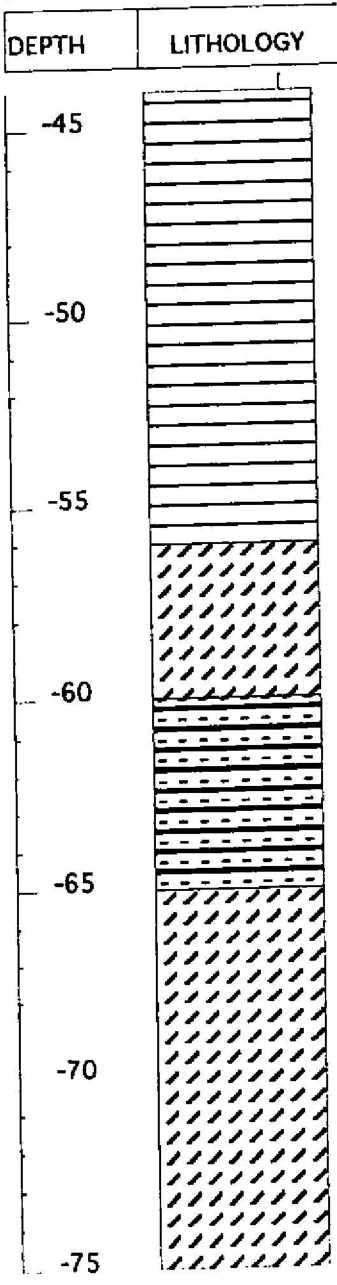
DATE OF BORING: 11-20-98

TOTAL DEPTH: 29 ft.

TOTAL DEPTH MLW: 75 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



SAMPLE	DESCRIPTION
S-1 S-2	Massive clay: brown (7.5YR4/4) with a few thin sandy varves
S-3	Till: gravelly clay
S-4	Varved silt and clay: sandy, possibly flow till
	Till: sandy, with faceted stones of Newark Group sedimentary rocks

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Claremont Channel

BORING: CC-98-17

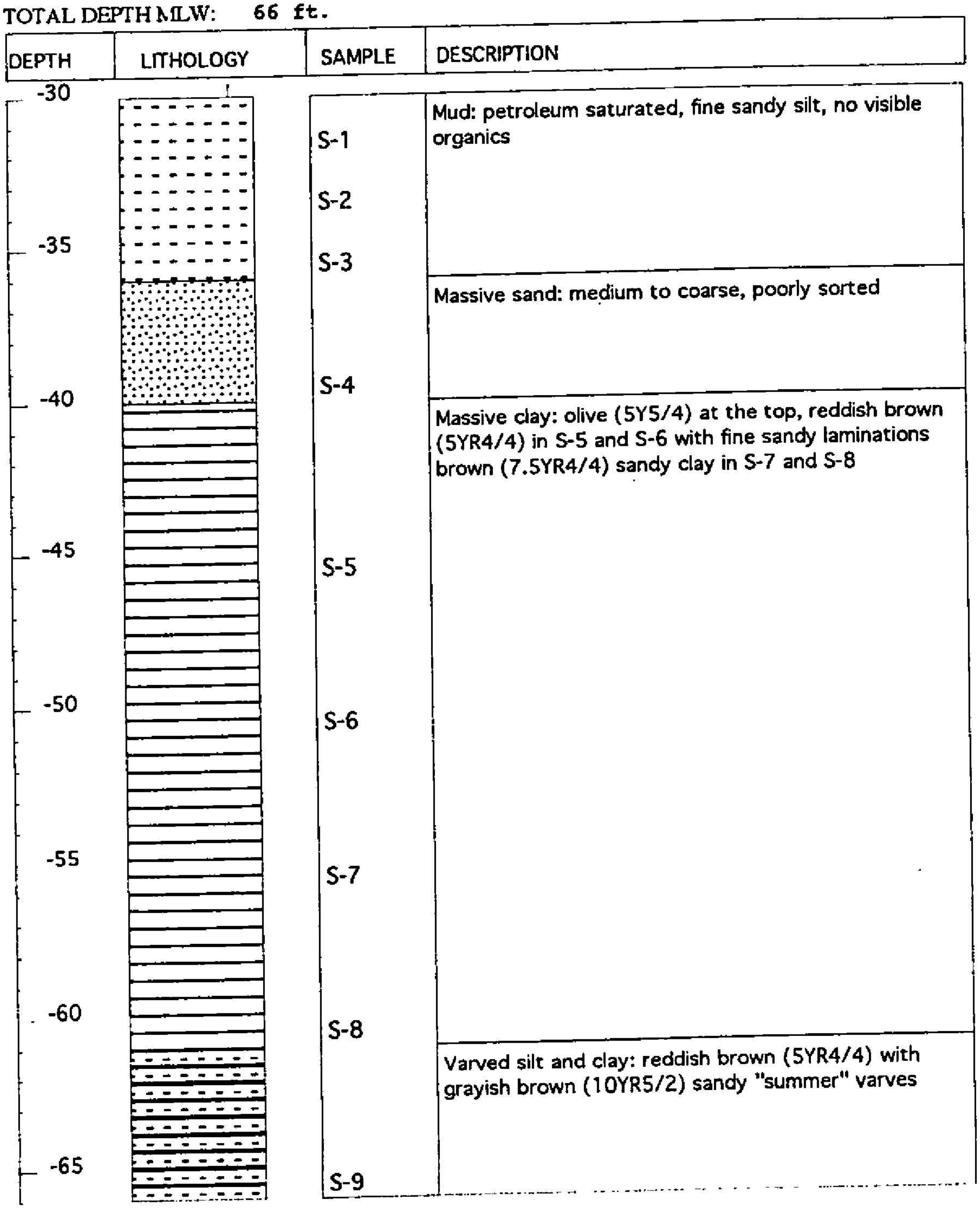
DATE OF BORING: 12-8-98

TOTAL DEPTH: 36 ft.

TOTAL DEPTH MLW: 66 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



Mud: petroleum saturated, fine sandy silt, no visible organics

Massive sand: medium to coarse, poorly sorted

Massive clay: olive (5Y5/4) at the top, reddish brown (5YR4/4) in S-5 and S-6 with fine sandy laminations brown (7.5YR4/4) sandy clay in S-7 and S-8

Varved silt and clay: reddish brown (5YR4/4) with grayish brown (10YR5/2) sandy "summer" varves

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Claremont Channel

BORING: CC-98-21

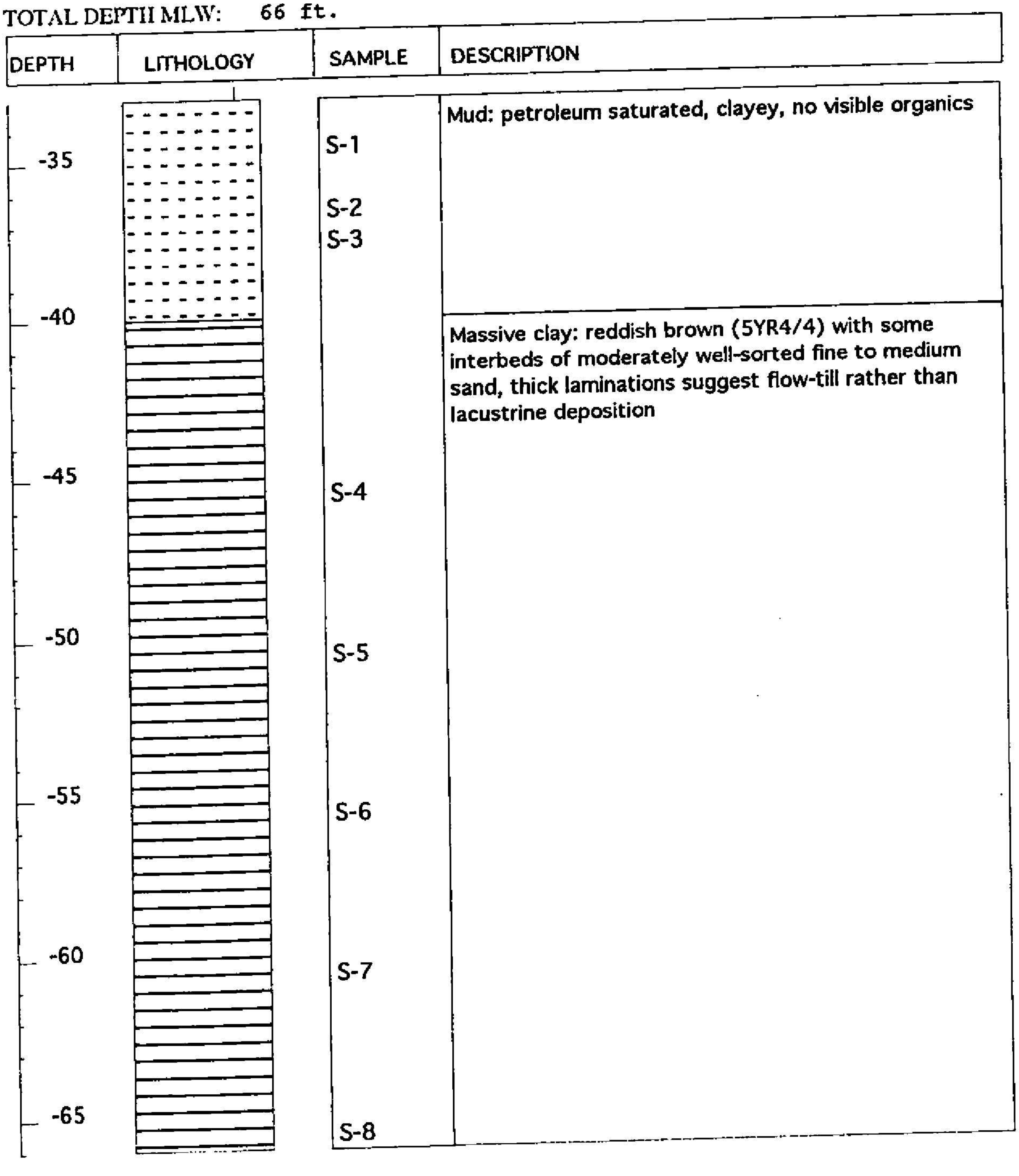
DATE OF BORING: 12-8-98

TOTAL DEPTH: 33 ft.

TOTAL DEPTH MLW: 66 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



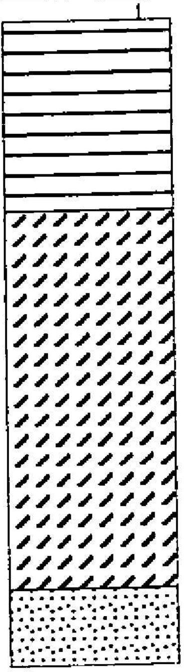
Mud: petroleum saturated, clayey, no visible organics

Massive clay: reddish brown (5YR4/4) with some interbeds of moderately well-sorted fine to medium sand, thick laminations suggest flow-till rather than lacustrine deposition

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Port Jersey
BORING: PJ-98-4
DATE OF BORING: 12-14-98
TOTAL DEPTH: 17 ft.
TOTAL DEPTH MLW: 60 ft.

LATITUDE: 40 degrees
LONGITUDE: 74 degrees



DEPTH	LITHOLOGY	SAMPLE	DESCRIPTION
-45		S-1	Massive clay: reddish brown (5YR4/4) with gray laminations
-50 -55		S-2 S-3	Till: gravel in matrix of reddish brown (5YR4/4) clay, clasts are angular shale sandsone, and other Newark Group sedimentary rocks at top with heterolithic sands (feldspars, some volcanics) noted near base
-60		S-4	Massive sand: heterolithic with angular diabase pebbles noted

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Port Jersey

BORING: PJ-98-6

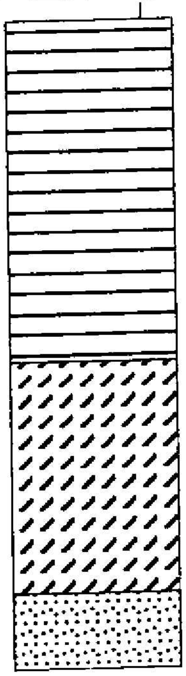
DATE OF BORING: 12-14-98

TOTAL DEPTH: 17 ft.

TOTAL DEPTH MLW: 56 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



DEPTH	LITHOLOGY	SAMPLE	DESCRIPTION
-40		S-1	Massive clay: reddish brown (5YR4/4) with gray clay interbeds noted in S-2
-45		S-2	
-50		S-3	Till: bouldery, with clasts of diorite, sandstone, and chert
-55		S-4	Massive sand: coarse, poorly sorted, and heterolithic with feldspars, quartz, and igneous rock fragments

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Port Jersey

BORING: PJ-98-7

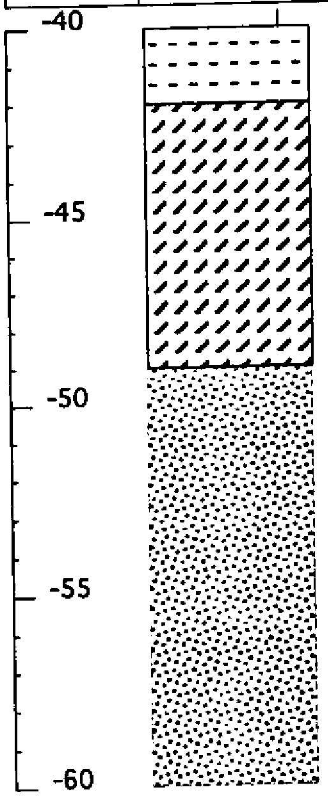
DATE OF BORING: 12-10-98

TOTAL DEPTH: 20 ft.

TOTAL DEPTH MLW: 60 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees

DEPTH	LITHOLOGY	SAMPLE	DESCRIPTION
		S-1	Mud: black, with petroleum odor
		S-2 S-3	Till: angular gravel in matrix of reddish brown (5YR4/4) clay
		S-4 S-5	Bedrock, igneous or metamorphic: saprolitized schist changing to gneiss with depth

GEOARCHEOLOGY RESEARCH ASSOCIATES

NEW YORK AND NEW JERSEY HARBOR STUDY

STRATIGRAPHIC LOG

STUDY AREA: Buttermilk Channel

BORING: BC-98-20A

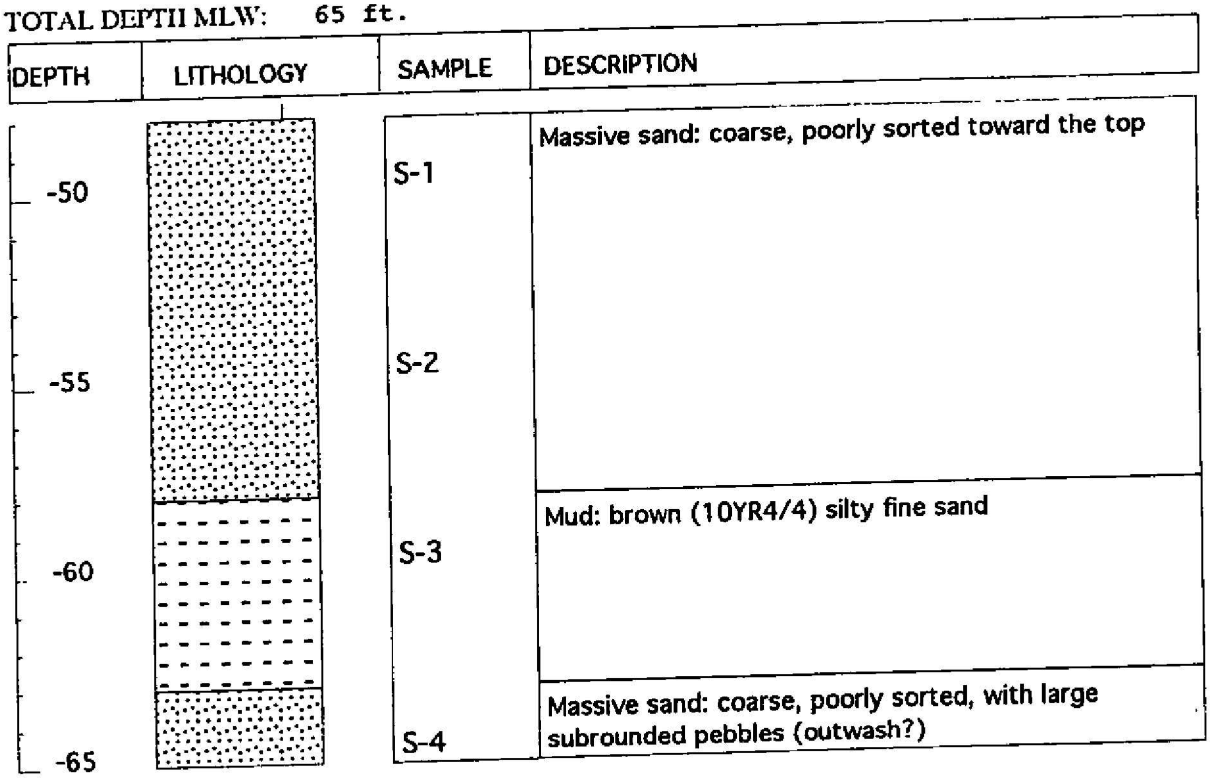
DATE OF BORING: 12-15-98

TOTAL DEPTH: 15 ft.

TOTAL DEPTH MLW: 65 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



Massive sand: coarse, poorly sorted toward the top

Mud: brown (10YR4/4) silty fine sand

Massive sand: coarse, poorly sorted, with large subrounded pebbles (outwash?)

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Buttermilk Channel

BORING: BC-98-24A

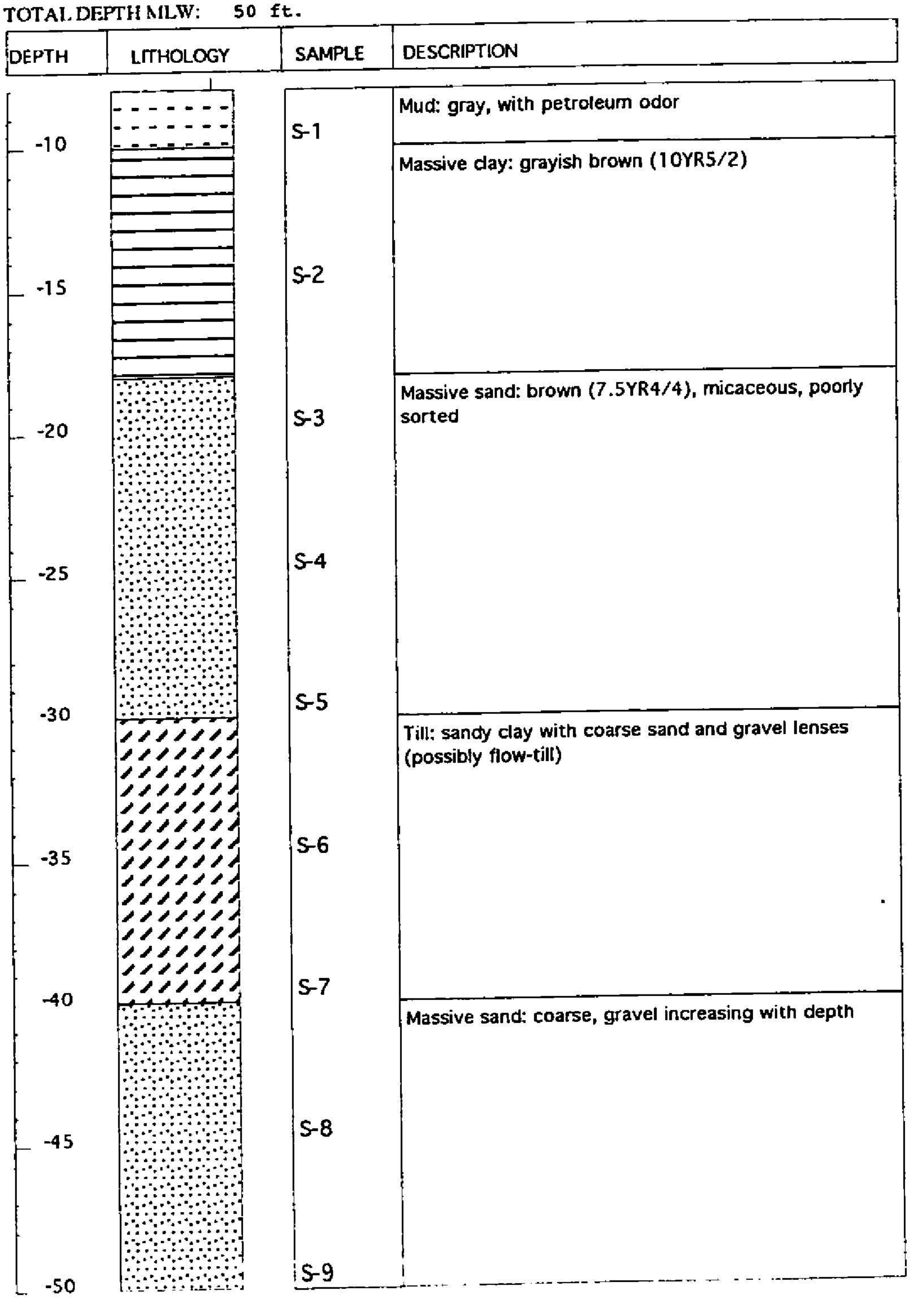
DATE OF BORING: 12-10-98

TOTAL DEPTH: 50 ft.

TOTAL DEPTH MLW: 50 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



Mud: gray, with petroleum odor

Massive clay: grayish brown (10YR5/2)

Massive sand: brown (7.5YR4/4), micaceous, poorly sorted

Till: sandy clay with coarse sand and gravel lenses (possibly flow-till)

Massive sand: coarse, gravel increasing with depth

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Buttermilk Channel

BORING: BC-98-27

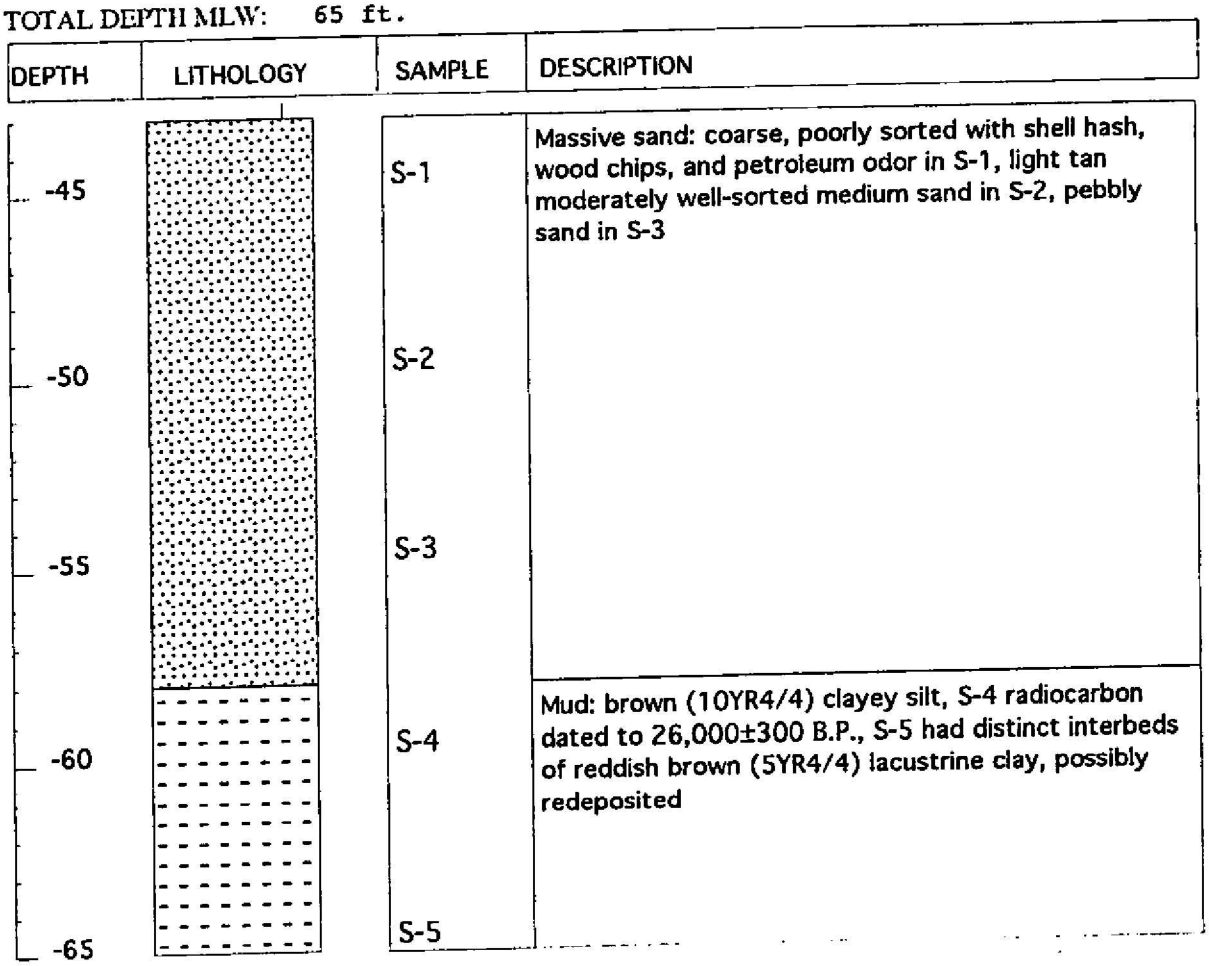
DATE OF BORING: 12-15-98

TOTAL DEPTH: 22 ft.

TOTAL DEPTH MLW: 65 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



Massive sand: coarse, poorly sorted with shell hash, wood chips, and petroleum odor in S-1, light tan moderately well-sorted medium sand in S-2, pebbly sand in S-3

Mud: brown (10YR4/4) clayey silt, S-4 radiocarbon dated to 26,000±300 B.P., S-5 had distinct interbeds of reddish brown (5YR4/4) lacustrine clay, possibly redeposited

GEOARCHEOLOGY RESEARCH ASSOCIATES
NEW YORK AND NEW JERSEY HARBOR STUDY
STRATIGRAPHIC LOG

STUDY AREA: Buttermilk Channel

BORING: BC-98-29A

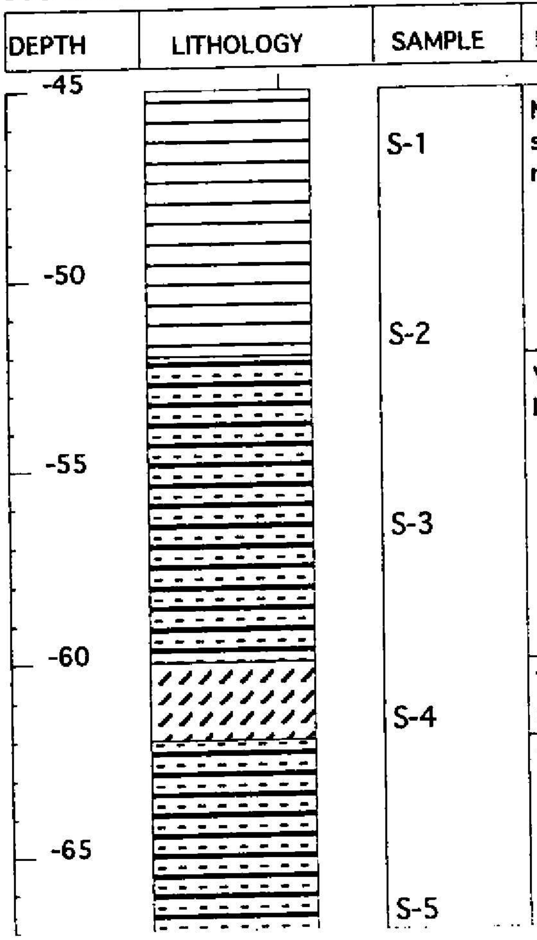
DATE OF BORING: 12-15-98

TOTAL DEPTH: 22 ft.

TOTAL DEPTH MLW: 67 ft.

LATITUDE: 40 degrees

LONGITUDE: 74 degrees



DESCRIPTION

Massive clay: grayish brown (10YR5/2) with common shale gravel and wood chips in S-1,S-2 has ripped-up reddish brown (5YR4/4) clay

Varved silt and clay: some medium to coarse sand lenses

Till: sandy clay with large angular and faceted pebble clasts near the base

Varved silt and clay: sets characterized by color alternation between reddish and gray-green, sandy "summer" varves

APPENDIX 3

Radiocarbon Dates for Samples from Geotechnical Borings in New York and New Jersey Coastal and Estuarine Contexts

BETA ANALYTIC INC.
RADIOCARBON DATING SERVICES

Mr. DARDEN G. HOOD
Director

RONALD E. HATFIELD
Laboratory Manager

CHRISTOPHER PATRICK
TERESA A. ZILKO-MILLER
Associate Managers

March 3, 1999

Dr. Joseph Schuldenrein
Geoarcheology Research Associates
5912 Spencer Avenue
Riverdale, NY 10471

Dear Joe:

Please find enclosed the radiocarbon dating result for one sample of organic sediment (98ANC44 S16 30-32') which was submitted for analysis on January 21. It provided plenty of carbon for accurate radiometric analysis with extended counting and all analytical steps went normally. As usual, we analyzed the bulk organic carbon after removing any carbonates or rootlets. The accuracy of the results depends upon this material being of primary origin to the deposition of the sediment.

Our invoice is enclosed. It includes the charges for the two samples which are pending AMS analysis and one examination and pretreatment charge for a sample which was canceled. Please, immediately give the to the appropriate office for prompt payment or send VISA charge authorization. Thank you. As always, if you have any questions, please do not hesitate to contact us.

Sincerely,

Darden Hood

PS Our web site now has down-loadable and on-line data sheets (www.radiocarbon.com).

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305/667-516[illegible] FAX: 305/663-0964
E-MAIL: beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Joseph Schuldenrein — January 21, 1999

Geoarcheology Research Associates — March 3, 1999

Sample Data	Measured C14 Age	C13/C12 Ratio	Conventional C14 Age (*)
Beta-127019	9400 +/- 150 BP	-25.0* o/oo	9400 +/- 150* BP

SAMPLE #: 98ANC44 S16 30-32'
ANALYSIS: radiometric-standard
MATERIAL/PRETREATMENT:(organic sediment): acid washes
COMMENT: the small sample was given extended counting time

NOTE: It is important to read the calendar calibration information and to use the calendar calibrated results (reported separately) when interpreting these results in AD/BC terms.

NOTE: Sample (NB 98-23 43-44') is "on hold" pending instructions. Two additional samples from this set are being analyzed by AMS and will be reported separately.

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

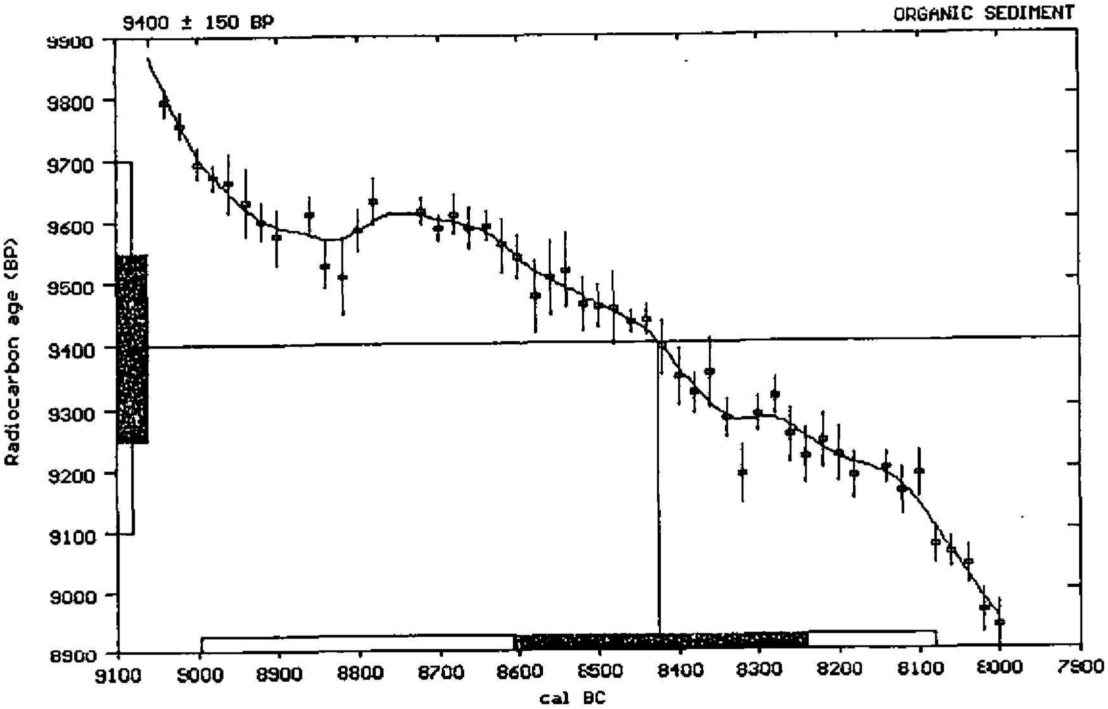
(Variables:estimated C13/C12=-25:lab mult.=1)

Laboratory Number:	Beta-127019
Conventional radiocarbon age*:	**9400 ± 150 BP**
Calibrated results: **(2 sigma, 95% probability)**	**cal BC 8995 to 8080**

* C13/C12 ratio estimated

Intercept data:

Intercept of radiocarbon age with calibration curve:	cal BC 8425
1 sigma calibrated results: (68% probability)	cal BC 8610 to 8240



References:

Pretoria Calibration Curve for Short Lived Samples
Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, Radiocarbon 35(1), p73-86
A Simplified Approach to Calibrating C14 Dates
Talma, A. S. and Vogel, J. C., 1993, Radiocarbon 35(2), p317-322
Calibration - 1993
Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, Radiocarbon 35(1)
Calibration of Radiocarbon Dates for the Late Pleistocene Using T/Uh Dates on Stalagmites
Vogel, J.C., Kronfeld, J., 1997, Radiocarbon 39(1), p27-32

BETA ANALYTIC INC.

RADIOCARBON DATING SERVICES

Mr. DARDEN G. HOOD
Director

RONALD E. HATFIELD
Laboratory Manager

CHRISTOPHER PATRICK
TERESA A. ZILKO-MILLER
Associate Managers

March 15, 1999

Dr. Joseph Schuldenrein
Georcheology Research Associates
5912 Spencer Avenue
Riverdale, NY 10471

Dear Joe:

Please find enclosed the radiocarbon dating results for two samples of organic sediment (98 NB 28 S4 PT1 & BC-98-27 58-60) which were authorized for AMS analysis on February 23rd. They each provided plenty of carbon for accurate radiometric analysis and all analytical steps went normally. In each case, we analyzed the bulk organic carbon after removing any carbonates or rootlets. The accuracy of the results depends upon this material being of primary origin to the deposition of the sediment.

Please note that our calendar calibrations are now calculated back to about 19,000 years using the newest calibration data as published in *Radiocarbon*, Vol. 40, No. 3, 1998 using the cubic spline fit mathematics as published by Talma and Vogel, *Radiocarbon*, Vol. 35, No. 2, pg 317-322, 1993: A Simplified Approach to Calibrating C14 Dates. Results are reported both as cal BC and cal BP. Calibration of results beyond about 10,000 years is still very subjective. The calibration data beyond about 13,000 years is a "best fit" compilation of modeled data and, although an improvement on the accuracy of the radiocarbon date, should be considered illustrative. Since It is likely that calibration data beyond 10,000 years will change in the future, it is very important to quote the original BP dates and these references in your publications so that future refinements can be applied to your results.

Our invoice has been sent separately. A copy is enclosed. Thank you for your prior efforts in arranging payment.

Sincerely,

Darden Hood

PS Our web site now has down-loadable and on-line data sheets (www.radiocarbon.com).

4985 S.W. 74 COURT, MIAMI, FL 33155 U.S.A.
TELEPHONE: 305-667-5167 / FAX: 305-663-0964 / INTERNET: beta@radiocarbon.com
WEB SITE: http://www.radiocarbon.com

BETA

BETA ANALYTIC INC.

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Joseph Schuldenrein | Auth. Feb. 23, 1999

Geoarcheology Research Associates | March 15, 1999

Sample Data	Measured C14 Age	C13/C12 Ratio	Conventional C14 Age (*)
Beta-127020 SAMPLE #: 98 NB 28 S4 PT1 ANALYSIS: Standard-AMS MATERIAL/PRETREATMENT:(organic sediment): acid washes	29600 +/- 360 BP	-26.9 o/oo	29570 +/- 360 BP
Beta-127022 SAMPLE #: BC-98-27 58-60 ANALYSIS: Standard-AMS MATERIAL/PRETREATMENT:(organic sediment): acid washes	26000 +/- 300 BP	-29.1 o/oo	25940 +/- 300 BP

NOTE: It is important to read the calendar calibration information and to use the calendar calibrated results (reported separately) when interpreting these results in AD/BC terms.

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

APPENDIX 4

Map Data Sources

MAP DATA SOURCES

The maps presented in this report were created in a number of different software packages. In general, they were first generated in the ArcView GIS application and then modified in Adobe Photoshop. Data sets used in their creation were downloaded from various state and federal World Wide Web sites.

1) The modern shoreline in all the figures was generated from segment EC80_04 of NOAA's medium resolution digital vector shoreline files: (http://seaserver.nos.noaa.gov/projects/shoreline).

2) The navigation channels in all the figures were generated by an ArcInfo export file provided by the U.S. Army Corps of Engineers, New York District.

3) The USGS 7.5 minute quadrant maps (Figures 2 and 3) were downloaded from the Geography Department of Rutgers University's Topographic Map Download Depot: (http://geography.rutgers.edu/features/quadpage/index.html).

4) The bathymetric contours in Figure 5 were generated in the QuickGrid contour producing program from various bathymetric data files downloaded from the Coastal Engineering division of the U.S. Army Corps of Engineers (http://bigfoot.wes.army.mil) and the NOAA's World Data Center for Marine Geology and Geophysics: (http://www.ngdc.noaa.gov/mgg/global/seltopo.html).

5) The Wisconsinan Ice Margin in Figure 5 was digitized from the USGS Quaternary Map of the Hudson river 4 x 6 Quadrangle, United States and Canada.

6) Shorelines and bathymetric contours in Figures 12, 13, and 14 are derived from an 1874 map of the New York Harbor region (CP1268c) downloaded from Image Archives of the Historical Map & Chart Collection/Coast Survey/National Ocean Service/NOAA (http://anchor.ncd.noaa.gov). A vector version of the lines was created from the chart in MiniCad and imported into ArcView. Please note that due to resolution and projection issues the lines location are closely approximate.

7) The Sensitivity Zones in Figures 15, 16, 17, and 18 were added in Photoshop to images exported from ArcView via ArcPress.

APPENDIX 5

Report on Foraminifera found in Sediment Samples from Geotechnical Borings in the New York and New Jersey Harbor Navigation Channels

Dr. E. Thomas
Research Professor
Department of Earth & Environmental Sciences
Wesleyan University
Middletown CT 06450-0139

Prepared for Geoarcheology Research Associates
July 18, 2000

Introduction: Foraminifera

Foraminifera are one-celled organisms with a complex cell-structure. The genetic material (DNA) is stored within one or more nuclei, and foraminifera thus belong to the Eukaryotes, in contrast to the Prokaryotes (bacteria), in which the genetic material is not separated from the cell content.

Foraminifera make a shell, which is called test. The living protoplasm is arranged both inside and outside the test. The foraminifer has one main, large opening (called aperture), which it uses to send out the protoplasm in pseudopodia: thin, fairly rigid, and branching repeatedly. The pseudopodia pull in food particles, which the foraminifer digests inside its protoplasm. We do not know the function of the test: it can not offer structural support - gravity is unimportant for creatures of that size, living in water. It offers no protection against being eaten: organisms that eat foraminifera gobble them up test-and-all.

The test shape is generally used to distinguish species, and there is very little genetic information available to judge whether such shape-groups (morpho-species) are indeed biological species. The foraminiferal test can be simple and consist of one chamber, but more commonly tests have many chambers: as the foram grows, it adds chambers.

Foraminiferal tests are made up either of calcite (calcareous foraminifera), or of glued-together very small sand-grains, which are kept together by organic material (agglutinated foraminifera). By far the most species are calcareous, but in coastal marshes and on the bottom of the deepest oceans (below about 5 km depth) agglutinated foraminifera dominate, because in these regions calcium carbonate is actively dissolved and foraminifera can not precipitate it.

Foraminifera are heterotrophs: they eat like animals, do not photosynthesize like plants. They eat almost everything smaller then themselves (bacteria, algae, small crustaceans, other foraminifera, organic matter). They can live burrowing in the sediment, stuck to plants, on the sediment surface, or floating in the surface waters of the oceans. Some species have internal symbiotic algae, and live on waste products of the symbionts. Foraminifera occur in the oceans from the deepest trenches to the marginal salt marshes. They live on the ocean floor as benthos over the full depth range of the oceans (benthic foraminifera), as well as floating in the surface waters of the open ocean (planktonic foraminifera). Foraminifera do not occur in fresh water; in brackish water the salinity must be over about 15 ‰. In fresh water there are Thecamoebians, one-chambered organisms related to Foraminifera, which are all agglutinated.

Foraminifera as environmental indicators

Benthic foraminiferal species are excellent environmental indicators (e.g. Murray, 1991). In marginally marine regions their tests are used to reconstruct sub-environments within the intertidal zones in a salt marsh (e.g., Scott and Medioli, 1980), with a vertical resolution of 15-25 cm (see e.g., Varekamp and Thomas, 1998). Marine benthic foraminifera are used to reconstruct paleo-depths; at shelf depths and less zones of tens of meters depth can be recognized, but at greater depths the zones are hundreds to thousands of meters thick (e.g., Murray, 1991). Benthic foraminifera are Eukaryotes and thus sensitive to oxygen levels in the waters of sediments where they live. They can survive very low oxygen levels (e.g., Bernhard, 1996), but such levels are clearly indicated by the occurrence of specific low-oxygen taxa. Shallow water benthic foraminifera and planktonic foraminifera have been used extensively as age indicators ('guide fossils'), especially where only small samples are available (oil wells, deep-sea drilling holes; e.g., Bolli et al., 1994).

In this report the environmental interpretation of salt marsh foraminifera after Scott and Medioli (1986) was used, as modified for marshes in New England by Thomas and Varekamp (1991), Nydick et al. (1995) and for New Jersey marshes by Varekamp and Thomas (1998). For neritic marine foraminifera this report follows the global and regional compilations of Murray (1991), incorporating data by Phleger and Walton (1950), Parker (1952) and Buzas (1965), and taxonomy of *Elphidium* spp. after Miller et al. (1992).

Processing of samples.

Two processing methods were used for the samples from New York Harbor, in order to test which method would work best and not result in destruction of specimens. Foraminiferal samples are usually processed by the simple method of drying the material in an oven overnight at 50-60 °C, soaking it overnight in a soap solution, then washing it through a 63 m sieve and drying the fraction left on the sieve at 50-60 °C. This size fraction is then used for study (e.g., Murray, 1991). We used this method for all samples. Some samples, however, were split, one half processed as described above, the other following the methods developed by Scott and Medioli (1986) and modified by Thomas and Varekamp (1991) and Saffert and Thomas (1998).

The alternative method was developed for very organic rich material, in which Foraminifera (both living protoplasm and the organic matter in the test) are easily degraded by the action of the abundant bacteria. All peat samples taken for the study of foraminifera thus must be either put in formaldehyde in the field, or wrapped tightly to prevent access of oxygen. Samples must be either processed (see below) or placed in refrigeration directly after arrival in the laboratory, and never left for more than 8-10 hours at room temperature.

Half of the New York Harbor samples that on visual inspection might be judged to be rich in organic matter (dark gray-black in color) were treated as peat samples, and soaked without drying at least overnight in 30% ethanol (Scott and Medioli, 1981). They were then washed over a 63 m sieve (removing the fine-grained organic matter), and dried at room temperature.

Peat samples with living specimens are usually stained with Rose Bengal, after fixing the protoplasm in buffered formaldehyde (Walton, 1950). This procedure was not performed for the New York Harbor samples and we thus could not distinguish individuals that were living at the time of collection. The samples were not frozen, wrapped or placed in buffered formaldehyde in the field directly after collection; we can thus not be certain that agglutinated specimens did not decay before arrival in the laboratory (see below).

After the material had dried, it was spread in a picking tray, and at least 5 trays of material were studied in order to ascertain whether foraminifera were present. Foraminifera were picked and placed in cardboard slides. All picked individuals were determined as to species. During picking, other components of the size fraction studied (sand size) were also recognized, described, and entered in the spread sheet (Table 1).

Results

Out of the 23 samples investigated, 18 samples contained benthic foraminifera, and an environment of deposition could be determined with confidence (Table 1). There were no significant differences in microfaunas in the splits of the samples that were processed in two different ways. We thus conclude that none of the samples had at the arrival in the laboratory so much organic matter with bacterial activity that treatment with ethanol or formaldehyde was necessary. On the other hand, the samples were not refrigerated or treated with ethanol or formaldehyde directly after sampling. It thus remains a possibility that the number of foraminifera in some samples was under-estimated because part of the agglutinated fauna had been oxidized during sample transport.

All samples that contained foraminifera had relatively low numbers of foraminifera per gram, as compared with other samples deposited in similar environments (e.g., Phleger and Walton, 1950; Buzas, 1985; Scott and Medioli, 1986; Saffert and Thomas, 1998). This might have resulted from oxidation of foraminifera after sample collection, but this was probably not the main cause of the low abundance in most samples (except where described below). In many samples dominated by calcareous foraminifera the absolute abundances were low, and these specimens are not destroyed by oxidation. They were well-preserved and do not show signs of carbonate dissolution. The low abundances are thus probably caused by high sedimentation rates of terrigenous material.

Planktonic foraminifera were absent in all samples; none were thus deposited under open-ocean conditions at depths of at least about 100 m. All samples with foraminifera were deposited in shallow shelf (neritic) - mud flat - marginally marine marsh environments. In some cases several samples were studied belonging within one core, and the environmental development over time could thus be determined.

Location 98 ANC 25

Three samples from this location were investigated, at 20-22', 24-26', and 26-28' depth-in-core. The terrigenous component was similar in all three samples (fine quartz sand, mica dominant), and there thus was no change in dominant terrigenous input over the time of deposition of the samples. Fragments of Metaphyta (mainly various salt marsh grasses) were present in all samples, but most common in the lowermost sample. In all samples bivalves were common, in the uppermost sample centric (planktonic) diatoms - unicellular algae - occurred, but they were rare.

In all samples the benthic foraminifer *Elphidium excavatum* s.l. was present and the most common species; foraminifera were common to abundant, especially so in the upper two samples. In the middle species *Buccella frigida* was also present, in the upper samples there were rare specimens of the common salt marsh agglutinated species *Trochammina inflata*. The extreme dominance of *E. excavatum*, a very common species in coastal areas worldwide and in the northeastern US coastal zone, and the dominant species in Long Island Sound (e.g., Parker, 1951; Buzas, 1965; Miller et al., 1982) indicates deposition below the intertidal zone, at depths probably not greater than about 25 m; similar environments are very common within the present Long Island Sound.

The common occurrence of salt marsh grass fragments, and the occurrence of salt marsh foraminifera in the uppermost sample suggest that a salt marsh was in existence close to the core location. The increase in cord grass fragments from the lower to the higher sample and the occurrence of the salt marsh foraminifer in the upper sample suggest that the salt marsh extended closer to the region of deposition of the core over the time period represented in the samples, because salt marsh foraminifera are easily oxidized and do not survive transport for long distances. None of the samples contained obviously anthropogenic material (such as fly ash) that would suggest deposition since the industrial revolution. In many coastal areas, however, centric diatoms increased in abundance after increasing nutrient loads resulting from land clearing and fertilization (Brush, 1989; Brush et al., 1982; Cooper and Brush, 1991, 1993; Nixon, 1997), and the rare occurrence of of drought. Alternatively, the marsh might have formed at a salinity too low to permit survival of foraminifera and other estuarine organisms such as bivalves, ostracodes or diatoms, but this is rather unlikely because of the absence of plant fragments indicating such low salinity environments (e.g., sedges, *Phragmites*). Such plant remains are usually abundantly present in samples from low-salinity marshes and are easily recognized. Another possibility is that this sample represents rather rapid reworking of plant material derived from a marsh at a location that is a bit further away from the core location, so that foraminifera did not survive the transport; a possible example could be transportation of fairly large pieces of salt marsh peat during a storm, and re-deposition at the core location.

If the first possibility is the correct explanation, it suggests that the water depth at the core location increased between the time represented by the lower sample and the second sample from the bottom. The occurrence of centric diatoms and the absence of benthic diatoms suggests that the water turbidity was fairly high, and could be interpreted as resulting from deposition after significant deforestation in the middle of the 18th century (e.g., Cooper and Brush, 1991, 1993). No material that suggest deposition after the industrial revolution was found.

Location 98 ANC 44

Four samples were investigated from this location, at 12-14', 14-16', 16-18', and 22-24'. In all samples the terrigenous fraction was dominated by coarse quartz; the lower two samples have sediment clumps (some armored), the upper two samples contain lithic fragments and metamorphic minerals (pyroxenes, amphiboles). The lower two samples contain common plant (Metaphyta) fragments, and the benthic foraminiferal faunas consist of agglutinated foraminifera only, including *Trochammina macrescens* and *Arenoparrella mexicana*. These foraminifera are most common in a middle to high marsh setting (e.g., Scott and Medioli, 1986; Nydick et al., 1995; Saffert and Thomas, 1998), i.e., within the intertidal zone in a salt marsh. This environmental assignment agrees with the common occurrence of salt marsh grass fragments.

The third sample from the bottom (14-16') and the top sample contains much less common plant fragments. There are some bivalve fragments, and benthic foraminifera include the calcareous *Elphidium excavatum* and the agglutinated salt marsh foraminiferal species *Trochammina macrescens*. This sample was probably deposited on subtidal mud flats close to a salt marsh, at water depths not exceeding about 20 m.

Insect fragments are present in the uppermost sample only, as are flyash and carbonaceous spheric particles (Rose, 1995) and centric diatoms. Benthic foraminiferal faunas consist of *Elphidium excavatum* s. l. only; there are common bivalves. This upper centric diatoms towards the sample at 20-22' might possibly indicate deposition of the sample at a time after about 1750 AD.

Location 98 ANC 29

One sample was investigated from this location, from a depth-in-core of 18-20'. The terrigenous fraction is similar to that at 98 ANC 25, dominated by fine quartz, but more lithic fragments are present, including metamorphic minerals (amphiboles, pyroxenes). There are no plant fragments that could without doubt be assigned to marsh grasses. Bivalves occur as rare fragments, and there are a few, smooth ostracode valves present. There are also centric diatoms; the foraminiferal faunas is dominated by *Elphidium excavatum* s.l., with *Buccella frigida* present. No anthropogenic material is present. This samples was deposited below the intertidal region, in an area were no material from a salt marsh was deposited, and where water depth was less than about 25 m. The environment of deposition is very similar to that of the samples in core 98 ANC 25, except for the close presence of a salt marsh area to the former.

Location 98 ANC 44

Four samples were investigated from this location, at 20-22', 22-24', 24-26', and 26-28'. The terrigenous fraction in all samples is gray silt, with fine quartz common in the uppermost sample. The sediment also has common sediment clumps - aggregates of fine material. All samples contain common plant fragments (Metaphyta), but these are abundant in the lowermost sample. Centric (planktonic) diatoms are common in the samples at 22-24' and 24-26', less common in the upper samples and absent in the lower sample. The lower sample did not contain any macro- or microfossils suggesting marine influence. The upper three samples contained *Elphidium excavatum* s. l.. The top sample contained only rare foraminifera, with *E. excavatum* the only species present. The sample at 22-24' also contained rare agglutinated salt marsh foraminifera such as *Trochammina macrescens* and *Trochammina inflata*. The sample at 24-26' contained *E. excavatum* only. The upper and two lower sample contain insect fragments.

The environment of deposition of the upper three samples is similar to that of the samples from 99 ANC 28 and -29: below the intertidal zone and above a depth of about 25 m. A salt marsh was present fairly lose by, and was closest during deposition of the samples at 22-24'.

The lowest sample with abundant plant fragments did not contain foraminifera. This could be explained in different ways: it may have been a salt marsh sample in which foraminifera were oxidized either after sampling, or shortly after deposition during a period sample was thus deposited in a subtidal, neritic zone (i.e., at depths of less than about 20 m); a salt marsh was present but not very close. The sample contains anthropogenic material derived from fossil fuel burning (probably coal) and was thus probably deposited after the industrial revolution at the end of the 19th century.

The samples from this location thus show an environmental change from the oldest to the youngest samples from a salt marsh environment to a mud flat to a shallow neritic environment. Such a change might have resulted from rising sea levels, but also from the migration of a channel from a location away from the core site to a location over the core site.

Location 98 ANC 104

Two samples were investigated from this location, at 34-36' and 38-40'. Neither contains foraminifera or any other estuarine or marine indicator. Both contain coarse lithics (> 1 mm), a terrigenous fraction dominated by coarse to medium- grained quartz and abundant mica. The paleoenvironment is not clear - this might be river sediment, deposited by fairly rapid flowing water, or sediment deposited in a pond or other fresh water wet land. There are, however, no plant fragments present and vegetated wetlands thus appear to not be a probable environment of deposition. It also might be older, glacial material, or dumped by human activity (but no traces of anthropogenic activity were found).

Location NB 98 24

Four samples were investigated from this location, at 41.5-43.5', 43,5-45.5', 48.5-50.5' and 53.5-55.5'. The lower three samples consist of reddish-brown silts, sands, and grits, the uppermost sample of brownish silts, sands and grits. The lower two samples contain common barite crystal aggregates ('desert rose'), and typically occur in the Triassic-Jurassic redbeds of the Newark and Hartford basins of the northeastern US. These sediments have clearly been eroded and re-sedimented, in view of their non-indurated character. There has been little or no chemical erosion (presence of barite), suggesting that the sediments were eroded and reworked by the ice age glaciers in the region. They were re-deposited in the large pre-glacial lakes (e.g., Szak, 1987; Stanford and Harper, 1991; Lewis and Stone, 1991).

Interestingly, the samples at 43.5-45.5 and 48.5-50.5' contain calcareous benthic foraminifera, belonging to the species *Ammonia beccarii*. The uppermost sample contains both *A. beccarii* and *Elphidium excavatum* s.l., as well as fragments of bivalves. The two samples with only *A. beccarii* must have been deposited in brackish water a salinity of at least 15-50 ‰. This species is common in intertidal to shallow subtidal regions worldwide, and is well known from various brackish lakes, away from the sea (e.g., Curtis and Hodell, 1996; Patterson et al., 1997). They can thus probably survive transport in dried mud on the feet of water birds (Patterson et al., 1997). The top-most sample represent shallow marine, subtidal environments.

The specimens appear to be present within the sediment and not be superficial contamination resulting from the coring or sampling operations. They are almost certainly not the result of downward bioturbation, because the species do not bioturbate for a depth greater than a few cm, and they occur much further below a contact with estuarine muds.

It thus appears possible that the pre-glacial lakes flooded gradually by the sea, possibly with penetration of salty water into the lakes before a true connection with the sea existed. If this interpretation is correct, these samples were deposited at some time after the initial retreat of the Laurentide ice sheet (estimated at about 19 ka or so; Stone et al., 1998), and before full deglaciation at about 15 ka.

Location NB 98 28

Three samples were investigated from this location, at 0-6', 17-9' and 30-32'. The two lower samples consist of reddish-brown silts, sands, and grits, the uppermost sample of brownish silts, sands and grits. They contain common barite crystal aggregates ('desert rose'), which typically occur in the Triassic-Jurassic redbeds of the Newark and Hartford basins of the northeastern US. These sediments have clearly been eroded and re-sedimented, in view of their non-indurated character. There has been little or no chemical erosion (presence of barite), suggestion that the sediments were eroded and reworked by ice age glaciers, and re-deposited in pre-glacial lakes. They thus are similar to the lowermost samples at location 98-24, and none of the two samples contains benthic foraminifera. There is here thus no evidence of salt water influx. The sediment were deposited before deglaciation and after the regression of the Laurentide ice sheet from its southernmost margin at about 19 ka (see e.g., Stone et al., 1998).

The uppermost sample is completely different. Its terrigenous fraction consists dominantly of gray silt, mica, minerals from metamorphic rocks (pyroxenes, hornblende) and some quartz, with sediment clumps present. Plant fragments of salt marsh grasses are fairly common, and rare centric diatoms occur. The benthic foraminiferal fauna consists of the calcareous *Ammonia beccarii*, and the agglutinated salt marsh foraminifera *Trochammina macrescens*, *Miliammina fusca*, *Ammoastuta inepta* and *Trochammina macrescens*. This combination suggests deposition in the intertidal zone, with brackish water at fairly low average salinity, either in a low marsh region or (in view of the not abundant plant fragments) on mud flats adjacent to a low marsh. This sample contains flyash and spherical carbonaceous particles produced by fossil fuel burning, and was thus probably deposited after the industrial revolution in the late 19th century.

Location 98 STA 25

Two samples were investigated from this location, at 6' and 8'. Both samples contain coarse to medium grained quartz in the terrigenous fraction, with lithic fragments and mica. Both samples contain sediment clumps, in the lower sample commonly limonite-encrusted. Both samples contain insect fragments. The lower sample contains no foraminifera. The occurrence of common limonite encrusted sediment particles and common plant fragments suggests deposition in a marshy environment that dried out intermittently. During drying out the agglutinated foraminiferal tests as well as some pyrite oxidized; sediments from such environments commonly do not contain foraminifera.

The upper sample contains rare, smooth ostracodes as well as the calcareous foraminifera *Ammonia beccarii* and *Elphidium excavatum*, together with the agglutinated salt marsh foraminifera *Trochammina inflata*. This samples was probably deposited on mud flats just below the intertidal zone, close to a salt marsh.

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APPENDIX 6

Report on Plant Macrofossils found in Sediment Samples from New York and New Jersey Coastal and Estuarine Contexts

The samples were all soaked in a 5% solution of NaOH (sodium hydroxide to break up the humic acids and clay. Each sample was then sieved through a 0,125 mm brass geologic sieve and the material remaining in the sieve was examined using a Zeiss Stemi-scope (binocular zoom) up to 50X magnification.

98ANC 65 S10 18-20′

some woody looking material that was not wood structure upon higher magnification, possibly fern. 5 leaf fragments may also be fern. I think this is a terrestrial section but there were not any seeds or tree leaf fragments which I typically find in terrestrial samples. There were a few charred fragments and 2 of them clearly have wood structure but there is not enough there to make a firm ID.

98ANC65 S11 20-22′

Charcoal-more than 65 and may be 100 fragments, but many too small to extract with forceps. Examination under higher magnification showed the vessels to be occluded with sediment and the structure could not be identified. Some may be terrestrial.

Woody-like material-but doesn't have the structure of terrestrial wood-more than 50 fragments

5 nodes of unidentified plant aquatic leaf material

orange and yellow concreted sediments-The sediments along with the charcoal suggest drying (drop in water level followed by fire of intense heat according to William Patterson, UMASS, Amherst, personal communication regarding similar pattern at Pequot Cedar Swamp).

NB-B10 8-10′

This is a mixture of sedges and Juncus (rush) plus and what look to be Spartina roots. There are also roots that I termed "pop-it bead-like because they look like a strand of pop-it beads when still together. In this case there were more than 40 individual segments. Upon inquiry at the forestry school I was told by Dr. Khristina Vogt that these indicate repeated wetting and drying of the plant roots. I typically found them in association with shrubs when I was collecting study samples in swamps. Only 1 piece of charcoal, unidentifiable

2 sedge seeds, possibly 1 lenticular Carex sp.

Juncus seeds and material from the Juncus seed capsule.

roots with silvery bark (I would want to check out Iva roots, which I don't have a sample of now.)

abundant other root material Beetle body parts and possible insect capsules

I didn't see evidence of terrestrial leaves. This is looking like a high salt marsh environment and transition.

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APPENDIX 7

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EDUCATION

Ph.D.	University of Chicago	Anthropology	1983
M.A.	University of Chicago	Anthropology	1976
B.A.	State University of New York at Stony Brook	Anthropology Departmental Honors	1971

EMPLOYMENT HISTORY

1989-present President/Principal Archeologist, Geoarcheology Research Associates Riverdale, New York

1988-1989 Principal Archeologist and Geomorphologist, John Milner Associates, Inc., West Chester, Pennsylvania

1982-1988 Senior Cultural Resource Manager, Gilbert/Commonwealth, Reading, Pennsylvania

RESEARCH AND TEACHING EXPERIENCE

1996-present Geoarcheologist and Co-Principal, Beas River Study of Settlement and Production Systems in the Harappan Hinterlands. Wenner-Gren grant to New York University (with Dr. Rita Wright) and Government of Pakistan.

1995-present Geoarcheological Consultant, Eastern Wadi el Hasa Drainage System, Jordan. National Science Foundation Grant to Arizona State University.

1994-present Geoarcheological Consultant, South India Paleolithic Project, Karnakata, India. Museum of Natural History, Smithsonian Institution, Washington, D.C.

1994-present Geoarcheological Consultant, Konispol Project, Albania. The University of Texas at Arlington.

RECENT PROJECT MANAGEMENT EXPERIENCE

1999 Archeological and Subsurface Testing at Mud Run, Northampton, County, Pennsylvania. Kittatiny Research Associates, Stroudsburg, Pennsylvania and McTish, Kunkel and Associates, Allentown, Pennsylvania.

1999 Subsurface Archeological Explorations Along the North Branch, Susquehanna River, Great Bend-Hallstead, Pennsylvania. CHRS Consultants, North Wales, Pennsylvania and Pennsylvania Department of Transportation.

1998-present	Cultural Resource Assessment of Near Shore and Offshore Environments in Proximity of the New York City Shoreline, New York and New Jersey. Panamerican Consultants, Tuscaloosa, Alabama and U.S. Army Corps of Engineers, New York City District.
1998-present	Prehistoric and Geoarcheological Investigations at Governor's Island, New York. Public Archaeology Laboratory, Providence, Rhode Island and U.S. Coast Guard, New York, N.Y.
1997-98	Archeological Investigations of the Carmel Site, Huntington, Suffolk County, New York. Reckson Development Corporation. Principal Investigator.
1997-98	Geoarcheological Assessment of the F-117 Crash Site Crater, Zuni Pueblo, Zuni, New Mexico. Foster-Wheeler Environmental Corporation, Albuquerque, New Mexico and U.S. Army Corps, Albuquerque District. Principal Investigator.
1997-98	Southside Urban Renewal Project: Archeological and Documentary Studies. New York City Department of Housing Preservation and Development, Office of Planning, New York, N.Y. Principal Investigator
1997-present	Prehistoric and Subsurface Archeological Investigations for the Route 21 Expansion Project, Passaic County, New Jersey. URS Greiner-Woodward Clyde, Florence, N.J. and New Jersey Department of Transportation.
1997-present	Millennium Pipeline Project: Pennsylvania to New York. Inter-disciplinary Investigations. Gray and Pape, Inc., Cincinnati, Ohio and Millennium Pipeline Co., Fair Lakes, Virginia. Principal Geoarcheologist
1996	Historic Archeological Investigations at the Van Cortlandt Manor and Estate, Bronx, N.Y. Bellvale Construction, Bellvale, N.Y. and N.Y.C. Department of Parks and Recreation
1996-98	Phase I, II, and III Subsurface Geomorphological and Prehistoric Investigations in Conjunction with the Goethals Bridge Improvement Project. Parsons-Brinckerhoff, Quade and Douglass, Inc., New York, N.Y. and Port Authority of NY-NJ. Principal Investigator.
1996-97	Prehistoric and Geoarcheological Investigations at the Derewal Chemical Company Superfund Site, Hunterdon County, New Jersey. Hunter Research Associates, Trenton, New Jersey and U.S. Army Corps of Engineers, Philadelphia and Kansas City Districts. Co-Principal Investigator.
1995-96	Geoarcheological Investigations at the Lawson Army Airfield, Fort Benning, Georgia and Alabama. New South Associates, Atlanta, Georgia and National Park Service, Atlanta.
1995-96	Geomorphological Investigations for the Wyoming Valley Levee Raising Project, Pennsylvania. R. Christopher Goodwin, Frederick, Maryland, and U.S. Army Corps of Engineers, Baltimore District. Principal Investigator.
1995-96	Shoreline Reconstructions in Conjunction with Erosion Studies Along the Middle Atlantic Coast, southern New Jersey. Hunter Research Associates, Trenton, New Jersey and U.S. Army Corps of Engineers, Philadelphia District. Principal Investigator.

SELECTED PUBLICATIONS

1998 Wyoming Valley Landscape Evolution and the Emergence of the Wyoming Valley Culture (with D.M. Thieme). Pennsylvania Archaeologist 68(2): 1-17.

1998 Geomorphology and Stratigraphy of Prehistoric Sites along the Wadi al-Hasa. In The Archaeology of the Wadi al-Hasa, West Central Jordan, Volume I: Surveys, Settlement Patterns and Paleoenvironments (N. Coinman, ed.): 205-228. Anthropological Research Papers No. 50. Arizona State University

1998 Changing Career Paths and the Training of Professional Archaeologists: Observations from the Barnard College Forum: Part II. Bulletin of the Society for American Archaeology 16 (3): 26-29.

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1995 The Care and Feeding of of Archaeologists: A Plea for Pragmatic Training in the 21st Century. Bulletin of the Society for American Archaeology 13 (3): 22-24.

1995 Prehistory and the Changing Holocene Geography of Dogan Point. In Dogan Point: A Shell Matrix Site in the Lower Hudson Valley. Publications in Northeastern Anthropology No. 14 (C. Claassen, ed.): 39-64.

SYMPOSIA CHAIRED AT PROFESSIONAL MEETINGS

1992 Geoarchaeology and Site Mitigation Concepts, Applications and Regulatory Requirements. Symposium sponsored by Z-Environmental Services, Harrisburg, PA.

1992 Management of Cultural Resources. Fifty seventh Annual Meeting of the Society for American Archeology, Pittsburgh.

PROFESSIONAL AFFILIATIONS

American Anthropological Association
Archaeological Institute of America
American Quaternary Association
International Society of Sedimentologists
New York State Archaeological Association
Plains Conference on Archeology
Professional Archaeologists of New York City
Society for American Archaeology
Society for Archaeological Science
Society of Professional Archaeologists (SOPA)

TECHNICAL AND RESEARCH SKILLS

Cultural Resources Management
Environmental and Paleoclimatic Reconstruction
Stratigraphic and Geomorphic Interpretation
Aerial Photography
Pedology and Soil Micromorphology
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Computer and Statistical Analysis
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1982 B.A. Philosophy

CERTIFICATES

ROPA	Register of Professional Archaeologists. February 1999
HAZMAT	Health and Safety Training for Hazardous Waste/Materials. Certified by Woodward-Clyde. July 1994.

EMPLOYMENT HISTORY

1993-present	Department of Geology, University of Georgia, Athens, GA
1993-present	Geoarcheology Research Associates, Riverdale, NY
1991-1993	DRE Environmental Services, Inc., Brentwood, TN
1990-1991	DuVall and Associates, Inc., Franklin, TN
1987-1990	Center for Archaeological Investigations, Southern Illinois University at Carbondale, IL

FIELD AND RESEARCH EXPERIENCE

1993-present	Studies of Holocene alluvial stratigraphy, soil formation, and sea-level change with reference to prehistoric archaeological sites in the Northeastern and Southeastern United States
1994-present	Petrographic analysis of temper inclusions in historic and Prehispanic ceramics from Mexico, University of Georgia and the American Museum of Natural History

SELECTED RECENT PAPERS

2000 A Stratigraphic and Chronometric Investigation of the Alluvial Deposits of the North Branch of the Susquehanna River. Ph.D. dissertation, University of Georgia, Athens.

2000 Archaeological Site Formation in Settings with Ice-contact and Meltwater-Derived Deposits, Southern New York and New Jersey. The New York Natural History Conference VI, Albany, New York, Abstracts.

2000 Holocene Paleogeography and Potential Preservation of Submerged Archaeological Sites in New York and New Jersey Harbor. Society for American Archaeology, 65th Annual Meeting, Philadelphia, Pennsylvania, Abstracts.

2000 Possible effects of North Atlantic Ocean surface temperatures on the Holocene alluvial stratigraphy of the Susquehanna River valley (with Ervan G. Garrison), Northeastern Section of the Geological Society of America, 35th Annual Meeting, New Brunswick, New Jersey, GSA Abstracts.

1999 Late Pleistocene through Holocene degradational sequence in the Chattahoochee alluvial valley below the Fall Line. Southeastern Geology, v. 30.

1999 Hands washed in a muddy stream: corrections and further thoughts on "Wyoming Valley Landscape Evolution... " Pennsylvania Archaeologist 69(2).

1999 Geochemical analysis of cultural residues: recent studies on prehistoric and historic archaeological sites. Southeastern Section of the Geological Society of America, 48th Annual Meeting, Athens, Georgia, GSA Abstracts, v. 31, no. 3, p. 70.

1998 Wyoming Valley Landscape Evolution and the Emergence of the Wyoming Valley Culture. Pennsylvania Archaeologist, v. 68, no. 2, p. 1-17.

1998 Late Pleistocene through Holocene paleohydrology of the Hackensack and Passaic drainages and the potential for deeply buried archaeological sites. Northeastern Section of the Geological Society of America, 33rd Annual Meeting, Portland, Maine, GSA Abstracts, v. 30, no. 1, p. 78.

1997 Tradition and continuity of ceramic production and utilization of clay sources in the vicinity of Santa Maria Atzompa from the Late Formative to the present. American Anthropological Association, Washington, D.C., 96th Annual Meeting , Abstracts.

1997 Prehistoric landscapes and site preservation in northern New Jersey: advances in geoarchaeology and environmental reconstruction. Eastern States Archaeological Federation, 64th Annual Meeting, Trenton, New Jersey, Abstracts, p. 18.

1997 Archaeological implications of degradational sequences in Georgia river valleys. Southeastern Section of the Geological Society of America, 46th Annual Meeting, Auburn, Alabama, GSA Abstracts, v. 29, no. 3, p. 74.

SELECTED TECHNICAL REPORTS

2000 Geomorphological and Archeological Study Northeast of Shooters Island, Hudson and Union Counties, New Jersey, in connection with the Arthur Kill – Howland Hook Marine Terminal Channel Project: Report prepared for the U. S. Army Corps of Engineers, New York District.

2000 Phase I Geoarcheological Investigations of the Planned Project Area for the S.R. 0611 – Mud Run Bridge Replacement Project, Lower Mount Bethel Township, Northampton County, Pennsylvania: Report submitted to Kittatinny Archaeological Research, Inc., Stroudsburg, Pennsylvania.

1999 Geomorphological and Archeological Study of New York and New Jersey Harbor Navigation Channels. Report prepared for the U.S. Army Corps of Engineers, New York District.

1999 Geoarchaeological Deep Testing of Areas to be Impacted by Replacement of the S.R. 611 Bridge over Mud Run in Northampton County, Pennsylvania. Report submitted to Kittatinny Archaeological Research, Inc., Stroudsburg, Pennsylvania.

1999 Report of Geomorphological Investigations at the Proposed Wetland Replacement Area on the Berinski Farm, Morris County, New Jersey. In Route 21 Freeway Extension, Section 6L Phase I/II Archaeological Investigation, Lincoln Park , Wetland Mitigation Site, Morris County, New Jersey. Appendix A. Report prepared for the New Jersey Department of Transportation by URS Greiner, Inc.

1999 Geoarchaeological Investigations at Site 28PA145, Route 21 Corridor, Passaic County, New Jersey. In Archaeological Investigations at Sites 28PA39, 28PA40, 28PA145, the Early Dundee Canal Terminus Area, and the Eagle Foundry Site, Route 21 Extension Cultural Resources Mitigation, Passaic County, New Jersey, Volume 2, Appendix A. Report prepared for the New Jersey Department of Transportation by URS Greiner, Inc.

1998 Geomorphology and Sediment Stratigraphy. In Technical Report, Phase II Archaeological Testing of the Governors Island National Historic Landmark District, Governors Island, New York. Report prepared for the U.S. Coast Guard by The Public Archaeology Laboratory, Inc.

1998 Geomorphological Overview, Probability Statements, and Deep Testing Results (with Joseph Schuldenrein, Susan T. Goodfellow, and Christopher Dorion). In Phase I Cultural Resources Investigations of the Millennium Pipeline System: Erie and Pike Counties, Pennsylvania, and Chautauqua to Westchester Counties, New York. Report prepared for The Millennium Pipeline Company, L.P. by Gray and Pape, Inc.

1998 Riverlog of Quaternary Deposits and Archaeological Sites along the North Branch of the Susquehanna River, Pa-NY Border to Northumberland, Pennsylvania. Report prepared for the Pennsylvania Geological Survey.

1998 Paleoenvironmental Analysis of the Combined Sewer Overflow Planning Study Planning Area IA, North Bergen (West), Hudson County, New Jersey. Report prepared for Richard Grubb and Associates, Inc.

1998 Phase I Geoarchaeological Investigations, I-276 Extension into New Jersey for the I-95/I-276 Interchange Project. Report prepared for KCI Technologies, Inc.

1998 Archaeological Monitoring for the City Island Temporary Force Main, Bronx, NY. Letter reports to Spearin, Preston, and Burrows, Inc.

1997 Results of the Geomorphological Investigations. In Technical Report, Phase IB Archaeological Survey of the Governors Island National Historic Landmark District, Governors Island, New York. Report prepared for the U.S. Coast Guard by the Public Archaeology Laboratory, Inc.

1997 Geoarchaeological Investigations for Project AMD 32/2447 101.1 along Crooked Creek, Indiana County, Pennsylvania. Report prepared for Cultural Heritage Research Services, Inc.

PROFESSIONAL AFFILIATIONS

Geological Society of America
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Society for Archeological Sciences
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TERRENCE W. EPPERSON

Special Projects Manager/Principal Investigator
Geoarchaeology Research Associates
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EDUCATION

Ph.D.	Temple University	Anthropology	1991
M.A.	Idaho State University	Anthropology	1977
B.A.	Towson State University	History	1975

EMPLOYMENT HISTORY

1999-present	Special Projects Manager, Geoarchaeology Research Associates, Riverdale, New York
1995-present	Adjunct Anthropology Instructor, Montgomery County Community College, Blue Bell, Pennsylvania
1994-1999	Vice President and Principal Investigator, Cultural Heritage Research Services, Inc., North Wales, Pennsylvania
1991-1994	Principal Invesitgator, Hunter Research, Inc., Trenton, New Jersey

PROFESSIONAL EXPERIENCE

Terrence W. Epperson, Ph.D. serves as GRA's Special Projects Manager. With sixteen years of relevant supervisory experience, Dr. Epperson has directed historical, archaeological, and historic preservation investigations at all levels of effort in Utah, Idaho, Virginia, Maryland, New York, New Jersey, and Pennsylvania for clients in the private sector as well as for municipal, state and federal agencies. He has also been certified as an expert witness for a range of historic preservation issues and has provided both deposition and open-court testimony. Dr. Epperson's primary areas of expertise are historical archaeology, documentary research and project management.

For the past decade, Dr. Epperson has worked in the mid-Atlantic region where he has been a P. I. on a wide range of projects including: Phase II and Phase III prehistoric site excavations in Susquehanna County, PA; HABS/HAER recordation of a Gravity Railroad engine house complex in Lucerne County, PA; Phase I and II cultural resource investigations for a wetlands replacement project in Clinton County, PA; an Archaeological Sensitivity Assessment of the African Burial Ground and The Commons National Historic Landmark in New York City; Phase III excavations at the Water's Edge Site in Trenton's NJ ; Phase IA survey for the Eddystone Natural Gas Pipeline in Delaware County, PA: and Archaeological Investigations at the Batso Sawmill in Burlington County, NJ .

In addition, the Cultural Resources Survey for the Sun Inter-Refinery Pipeline in Delaware County and Philadelphia, PA and Gloucester County, NJ was a particularly complex project which involved reviewer in two states and numerous federal agencies. Dr. Epperson recently directed the production of an educational video about the Delaware and Hudson Canal Company Gravity Railroad.

Dr. Epperson has also held research fellowships at the Smithsonian Institution and the University of Virginia's Carter G. Woodson Institute for African American and African Studies. His recent publications include: "Race and the Disciplines of the Plantation" ***Historical Archaeology*** [1990] and "The Contested Commons"; "Archaeologies of Race, Repression, and Resistance in New York City", in ***Historical Archaeologies of Capitalism,*** edited by M.P. Leone and P.H. Potter [1999]. Dr. Epperson has received specialized training in implementation of the Native American Graves Protection and Repatriation Act and in the identification management of Traditional Cultural Properties.