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A Geomorphological and Archaeological Analysis of Potential Dredged Material Management Alternative Sites in the New York Harbor-Apex Region

Affecting the Coastal Areas of New York, Queens, Kings and Richmond Counties in New York
and
Bergen, Hudson, Middlesex and Monmouth Counties in New Jersey

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835

MANAGEMENT SUMMARY

This geomorphological and archaeological analysis of the New York Harbor-Apex region has been conducted in connection with the Army Corps of Engineers (New York District) review of suitable sites for the New York-New Jersey Harbor Dredged Material Management Plan (DMMP). An interim report issued by the Corps in September 1996 had identified 53 alternative methods and locations throughout the New York Harbor-Apex region that met specific technical siting criteria for dredged material disposal. More site-specific information was required for the next phase of work, especially in the area of cultural resource management, as the potential for impacting cultural resources had not been considered as an exclusionary criterion in the earlier stages of the project.

The purpose of this phase of the DMMP Project was to gather physical information on sediment characteristics in a total of nine candidate sites for dredged material containment facilities. These sites are: the lower Hudson River; Constable Hook/Port Jersey; Newark Bay; Ward's Point; Bowery Bay; Red Hook/Bay Ridge; and Zones of Siting Feasibility 1, 2 and 3. The goal of the This geomorphological and archaeological analysis for this project is to identify, through evidence available in the sediment, faunal and floral records of the New York Harbor-Apex region, former land surfaces that may have been occupied by prehistoric peoples. This work was conducted in compliance with Federal statutes and regulations, including Section 106 of the National Historic Preservation Act, as amended through 1992 and the Advisory Council of Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800).

While the need for further technical information regarding capacity estimates and structural design of disposal sites drove the selection of study areas for the current phase of the project, consideration of potential prehistoric resources helped to refine the coring/boring strategy. In making recommendations for cultural resource sampling, we judged certain paleoenvironmental settings to have been of greatest interest and utility to prehistoric peoples that may have inhabited the region. These included possible riverbank and shore sites, as well as former elevated terraces that may have been attractive as habitation or subsistence sites. Sediments were collected by Vibracore and split spoon boring. For the collection of samples for cultural resource analyses, we specified that samples should be taken whenever the sediment characteristics (e.g., color, grain size, bed forms) suggested the existence of an erosional surface or paleosol.

In light of the New York Bight's geologic and archaeological history, and our preliminary findings from the study, we feel that the potential for submerged archaeological sites is actually greater than previously recognized (i.e., Boesch, 1994). As a guide to future investigations, we feel that the proposed DMMP sites in the New York Harbor-Apex can appropriately be ascribed varying levels of sensitivity in terms of the potential of encountering prehistoric cultural resources. Ward's Point and a portion of Zone 1 are areas of high sensitivity, since they still preserve much of the Holocene stratigraphy and were probably in close proximity to favorable living sites. The probability of impact is low in the Hudson River and Constable Hook/Port Jersey, because either the sediments are already disturbed or no Holocene sediments were preserved. Bowery Bay, Newark Bay and Red Hook/Bay Ridge, the remaining portion of Zone 1 and Zones 2 and 3 all possess a moderate to low probability of preserving intact cultural deposits owing to the limited preservation of Holocene sediments in close proximity to industrialized regions and shipping lanes.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

This geomorphological and archaeological analysis of the New York Harbor-Apex region has been conducted in connection with the Army Corps of Engineers (New York District) review of suitable sites for the New York-New Jersey Harbor Dredged Material Management Plan (hereafter referred to as the DMMP). An interim report issued by the Corps in September 1996 had identified 53 alternative methods and locations throughout the New York Harbor-Apex region that met specific technical siting criteria for dredged material disposal. More site-specific information was required for the next phase of work, especially in the area of cultural resource management, as the potential for impacting cultural resources had not been considered as an exclusionary criterion in the earlier stages of the project.

The purpose of this phase of the DMMP Project was to gather physical information on sediment characteristics in a total of nine candidate sites for dredged material containment facilities (i.e., subchannel pits, dredged material islands, etc.). These sites are:

Upper Bay:	Hudson River Constable Hook/Port Jersey Newark Bay Bowery Bay Red Hook/Bay Ridge
Lower Bay:	Ward's Point Zone of Siting Feasibility 1 (approx. boundaries 40.47-40.50°N lat., 74.16-74.22°W long.) Zone of Siting Feasibility 2 (approx. boundaries 40.48-40.53°N lat., 74.06-74.11°W long.)
N.Y. Bight Apex:	Zone of Siting Feasibility 3 (approx. boundaries 40.39-40.41°N lat., 73.71-73.76°W long.)

The goal of the geomorphological and archaeological analysis for this project is to identify, through evidence available in the sediment, faunal and floral records of the New York Harbor-Apex region, former land surfaces that may have been occupied by prehistoric peoples. Historic resources were addressed in a separate study. Under the terms of the original scope of work, the cultural assessment was also to include remotely sensed data (i.e., high resolution seismic profiles) to identify paleotopography; however, such data were not available in interpreted form at the time of this filing. This work was conducted in compliance with Federal statutes and regulations, including Section 106 of the National Historic Preservation Act, as amended through 1992 and the Advisory Council of Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800).

Based upon the results of our investigation, we feel that the proposed DMMP sites in the New York Harbor-Apex can be ascribed varying levels of sensitivity in terms of the potential of encountering prehistoric cultural resources. Areas of high sensitivity include Ward's Point and portions of Zone 1, because these areas include geomorphological features, such as submerged estuaries and lagoon sequences, whose fragile environments may be protected intact in a sealed context by overlying sediments. The probability of impact is low in the Hudson River because the channel is scoured to the base of the Pleistocene deposits and has probably served as a river channel prior to human occupation of the region. However, the margins of the river remain culturally sensitive and would warrant further investigation. Due to industrialization, the only sediments remaining in the vicinity of testing at Constable Hook/Port Jersey are Pleistocene in age and therefore warrant less consideration. Bowery Bay, Newark Bay and Red Hook/Bay Ridge all posses a moderate to low probability of preserving intact cultural deposits due to their proximity to industrialized regions and shipping lanes. The remaining portion of Zone 1, plus Zones 2 and 3, possesses a moderate probability of impact because of the likelihood that much of these areas of the shelf were eroded during Holocene sea level rise.

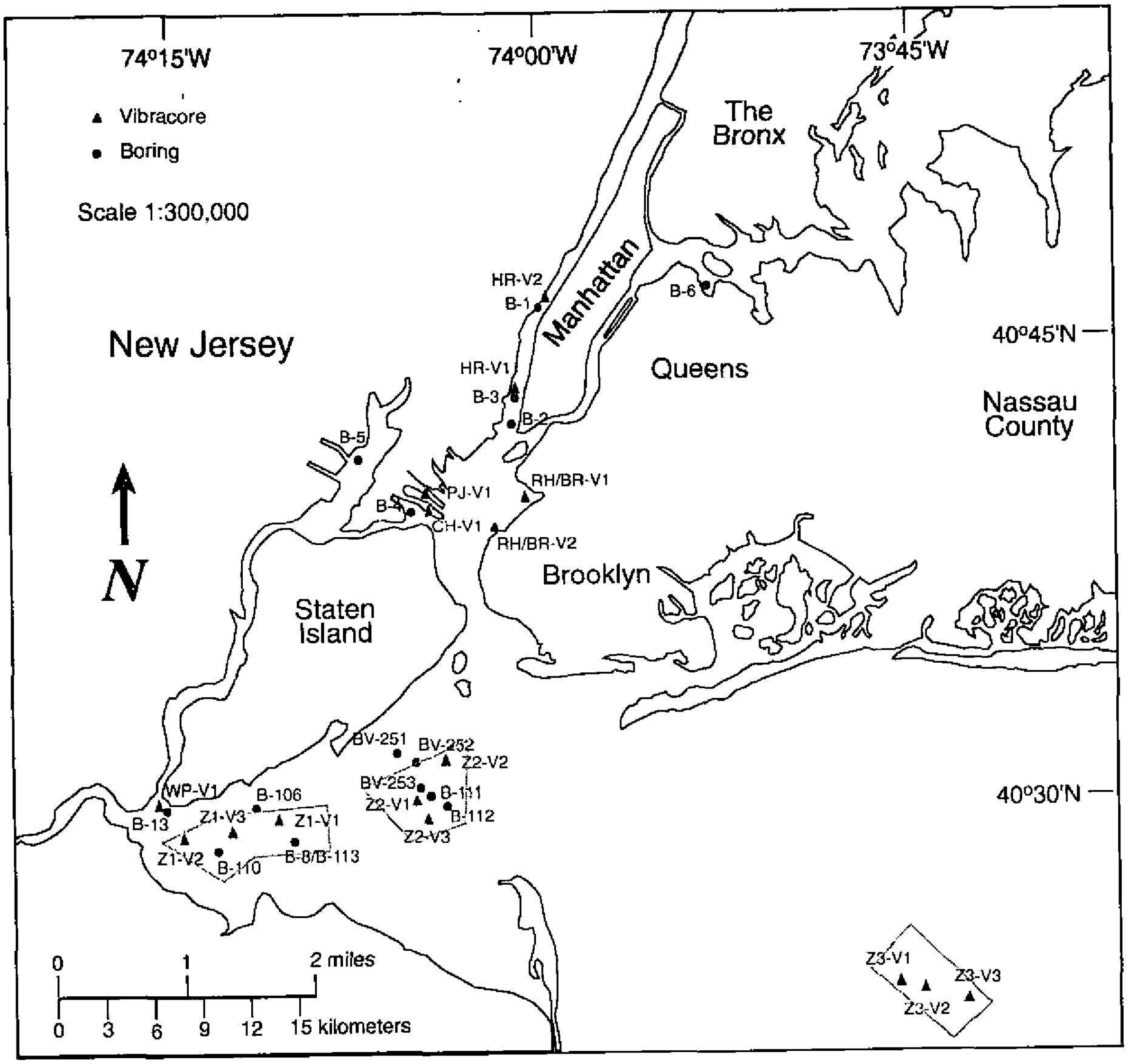

Fig. 1. Summary of Vibracore and boring locations for the current phase of the DMMP Project.

BACKGROUND RESEARCH

Pleistocene-Holocene Geology

The New York Harbor-Apex region (or New York Bight) is a highly complex coastal plain-estuarine environment that has been significantly shaped by the Pleistocene ice ages and subsequent Holocene post-glacial sea-level rise (e.g., Freeland and Swift, 1978; Duedall et al., 1979; Field et al., 1979; Freeland et al., 1981; Stanford and Harper, 1991). When sea level fell at the beginning of the Pleistocene glaciation, the base level of the Hudson River was lowered significantly. The river began to incise a valley that ultimately extended across the continental shelf, creating the present-day Hudson Canyon. Repeated advances and retreats of the ice sheets throughout the Pleistocene overdeepened the valley and modified it, effects enhanced by the isostatic response to the presence and removal of the ice sheet load. The advance and retreat of ice sheets also resulted in the fall and rise of relative sea level, which alternately carved shorelines or permitted the build-up of deltas such as the Hudson Apron further out on the continental shelf.

It is unclear just how many glacial advances and retreats affected the New York Bight region, partly because age controls on the glacial sediments are poor, and partly because the highly variable nature of glacial deposits in general makes correlation between sections difficult (e.g., Rampino and Sanders, 1981; Sirkin, 1986; Merguerian and Sanders, 1994). Certainly there are tills of varying ages present across Long Island. Merguerian and Sanders (1994) have proposed a basic four-part stratification of the tills based upon their sedimentology, the direction of ice sheet advance (inferred from the provenance of the clasts in the sediment), and observable stratigraphic relationships. The two youngest units are of principal interest for this study, as they are the most widespread in the Bight area. The youngest glacial unit, Till IV, is a gray-brown till marking ice sheet flow from NNE to SSW, directly down the Hudson River valley; this unit is thought to be the terminal moraine for the last Wisconsin ice advance circa 18,000 B.P. Till III is characterized by a reddish-brown color and the presence of Mesozoic-age clasts in abundance, indicating an ice transport direction of NW to SE. A named deposit included in the Till III classification is the Harbor Hill Moraine and associated outwash, which stretched from Long Island across to Staten Island.

Data from the mid-Hudson Valley, northern New Jersey and the Connecticut Valley indicate that the last Wisconsin ice sheet had already retreated more than 100 miles north of the New York Bight by approximately 15,000 B.P. (e.g., Connally and Sirkin, 1970; Witte, 1997). In the wake of the ice's retreat, the land remained depressed and collected glacial meltwaters. Between approximately 19,000 and 15,000 B.P., a series of lakes developed behind a dam created by the Harbor Hill moraine (Reeds, 1927; Newman et al., 1969; Lovegreen, 1974; Stanford and Harper, 1991). These lakes persisted, shifting their positions as the land rebounded, until the dam was breached at the Narrows (Stanford and Harper, 1991). The sediments of these glacial lakes are typically silty clays with small shell fragments, and are often laminated; they accumulated virtually anywhere in the Bight that was submerged at the time. Projections of the inferred maximum lake levels across outcrops and drill cores along the length of the Hudson Valley demonstrate the effects of isostatic rebound beautifully (Stanford and Harper, 1991). Areas further up the Hudson Valley that were once depressed under the weight of the ice are now up to 60 feet above sea level, and those areas that had been elevated to compensate for the ice have subsided 60 to 80 feet below sea level (e.g., Pickman, 1988). For reasons that are not quite clear, the rebound of the Bight region was delayed until about 13,000 B.P., as reflected by changes in the drainage patterns of the

Hackensack Lowlands at that time (Stanford and Harper, 1991). Isostatic rebound of the land continues today at a much slower pace, estimated to be approximately 1.94 mm/yr (Peltier, 1996). At the end of the Pleistocene, Lower New York Bay may have been largely a dry coastal plain (Edwards and Merrill, 1977; Ferguson, 1986), with sites potentially located at the current 20-m isobath or lower (Stright, 1995). Inland sites (with respect to the paleoshoreline), such as riverbank or estuarine sites, may have been populated from this time forward (Miller et al., 1990; Grossman, 1992; Schuldenrein and Thieme, 1996).

Global sea levels rose to within ~10 meters of the present-day level by approximately 6,000 BP (Fairbanks, 1989; Bard et al., 1990). Since that time, the topography of the now-submerged portions of the continental shelf has been modified by storm-wave action and long-shore currents. Some difference of opinion exists as to whether widespread shoreface erosion has completely reworked the uppermost sediments of the shelf (e.g., Freeland et al., 1981), or whether sporadic sea level rise permitted the preservation of some older sand barrier features (e.g., Sanders and Kumar, 1975; Stubblefield et al., 1984). It is a complex issue to address, largely because there are a number of local factors, such as tides, tectonic activity and sediment supply that can determine whether sediments are preserved or reworked (Belknap and Kraft, 1981; Panangeotou et al., 1986; Stright, 1986, 1995). Such complexities are frequently not appreciated by the general research community, which typically adopts a basic model for the sake of simplicity. While useful for identifying first-order trends in sea level change, these models can be terribly misleading on the local scale of investigation that is of principal interest. For example, the present rate of sediment supply to the Hudson estuary is higher than the rate of relative sea level rise (e.g., Weiss, 1974); this phenomenon is reflected in the sedimentary record as relative sea level fall, even though we are in the midst of a global sea level rise. Clearly, the wrong assumptions about sea level variations and their effects would have important consequences for identifying submerged prehistoric cultural resources.

Paleoenvironment

During the Last Glacial Maximum (LGM) climatic conditions seem to have been drier than at present, with more open forest cover. Jack pine seems to have been a dominant species east of the Appalachians, indicating relatively dry conditions, and an open forest canopy. Xerophytic full-glacial plant communities are recorded from the Atlantic coastal plain at White Pond, South Carolina, as well as at Singletary Lake, North Carolina (Wells, 1992). A mosaic of open pine-dominated forests, with spruce and prairie grass, existed in the northeast between 22,000 B.P. and 13,500 B.P. (Watts, 1980). In Maryland, pollen evidence indicates pine-birch barrens and spruce park land dominating the interval between 30,000 B.P. and 13,000 B.P. (Wells, 1992). The abundance of chenopods (e.g., *Atriplex*) and compositae (e.g., *Artemesia* and *Ambrosia*) characterize present day steppe regions and associated mammal fauna, including open ground grazing herbivores. This suggests that the LGM vegetation of the eastern United States may have been park land or open woodland, similar to the present day Eurasian forest steppe (Tallis, 1990). There is also abundant sedimentological evidence indicating the presence of blow-outs and shifting sand dunes during the LGM (Wells, 1992). Along the Maryland coastal plain, south to Georgia, dune activity is recorded from 22,000 B.P. to approximately 13,000 B.P. The density and extent of the aeolian features suggest that many areas of the eastern United States had an open sparse vegetation, a mosaic of pine and spruce woodland, with associated open herbaceous, and xerophytic vegetation. Wells (1992) suggests that during the LGM, annual precipitation may have declined to one-fifth or one-third (200 to 450 mm) of the present values (1,000 to 1,400 mm). The geological evidence suggests that a temperate woodland or open boreal forest, not a closed forest vegetation, existed in the eastern United States at the LGM.

Traditionally, the palynological analysis of recovered cores resulted in the interpretation of broad vegetation zones whose floral components represented a static assemblage in dynamic equilibrium with the advancing or waning Pleistocene ice sheets (Deevey, 1939; Davis, 1958; Sirkin, 1967). This conceptual framework often led to the perception of broad, parallel, vegetation zones trending as east-west bearing stripes along the ice front. Until the present time, it has not yet been fully established as to whether broad vegetation belts actually existed during the LGM. This traditional view (Deevey, 1939; Davis, 1958; Sirkin, 1967) also envisaged a tripartite pollen subdivision referred to simply as zones A through C, which was established to better illustrate the floral succession along the eastern seaboard. Although there are several contemporary views of floral zones and their dynamics, the traditional pollen zones: A) spruce-fir, B) pine, and C) spruce-oak are well established for the northeastern United States (Davis, 1958). Zone A is distinguished by a maximum percentage of spruce and fir. Pine is also dominant in zone A and oak is present, but generally went unexplained in the past. Zone A would encapsulate, in the study area, a time period from approximately 12,500 B.P. to 10,000 B.P. During this time period of extant glacial lakes, spruce would rise and decline in abundance along with fir, while pine will increase in abundance along with oak. This perturbation in the spruce-fir-pollen peaks indexes the younger Dryas, a period of global cooling, approximately 11,000 B.P. to 10,000 B.P. (Peteet, 1992). The younger Dryas is a Zone B, the pine pollen zone, is recognized by its extreme abundance of pine pollen, sometimes greater than 50%. A continued sharp decline in spruce, and persistence of oak would characterize the time period of approximately 9,000 B.P. At approximately 8,500 B.P. a short global warming trend, the hypsithermal, is indexed by a dramatic increase in oak populations. Large portions of the Laurentide ice sheet remained at 8,000 B.P. due to thermal inertia; that is they were simply so large they had not yet had time to melt in warmer climates. By 8,000 B.P. oak increases in abundance markedly, while pine drops to an average of about 35%. Zone C, the oak pollen zone, is characterized by the abundance of oak greater than 25% in most samples. Pine is still present, although there is a relative increase in percentages of hemlock, hickory, and chestnut. From 7,500 B.P. to 5,000 B.P. the forest contains a canopy of oak, pine, and hemlock. From 5,000 B.P. to 2,000 B.P., the mosaic shifts to one dominated by oak, pine and hickory, characterizing the eastern deciduous forest. From approximately 2,000 years ago to the present, oak, pine, hemlock, hickory, beech, birch and chestnut, the deciduous hardwood forests, characterize the lower Hudson River estuary to the present time. The appearance of non-arboreal pollen and holly indicate a return to cooler, moister climatic conditions until approximately 1,000 B.P. until the present day. Oak, birch and chestnut increase in accordance with a continuation of a cool, moist climate.

Prehistoric Cultural History / Known Sites of the Region

The discovery of the Paleoindian site at Cactus Hill, along the Nottoway River in southeastern Virginia, represents the earliest prehistoric human occupation occurring along the eastern seaboard (McAvoy and McAvoy, 1997). A radiocarbon date of 15,070 ± 70 B.P. was obtained from white pine below a fluted point-bearing horizon. An additional radiocarbon date of 10,920 ± 250 B.P. was obtained from an overlying stratum bearing southern hard pine. The site occurs on a sandy bluff overlooking the Nottoway River, along the Virginia coastal plain. Confirmation of the early age dates at Cactus Hill shed supportive light on the early radiocarbon dates from Meadowcroft, Pennsylvania (e.g., Adovasio et al., 1985), which are not associated with cultural remains.

Paleoindian is a cultural term used to describe prehistoric people who lived from 11,500 B.P. to 8,000 B.P. Paleoindian people are thought to have lived in small groups that frequented ridge tops, rivers, streams, caves, rock shelters, and lake shores. Although they are usually associated with mammoth and mastodon-bearing sites, the presence of oyster shells in coastal middens suggests a broad spectrum economy (Henderson et al., 1998). Floral and faunal data recovered from the Dutchess Quarry Caves (e.g., Funk et. al., 1994) indicates that Paleoindian peoples had a varied diet of birds, fish, and fruit. A variety of Paleoindian site types exist and the interpretations include base camps, hunting camps, quarry shops, and megafaunal kill sites (Funk, 1972; Gramly, 1982).

Prehistoric occupation of the New York City area is initiated with a very early Paleoindian radiocarbon date of 12,500 B.P. recovered from the Dutchess Quarry Cave # 1, Orange County, New York, although the date and associated fluted point have been the subject of controversy as of late (Steadman et al., 1997). Fluted projectile points have also been found throughout eastern and central Long Island, northwestern New Jersey, and southeastern New York. The Port Mobil site on Staten Island (Funk and Hayes, 1977) is yet another example of a Paleoindian site occurring on a sandy ridge above a waterway in the New York City area. The Turkey Swamp site (8,730 B.P. to 8,000 B.P.) was also discovered on a minor water course of the Manasquan River in east-central New Jersey, not far from Sandy Hook. The tools associated with the Turkey Swamp site have been referred to as Late Paleoindian (Cavallo, 1981).

The Archaic Period (10,000 B.P. to 3,000 B.P.) is divided into the Early (10,000 B.P. to 8,000 B.P.), Middle (8,000 B.P. to 6,000 B.P.), and Late (6,000 years B.P. to 3,000 years B.P.) stages. Archaic culture is generally characterized as a mixed subsistence economy that did not exploit the megafaunal resources used by Paleoindian cultures. Many do believe that Early Archaic subsistence was probably much similar to the lifeways of earlier Paleoindian groups, minus the presence of the fluted point technology. During the Archaic Period, much emphasis was placed on small-game hunting, fishing and shell-fishing. Archaic tool assemblages are characterized by large, broad-based, dart points, as well as ground and polished stone tools. Villages, camp sites, shell middens and cemeteries comprise the majority of Archaic sites illustrated. Sites in which occupation has spanned the entire Archaic Period are the Goodrich, Old Place, and Goethals Bridge sites in Staten Island (Anderson, 1964); the Arlington Place, Arlington Avenue, Arlington Station and Gerties Knoll sites, also on Staten Island (Skinner, 1909); four village sites in Bayonne, New Jersey (Skinner and Schrabisch, 1913), and scattered artifacts from sites in Elizabeth, New Jersey (Skinner and Schrabisch, 1913). In southern New England (Dincauze and Mulholland, 1977) and eastern Long Island (Ritchie, 1959), Early Archaic sites are usually located within 50 kilometers of the modern shore line, in areas associated with fertile lowlands and deciduous forests. However, in the New York City area, most Early Archaic sites lie within a few kilometers of the present day shoreline. The radiocarbon dates retrieved from these sites range from 9,360 B.P. to 7,260 B.P. Over the years, bifurcate base projectile points have been found at Ryders Pond in Brooklyn, near Sheepshead Bay (Lopez and Wisniewski, 1972; Dincauze, 1975), and great numbers of bifurcate points have been found in the vicinity of Ward's Point, Staten Island (Ritchie and Funk, 1971; Jacobson and Grumet, 1995). The Ward's Point site has yielded Kirk-stemmed points, as well as LeCroy and Kanawha-stemmed points. Other Early Archaic sites include the Old Place site on the western shore of Staten Island (Anderson, 1964), Richmond Hill, and in Westchester County, New York, the Piping Rock site, Montrose Point, and the lowest levels of Dogan Point (Claasen, 1994).

Oddly enough, the diagnostic tool types which characterize the Early Archaic are fashioned from raw material sources which outcrop to the north and northwest, up to a distance of 50 to 150 kilometers away. In fact, most Early Archaic diagnostic stone tools are fashioned from the same raw materials that were exploited by the previous Paleoindian peoples. These include Catoctin rhyolite from southeastern Pennsylvania, Pennsylvania jasper, Oriskany chert, and Normanskill cherts. All of this suggests that Late Paleoindian and Early Archaic are part of a cultural continuum, and the presence of sites along coast lines is an artifact of normal processes of erosion, as well as sampling design. The only raw material source in close proximity to the continental shelf from the Paleoindian through the Early Archaic period would be the Miocene cobble deposits occurring near Cape May, New Jersey (La Porta, unpublished data).

Middle Archaic site types include spring fishing camps, hunting camps, rock shelters, and shell fishing stations, all of which are present in the lower Hudson River valley (Dincauze, 1975; Brennan, 1977; Starbuck, 1980; Wiegand, 1983). The varying types of Middle Archaic sites suggest an established pattern or strategy for food gathering in localized areas.

The Late Archaic Period can be further subdivided into the Laurentian tradition (6,000 B.P. to 4,500 B.P.), the Sylvan Lake tradition (4,500 B.P. to 4,000 B.P.), and Terminal Archaic (3,700 B.P. to 3,000 B.P.). Late Archaic subsistence patterns are interpreted as being extremely diverse, including; coastal, river-side, lake-side, marsh margins, upland sites and quarries. If the Laurentian tradition exists, its antecedents lie in the boreal arctic landscape. This would suggest that Frontenac is a ceremonial phase, while Sylvan Lake is a riverine adaptation with a lithic tradition focused upon the exploitation of Taconic-age vein quartz (La Porta, unpublished data). All this would suggest that the River phase in the Hudson Valley is related to the Sylvan Lake tradition. A few Late Archaic sites in the New York City area include the Rudge-Breyer site (Gwynne, 1985), the Remsen Hill site at Mount Sinai (Kalin, 1989), and the Mount Sinai Harbor Site, dated at 2,400 B.P. (Johannemann in Stright, 1990), all on Long Island; and the Twombly Landing site (Brennan, 1968), near Edgewater, New Jersey below the Palisades Cliffs. Investigations of the Mount Sinai Harbor site suggest year-round settlements along coastal Long Island (Gramly, 1977; Wisniewski and Gwynne, 1982).

The Terminal Archaic is characterized by the presence of broad blade projectile points and the use of steatite for the manufacture of soapstone pots. A great number of Terminal Archaic sites have been located along the New Jersey shoreline, especially along the Shark and Manasquan rivers. The Terminal Archaic closes with the appearance of the Orient phase (3,200 B.P. to 2,700 B.P.) (Ritchie, 1980; Kraft, 1970). Orient sites include several coastal occupation sites and five cemeteries. The presence of ceramics in Orient sites marks the transition between Archaic and Woodland periods.

The Woodland period is divided into three stages, Early (3,000 B.P. to 2,000 B.P.), Middle (2,000 B.P. to 1,000 B.P.), and Late (1,000 B.P. to European contact). The characteristic cultural feature of the Woodland period is the presence of pottery. Based on ceramic studies, the Woodland period in New York is divided into the Windsor and East River traditions. The North Beach phase of the Windsor tradition is contemporaneous with the Orient phase of the Terminal Archaic. At some sites, Orient fishtail projectile points are found in associated with steatite vessels, Vinette I and Windsor ceramics. Sites associated with this phase are small, temporary and coastal (Lightfoot et al., 1985). Following the North Beach phase is the Clearview phase, which is Middle Woodland in age. The third and final phase of the Windsor tradition is the Sebonac phase, which is poorly represented in the New York metropolitan area. The initial phase of the East River tradition is Bowmans Brook (1,000 A.D.). Bowmans Brook-age sites are commonly found on the coastline. The Bowman Brook site on Staten Island may have been a semi-permanent village (Ritchie, 1980). The final phase of the East River tradition is the Clasons Point phase (1,300 A.D.). The Early Woodland period is poorly represented in the lower Hudson River valley, and most sites are shell middens and temporary fishing stations. Occasionally burial ceremonialism is associated with Early and Middle Woodland period sites. Settlement sites during the Middle Woodland have been interpreted by Funk (1976) as being more permanent, based on the presence of large pits, possibly used for food storage, and associated large-size ceramic vessels. Middle Woodland sites present in the lower Hudson River valley include: Parham Ridge, Crawbuckie 1 through 11, Hanotac rock-shelter and Van Cortlandt (Brennan, 1962; Funk, 1976). The Late Woodland is associated with the development of horticulture and large scale villages (Smith, 1950; Solecki, 1950; Salwen, 1975; Ceci, 1979; Ritchie, 1980).

Prehistoric Archeological Sites Occurring in the Study Area as Documented from the Early Literature

There are numerous prehistoric sties within the New York City area that have not been age dated to a specific cultural period. Campsites occur on the northwestern side of Bayonne, starting at Bergen Point and extending north to Hudson County Bayonne Park at 39th Street. Yet another site area can be found in Hudson County Park between Avenue A and the shoreline. Additional campsites also occur on or near the shoreface of Newark Bay in Bayonne, near the foot of 25th Street, along the Central Railroad, and at the tip of Bergen Point (Skinner and Schrabisch, 1913). The Bowmans Brook site, which is age dated at approximately 1,000 A.D. (Smith, 1950) is situated across the Kill van Kull from Bergen Point in Bayonne. A village site once stood on Constable Hook, which was probably a Late Woodland occupation (Skinner and Schrabisch, 1913). The village and associated campsites occurred on a high ground in the middle of the peninsula. According to Bolton (1920), the village site at Constable Hook may have been the contact period, 17th century settlement, known as Nipnichsen. No evidence of these sites remains according to the Kardas and Larrabee's survey (1978). Sites also occur where Bayonne Bridge has been built, and near the former site of the Englander Mattress Company, near New Jersey Route 440. During Phase 1 testing for another study, Kardas and Larrabee (1984) recorded oyster and clam shells, lithic debris, and a stone chopper. In general, it is considered that the entire bluff facing Newark Bay served as an occupation area for prehistoric groups.

RESEARCH DESIGN

During the initial phase of the DMMP Project, 53 alternative locations were identified in the New York Harbor-Apex region that met specific technical criteria for dredged material disposal. At that time, however, the potential for encountering prehistoric cultural resources within the proposed sites was not considered. While the need for further technical information regarding capacity estimates and structural design of disposal sites drove the selection of study areas for the current phase of the project, consideration of potential prehistoric resources helped to refine the coring/boring strategy. In making recommendations for cultural resource sampling, we judged certain paleoenvironmental settings to have been of greatest interest and utility to prehistoric peoples that may have inhabited the region. These included possible riverbank and shore sites, as well as former elevated terraces that may have been attractive as habitation or subsistence sites (e.g., Heritage Studies, 1985; Miller et al., 1990; Stanley and Warne, 1997).

Sediments were collected by Vibracore and split spoon boring. For the collection of samples for pollen, foraminiferal and sedimentological analyses, we specified that samples should be taken by the geotechnical crews on the drilling platforms whenever they encountered the following conditions:

- An abrupt sediment grain-size change from finer to coarser-grained. Samples should be taken from above and below the contact between the two grain sizes, but if it is only possible to collect one sample, it should be taken from the finer-grained material.

- An abrupt color change in the sediment. Samples should be taken from above and below the contact between the two colors, but if it is only possible to collect one sample, it should be taken from the darker colored material.

- An indication that a buried soil horizon has been encountered (signs include the presence of plant roots or other debris, concentrated organic material). Samples should be taken from above and below the top of the soil horizon, but if it is only possible to collect one sample, it should be taken from the soil.

- Cultural remains (e.g., bone, stone tools, and especially shell material) or wood fragments.

Abrupt changes in sediment grain size and/or color are often indicative of erosion surfaces or soils, or in the very least a change in environmental conditions, and so have good potential as marker horizons for correlating between sampled sections. Datable faunal and floral information from above and below such horizons are therefore quite important. Our preference for finer-grained and/or darker colored material stemmed from an interest in getting the best possible samples for the cultural analyses; pollen and foraminifera are best preserved in the finest-grained sediments, while dark organic-rich sediments offer the possibility of radiocarbon dating.

The depth of sediment sampling was dictated partly by engineering concerns, i.e., boring would cease once bedrock was encountered or a depth of 120 feet below mean low tide, whichever came first. In contrast, Vibracore sampling did not exceed a depth of approximately 30 feet below the sediment-water interface owing to the limitations of the drilling apparatus. As a guide for the geotechnical crews, we recommended gathering cultural resource samples from areas above the first glacial till encountered for inner harbor sites, and from the first 60 feet of section from the Lower Bay and offshore sites. We later chose some additional samples at greater depths for pollen and foraminiferal analyses in the hopes of acquiring further chronological constraints. Samples chosen for sedimentological analyses (i.e., grain size, provenance studies) have not been processed and are being reserved for future analyses.

The issue of whether prehistoric sites are preserved on the Atlantic continental shelf will not be settled until a site has actually been found. Some researchers have suggested that shoreface erosion during Holocene sea-level rise would have completely planed off or reworked as much as 10-15 meters of the shelf, virtually guaranteeing that any sites that had existed would have been destroyed (e.g., Freeland and Swift, 1978; Field et al., 1979; Swift et al., 1980). Based upon a review of the literature and our own experience, such broad-brush views of sediment dynamics on the shelf are generally far too simplistic. It is indeed quite probable that sites closer to the shelf edge (approximately 100-110 miles from the present-day coastline, at about the 80-meter isobath) may have been extensively reworked, because the increased slope of the shelf there would have absorbed the brunt of wave energy of the advancing sea. However, that does not need to be the case along the inner edge of the shelf, which would have experienced rising sea levels only in the middle Holocene (Weiss, 1974; Fairbanks, 1989; Bard et al., 1990, 1992). Moreover, early post-glacial topography in the New York Bight is likely to have been highly irregular owing to ice erosion and glacial sediment deposition, affording plenty of spaces for rapid and relatively undisturbed sediment accumulation (e.g., Pickman, 1990, 1994). In our estimation, the potential for some prehistoric cultural sites to have survived post-glacial transgression in the New York Bight should be good. Perhaps none have yet been found because none were expected to exist.

RESULTS AND INTERPRETATIONS

The following discussion represents a synthesis and summary of the data gathered during this phase of the DMMP Project. Detailed descriptions of sediment types, sample depths, etc. can be found in Appendices 2 through 5 below; please note that not all types of analyses were conducted on samples from each site under consideration. It is generally possible to determine broad stratigraphic trends, although there is considerable variability in the prehistoric cultural resource preservation potential from site to site, a legacy of the glaciated paleolandscape.

1. Hudson River

Core locations - Cores B-1 and HR-V2 appear to have been taken from previously undisturbed riverbed, whereas cores B-3 and HR-V1 were apparently taken from a previously dredged area (Gross, 1976). Core B-2 was sampled at the Manhattan shoreline (Fig. 2).

Sedimentology - With one exception, each of the cores taken from the Hudson River is dominated by a dark gray organic silt or silty clay to a maximum depth of 72 feet. The sediment is commonly homogenous and lacks bedding structures, probably owing to the activities of benthic (bottom-dwelling) fauna reworking the sediment. Small scattered sea shells and shell fragments are common in all sections, although Section B-3 is the only section with more than a trace of fine- to medium-grained sand. Section B-2, located adjacent to the riverbank in southern Manhattan, was completed early when Paleozoic quartzite and schist basement rocks were encountered beneath a thin veneer of organic silt.

Pollen Analyses - Core B-1 was taken from the Manhattan side of the Hudson River, across from Weehawken, New Jersey. This core exemplified good recovery and pollen counts were taken at the 50-52 foot and 60-62 foot intervals. The lower interval (60-62 feet) indicates pollen peaks of 34% for Fagaceae *Quercus* (oak), with Pinecae *Pinus* (pine) at 13.0% and Juglandaceae *Carya* (hickory) at 6.2 %. Fagaceae *Fagus* (beech) at 4.7 % and Betulaceae *Betula* (birch) at 3.8 % are also present, along with Pinaceae *Tsuga* (hemlock) at 5.7% and Aceraceae *Acer* (maple) at 4.3%. Poaceae (grasses), Cyperaceae (sedge), and Asteraceae (thistle) are also abundant in the core. The upper interval (50-52 feet) captures the Fagaceae *Quercus* (oak) maximum at 48%. Pinecae *Pinus* (pine), Pinaceae *Tsuga* (hemlock), and Pinaceae *Picea* (spruce) comprise and additional 22% of the profile. Poaceae (grasses), Cyperaceae (sedge) and Asteraceae (thistle) are also present.

Core B-3 originates from the center of the river channel, well to the south of B-1, across from Hoboken. The three sampling intervals include 65-67 feet, 55-57 feet, and 50-52 feet. The lowest interval (65-67 feet) intersected reworked Cretaceous pollen, and although recovery is

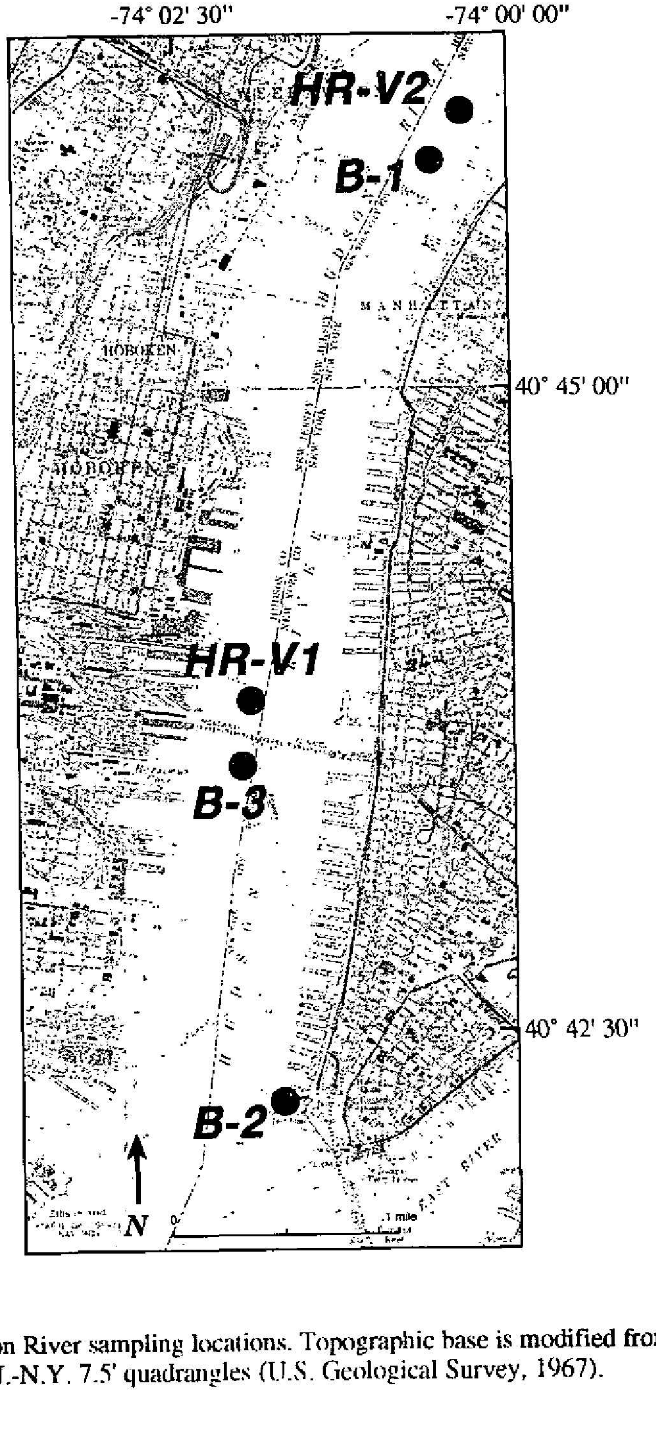

Fig. 2. Map of Hudson River sampling locations. Topographic base is modified from the Weehawken, N.J.-N.Y. and Jersey City, N.J.-N.Y. 7.5' quadrangles (U.S. Geological Survey, 1967).

good, the pollen is thoroughly mixed. Despite the mixing, a Fagaceae *Quercus* (oak) peak at 44.7% is visible, followed by Pinecae *Pinus* (pine) at 27.4%. Poaceae (grasses) also make their presence in the lower section of the core. The 55-57 foot interval shows less mixing and clearly illustrates an Fagaceae *Quercus* (oak) peak at 42.9%, followed by Pinecae *Pinus* (pine), Pinaceae *Tsuga* (hemlock) and Pinaceae *Picea* (spruce) contributing a total of 26% of the additional pollen. Fagaceae *Fagus* (beech), Fagaceae *Castanea* (chestnut), and Betulaceae *Betula* (birch), Aceraceae *Acer* (maple), as well as Poaceae (grasses) and Cyperaceae (sedge) are also present in low percent. The upper section (50-52 feet) contains 42.7% of Fagaceae *Quercus* (oak) and 25.5% of Pinecae *Pinus* (pine) and Pinaceae *Picea* (spruce).

Interpretation - Core B-1 has integrity, possibly due to the positioning of the drill to the right of the Hudson channel. The pollen profiles are illustrative of the Early to Middle Holocene episode, or post-glacial. The strong presence of oak suggest Holocene environmental conditions. Cores B-3 and HR-V1unfortunately were located in the center of the Hudson channel, well to the south of B-1. The lowest levels of the core seem to have intersected intact or reworked Cretaceous pollen, and the intermediate to upper levels illustrate strong pine, spruce, and hemlock peaks, which are suggestive of Late Pleistocene/Earliest Holocene times. The reworking of these sediments, and the presence of coarse sand, suggest a high degree of mixing, and lack of integrity. On the other hand, core B-1 holds great promise as an intact, undisturbed section. Core HR-V2, adjacent to B-1 but not examined in detail, may also be intact.

2. Constable Hook/Port Jersey

Core locations - Cores PJ-V1, CH-V1 and B-4 all appear to have been taken from previously undisturbed flats (Fig. 3).

Sedimentology - Three sections were sampled in this general area. The northernmost section, PJ-V1 from Port Jersey, is composed entirely of reddish-yellowish brown diamict that includes numerous clasts of materials derived from the Mesozoic bedrock (red sandstones, basalts) of New Jersey. The section from Vibracore site CH-V1 is quite similar to the uppermost ~16 feet of boring site B-4; both sections record ~10-12 feet of dark gray, unremarkable silt and silty clay with minor sea shell fragments, underlain by a yellowish-brown to brown fine to medium-grained sand.

Pollen Analyses - Pollen samples were retrieved from three levels of core B-4, 35-37 feet, 40-42 feet, and 45-47 feet. All samples contain reworked Cretaceous pollen, and the upper two samples exhibited good recovery. The stratigraphically lower sample contained reworked Cretaceous pollen and low values for (oak), at approximately 14.6%. Pinaceae *Picea* (spruce) and Pinaceae *Pinus* (pine) total 42% of the pollen, suggesting a Pleistocene-age for the sediment. The stratigraphically higher samples also contain elevated Pinaceae *Picea* (spruce) and Pinaceae *Pinus* (pine), and the upper sample, at 40 feet, contained 67.5% Pinaceae *Picea* (spruce), Pinaceae *Pinus* (pine), and Pinaceae *Tsuga* (hemlock). At this level, 40-42 feet, Fagaceae *Quercus* (oak) is present in only 5.5%, suggesting a Pleistocene-age for the pollen and associated sediments.

Interpretation - The yellowish-brown sediments in these sections, particularly the diamict at Port Jersey, are probably related to Merguerian and Sanders' (1994) late Wisconsin-age Till III. Holocene sedimentation encapsulates the upper 15 feet of Core B-4. The core sandy sediments, and their associated pollen counts, below the 15 foot interval, are Pleistocene in age.

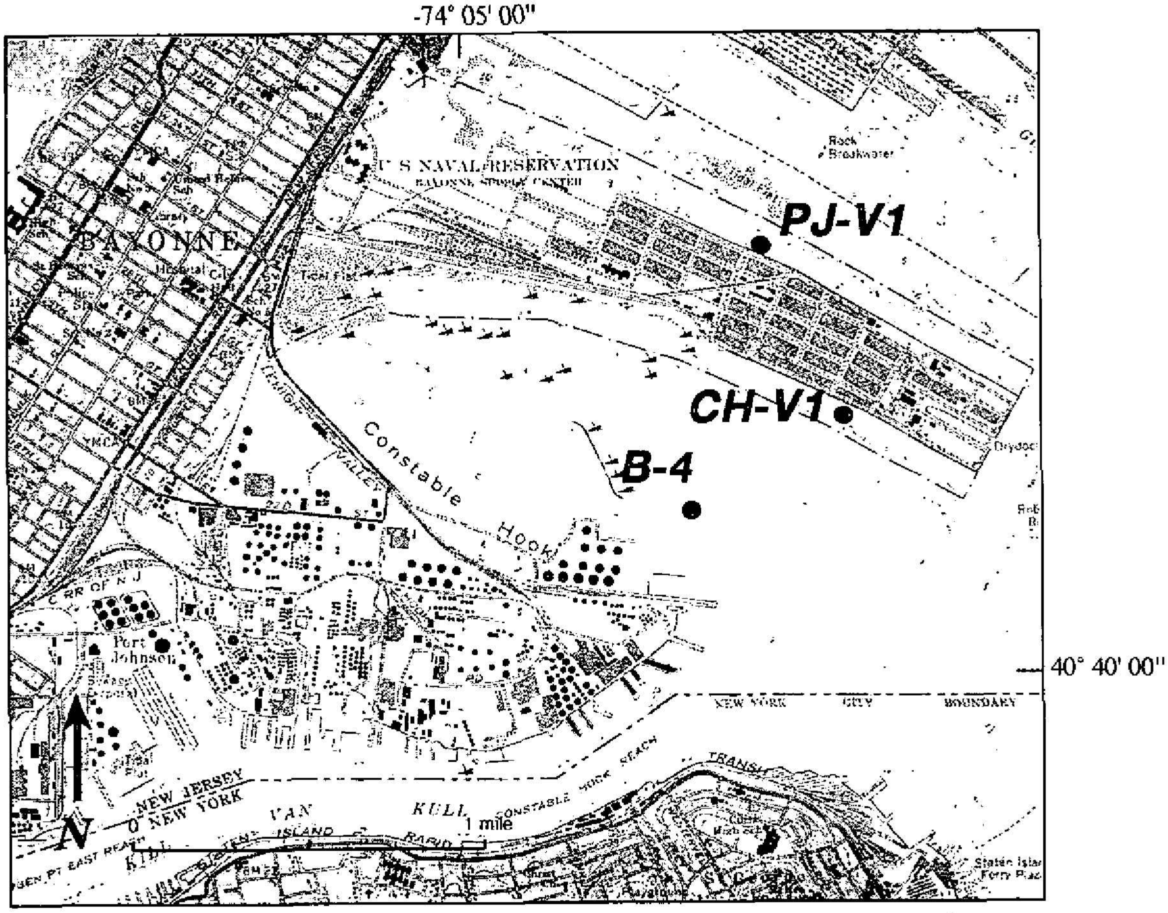

Fig. 3. Map of Constable Hook/Port Jersey sampling locations. Topographic base is modified from the Jersey City, N.J.,-N.Y. 7.5' quadrangle (U.S. Geological Survey, 1967).

3. Newark Bay

Core location - Core B-5 was apparently taken from previously undisturbed shallows in close proximity to shipping channels (Fig. 4).

Sedimentology - One section, B-5, was sampled in this area. The section is composed chiefly of reddish brown to yellowish red, poorly sorted mixtures of fine- to coarse-grained and gravelly sand with lean clays. The uppermost 2 feet consists of dark gray organic silt with a trace of fine sand and sea shell fragments.

Pollen Analyses - Three samples from core B-5 were analyzed from 80-82 feet, 60-62 feet and 40-42 feet. The lowest level (80-82 feet) retrieved pollen of Cretaceous age, most of which was reworked. The intermediate level (60-62 feet) also retrieved reworked, Cretaceous pollen. Present within this level were Pinaceae *Pinus* (pine), Pinaceae *Tsuga* (hemlock), and Pinaceae

Picea (spruce) contributing a total of 40% of total pollen, while Fagaceae *Quercus* (oak) contributed 21.8% of the total. The upper level (40-42 feet) had negligible recovery.

Interpretation - As with Constable Hook/Port Jersey, the reddish-brown sediments lower in this section are probably related to Merguerian and Sanders' (1994) late Wisconsin-age Till III. Possibly the entire sample contains reworked Cretaceous and Pleistocene sediments, with minor amounts of Holocene contribution from the clay component.

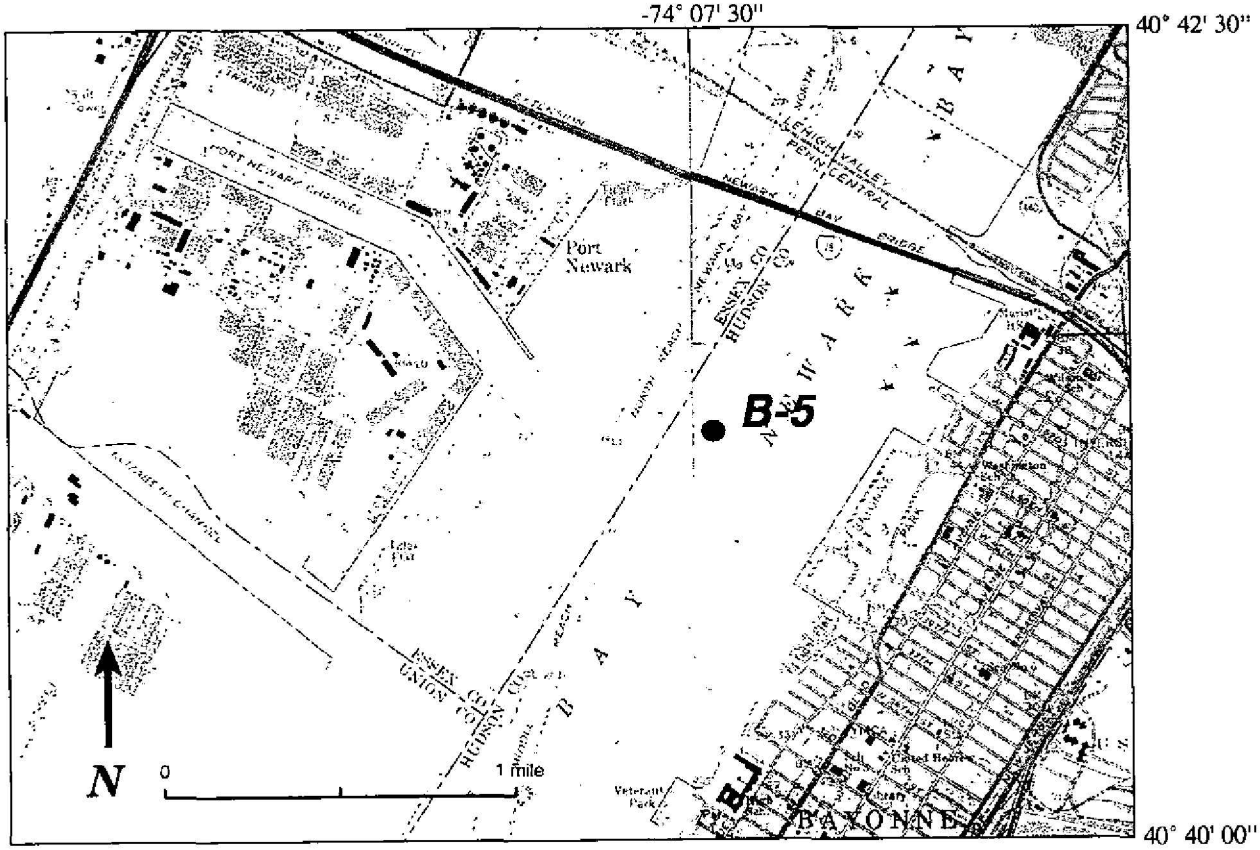

Fig. 4. Map of Newark Bay sampling location. Topographic base is modified from the Elizabeth, N.J.-N.Y. and Jersey City, N.J.,-N.Y. 7.5' quadrangles (U.S. Geological Survey, 1967).

4. Ward's Point

Core locations - Cores WP-V1 and B-13 were both taken from within a previously channelized area; remarkably, previous dredging has apparently affected only the uppermost ~10 feet of the cores (Fig. 5).

Sedimentology - The two sections sampled , WP-V1 and B-13 show some general similarities to a depth of ~28 feet; both consist largely of dark gray organic silt and silty clay yielding downward to peat-rich deposits. However, the immediate vicinity of WP-V1 has clearly been disturbed in historic times. That section is capped by more than 5 feet of foul-smelling, black organic mud and 2 feet of light olive brown clayey sand. Section B-13 lacks such sediments and so has probably remained undisturbed. Below a depth of 28 feet, Section B-13 yields a thick clay overlying red and brownish yellow clayey gravels, more silt and sand, and some pockets of peat.

Pollen Analyses - Core B-13 from Ward's Point was most revealing. Pollen samples were retrieved from 70-72 feet, 40-42 feet, 30-32 feet, 25-27 feet, 20-22 feet, 14-16 feet and 10-12 feet. Samples taken from 70-72 feet and 40-42 feet yielded reworked Cretaceous pollen. The sample retrieved from 30-32 feet showed a marked spike for Pinaceae *Picea* (spruce), Pinaceae *Pinus* (pine), and Pinaceae *Tsuga* (hemlock), with totals for approximately 46%. Fagaceae *Quercus* (oak) is diminished to 19.5% at the 32-foot level. At 25-27 feet, in the vicinity of the organic peat layer, Fagaceae *Quercus* (oak) pollen totals reach 36.3%, while Pinaceae *Pinus* (pine), for Pinaceae *Picea* (spruce), and Pinaceae *Tsuga* (hemlock) are at about 36% of the total pollen. Stratigraphically upward in the section at 20-22 feet, Fagaceae *Quercus* (oak) increases to 38.1%, while Pinaceae *Pinus* (pine) and for Pinaceae *Picea* (spruce) diminish to 17.4%. At this interval, Poaceae (grasses) achieve 14.9% of the total pollen, while Cyperaceae (sedge) accounts for 16.8% of the pollen. The 14-16 foot interval, Fagaceae *Quercus* (oak) comprises 34.4% of the total pollen, while Pinaceae *Pinus* (pine) and for Pinaceae *Picea* (spruce) achieve 11.6%. Poaceae (grasses) achieve a conspicuously high amount at 29.5% at this level. The upper 10-12 foot interval records 38% pollen and 13% Pinaceae *Pinus* (pine) and for Pinaceae *Picea* (spruce). Poaceae (grasses), Cyperaceae (sedge), Cheno-Am (pigweed), and Asteraceae (thistle) comprise 22% of the total pollen inventory at this interval. Core B-13, Y1292 taken at 22 feet illustrates results comparable to those achieved at the 22 foot interval of B-13. The sample retrieved from WP-V1 at the 16.2 foot interval shows a subtle spike for Typhaceae (cat tail) at 1.8%.

Foraminiferal Analyses - The arenaceous foraminifera found in Ward's Point Section B-13, in laminated silty clay at a depth of 70-72 feet, are typically found in estuarine or coastal marsh environments at shallow water depths (< 5 meters) (Weiss, 1974). No radiocarbon date is associated with this sample, making it difficult to determine whether these foraminifera pre-date or post-date the Last Glacial Maximum.

Radiocarbon Dating - A peat sample from Section WP-V1, at a depth of 27.5 feet, yielded a conventional ^{14}C date of 7950 +/- 70 B.P. Such a date is compatible with other radiocarbon-dated peats found in the region (e.g., Field et al., 1979). We note that a radiocarbon date of 9840+/- 300 ^{14}C B.P. was obtained for organic matter in an unnamed foraminiferal clay on Sandy Hook at a depth of 85-92 feet below sea level (Minard, 1969). The comparison of this date and depth with that obtained from WP-V1 suggests either that sedimentation rates were quite high (on the order of 34 feet/k.y.) and/or that isostatic adjustment of the landscape was still in progress (Stanford and Harper, 1991). In that context, the peaty deposits near the bottom of B-13 could also be post-glacial. Such high sedimentation rates are not unusual during the paraglacial period (i.e., rapid environmental readjustment following glacial retreat) as unconsolidated glacigenic sediments (e.g., lateral moraines, kame terraces) and oversteepened rock slopes can provide ample sediments to fluvial systems, even thousands of years after glaciation (Church and Ryder, 1972; Ballantyne and Benn, 1996).

Interpretation - The pollen core retrieved from Ward's Point, B-13, is the most complete and informative core in the entire study. The sampling interval from 70-72 feet and 40-42 feet intersects reworked Cretaceous and Pleistocene pollen types. The approximate age for the two samples is Late Pleistocene. Sample 32 is associated with the sedimentological shift from gray clays to red and brown clay gravels, and the pronounced pine, spruce, and hemlock peaks are associated with the Terminal Pleistocene and period of accelerated glacial outwash. The interval between 27-30 feet would represent the earliest Holocene sediments in the core. The sample interval at 25-27 feet is in association with an organic peat layer, and a crisp oak peak at 36.3%. The pronounced pine, spruce, hemlock peak at this interval is testimony to the early Holocene post-glacial floral mosaic, which contains increased oak in association with relict stands of pines. The remaining three samples, beautifully illustrate the decrease in pine, spruce and hemlock, in accordance with the development of the deciduous, broad-leafed forests, earmarked by the presence of oak. The presence of grass, sedge, and cat-tail are all testimony to the newly developed marsh regime achieved at Ward's Point in the Middle-Late Holocene.

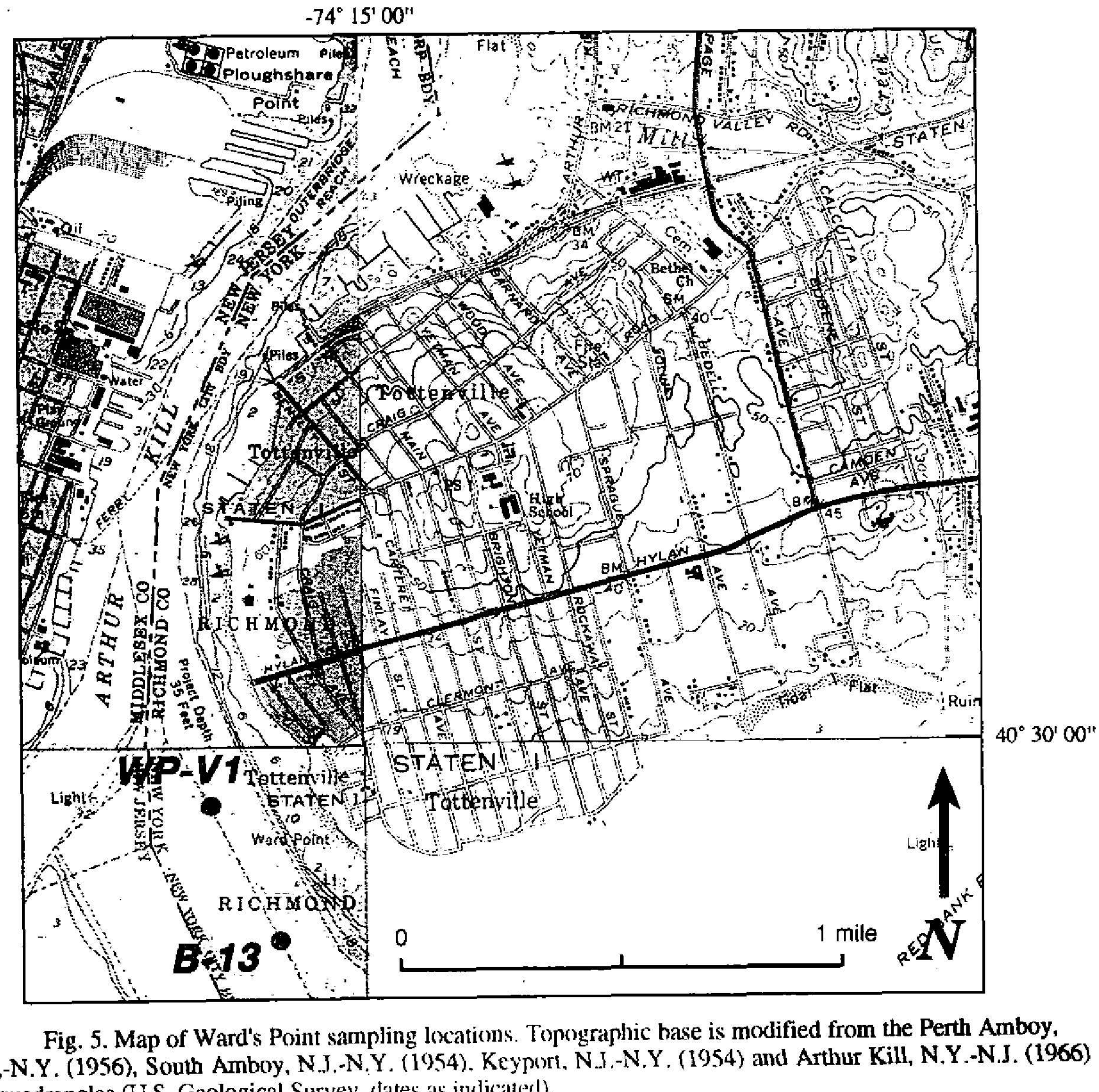

Fig. 5. Map of Ward's Point sampling locations. Topographic base is modified from the Perth Amboy, N.J.,-N.Y. (1956), South Amboy, N.J.-N.Y. (1954), Keyport, N.J.-N.Y. (1954) and Arthur Kill, N.Y.-N.J. (1966) 7.5' quadrangles (U.S. Geological Survey, dates as indicated).

5. Bowery Bay

Core location - Cores B-6 was taken from apparently undisturbed shallows (Fig. 6).

Sedimentology - The boring revealed dark gray organic silt with some sand to a depth of ~19 feet, underlain by gray and brown poorly sorted sand and diamict before reaching deep silts and saprolites and diorite bedrock at a depth of 87 feet.

Pollen Analyses - Core B-6 had samples taken at the 20-22 foot, 30-33 foot, 35-37 foot, 55-foot, and 60-foot levels. The sample retrieved from Y1239 indicates the presence of Holocene pollen, but unfortunately the count is so low as to render the sample meaningless. Likewise, the samples retrieved from the 30-33 foot and 60-foot levels, showed poor results and low pollen counts. However, the samples taken from the 35-37 foot and 55-foot levels illustrate Fagaceae *Quercus* (oak) pollen from 27-29%, and the lower level (60-foot) contains 20% Pinaceae *Pinus* (pine) and Pinaceae *Picea* (spruce). Although the recovery was good for the lower level, the pollen count suggests a Pleistocene-age for the sediments at these levels.

Interpretation - All pollen samples were taken from below the 19-foot interval, and unfortunately reflect Pleistocene vegetation at depths as shallow as 30-32 feet. More likely, Holocene sedimentation begins at approximately the 19-foot interval, and all coarse sediments below this level are Pleistocene in age and contain little information for paleoenvironmental reconstruction.

6. Red Hook/Bay Ridge

Core locations - Cores RH/BR-V1 and RH/BR-V2 were taken from areas on the edge of and adjacent to Bay Ridge Channel (Fig. 7).

Sedimentology - Two sections were sampled by Vibracore in this area. RH/BR-V1, located close to the edge of the Harbor Hill Moraine in Brooklyn, clearly reflects a reworking of glacial outwash sediments in the upper portion of this core. The lowermost ~7 feet of the section is a reddish brown and brown silty clay that may be related to Merguerian and Sanders' (1994) Till III. In contrast, RH/BR-V2 is composed chiefly of fairly monotonous dark gray silty clay with scattered sea shell fragments. In both sections, however, the uppermost part of the core is represented by a black, foul-smelling organic mud deposited in historic times.

Pollen Analyses - No pollen cores retrieved.

Interpretation - Core RH/BR-V1 is likely to be almost entirely Pleistocene in age. The silty clays RH/BR-V2 may represent Late Pleistocene glacial lake deposits, or else be Holocene in age. The presence of a thick layer of historic mud however, suggest the possibility that disturbance of the uppermost sediments may be common in this area.

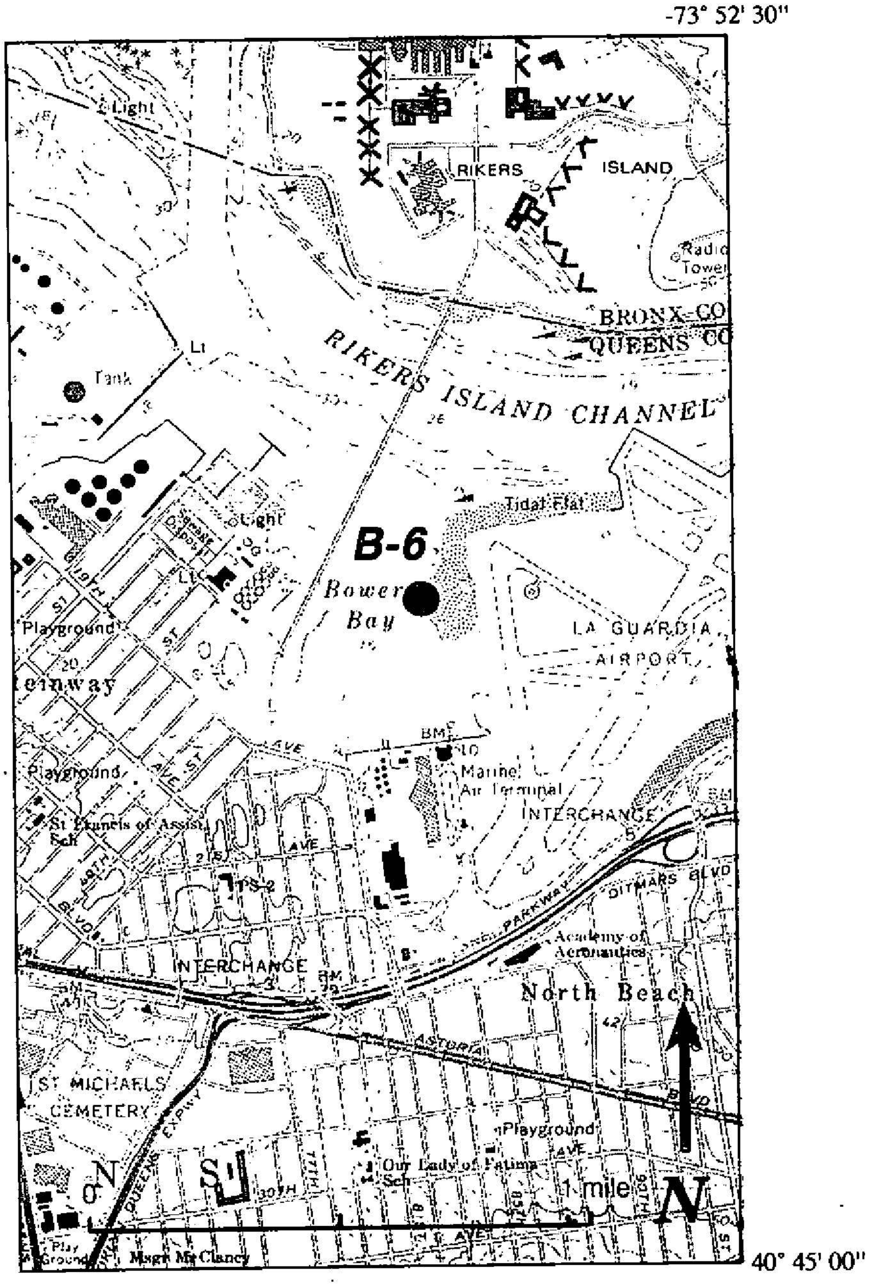

Fig. 6. Map of Bowery Bay sampling location. Topographic base is modified from the Central Park, N.Y.-N.J. 7.5' quadrangle (U.S. Geological Survey, 1966).

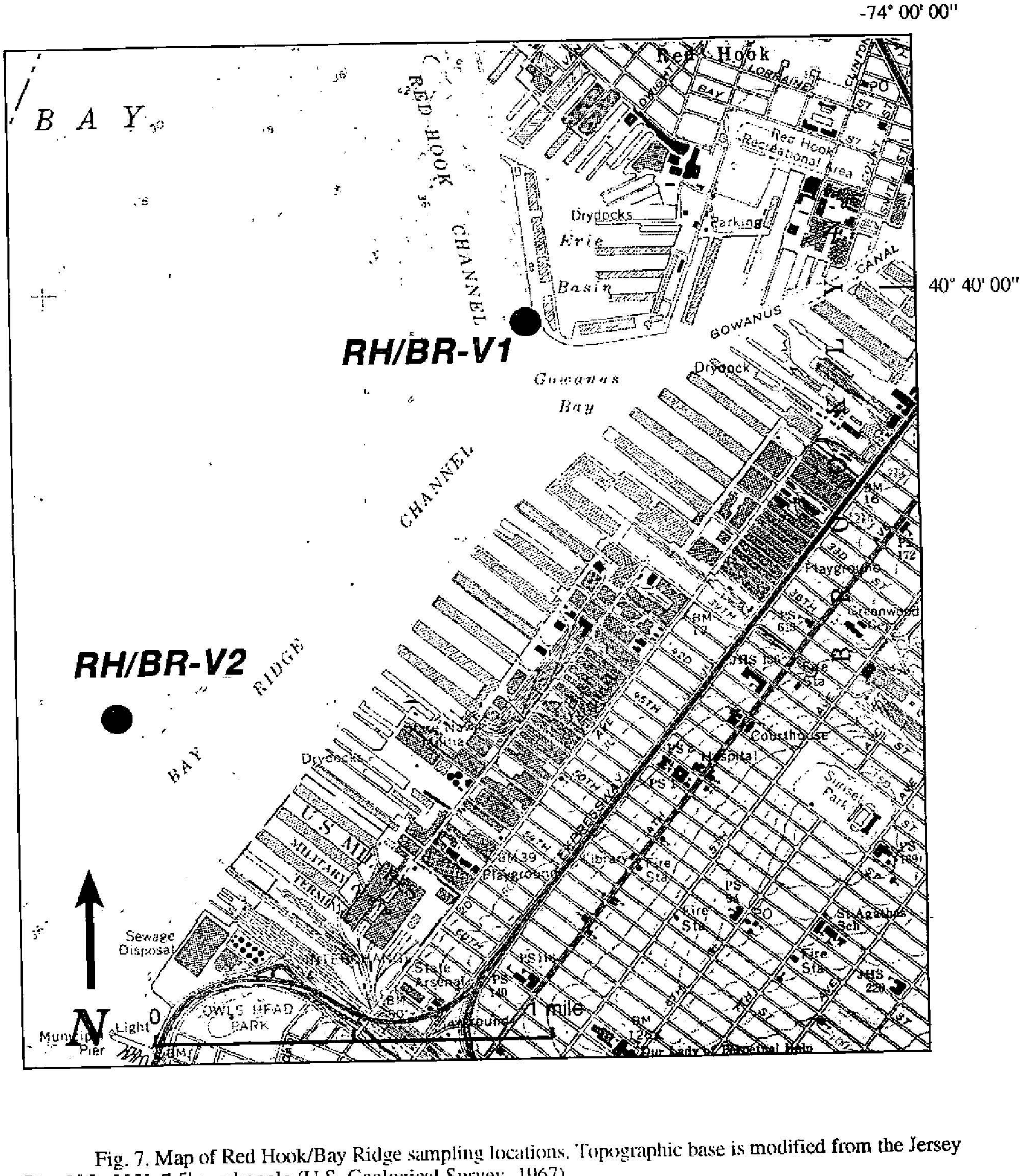

Fig. 7. Map of Red Hook/Bay Ridge sampling locations. Topographic base is modified from the Jersey City, N.J.,-N.Y. 7.5' quadrangle (U.S. Geological Survey, 1967).

7. Zone 1

Core locations - All cores were apparently sampled from areas not subject to prior dredging (Fig. 8).

Sedimentology - All three Vibracores from Zone 1 are remarkably consistent in that they are composed of dark gray, homogeneous silty clay or clay with rare shell fragments, topped by a thin layer (<3 feet) of black, organic, foul-smelling mud. Boring B-110 follows a similar pattern, but the remaining borings are somewhat sandier and siltier. Below a depth of 30 feet, the borings generally consist of sands, silts and clays, but the succession of sediments is somewhat different within each section.

Pollen Analyses - Only cores B-8, B-106 and B-110 exhibited appreciable pollen recoveries that could provide some insight into the stratigraphy and paleoenvironment in Zone 1, Raritan Bay. Core B-8 exhibited only Cretaceous and possibly reworked Tertiary pollen grains from 70-72 feet up to 25-27 feet. Core B-106 was disappointing in a similar fashion. Samples were taken at the 63-65 foot level, at 48-50 feet, 33-35 feet, and 23-25 feet. With the exception of a slight indication of Pleistocene pollen in the uppermost level, this core produced only Cretaceous and reworked Tertiary pollen. The presence of Pinaceae *Pinus* (pine), Pinaceae *Tsuga* (hemlock), and Pinaceae *Picea* (spruce) at approximately 59% of the total pollen in the uppermost level of B-106 clearly illustrates that the upper levels are Pleistocene in age. Core B-110 had retrieval from 47-49 feet and 17-19 feet. The lower level retrieval showed negligible pollen counts, and therefore was not useful. The upper level however had good recovery, and although the sample contained reworked Cretaceous pollen, B-110 seems to clearly indicate intact Holocene sediments at shallow depths. The presence of Fagaceae *Quercus* (oak) at 54.7% and declining Pinaceae *Pinus* (pine), Pinaceae *Picea* (spruce), and Pinaceae *Tsuga* (hemlock) at 16.1% is suggestive of Early to Middle Holocene climatic conditions.

Foraminiferal Analyses - Elphidium excavatum was present in four of the cores sampled from Zone 1, at depths ranging from 17-19 feet (Section B-110) to ~27 feet (Sections Z1-V1, V2 and V3). This particular species of benthic foraminifera is widespread on the modern New Jersey and Long Island shelves (Gevirtz et al., 1971; Poag et al., 1980). Although typically associated with sandy muds of the inner shelf, *Elphidium excavatum* is also common in Quaternary-age relict assemblages across the width of the shelf, as short-lived pauses in post-glacial transgression permitted the development of inner shelf environments (Lagoe et al., 1997). The presence of this species is indicative of low-energy conditions and the accumulation of predominantly muddy sediments. In the absence of radiocarbon dates for these samples, it is not possible to discern whether these foraminifera pre-date or post-date the Last Glacial Maximum.

Other foraminiferal species present in Zone 1 samples are *Epistominella exigua* and *Globobulimina auriculata*. These species are typically associated with deep-water settings and/or older Tertiary sediments (e.g., Thomas and Gooday, 1996). Their low numbers suggest that they have been transported to the inner shelf, probably during post-glacial sea-level rise.

Interpretation - Core B-110 exemplifies the presence of intact Holocene to Pleistocene sediments at extremely shallow depths, possibly to as much as 30 feet. The siltier/sandier units below 30 feet may be interpreted as Late Pleistocene outwash; however, all other core samples taken below 30 feet indicate reworked Cretaceous and Tertiary pollen, suggesting the presence of an unconformity, or severe channel scour and headland erosion possibly coincident with the Last

Glacial Maximum (prior to possible human occupation). The presence of intact Holocene sediments at shallow depths, as indicated in core B-110, sheds supportive light on current models of headland erosion of archaeological sites during periods of slow-rising sea level (Belknap and Kraft, 1977, 1981). Those culturally sensitive areas contiguous with barrier islands and marine transgressive lagoon sequences may contain intact and sealed cultural deposits.

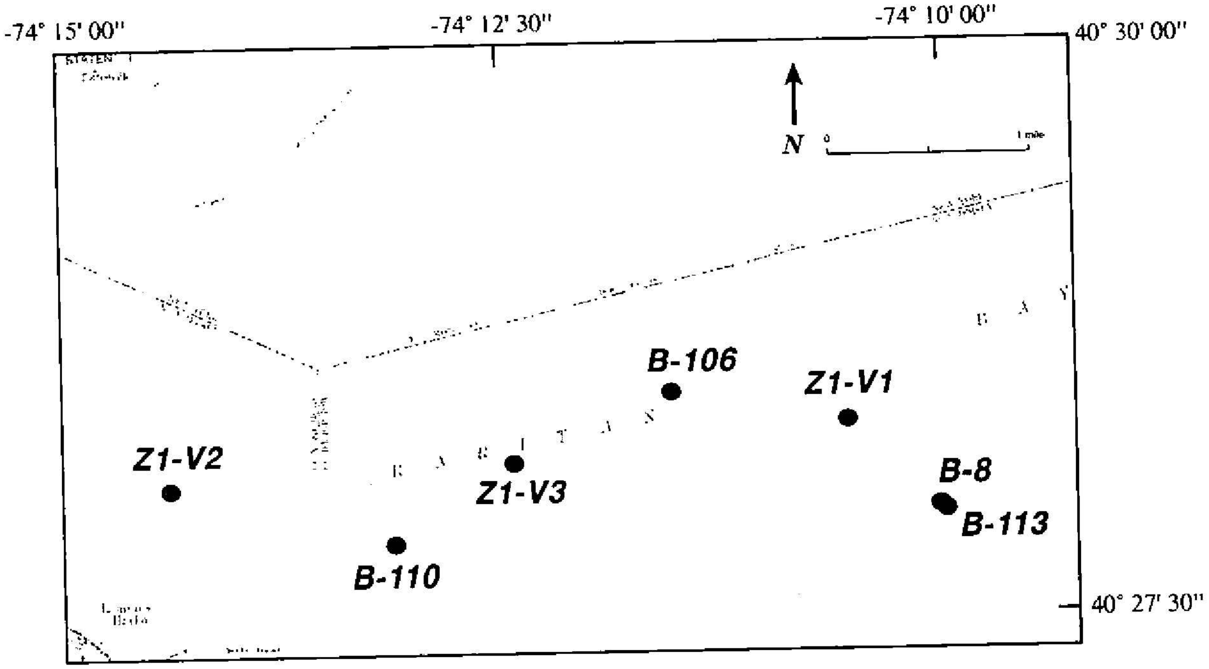

Fig. 8. Map of Zone 1 sampling locations. Topographic base is modified from the Keyport, N.J.,-N.Y. 7.5' quadrangle (U.S. Geological Survey; 1967).

8. Zone 2

Core locations - All cores were apparently sampled from areas not subject to prior dredging (Fig. 9).

Sedimentology - Overall, the sediments in Zone 2 are considerably coarser than those of Zone 1. The shades of brown coloring of much of the sediments suggests that they are reworked glacial outwash associated with Till IV; gray silts and fine-grained sands that are likely post-glacial in age are relatively thin (<3 feet).

Pollen Analyses - Core B-111 yielded predominantly reworked Cretaceous pollen, as did Core B-112. Core BV-251 showed fairly poor recovery, except in the shallowest depths of 42-44 feet. Pollen retrieved from the 42-44 foot interval yielded 33% Pinaceae *Picea* (spruce), Pinaceae *Pinus* (pine), and Pinaceae *Tsuga* (hemlock), and lower values of 26.3 % for Fagaceae *Quercus* (oak), suggesting a Pleistocene age for this level. Core BV-252 yielded an extremely low pollen count that could not be analyzed.

Interpretation - In the vicinity of Core BV-251, the coarse-grained sediments possess low potential for pollen preservation. The brown color and coarse nature of the sands, and disproportionately small values for silt and clay layers suggest the presence of a thick wedge of glacial outwash occurring throughout the section. There appears to be very little preservation of intact Holocene sediments within these cores.

9. Zone 3

Core locations - All cores were apparently sampled from areas not subject to prior dredging, although the sampling sites do seem to be in close proximity to previous disposal sites (Gross, 1976; see Fig. 10).

Sedimentology - The three Vibracores from this location are uniformly composed of silts and fine-grained sands, although a change to brown coloring from gray in Z3-V1 and Z3-V2 suggests the presence of glacial outwash sediments in these sections.

Pollen Analyses - No pollen cores retrieved.

Interpretation - The brown sands and silts in this area may be related to Merguerian and Sanders (1994) Late Wisconsin Till IV. The overlying gray sediments could be either latest Pleistocene or Early Holocene; without additional age data, it is not possible to classify these sediments further.

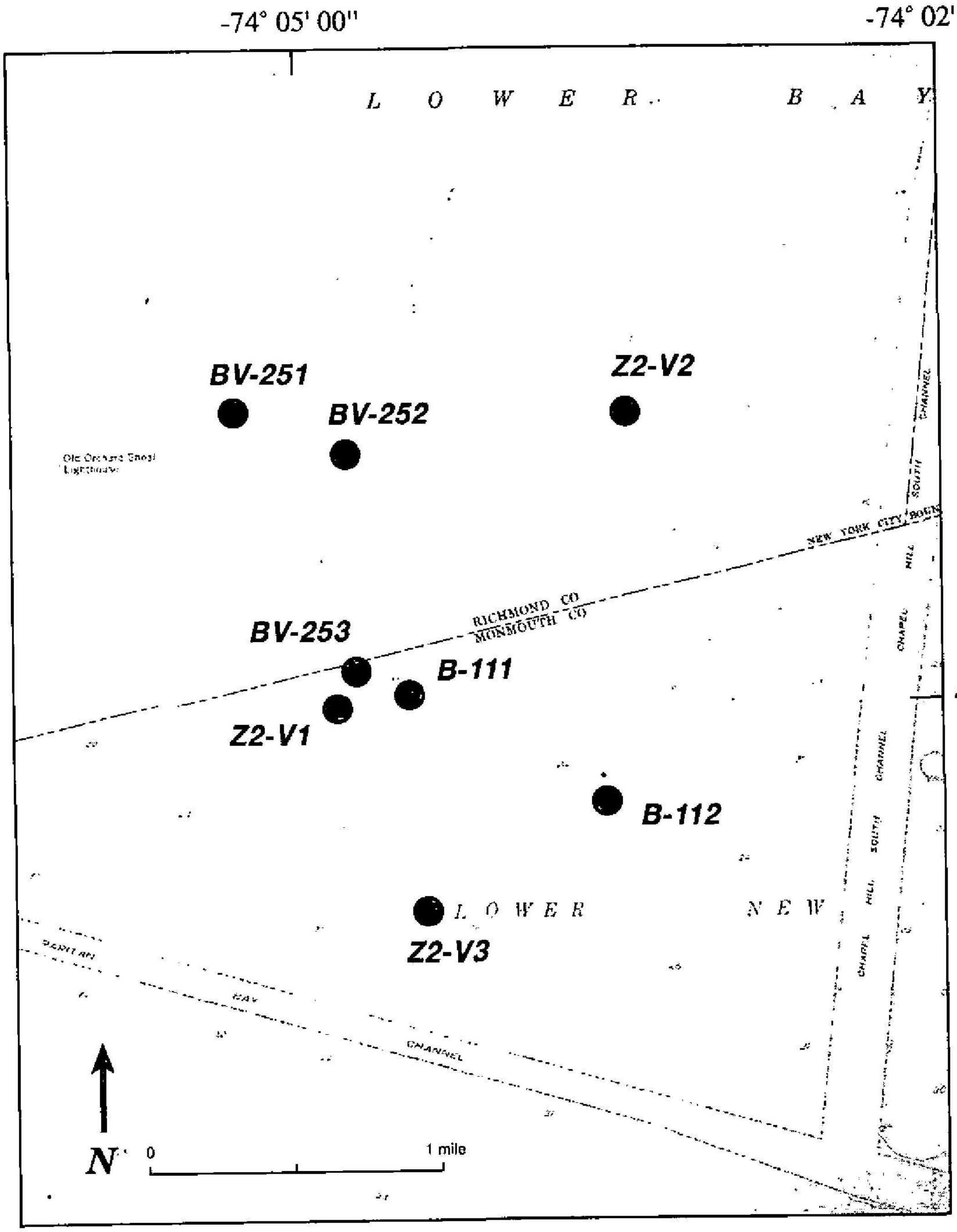

Fig. 9. Map of Zone 2 sampling locations. Topographic base is modified from the Sandy Hook, N.J.,-N.Y. (1954) and The Narrows, N.Y.-N.J. (1966) 7.5' quadrangles (U.S. Geological Survey, dates as indicated).

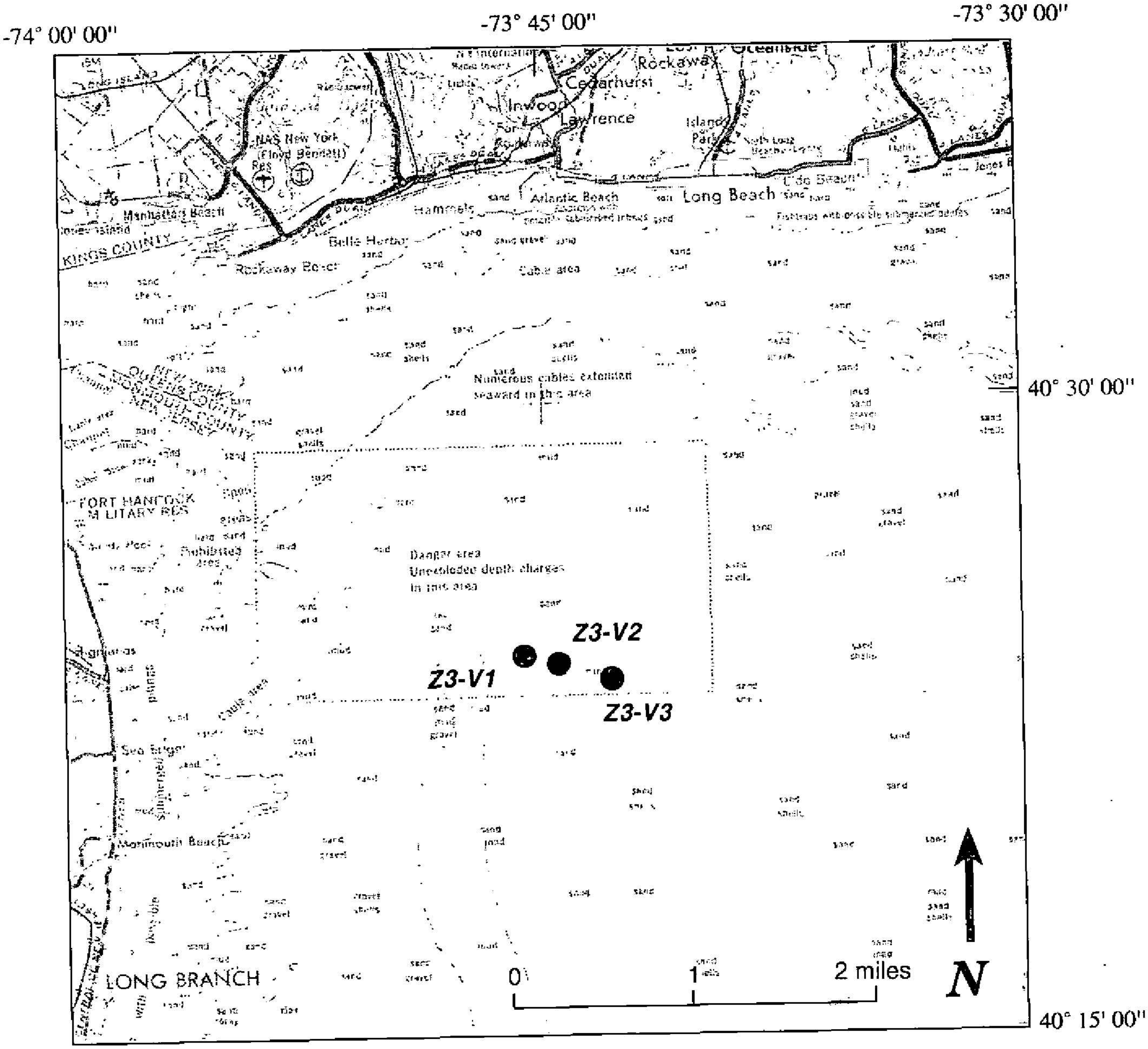

Fig. 10. Map of Zone 3 sampling locations. Topographic base is modified from the New York 1:250,000 Map Sheet (NK 18-12) (U.S. Geological Survey, 1960).

RECOMMENDATIONS FOR CULTURAL RESOURCE MANAGEMENT

General Observations

The suggestion has been made that classification of the coastline into zones on hydrodynamic grounds (e.g., as wave-dominated zones or tide-dominated zones) would be useful in predicting the preservation potential of submerged prehistoric site locations (Belknap and Kraft, 1977, 1981; Kellogg, 1995). The concept is appealing, and has been adopted by other researchers as a guide for determining preservation potential of sites in the New York Bight region (e.g., Rockman and Rothschild, 1979; Pickman, 1988). Implicit in many of these preservation assessment studies is the idea that prehistoric people would have chosen to live as close as possible to the paleoshoreline; thus areas closer to the present-day coast are expected to preserve only the youngest prehistoric cultures (i.e., Transitional and Woodland cultures), and the remains of older cultures (i.e., Paleoindian through Late Archaic) further out on the continental shelf are expected to have been destroyed by post-glacial sea level rise.

It is important to recognize, however, that the location of the paleoshoreline at any given time only provides a maximum limit to possible settlement areas on the continental shelf. Prehistoric people very likely lived and subsisted over a continuum of microenvironments, from the paleoshoreline well back into the continental interior (see, e.g., Gagliano et al., 1982). For example, the Paleoindian habitation sites at Dutchess Quarry caves in Orange County (e.g., Funk, 1972) would have been well inland of the paleoshoreline prior to 8,000 B.P.; even the sites at Port Mobil on Staten Island (Funk and Hayes, 1977), and Turkey Swamp in New Jersey near Sandy Hook (Cavallo, 1981), would not have been "coastal" habitation sites.

Additional evidence for the existence of a dynamic equilibrium within geomorphic systems is the site distribution of Early Archaic habitations occurring throughout the greater Staten Island area (e.g., Moir and Roberts, 1979). The density of prehistoric remains of this time period suggests prolonged occupation in an environment which, although changing, was still able to maintain subsistence at a distance from paleoshorelines (Funk and Ritchie, 1977; Jacobson and Grumet, 1995). Late Paleoindian and Early Archaic manifestations may actually have been focused on estuary and lagoonal resources such as those likely present at Ward's Point (i.e., related to the ~7950 B.P. peat layer at 27.5 feet in Vibracore WP-V1). The notion of a continuum of subsistence activities stretching from the ocean back into the hinterlands is further supported by the recent discovery of several well defined raw material sources in the vicinity of Staten Island, Ward's Point and the greater Newark Bay (La Porta, unpublished data). These lithic sources include a partially exhumed Miocene cobble embankment, which is rich in diverse raw materials and occurs as a sinuous band along the coastal plain; a variety of jasperoids, or iron-rich cherts, that crop out on the southeastern flanks of Staten Island; and and outcrops of fine-grained basalts, dolerites, and hornfelsic rocks in the vicinity of Newark Bay and Staten Island. The discovery of the well-defined peat layer at Ward's Point mentioned above, in conjunction with the known site distribution and in the light of previous unidentified mineral resources deposits strongly suggests that the late Paleoindian/Early Archaic estuary/lagoonal setting was a rich and diversified habitat that could support the full spectrum of prehistoic lifeways.

The realization that a continuum of habitation sites would have been possible because the food and materials needed for subsistence were available all across the landscape also suggests that areas now on the coast or just offshore may preserve cultural remains significantly older than have previously been considered; they may simply lie at a somewhat greater depth than some researchers have thought possible. (Prediction of site preservation is made more complicated by the fact that the New York Bight region was weighed down by the load of the Laurentide ice sheet; since the ice melted back faster than the land could rebound, some depressed areas of the Bight have accumulated sediment much faster than normal. Recall the Paleoindian radiocarbon date (Minard, 1969) reported from a peat bed now more than 85 feet below the surface of Sandy Hook!) The principal research question arising from this study, then, is: Given the more complex settlement patterns likely for prehistoric peoples, how can we more accurately predict where buried or submerged sites may be?

The solution to this question requires an integrated approach involving characterization of the local geomorphology; understanding of geological and geomorphological processes operative in the area; acquisition of subsurface data (e.g., high-resolution seismic, sediment cores); and knowledge of prehistoric lifeways. Two studies conducted for other areas of the U.S. continental shelf offer some ideas on how to proceed toward this solution. Gagliano et al. (1982), in their cultural resource assessment for the Gulf Coast continental shelf, took a holistic approach to the problem and considered all potentially habitable areas, from the hinterland to the coast, for *each separate time interval* under consideration. Their approach ensures that no simple, potentially misleading assumptions are made about the possible distribution of sites. They also strongly supported the use of geophysical data to characterize the subsurface along the coast and offshore. Moir and Roberts (1979) adopted a slightly different approach by focusing upon an isolated paleodrainage, for example the Great Egg Harbor of New Jersey, and using the available geophysical data to define the individual geomorphic elements all along that drainage. Here, too, they consider the evolution of these geomorphic patterns with time, so as to produce the best possible prediction of potential site preservation for each cultural interval under consideration.

Future archaeological assessments of the New York Bight-Apex region would benefit greatly from integrated approaches such as those employed by Gagliano et al. (1982) and Moir and Roberts (1979). High-resolution seismic data combined with sediment cores will be crucial for better characterizing the various geomorphological elements of this region (e.g., drainage systems, paleoshorelines of lakes and the ocean) and their evolution through time, starting with the earliest post-glacial landscape. Additional pollen analyses and radiocarbon dating or amino acid racemization of shell and/or organic material, wherever possible, will greatly enhance our ability to develop an accurate portrait of the region.

Specific Recommendations for this Study

In light of the New York Bight's geologic and archaeological history, and our preliminary findings from the study, we feel that the potential for submerged archaeological sites is actually greater than previously recognized (e.g., Boesch, 1994; cf. Pickman, 1988, 1994). Based upon the results of the current investigation, we have classified each of sampling locations according to the probability that potential DMMP activities would impact culturally sensitive areas:

- Sites are classified as having **low** probability of impact if either a) most or all of the sediments examined are older than latest Pleistocene (~15,000 B.P.); or b) previous dredging activity has already removed any sediments that would have been in the appropriate age range of potential human activity in this region. Further study of these sites is not recommended.

- Sites are classified as having **moderate** probability of impact if a) more than 5 feet of sediment could be latest Pleistocene (~15,000 B.P.) or younger in age; and b) the location is adjacent to probable submerged riverbanks or shorelines. Further study of these sites is recommended. Additional Vibracore sampling, and possibly some additional high-resolution shallow seismic data, should be sufficient for determining whether the site can be reclassified as having a low or high probability of impact.

- Sites are classified as having **high** probability of impact if either a) more than 5 feet of sediment is clearly Holocene in age (≤10,000 B.P.); and b) the location is adjacent to probable submerged riverbanks or shorelines. Further study of these sites is highly recommended. Additional Vibracore sampling, with radiocarbon dating of appropriate recovered materials (i.e., shell or wood fragments) should be combined with a tightly spaced grid (50-100 m line spacing) of high-resolution shallow seismic data in order to develop as accurate a picture as possible of the subsurface (e.g., depths of previous strandlines, etc.).

It is important to note that, unless a Vibracore sample actually intersects identifiable prehistoric cultural remains, the combination of additional Vibracoring and high-resolution seismic data acquisition is not likely to *clearly* identify submerged prehistoric sites. These methods will simply clarify whether disturbance of a prehistoric site is probable. Onshore sites may benefit from the use of ground penetrating radar (GPR) rather than shallow seismic acquisition, depending on the particular characterisitics of a site, but the goal of identifying buried horizons and/or other features (e.g., shell middens) is the same.

If all potential DMMP project activities are limited to existing channels, further study is not necessary. Our analysis of the sediments sampled for this study suggest that previous dredging activities may have removed much, if not all, of the sediment less than ~15,000 years old, which is the possible age range of human presence in this region; thus any prehistoric cultural remains that might have existed in the channel areas have probably been compromised (see also Wagner and Siegel, 1997). Should DMMP activities be extended from existing channels to adjacent areas, we recommend further testing as per sites with a moderate probability of impact described above.

If avoidance of a site designated as having a high probability of impact is not possible, further study along the lines of the recommendations listed above should be the first step taken. Should the additional analyses continue to suggest that the area is highly sensitive, or especially if cultural remains are encountered in the course of the additional Vibracoring work, a salvage effort to recover any possible remains is *strongly* recommended, as any such recovery from the northern U.S. Atlantic coast would be unprecedented. Such a site would definitely qualify for historic preservation.

The type of extensive excavation sometimes conducted for salvage of ships from shallow marine settings, involving the building of a retaining wall to hold back sea water from the site to be excavated (e.g., Arnold, 1996), is clearly not an appropriate approach for the recovery of submerged prehistoric sites of unknown extent. However, controlled dredging and screening of the sediments dredged would be an acceptable compromise, because it would allow for the recovery of cultural remains at a lower cost to the Army Corps of Engineers. Ideally, the region to be dredged would be first divided into a series of smaller areas to provide some degree of spatial control for the cultural materials. The removal of sediment could then proceed at limited depth intervals in order to help tie any finds with other stratigraphic information derived from Vibracores and seismic data, and possibly to provide some age control. Screening of the sediment should involve individual loads of not more than 1 or 2 tons, else the screening work will become too difficult to manage.

Our recommendations for future management of the specific sites examined for the DMMP project are as follows:

1. Hudson River

Low probability of impact: The sediments recovered suggest that areas within the central and deepest parts of the river channel were likely underwater even before significant post-glacial sea-level rise, so we would not expect them to contain cultural deposits. However a **moderate to high** probability of impact should be expected for areas along the outer portions of the river channel (not yet cored or bored), as these areas would have been exposed several thousand years ago and would have been favored locations for prehistoric subsistence activities (see Historic Conservation and Interpretation, 1983).

2. Constable Hook/Port Jersey

Low probability of impact: Sediments recovered from both Vibracore and boring appear to be largely glacial in origin, and therefore likely pre-date any prehistoric occupation of this region. It is also quite probable that modern construction has disturbed any prehistoric sites that might have been preserved in this area (e.g., Kardas and Larrabee, 1978). It is doubtful that construction of a disposal area would disturb any culturally significant sites.

3. Newark Bay

Moderate probability of impact: The combination of thin Holocene sedimentation and historic shipping activity in this area suggest that there may not be much cultural material of significance left in the channelized areas around the site of boring B-6. However, in light of the prior reports of significant cultural remains on the flatlands in the general vicinity of Newark Bay (e.g., Skinner and Schrabisch, 1913), we recommend additional studies if the areas to be dredged infringe upon the submerged tidals flats away from existing channels.

4. Ward's Point

High probability of impact: The presence of peat and related coastal sediments in this area suggests that this area would have been a likely location for prehistoric subsistence activity, and the generally undisturbed nature of the sediments is encouraging in terms of probable preservation of prehistoric sites. Given the Holocene age of the peat material at 27.5 feet, and in light of the numerous cultural artifacts previously found in the vicinity (Ritchie and Funk, 1971; Jacobson and Grumet, 1995), we suggest that Ward's Point be avoided as a disposal area.

5. Bowery Bay

Moderate probability of impact: The potential cultural context for this area is a bit more difficult to assess than the other areas, given only one core in the immediate area of interest and no other cores from nearby locations. We suggest a moderate probability of impact for this area as a compromise assessment, based upon its proximity to historical construction (i.e., La Guardia

Airport) and its location in a tidal flat area. Further study at this site would greatly clarify its prehistoric cultural resource potential.

6. Red Hook/Bay Ridge

Moderate to low probability of impact: At each of these three locations, the sediments preserved at depth have appeared to retain integrity, and could have preserved older prehistoric sites. However, the proximity of these locations to modern shipping activities, etc. suggests that some significant disturbance of the uppermost sediments may have already occurred. Pollen and foraminiferal analyses may help to determine the ages of the deeper sediments and the likelihood of prehistoric site preservation.

7. Zone 1

Moderate to high probability of impact: This part of the continental shelf could have been subject to rapid flooding and sedimentation during Holocene sea-level rise, which would have preserved prehistoric sites very nicely (e.g., Pickman, 1988). Core analysis suggests that a **high** probability of impact exists along a relatively narrow swath encompassing Vibracore sites Z1-V1, Z1-V2 and Z1-V3 and boring site B-110, and possibly B-106, as the uppermost ~30 feet of sediment at these locations appears to be latest Pleistocene to Holocene in age. A **moderate** probability of impact is assigned to the area encompassing boring sites B-8 and B-113, which are overall sandier and may have experienced greater erosion during the post-glacial sea-level rise.

8 and 9. Zones 2 and 3

Moderate probability of impact: Sediments recovered from these areas are suggestive of a paleoshoreline environment, consisting of reworked glacial outwash. While such an environment would normally have a high probability of impact, the location of Zone 3, and to a lesser extent Zone 2, on the continental shelf would have made them prone to extensive erosion during the late stages of Holocene sea-level rise. It is therefore quite possible that some prehistoric sites have been eroded away, although some of the oldest sites may have escaped destruction. Both Zone 2 and Zone 3 have potential as disposal areas, but some additional research would be helpful in clarifying the likelihood of prehistoric site preservation.

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APPENDIX 1

Final Scope of Work

STATEMENT OF WORK

Field Support for Assessment of Dredged Material Management Alternatives

February 25, 1998

1. **GENERAL.** The contractor shall perform sampling and interpretation in connection with the New York District's (NYD) assessment of various sediment management alternatives being considered as part of the New York-New Jersey Harbor Dredged Material Management Plan. The Interim Report for this plan was issued by the Corps in September 1996 which identified 53 alternative methods and locations throughout the NewYork Harbor-Apex region meeting specific technical siting criteria for dredged material disposal.

   Substantially more site-specific information is needed to support the next phase of DMMP options analysis. This scope of work responds to the need for cultural resource. Cultural resources were not considered an exclusionary criteria for the first iteration of DMMP options screening. An assessment must be made of the potential for prehistoric resources to be within the candidate sites. Existing seismic data and ongoing interpretations represent an important source of needed information that should be considered prior to commencing new field studies.

2. **PURPOSE.** The purpose of this work is to gather physical information on sediment characteristics to assist in the evaluation of several sites as candidates for dredged material containment facilities (i.e., subchannel pits, dredged material islands, etc.). The sites of interest are:

NEARSHORE CANDIDATE SITES:	Bowery Bay (Figure 1)
	Constable Hook (Figure 2)
	Bay Ridge Complex (Figure 3)
	Newark Bay Channel (Figure 4)
	Wards Point Bend (Figure 5)
	Hudson River (Figure 6)
LOWER BAY & OFFSHORE CANDIDATE SITES:	Zones of Siting Feasibility 1,2, and 3 (Fig 7)

   Boring and sampling at these sites will be conducted by a team of contractors responding to this scope of work for the Planning Division (CENAN-PL-ES) or by the contractor from the Engineering Division (CENAN-EN). The CENAN-EN contractor will provide boring platforms at Bay Ridge / Red Hook Flats, Newark Bay and Constable Hook. At all sites, LaPorta and Associaates will be responsible for cultural resource sample collection and preservation. LaPorta and Associates are expected to oversee initial sampling at sites. Subsequent sample collection may be accomplished by trained delegates.

3. **DESCRIPTION OF WORK.** This statement of work integrates the activities of two data gathering initiatives underway at the Corps. CENAN-PL-ES seeks to direct sampling at sites with potential for presence of prehistoric cultural resources through the identification of former landsurfaces. Cultural Resources will also be investigated via remote sensing to locate wrecks within the harbor. This statement of work defines how the contractor will support initiatives in each of the sites listed below for survey planning, sample collection, analysis and reporting.

Site	Cultural Resources	Remote Sensing
Bowery Bay	Y	
Constable Hook	Y	
Newark Bay	Y	
Hudson River	Y	
Bay Ridge / Red Hook Flats	Y	
Wards Point	Y	
Zone 1	Y	Y
Zone 2	Y	Y
Zone 3	Y	

Task 1. Survey Planning

Survey planning will define the most effective and cost-efficient logistical plan. Logistical planning will address timing, location selection and a tiered sequence of chemical analyses.

Subtask-1.1 Stations:

The survey plan will schedule stations based on site information priorities. Scheduling will also ensure sufficient coverage of boring operations by the cognizant geomorphologist and chemistry/geotechnical sampling specialists.

Selection of vibracore and SPT boring locations will reflect knowledge gained from the seismic interpretations being provided by the Corps. Locations will be selected in close cooperation with the Corps. Locations will be selected to optimize characterization of bedrock and investigation for the presence of prehistoric landsurfaces.

Ideally, the survey plan for cultural resources will be based on a literature review, interpretation of seismic data and existing boring records. The contractor will provide a geomorphologist to ensure several cores are taken from locations that appear to have been former topographic features such as terraces or high ground above river channels as these locations may have been favorable sites for Native American population.

Subtask-1.2 Sampling Strategy:

LaPorta and associates will produce a sampling protocol for collecting cultural samples from strategic locations.

Subtask-1.4 Remote Sensing Plan:

This scope of work requires the Contractor to conduct background research and a remote sensing survey for the two 3 square mile study areas in Raritan Bay. This work, as outlined below, will involve a review of previous research on the presence of shipwrecks within or nearby the proposed borrow area followed by a remote sensing survey which will include the use of a magnetometer, subbottom profiler and side scan sonar. It is important that the location, size and nature of any underwater objects be defined to the fullest extent possible from the remote sensing data. Current archaeological investigations will be conducted at this time.

The Contractor will develop a Remote Sensing Survey Plan for the investigation of the potential disposal areas and conduct initial background research on the potential for these areas to contain the remains of vessels. This research will develop a context for the present survey. The purpose of the plan is to specify the methods that will be used to locate potential cultural resources. The survey techniques, procedures, and remote sensing equipment shall be representative of the state of current knowledge and development. The Remote Sensing Plan will include the survey methodology to be used, the arrangement of the remote sensing survey tracklines, survey location stations, and equipment to be employed. Upon Corps approval of the Plan, the Contractor will proceed to the remaining tasks. The Remote Sensing Survey Plan will be included as an appendix to the draft and final reports. The research conducted will be used in the identification of targets and anomalies as potential cultural resources. It will provide a historic context for the potential to locate weeks within the area.

Task 2. Sample Collection

Subtask-2.1 Geotechnical and Chemical:

The same regiment of sample collection will occur at all sites regardless of which contractor is in charge of the vessel. The contractor under this scope of work will provide specialists geomorphology to be onboard as boring and coring operations proceed. At each site, a combination of borings and vibracores will be collected. Table 1 provides approximate boring/vibracoring locations for each site.

To optimize survey resources, prior to initiation of the boring/vibracoring portion of the study, the contractor will screen each site using seismic interpretations being provided by USGS/WHOI and SUNY Stony Brook. Based on the results of this screen, the contractor will define the best locatios to collect samples.

Subtask-2.2 Cultural Resources:

The geomorphologist will also define a sample collection protocol to identify which boring depths and visual cues should trigger samples to be subject to physical and chemical analyses for evidence of cultural resources.

Task 3. Sample Analyses and Reporting

Subtask-3.1 Geotechnical Sampling and Analyses:

The preliminary number of vibracores and Standard Penetration Test borings to be taken at all sites are listed in Table 1. (Boring operations at the shaded sites will be lead by the CENAN-EN contractor). The exact number and precise locations in each site will be finalized in cooperation with the Corps under Task 1 above.

Site	Vibracores	Borings
Bowery Bay	1	1
Constable Hook	1	1

Newark Bay	1	2
Hudson River	4	4
Bay Ridge / Red Hook Flats	2	4
Wards Point	2	2
Zone 1	2	2
Zone 2	2	2
Zone 3	3	2
Total	18	20

The coordinates (latitude and longitude) of the locations will be provided to the field teams. Survey maps and draft coordinates are included in Appendix A.

Subtask-3.4 Cultural Resource Analyses:

Up to 50 samples will be examined for evidence of cultural resources. These samples will be subjected to the following analyses: macrosedimentary analyses, grain size, geochemical analyses (organic carbon, kjeldahl nitrogen, zinc, iron, magnesium, copper, phosphates), Carbon-14, palynological and foraminiferal). The selection of cultural resource sample analyses will be defined during survey design in Task 1.

The results of Cultural Resource analyses will be assembled, and integrated with other geotechnical findings from this study, with the purpose of collating it in the preparation of interim, draft and final cultural resource reports. The report produced by the cultural resource investigation is of potential value not only for its specific recommendations but also as a reference document for other investigations of these sites.

The report will be a scholarly statement that can be used as a basis for future cultural resources work. It must meet both the requirements for the cultural 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' DMMP documents, a section must be included within the report that breaks down the discussion of potential resources and recommendations by area (i.e. Zones 1, 2 and 3, Hudson River Channel, etc) and must include a map of each zone on which the areas of sensitivity are depicted. The report layout and content specifications will be provided to the contractor by the Corps.

Subtask-3.5 Remote Sensing Analyses:

The Contractor will review the analyses performed by Dames & Moore's remote sensing team. The analyses should be aimed at determining the location, size and nature of identified targets and anomalies so that they may be avoided during construction, if necessary. In addition to discussions in the text of the report, the data will be presented as follows:

a. Project area base map, outlining the proposed zones.
b. Map of the survey tracklines.
c. Map(s) of the results of the remote sensing survey that will plot and distinguish between magnetometer anomalies and side scan targets. This map will also show all potential cultural resources, particularly possible shipwreck sites.
d. Table listing the target/anomaly or associated targets/anomalies, the coordinates for each and the potential identification of what each may be.
e. Tracklines and remote sensing anomalies should be provided in a digital, georeferenced

format. The digital data must be compatible with the overall DMMP GIS database and the final product must include pertinent Federal Geodetic Data Committee (FGDC) compliant metadata.

4. **PERIOD OF PERFORMANCE.** Field work is expected to commence as soon as mobilization can be achieved. Vibracoring and SPT borings are expected to continue for approximately 2 months, depending on weather contingencies and logistics with the CENAN-ES survey. Sample analyses will begin immediately with onboard geotechnical descriptions. Other sample analyses, such as analytical chemistry and foraminiferal enumeration will occur of a period of four to six weeks following sample collection.

Separate reports for field work, cultural sampling and interpretations will be submitted to Battelle as soon as each respective work element is completed.

TASK	Survey Plan	Field Report	Draft Report	Synthesis Report
Cultural Resources Samples	Y	Y	Y	Y
Cult. Resources Remote Sensing	Y		Y	Y

Two copies of a draft Field Report shall be provided to the NYD no later than 3 weeks after completion of all field work. Field Reports will summarize all logistical information from the cultural sampling (sampling dates, equipment, station locations, station depth relative to MLW, problems encountered and resolutions) and preliminary findings. The report will also include information on the disposition of all archived samples. The NYD review of the draft Field Report will take approximately seven calendar days from receipt of the draft report. Six copies of the final Field Report, incorporating all comments, shall be submitted no later than seven calendar days after receipt of NYD comments.

Interim reports on Cultural Resources will be submitted monthly. Four copies of the final draft will be submitted to the Corps for review by the Corps, NJHPO and NYSHPO within six weeks of the completion of sample analyses. Eight copies of the final report, reflecting the comments received, will be submitted within four weeks of receipt of comments.

The Corps' Environmental Analysis Branch will be provided with two copies of both the Remote Sensing Plan and the Remote Sensing Field Report and four (4) copies of the draft Remote Sensing report for review. Two of the draft reports will include original photographs, if applicable. The Contractor will provide six (6) copies of the final Remote Sensing report of this investigation, including one (1) unbound copy, with negatives, if applicable. Two of the final reports will include original photographs, if applicable. In addition, one (1) copy of the side scan sonar and magnetometer records will be provided to the Corps' Environmental Analysis Branch when the Final Report is submitted to be kept on file with the Final Report. Neither the Contractor nor his/her representatives shall release any sketch, photograph, report or other data, or material of any nature obtained or prepared under this contract without specific written approval of the Corps prior to the time of final acceptance of the government.

The Contractor will provide synthesis reports that integrate the results of geotechnical and cultural investigations and present these findings relative to the DMMP alternatives under consideration by the Corps.

5. **MATERIALS TO BE PROVIDED BY THE GOVERNMENT.**

a) Project maps showing locations of candidate sites to be sampled and proposed coring locations.
b) Any existing sediment profile information in NYD possession for the candidate sites (i.e., previous coring work).
c) Any existing information on exclusionary areas such as utilities, tunnels etc.
d) Interpretations of seismic data for zones 1, 2 and 3 depicting bedrock depths and any available approximations of prehistoric coastal landforms.
e) Timely delivery of properly preserved samples, vibracores and geophysical descriptions from sites occupied by the Structures and Design survey.

6. **PROJECT COORDINATION.** The Contractor will establish a work breakdown structure to clearly define key individuals responsible for each task area. The Program Manager will coordinate activities across all tasks and between the project team and the Corps. Task managers will report to the Program Manager weekly and provide input to the monthly status reports. The Contractor shall contact Battelle during the sampling program with verbal progress reports, and anytime a significant problem (i.e., potentially impacting project schedule or cost) arises. NYD reserves the right to observe work in progress.

7. **RELEASE OF DATA.** All data, reports, and materials obtained as a result of this contract shall become the property of the U.S. Government and shall be turned over to the Contracting Officer, NED Office, upon completion of the contract.

8. **QUALITY CONTROL.** The Contractor shall be held responsible for the quality of the services provided and for all damages caused the Government as a result of their negligence in the performance of any services under this contract.

Although submissions required by the contract are technically reviewed by the Government, it is emphasized that the Contractor's work shall be prosecuted using proper internal controls and review procedures. The letter of transmittal for each submission that the Contractor will make shall include a certification that the submission has been subjected to the Contractor's review and coordination procedures to insure a) completeness for each discipline commensurate with the level of effort required for that submission, b) elimination of conflicts, errors, and omissions, and c) the overall professional and technical accuracy of the submission. Documents which are significantly deficient in any of these areas will be returned to the Contractor for correcting and/or upgrading prior to completing the Government review. Contract submission dates will not be extended if a resubmission of draft material is required for this reason.

The Contractor will provide a safe working environment for all persons in his/her employ as prescribed by EM 385-1-1, "Safety and Health Requirements," dated April 1981. The Contractor will be responsible for all damages to persons and property that occur in connection with the work and services under this Contract, without recourse against the Government. The Contractor is responsible for having adequate insurance coverage for all activities required under this contract.

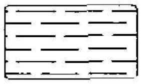
APPENDIX 2

Graphic Log Descriptions of Vibracores

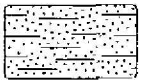
Explanation

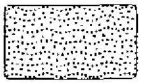
Sedimentology

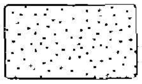
 Organic-rich mud

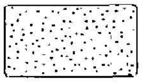
 Clay

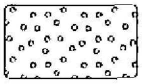
 Silty clay

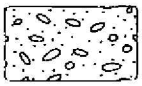
 Silty or clayey sand

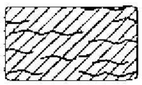
 Sand, very fine to fine-grained, well sorted

 Sand, medium to coarse-grained, well sorted

 Sand, very fine to coarse-grained, poorly sorted

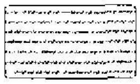
 Gravelly sand

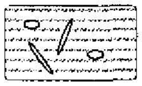
 Diamict

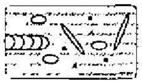
 Peat

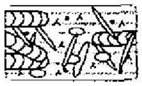
Visual Key for Bioturbation Index

(indicates level of biological mixing of sediment)

 ii = 1 No bioturbation

 ii = 2 Rare discrete burrows, bedding structures intact

 ii = 3 Some discrete burrows, bedding structures intact

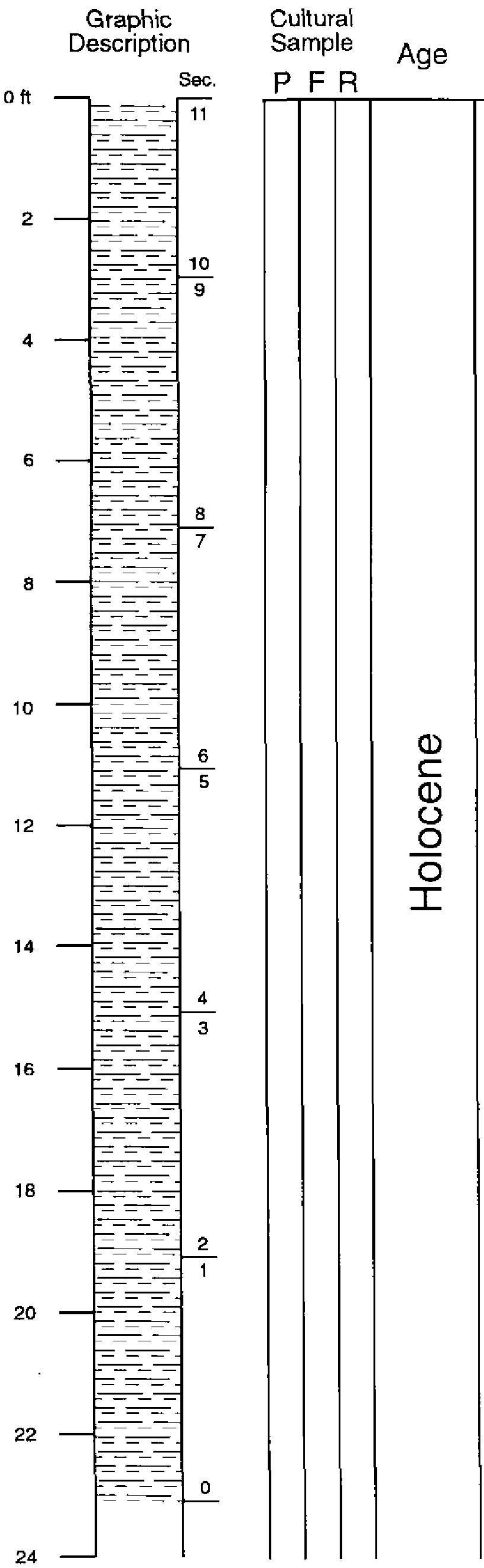
 ii = 4 Abundant discrete burrows, bedding structures intact

 ii = 5 Thoroughly bioturbated, bedding structures destroyed

Sediments classed as ii=5 can be further described as 5/1, 5/2, 5/3, or 5/4, where the second number is a measure of the concentration of discrete burrows in a homogeneous background. (Modified from Droser and Bottjer, 1991).

All Vibracore descriptions were completed by La Porta & Associates at Battelle Labs in Duxbury, Massachusetts. Note that HR-V2 was not described in detail, and so has not been included with the other sections here. A preliminary examination of that core suggests, however, that it is virtually identical in sedimentology to Vibracore HR-V1.

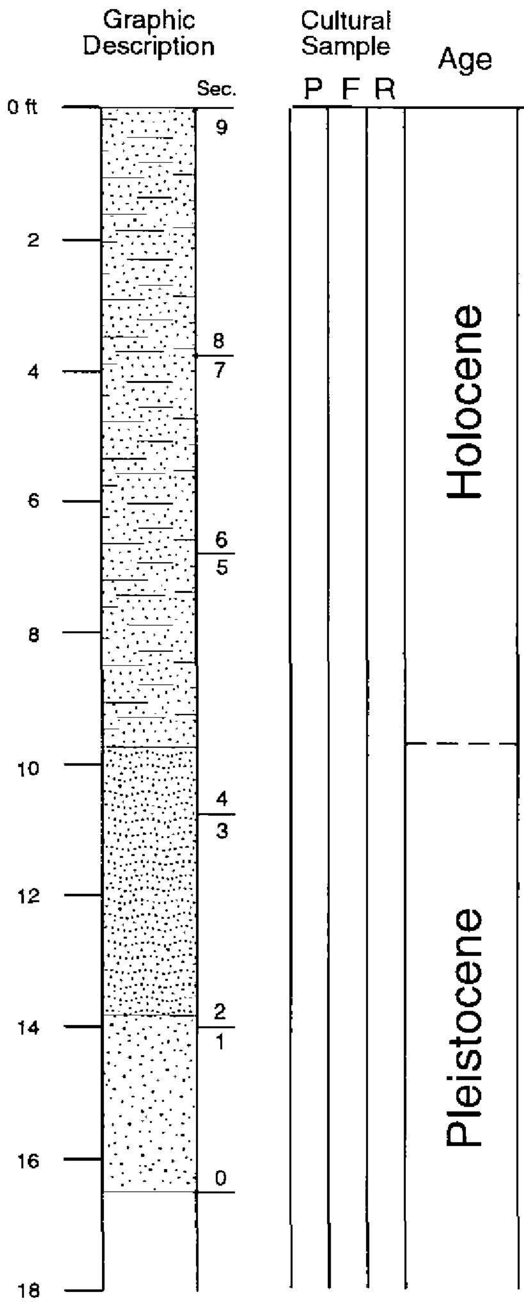
HR-V1 Hudson River   Lat. 40.72474833°   Lon. -74.02214722°



Sediment description

Dark gray (2.5Y 4/1) silty clay, very homogeneous (bioturbation index = 5/1) with a blocky texture. Contains scattered small (≤ 1 cm), thin-walled bivalve shells throughout, with some shell concentrations at 3 and 15 ft.

CH-V1 Constable Hook Lat. 40.66188056° Lon. -74.07629139°

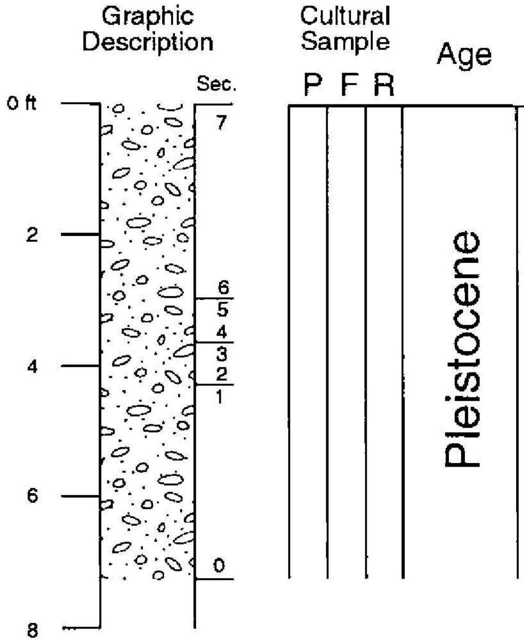


Sediment description

Dark gray (2.5Y 4/1) silty clay, very homogeneous (bioturbation index =5/1). Shell fragments up to 4-5 cm in length are abundant in Sections 9 and 8, becoming rare in Sections 7 through 4. Lower contact is gradational.

Yellowish brown (10YR 5/4) sand, generally fine to medium-grained and moderately sorted. Silt-filled burrows are visible in Sections 4 and 3 (bioturbation index = 2). Section 2 displays thin (1-2 inch) fining-upward intervals. Sections 1 and 0 are more poorly sorted overall, with more pronounced fining-upward intervals marked by sharp basal contacts; also includes siltstone pebbles presumably of Mesozoic origin.

PJ-V1 Port Jersey Lat. 40.66999667° Lon. -74.07984722°

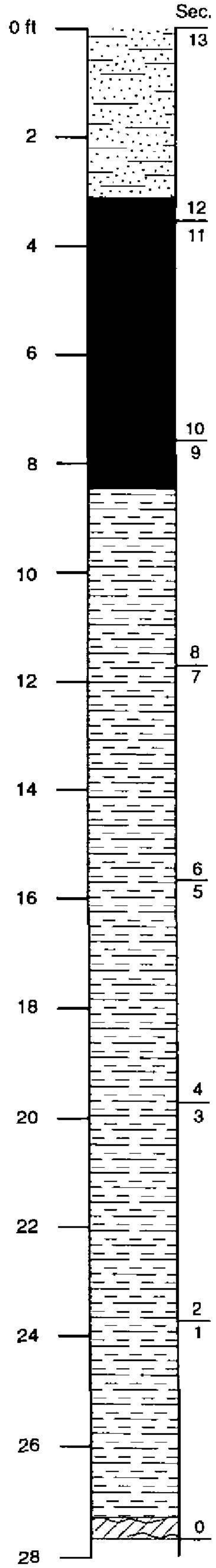


Sediment description

Strong brown (7.5YR 4/6), very poorly sorted diamict, with fine to medium-grained sandy clay matrix and numerous pebbles and cobbles up to 10 cm in length. Cobble composition includes basalt, argillite, arkosic sandstone and chert.

WP-V1 Ward's Point   Lat. 40.49826444°   Lon. -74.25680667°

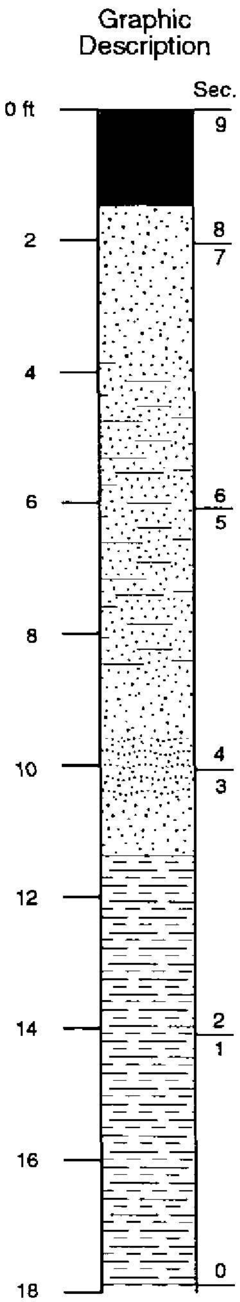
Graphic Description



Cultural Sample: P F R (samples marked in P and R at base of core, Section 0)

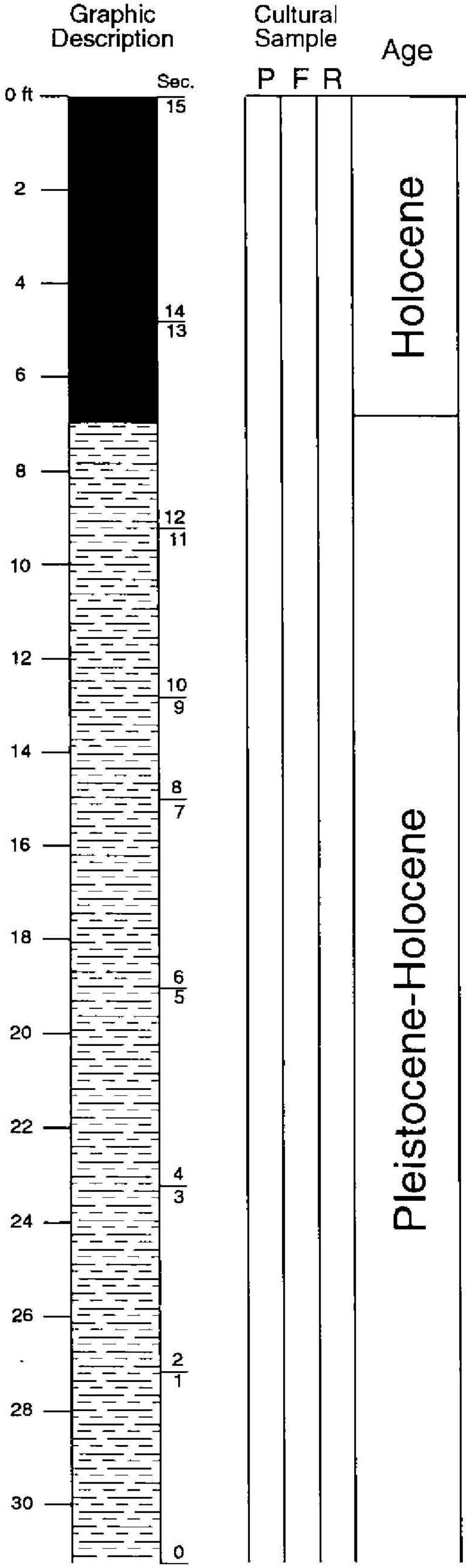
Age	Sediment description
Modern	Light olive brown (2.5Y 5/3), clayey to very fine-grained sand with rare shell fragments.
Modern	Dark gray (2.5Y 4/1) organic-rich mud, incredibly foul-smelling, possibly of historic origin.
Holocene	Dark gray (2.5Y 4/1) silty clay, homogeneous (bioturbation index = 5/2), with a stiff and blocky texture. Shell fragments are rare except for Section 7, which has shell fragments scattered throughout. Black staining is common throughout Sections 7 through 1, caused by either the presence of organic material or iron monosulfide (hydrotroilite). Scattered plant fragments visible in Sections 1 and 0.
7950 +/- 70 BP	Very dark gray (2.5Y 2/1) organic-rich soil (peat). Tiny roots and reed fragments are abundant. Upper contact is quite sharp.

RH/BR-V1 Red Hook/Bay Ridge   Lat. 40.66495889° Lon. -74.01906611°



Cultural Sample P F R	Age	Sediment description
	Modern	Black (N2.5/), organic muck, incredibly odorous - probably contaminated. Unit could represent historic channel fill with accumulation rates up to 5 cm/yr. Basal contact is knife sharp.
	Pleistocene-Holocene	Olive brown (2.5Y 4/3), poorly sorted, very fine-grained to pebbly sand slightly colored by organic material. Pebbles are slightly larger (up to 3 cm long) in Section 8; pebble lag occurs at ~3.75 ft. Sharp basal contact.
	Pleistocene-Holocene	Light olive brown (2.5Y 5/3) silty to very fine-grained sand with no apparent bedding structures. Slightly coarser and more poorly sorted intervals occur between ~8.6-9.6 ft. and 10.5-11.4 ft. Large sand-filled burrow is present at the base of Section 4.
	Pleistocene	Reddish brown (5YR 5/4) and brown (7.5 YR 5/2) silty clay, very homogeneous (bioturbation index = 5/1). Abrupt upper contact, as well as abrupt color change to solid brown (7.5 YR 5/2) at 14.9 ft.

RH/BR-V2 Red Hook/Bay Ridge Lat. 40.64384500° Lon. -74.04021722°

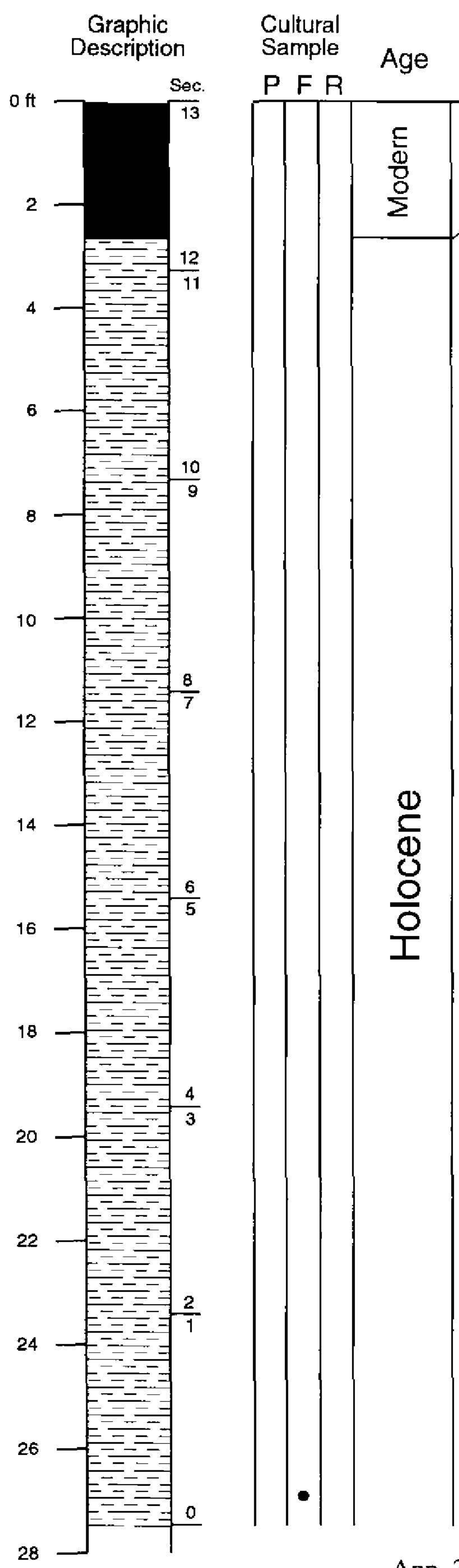


Sediment description

Black (N2.5/), organic mud, incredibly odorous - probably contaminated. Unit could represent historic channel fill with accumulation rates up to 5 cm/yr. Basal contact is knife sharp.

Dark gray (2.5Y 3/1) silty clay, very homogeneous (bioturbation index = 5/1). Contains scattered small (≤ 1 cm), thin-walled bivalve shells.

Z1-V1 Zone 1 Lat. 40.48977889˚ Lon. -74.17564944˚



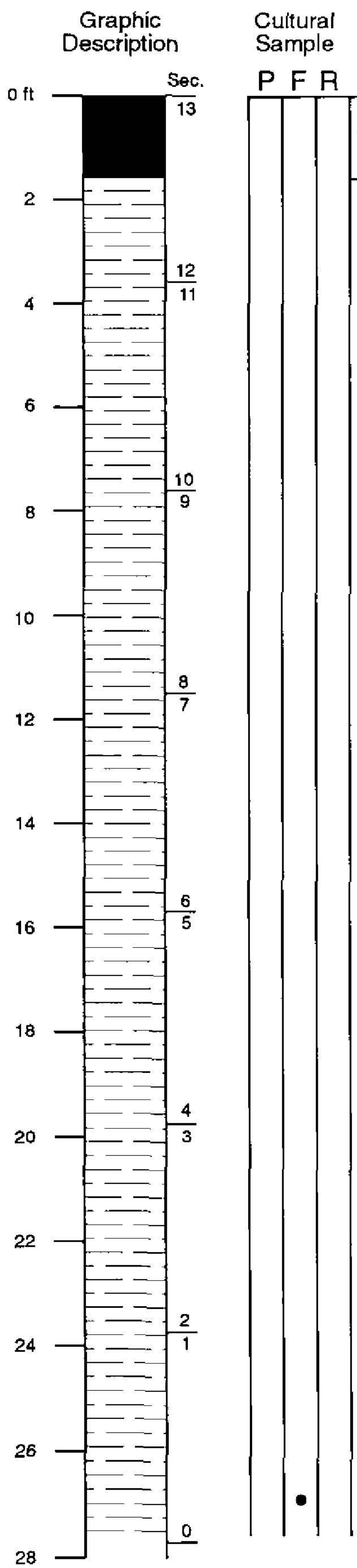
Sediment description

Black (N2.5/), organic mud, incredibly odorous - probably historic. Basal contact is knife sharp.

Very dark gray (10YR 3/1) silty clay, very homogeneous (bioturbation index = 5/1).

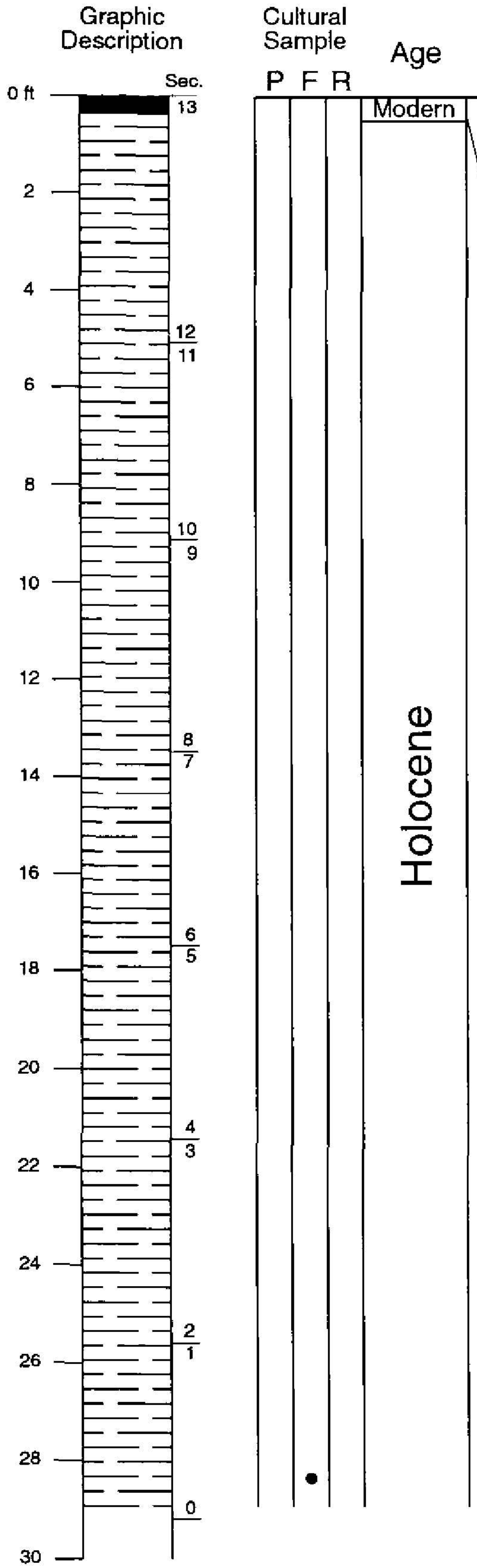
Dark gray (5Y 4/1) silty clay, homogeneous but with individual burrows clearly visible (bioturbation index = 5/2). Silt component is quite small in Sections 11 and 10. Contains scattered small (≤ 1 cm) bivalve shells in Sections 11 through 8, which become rare in Sections 7 through 0. Thin shell hash mixed with sand occurs at the bottom of Section 2.

Z1-V2 Zone 1 Lat. 40.47991806˚ Lon. -74.24002528˚



Age	Sediment description
Modern	Black (N2.5/) organic mud, incredibly odorous - probably historic. Basal contact is knife sharp.
Holocene	Very dark gray (10YR 3/1) clay, very homogeneous (bioturbation index = 5/1 to 5/2) with rare shell fragments.

Z1-V3 Zone 1 Lat. 40.48356472° Lon. -74.20735000°

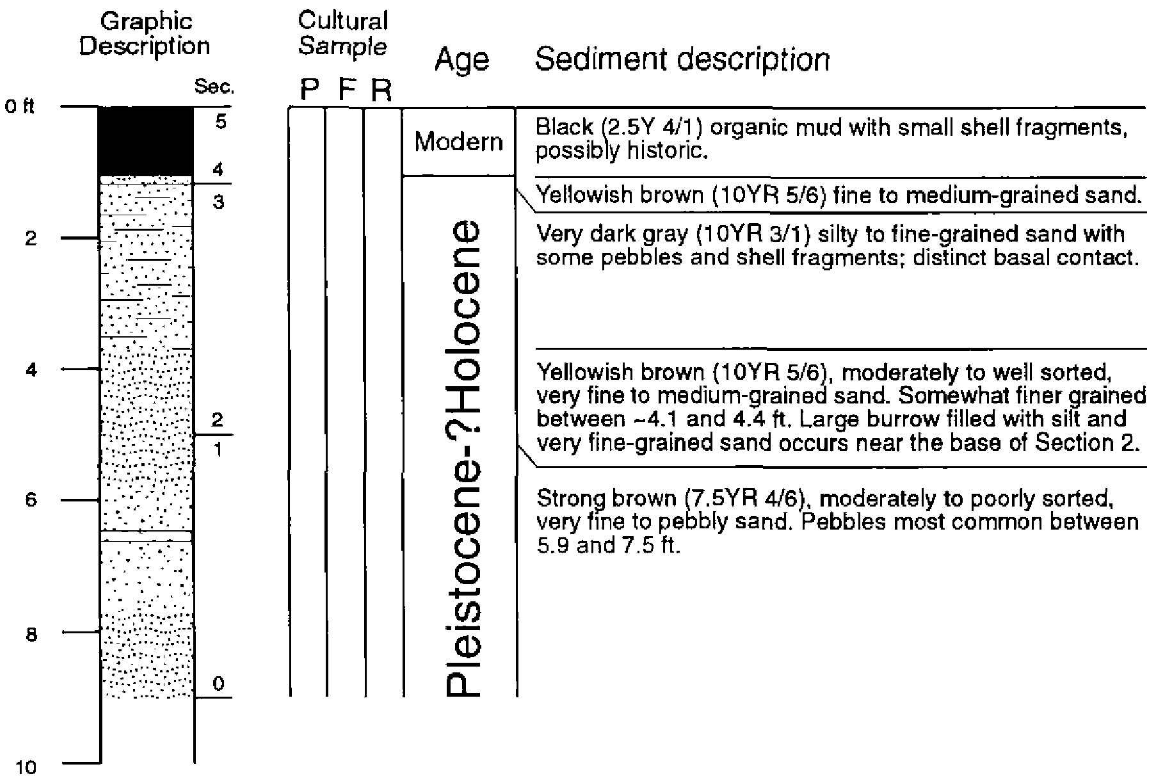


Sediment description

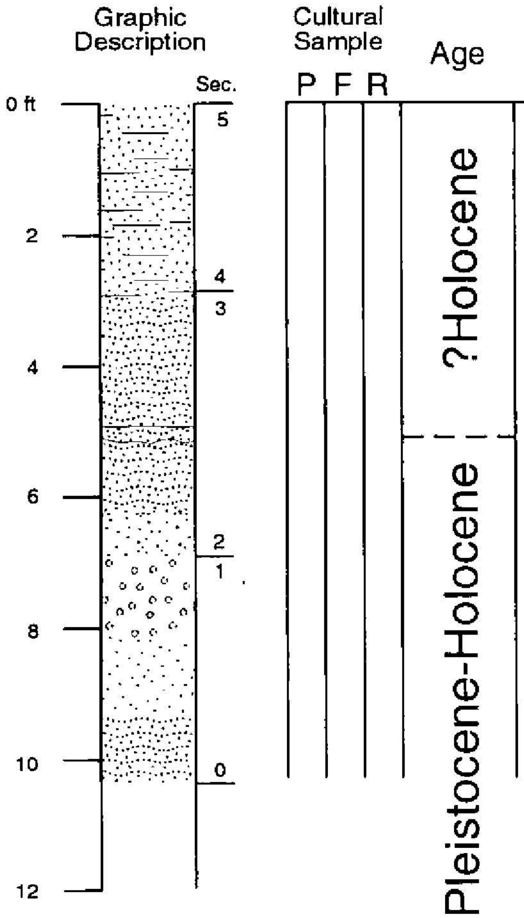
Black (N2.5/), organic muck, incredibly odorous - probably historic. Contains whole shells up to 6 cm in length as well as shell fragments. Basal contact is gradational over 1-2 inches.

Dark gray (2.5Y 4/1) clay, homogeneous (bioturbation index = 5/2). Contains scattered small shell fragments and rare silt grains throughout.

Z2-V1.2 Zone 2 Lat. 40.49931583° Lon. -74.08007111°



Z2-V2.1 **Zone 2** Lat. 40.51441917° Lon. -74.06102833°



Sediment description

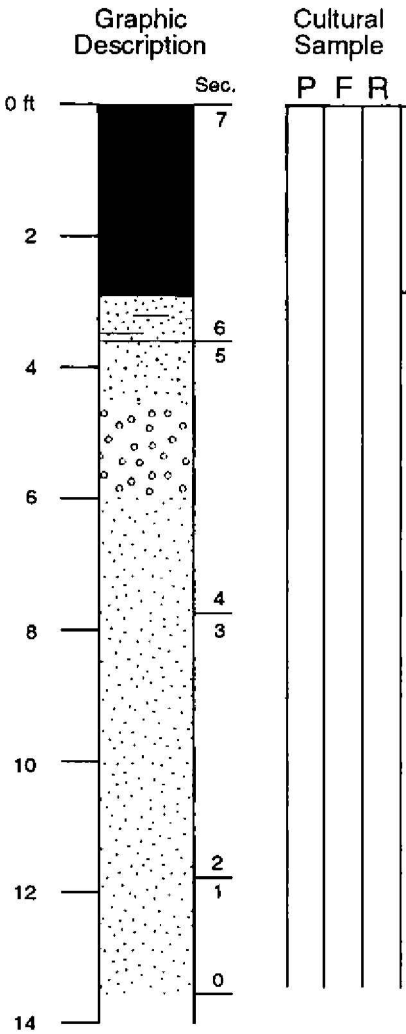
Dark gray (2.5Y 4/1) and yellowish brown (10YR 5/6) silty to very fine-grained sand with small shell fragments. Odorous - possibly historic.

Dark gray (2.5Y 4/1) silty to fine-grained sand with abundant shell fragments. Shell hash with pebbles is concentrated at ~2 ft., with a sharp, even surface at 2.25 ft. Sand becomes slightly coarser overall in the upper half of Section 3.

Black (10YR 2/1), very fine to fine-grained, organic-rich sand. Contains large shell fragments and whole pecten shells up to 4-5 cm in length. Upper contact is gradational over 1-2 inches, lower contact is quite sharp. Thin, dark gray (2.5Y 4/1), poorly sorted, very fine to coarse-grained sandy interval with irregular lower contact and sharp, even upper contact occurs at ~5 ft.

Dark grayish brown (10YR 4/2) to yellowish brown (10YR 5/4), poorly sorted, very fine-grained to pebbly sand. Faceted pebbles are up to 4 cm in length in Section 2, pebbles in Sections 1 and 0 are slightly smaller. Concentrated pebble layers within Section 0.

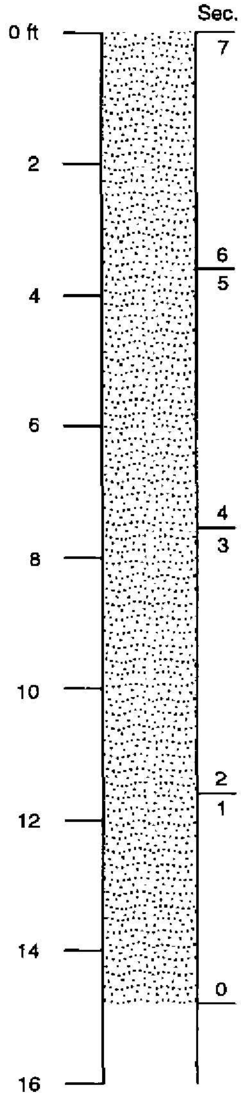
Z2-V3 Zone 2 Lat. 40.48975167° Lon. -74.07468917°



Age	Sediment description
Modern	Very dark gray (10YR 3/1), organic-rich mud, odorous, probably historic.
Pleistocene-?Holocene	Very dark gray (10YR 3/1) muddy, fine to medium-grained sand with some shell debris.
	Gray (10YR 5/1) silty to very fine-grained sand mixed with yellowish brown (10YR 5/4), poorly sorted silty to fine-grained sand. Pebbles and shell fragments up to 3 cm long are common. Yellowish brown sand is more common in lowermost 3 inches.
	Yellowish brown (10YR 5/4), poorly sorted very fine-grained to pebbly sand. Slightly better sorted below ~6 ft., becoming dominantly medium and coarse-grained sand. Pebbles are scattered throughout, but are generally smaller (≤ 1 cm) than those in Section 5; pebble lag occurs at ~6.5 ft.

Z3-V1 Zone 3 Lat. 40.40006278° Lon. -73.75829556°

Graphic Description



Cultural Sample: P F R

Age: Pleistocene-?Holocene

Sediment description

Medium gray (10YR 5/1), well sorted, very fine to fine-grained quartz sand with abundant dark mineral grains and lithic fragments. Bivalve and sand dollar fragments up to several cm long are common.

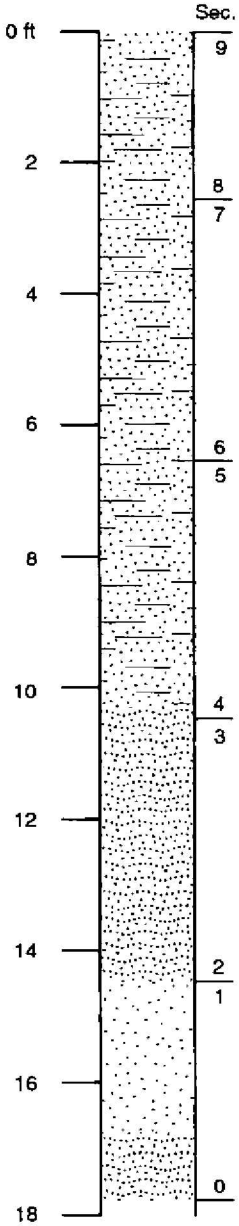
Whole sand dollars appear in Section 5.

Darker gray (10YR 3/1) intervals in Sections 3-2 (~9-10 ft.) and Sections 1-0 (~12.75-14.75 ft.).

Some darker mottling (burrowing) also occurs in Section 3 (bioturbation index = 2/3.

Z3-V2 Zone 3 Lat. 40.39660167° Lon. -73.74181250°

Graphic Description



Cultural Sample: P F R

Age: Pleistocene-?Holocene

Sediment description

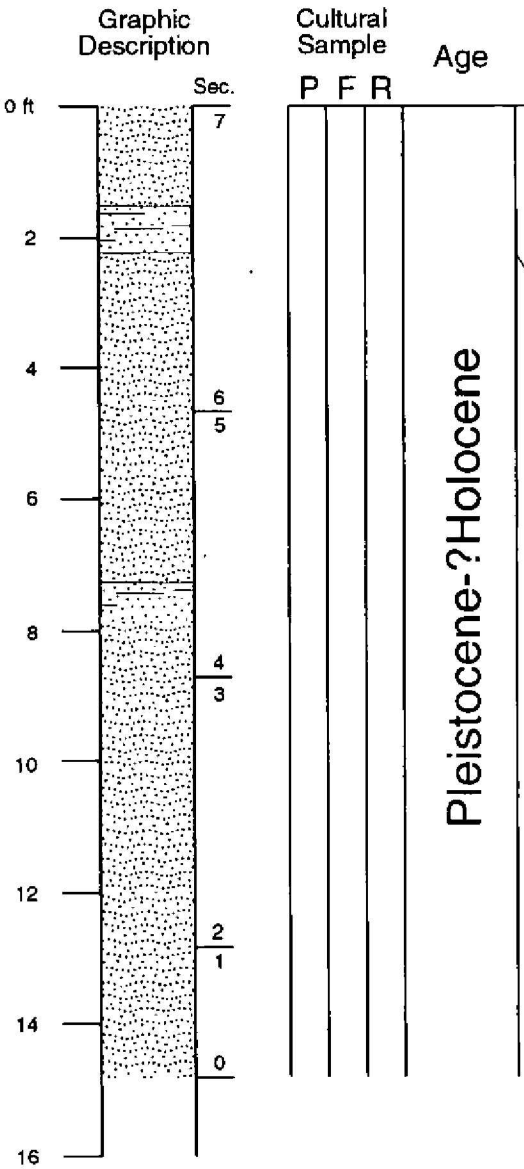
Medium gray (10YR 5/1), poorly sorted, silty to medium-grained quartz sand with abundant dark mineral grains and lithic fragments. Contains scattered bivalve fragments up to ~2 cm long.

Light brown (10YR 5/4 to 10YR 5/6), moderately sorted, very fine to medium-grained sand. Contains scattered pebbles but no shell fragments.

Light brown (10YR 5/6), moderately sorted, medium to very coarse-grained sand. Pebbles are common.

Brown (10YR 4/4), moderately sorted, very fine to medium-grained sand with no shell fragments.

Z3-V3 Zone 3 Lat. 40.39053333° Lon. -73.71270028°



Sediment description

Dark grayish brown (10YR 4/2), fairly well sorted, very fine to fine-grained sand; large shell fragment (~4 cm long) at base of unit.

Dark grayish brown (10YR 4/2), poorly sorted, silty to fine-grained sand with dark mineral grains. Thin silty laminae (~1 cm thick) at top of unit.

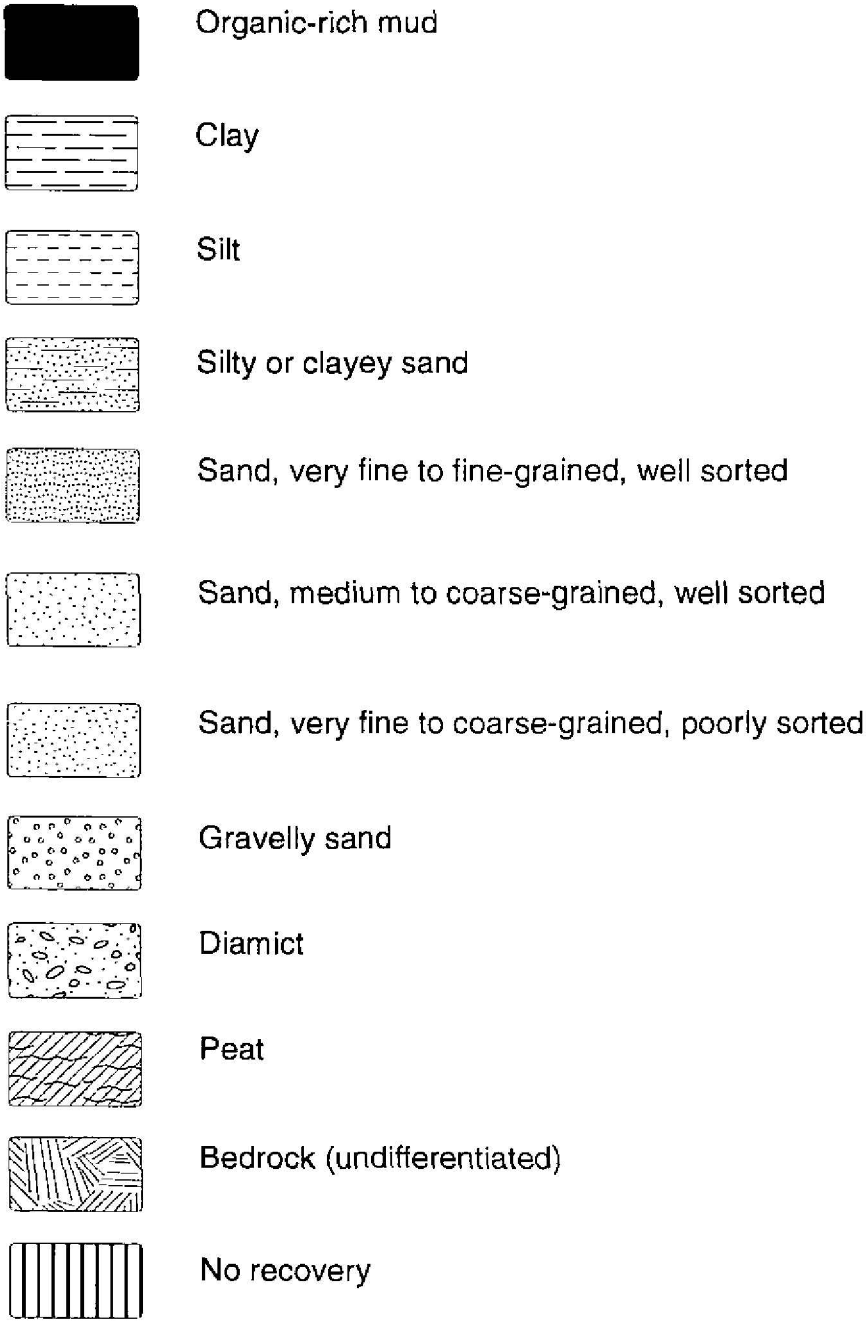
Brown (7.5YR 4/2), fine-grained quartz sand with 30-40% dark mineral fines; sharp basal contact.

Brown (7.5YR 4/2), very fine to fine-grained quartz sand with dark mineral fines. Slightly coarser overall in Sections 2-0; grades up to silty to very fine-grained sand in Section 4 (7.33-7.75 ft.).

APPENDIX 3

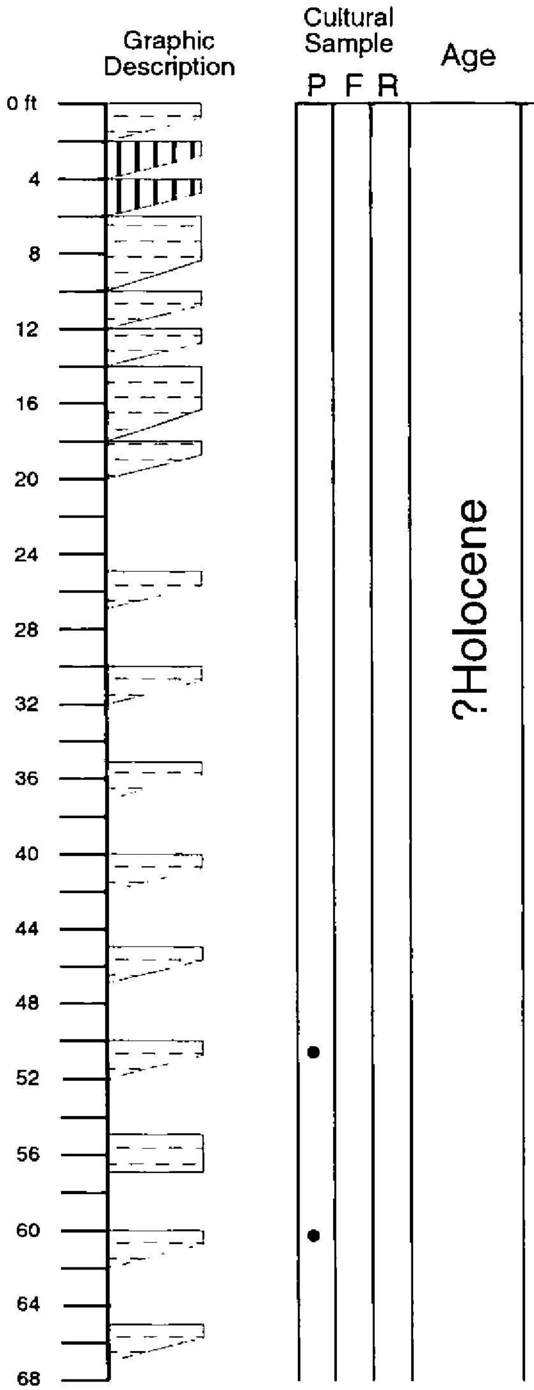
Graphic Log Descriptions of Borings

Explanation of Sedimentology



Descriptions of bores are adapted from notes supplied by Dames & Moore for this project. Note that B-115 (Zone 2) was acquired subsequent to the analyses compiled for this project.

B-1 Hudson River Lat. 40.768272° Lon. -74.006586°



Sediment description

Dark gray organic silt with trace of very fine to fine-grained sand

Grades with trace of fragments of slightly decomposed sea shells; sea shells grade out

Fine sand grades out, trace of very fine sand

Grades with increasing very fine to fine sand, trace of sea shell fragments

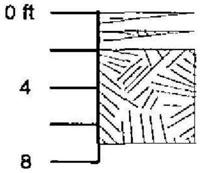
Sea shell fragments grade out

Grades with increasingly very fine to fine sand

(Boring completed at 67 ft)

B-2 Hudson River Lat. 40.704367° Lon. -74.020344°

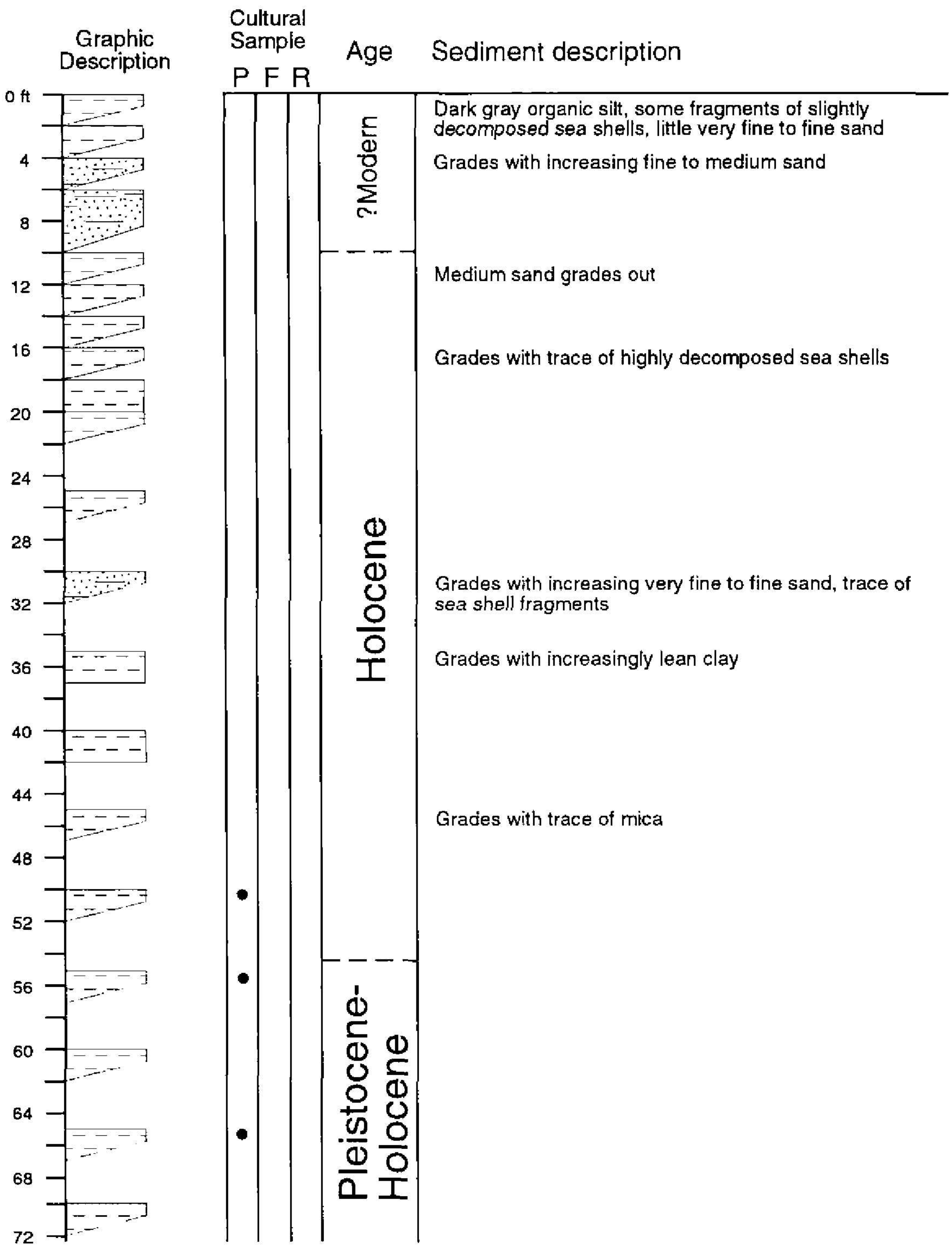
Graphic Description



Cultural Sample P	F	R	Age	Sediment description
			Paleozoic	Dark gray organic silt mixed with fine to coarse sand
				Gray, highly weathered quartzite and schist fragments intermixed with dark gray organic silt
				Bluish-gray micaceous granite with frequent quartzite layers, moderately to slightly weathered, closely to moderately-spaced near-horizontal and inclined fractures

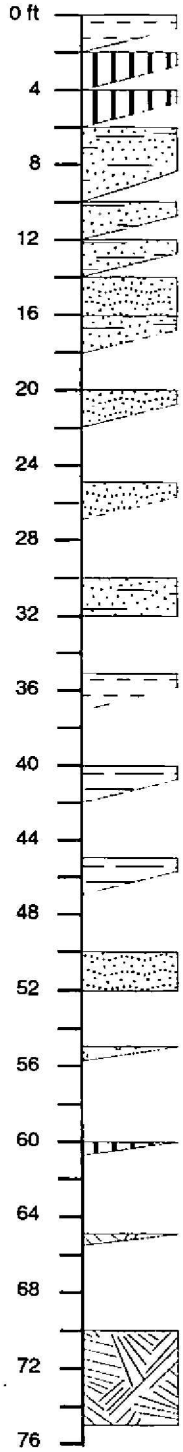
(Boring completed at 7.5 ft)

B-3 Hudson River Lat. 40.719353° Lon. -74.023231°



(Boring completed at 72 ft)

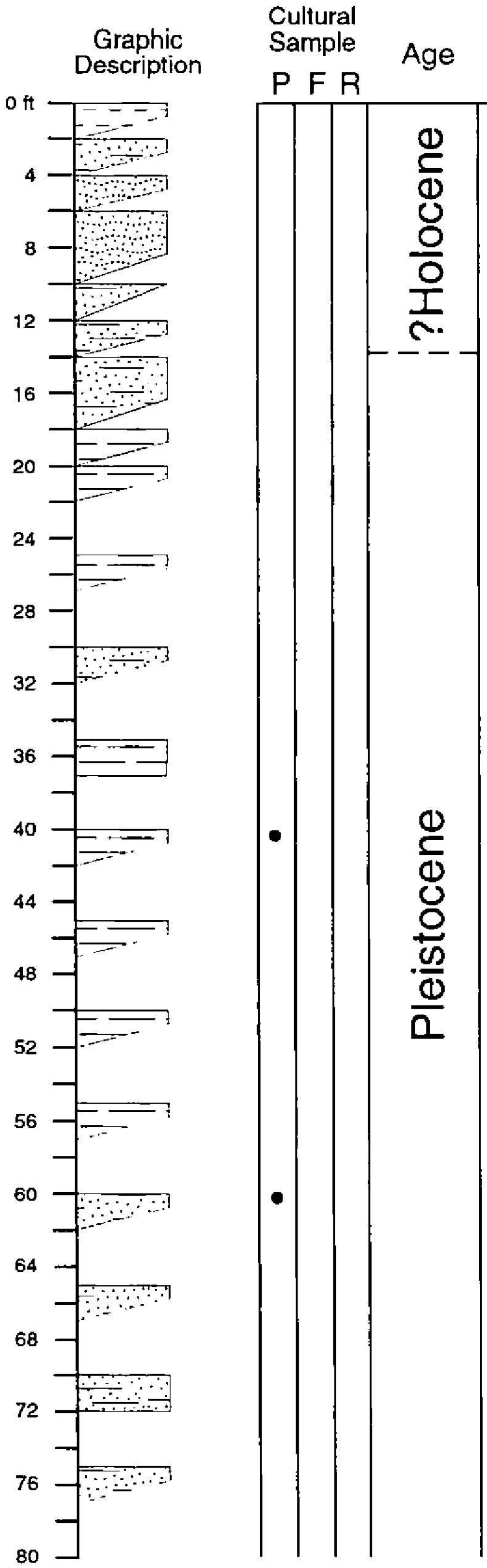
B-4 Constable Hook Lat. 40.660022° Lon. -74.083964°



Cultural Sample (P F R)	Age	Sediment description
	Holocene	Dark gray organic silt, trace of very fine to fine sand
		No recovery
		Grades with increasing fine sand, trace of slightly decomposed sea shell fragments
	Pleistocene	Brown fine sand, trace of inorganic silt
		Gray fine sand, little inorganic silt, trace of mica
		Gray fine to medium sand, trace of inorganic silt
		Reddish brown inorganic silt, some very fine sand
P		Very fine sand grades out
P		Brown inorganic lean clay, trace of very fine sand, trace of mica
P		Grades to mottled brown and gray
		Dark brown fine to medium sand, little angular coarse gravel (saprolite)
		Gray, coarse, subangular gravel, trace of fine sand
		No recovery
	Paleozoic	Gray granite schist, highly to completely weathered
		Grades to slightly weathered, closely fractured, near-horizontal fractures

(Boring completed at 75 ft)

B-5 Newark Bay Lat. 40.686706° Lon. -74.124722°



Sediment description

?Holocene

Dark gray organic silt, trace of fine sand, trace of sea shell fragments, grades to some very fine to fine sand

Gray, fine to medium sand, some fresh to slightly decomposed sea shell fragments, trace of organic silt

Grades with increasing silt

Pleistocene

Reddish brown lean clay, little fine to coarse sand, trace of fine gravel

Gravel grades out

Fine to coarse sand grades out

Grades with trace of fine to medium sand

Grades with trace of fine gravel

Grades with decreasing fine to medium sand, gravel grades out

Grades to yellowish red

Grades with increasingly very fine to fine sand

Grades with increasingly fine to medium sand

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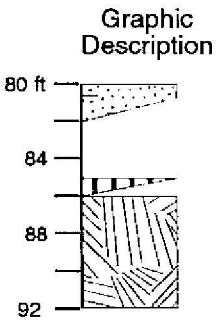
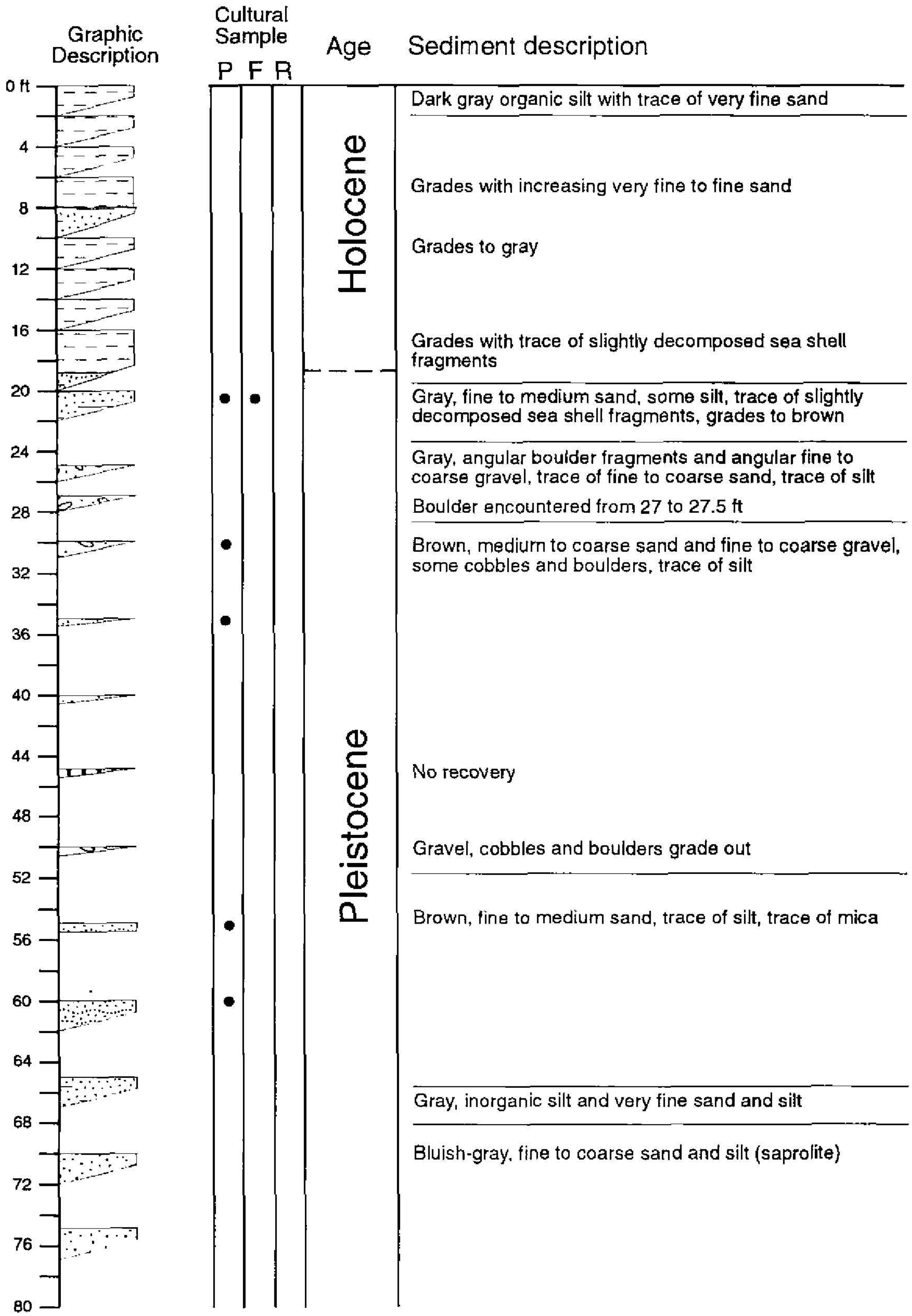
B-5 Newark Bay Lat. 40.686706° Lon. -74.124722° (cont.)



Cultural Sample P	F	R	Age	Sediment description
•			Pleistocene	Yellowish red lean clay, little fine to medium sand
			Mesozoic	No recovery Reddish brown quartz sandstone, fresh to slightly weathered, grades to shale and siltstone

(Boring completed at 92 ft)

B-6 Bowery Bay Lat. 40.777828° Lon. -73.887169°



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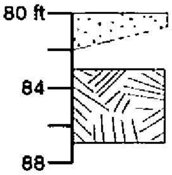
B-6 Bowery Bay Lat. 40.777828° Lon. -73.887169° (cont.)

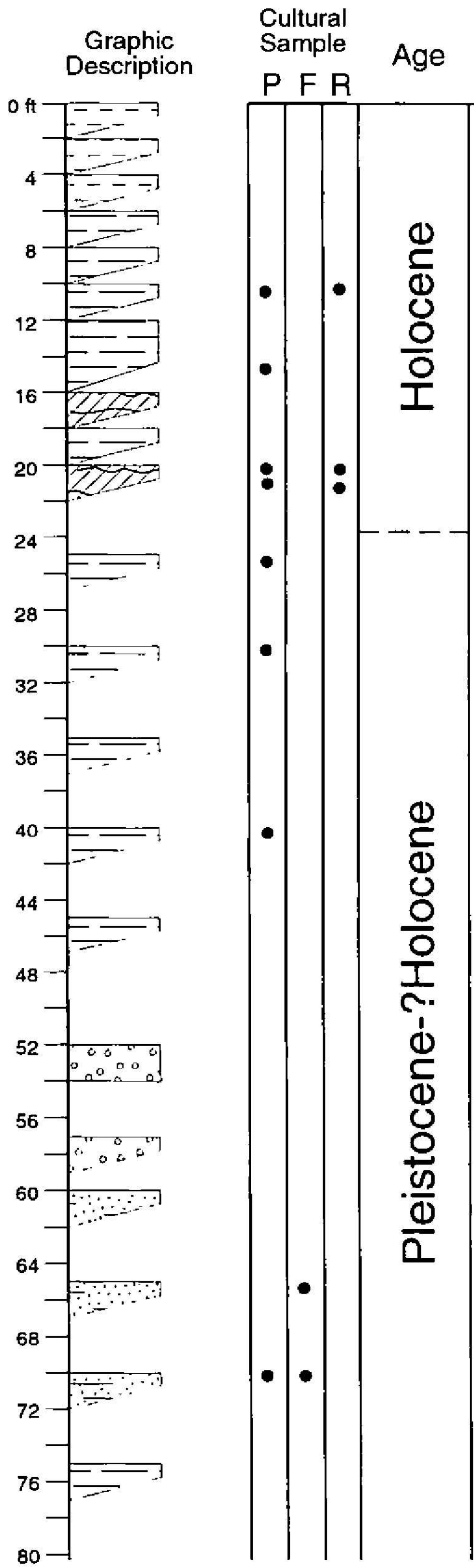
Graphic Description



Cultural Sample P	F	R	Age	Sediment description
			Pleisto-cene	Bluish-gray, fine to coarse sand and silt (saprolite)
			Paleozoic	Bluish-gray quartz diorite, slightly weathered to fresh, trace of pyrite

(Boring completed at 87 ft)

B-13 Ward's Point Lat. 40.493333° Lon. -74.253333°



Sediment description

Dark gray organic silt, trace of sea shell fragments

Occasional parting of some fine to medium sand

Dark gray organic clay, seams of coarse shell fragments

Grades with occasional pockets of peat

Grades with little aquatic vegetation, moderately decomposed

Grades to dark brown, some organic material (aquatic vegetation), moderately decomposed

Grades to mottled dark brown, dark gray and brownish yellow, increasing pockets of peat

Bluish-gray lean clay, trace fine sand, trace organics

Grades to dark gray, occasional seam of some medium sand, trace of mica

Light gray, red and brownish yellow clayey gravel with silt and sand; gravel is fine to coarse and rounded (terrestrial sediments)

Interbedded silty gravels and clayey gravels with sand, trace of glauconite

Gray fine to medium sand and inorganic silt, little fine subrounded gravel

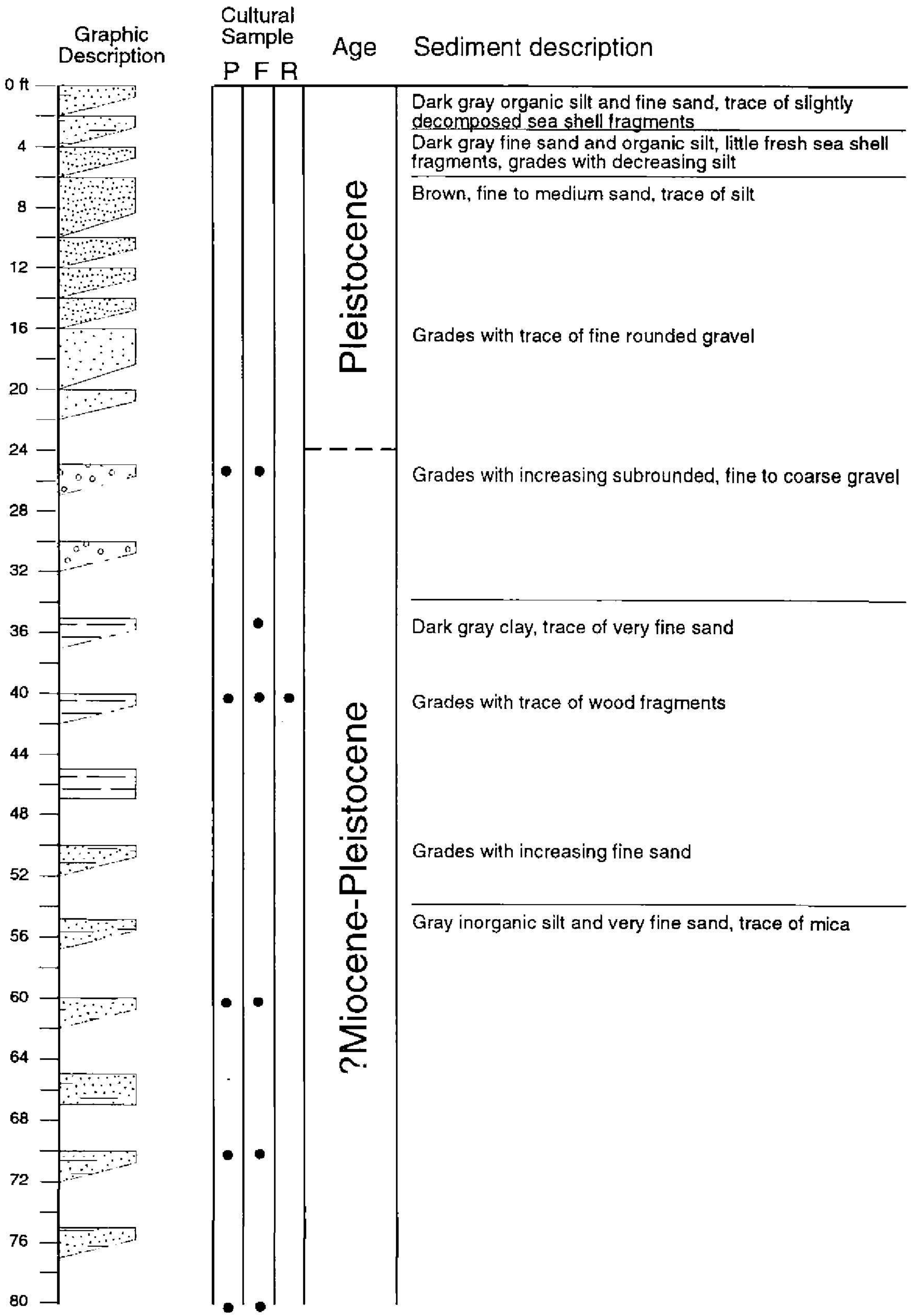
Grades with some clay and little silt

Dark gray inorganic silt and lean clay, trace of fine to medium sand, laminated

Very dark gray clay with pockets of peat and silt, trace of dark organic material, laminated

(Boring completed at 77 ft)

B-8 Zone 1 Lat. 40.475975° Lon. -74.166761



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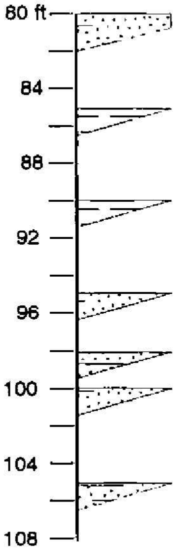
B-8 Zone 1 Lat. 40.475975° Lon. -74.166761° (cont.)

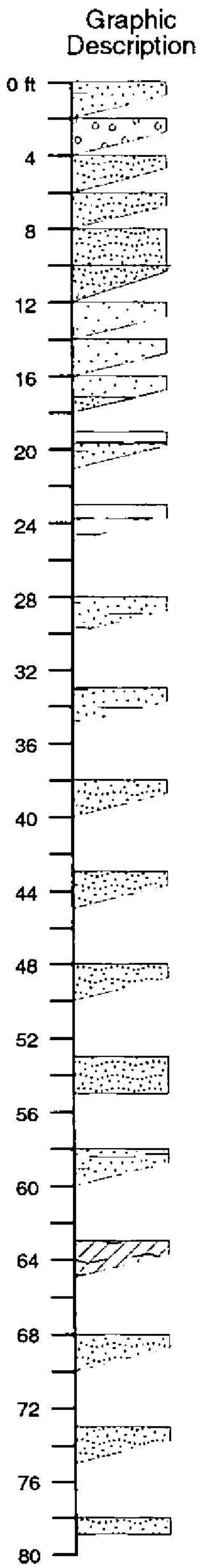
Graphic Description



Cultural Sample P	F	R	Age	Sediment description
			?Miocene-Pleistocene	Gray inorganic silt and very fine sand, trace of mica, grades with little dark gray lean clay
				Dark gray lean clay, some very fine to fine sand
				Grades with increasing fine sand
				Dark gray inorganic silt and very fine to fine sand, trace of mica

(Boring completed at 106 ft)

B-106 Zone 1 Lat. 40.494444° Lon. -74.192500°



Cultural Sample P	Cultural Sample F	Cultural Sample R	Age	Sediment description
			Pleistocene-Holocene	Dark gray fine to medium sand, some silt, abundant sea shell fragments, grades to reddish brown coarse sand and fine rounded gravels
				Yellowish brown, fine to medium sand, little organic silt
				Grades to medium sand with trace fine gravel
				Grades with increasing coarse sand and fine gravel
				Grades to fine sand
				Pale yellow clay
				Light gray fine sand and inorganic silt, trace of mica
				Grades with laminated clays and sands
●	●			Dark gray lean clay with seams of silt, trace of organics, laminated
			?Miocene-Pleistocene	Interbedded gray silty sand and dark gray clay, trace of mica, occasional organic seams
●	●			
				Light gray fine sand with occasional fat clay layer
				Grades with decreasing silt, clay layers grade out
●				
●	●			Grades with increasingly very fine to fine sand
				Gray very fine sand and inorganic silt, little fat clay partings, trace of mica
●	●			Trace of peat and pyrite nodules
				Gray fine sand, trace of inorganic silt, occasional organic pockets
●	●			Grades with medium sand
				Two-inch pyrite layer encountered at 78 ft

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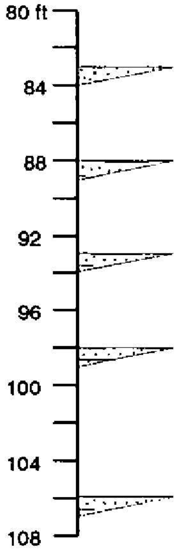
B-106 Zone 1 Lat. 40.494444° Lon. -74.192500° (cont.)

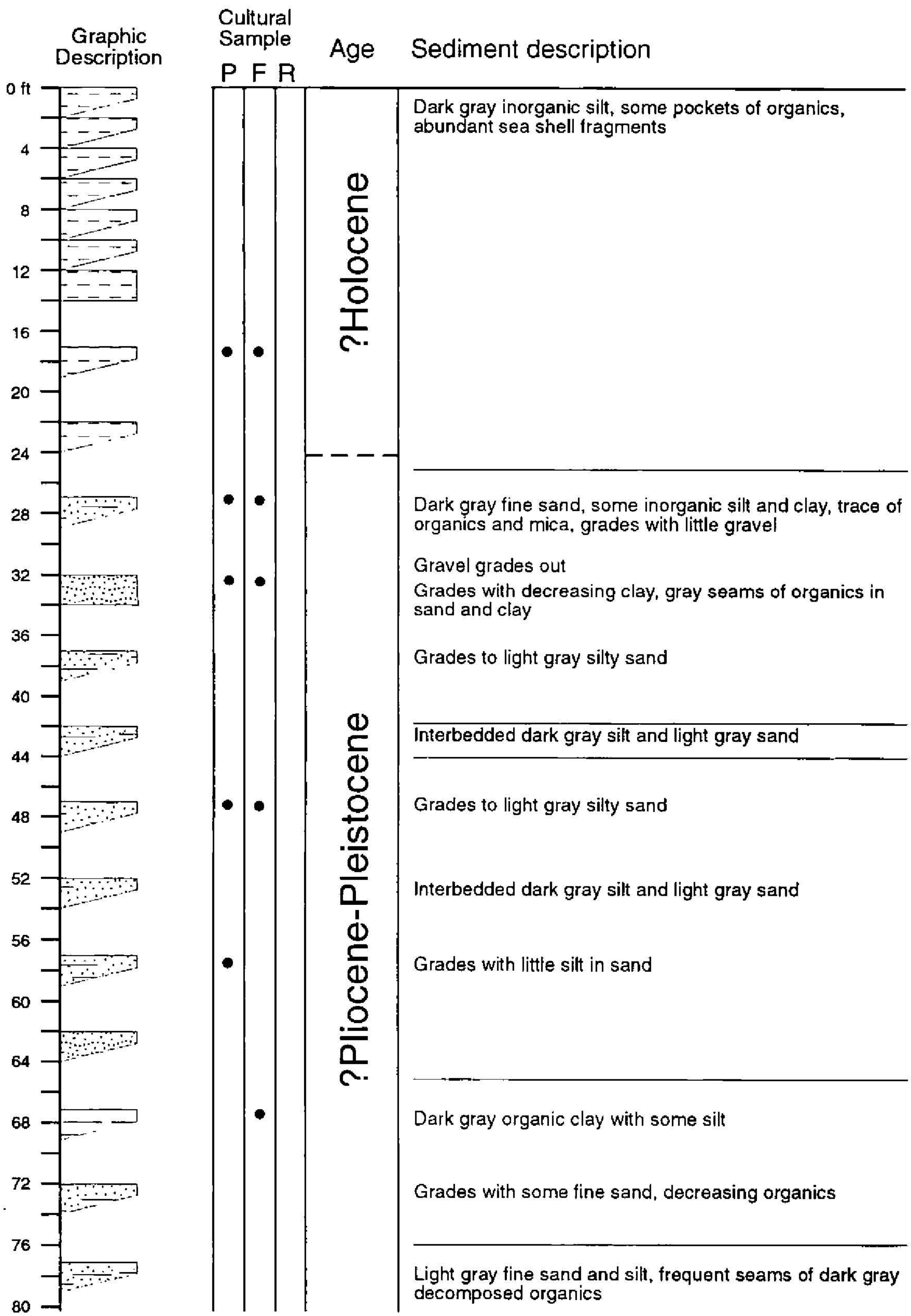
Graphic Description



Cultural Sample P	F	R	Age	Sediment description
			?Miocene-Pleistocene	Gray fine to medium sand, trace of inorganic silt, occasional organic pockets
• (88 ft)				Grades with increasing silt
• (92 ft)				

(Boring completed at 106.5 ft)

B-110 Zone 1 Lat. 40.471111° Lon. -74.218611°



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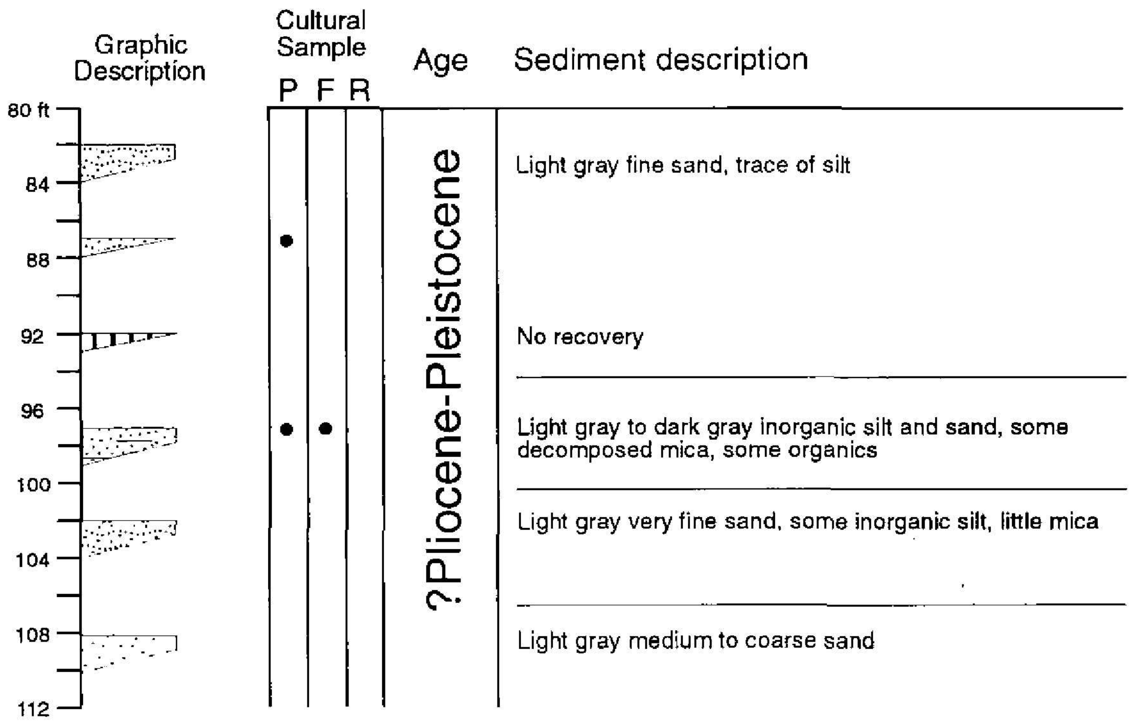
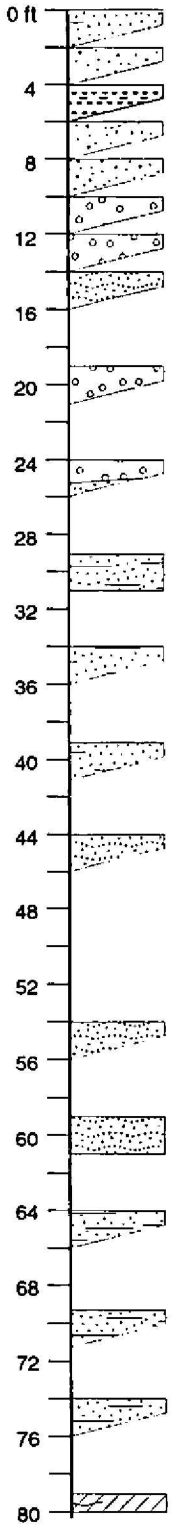
B-110 Zone 1 Lat. 40.471111° Lon. -74.218611° (cont.)



(Boring completed at 110 ft)

B-111 Zone 2 Lat. 40.500556° Lon. -74.075833°

Graphic Description | Cultural Sample (P F R) | Age | Sediment description



Age: Pleistocene-?Holocene

Sediment description:

Dark gray organic silt and fine to medium sand, little fine subrounded gravel, trace of sea shell fragments

Brown fine to coarse sand, trace of silt

Grades with increasing red silt, trace of fine gravel

Grades with predominantly coarse sand and some gravels

Brown fine to medium sand, trace of organic silt, trace of fine subrounded gravels

Grades to gravelly sands

Grades to brownish yellow

Abrupt change to brown fine sand, trace of inorganic silt

Yellowish brown fine sand and inorganic silt, trace of mica

Light gray to pale yellow very fine sand and inorganic silt, trace lean clay, laminated

Grades to gray with reddish brown staining, increasing fine sand, occasional pockets of organics and wood fragments, then to laminated sands and silts with some clay

Olive yellow very fine to fine sand, little inorganic silt

Grades to dark gray, trace of organics

Grades to light gray

Light gray very fine to fine sand, some silt

Grades with little gray lean clay, seam of peat and pyrite mineralization at 80.5 ft

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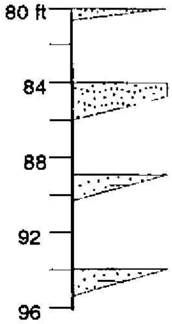
B-111 Zone 2 Lat. 40.500556° Lon. -74.075833° (cont.)

Graphic Description

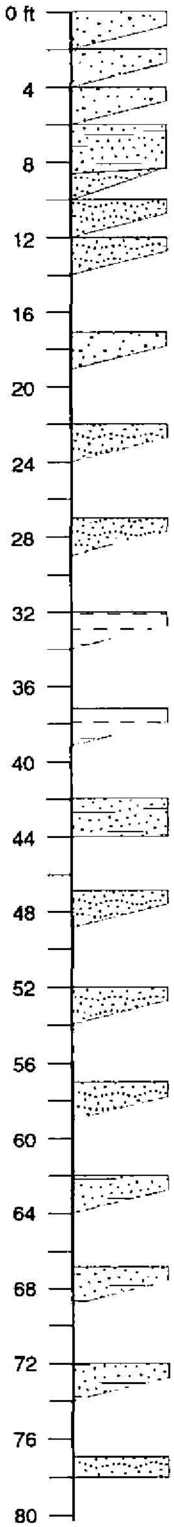


Depth	Cultural Sample P	Cultural Sample F	Cultural Sample R	Age	Sediment description
80 ft	•	•		Pleistocene	Light gray very fine to fine sand, little lean clay
84					Grades with decreasing silt
88		•			Grades with organic clay in occasional seams
92–96	•	•	•		Grades to interbedded seams of light gray fine sand and dark gray organic silt, some peat and organic material, highly decomposed, laminated

(Boring completed at 96 ft)

B-112 Zone 2 Lat. 40.495000° Lon. -74.062778°

Graphic Description | Cultural Sample P F R | Age | Sediment description



Age: Pleistocene-?Holocene

Sediment description

Dark gray silt, some fine to coarse sand, trace of sea shell fragments

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Dark gray fine to coarse sand, little inorganic silt, trace of fine subrounded gravel (terrestrial sediment)

Grades to brownish red, increasing fine subangular gravel

Reddish brown fine to medium sand, trace of inorganic silt, trace of fine subrounded gravel

Grades with trace of coarse sand

Grades to brown, coarse sand grades out

Brownish yellow inorganic silt, trace of clay, trace of fine sand

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Brownish yellow fine sand, some inorganic silt

Olive yellow fine to medium sand, trace of inorganic silt

Gray very fine sand and inorganic silt, trace of mica

Dark gray fine sand and inorganic silt, trace of mica

Grades with laminated seams of dark gray organic clay and silt, 2-inch layer of highly decomposed peat (lignite) at 68.5 ft

Grades with pockets of organics, pyrite mineralization in sand

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Gray fine sand, little inorganic silt, trace of organics

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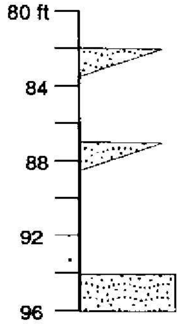
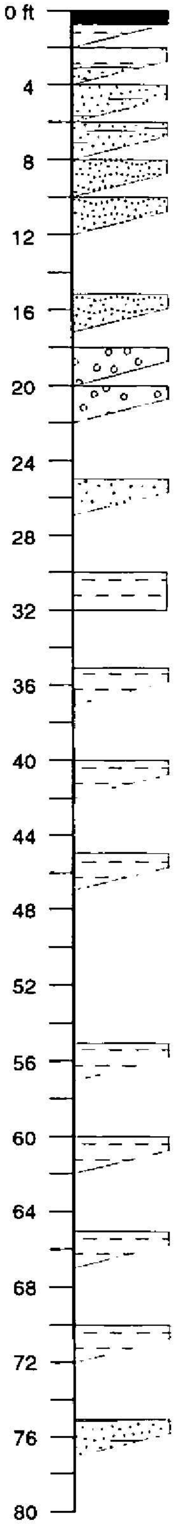
B-112 Zone 2 Lat. 40.495000° Lon. -74.062778° (cont.)

Graphic Description	Cultural Sample P	Cultural Sample F	Cultural Sample R	Age	Sediment description
	● ● ●	● ● ●		Pleistocene	Gray fine sand, little inorganic silt, trace of organics

(Boring completed at 96 ft)

B-113 Zone 1 Lat. 40.479383° Lon. -74.166662°

Graphic Description



Cultural Sample P	Cultural Sample F	Cultural Sample R	Age	Sediment description
			Modern	Black organic silt and clay with abundant sea shell fragments, worms; grades to very dark gray silt with some sand, little clay, traces of shell fragments, petroleum sheen apparent
			Holocene	
			Pleistocene	Olive yellow medium sand, trace of silt
				Grades with some silt and possibly glauconite
				Grades to brown fine and medium sand, some silt, little medium sand
				Brown coarse sand, some fine gravel
			?Pliocene-Pleistocene	Grades to brownish red fine to coarse sand, little fine gravel
				Dark gray silt, some organics
●	●			
				Grades to light gray with little to trace wood pieces in pockets
●	●			Grades to dark gray organic silt with some clay, very micaceous, seams of moderately decomposed dark brown to black organic material (wood)
				Grades with some lignite in seams
●	●			Organics grade out
				Grades back to clay with partings of fine sand, occasional pyrite inclusions

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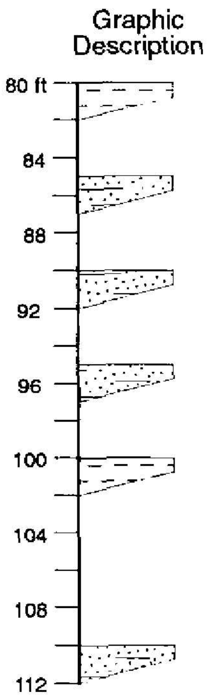
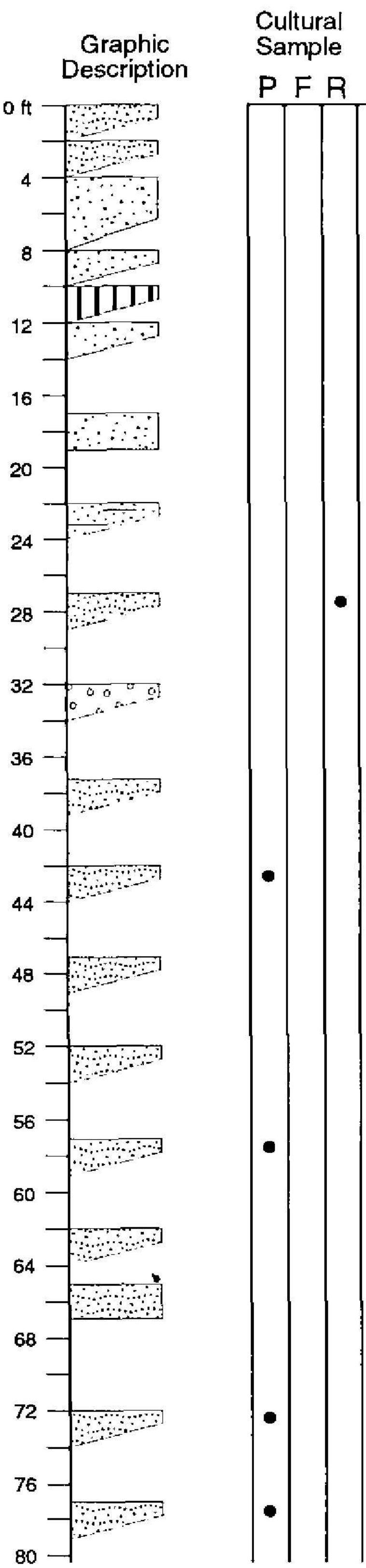
B-113 Zone 1 Lat. 40.479383° Lon. -74.166662° (cont.)



Cultural Sample P	F	R	Age	Sediment description
			?Pliocene-Pleistocene	Gray silt and light gray clay partings
	●			Grades with occasional seam of light gray very fine sand
				Gray fine sand and micaceous silt
				Grades with more sand throughout
	●			Dark gray silt, trace of organics and mica
				Light gray very fine sand and silt, occasional seam of very dark gray organic material

(Boring completed at 112 ft)

BV-251 Zone 2 Lat. 40.529660˚ Lon. -74.101600˚



Age: Pleistocene

Sediment description

Dark gray fine to medium sand, little inorganic silt, trace of sea shell fragments; grades to gray, trace of fine gravel, then to reddish brown, increasing fine to coarse gravel

Fine gravels grades with very fine sand

Fine sand grades out, trace of very fine sand

No recovery

Grades to fine to coarse sand, gravel grades out

Fine sand with little silt

Dark grayish brown fine to medium sand, some inorganic silt, frequent layers of organic silt, trace of wood fragments

Grades to predominantly gravel

Grades to light olive brown very fine to fine sand, trace of silt, some fine gravels

Grades to fine to medium sand

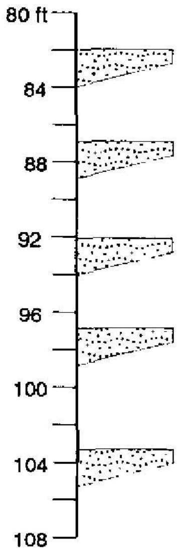
Olive brown fine sand, trace of inorganic silt

Grades to yellowish brown

(continued next page)

BV-251 Zone 2 Lat. 40.529660° Lon. -74.101600° (cont.)

Graphic Description



Cultural Sample: P F R (P marked at 92–93 ft)

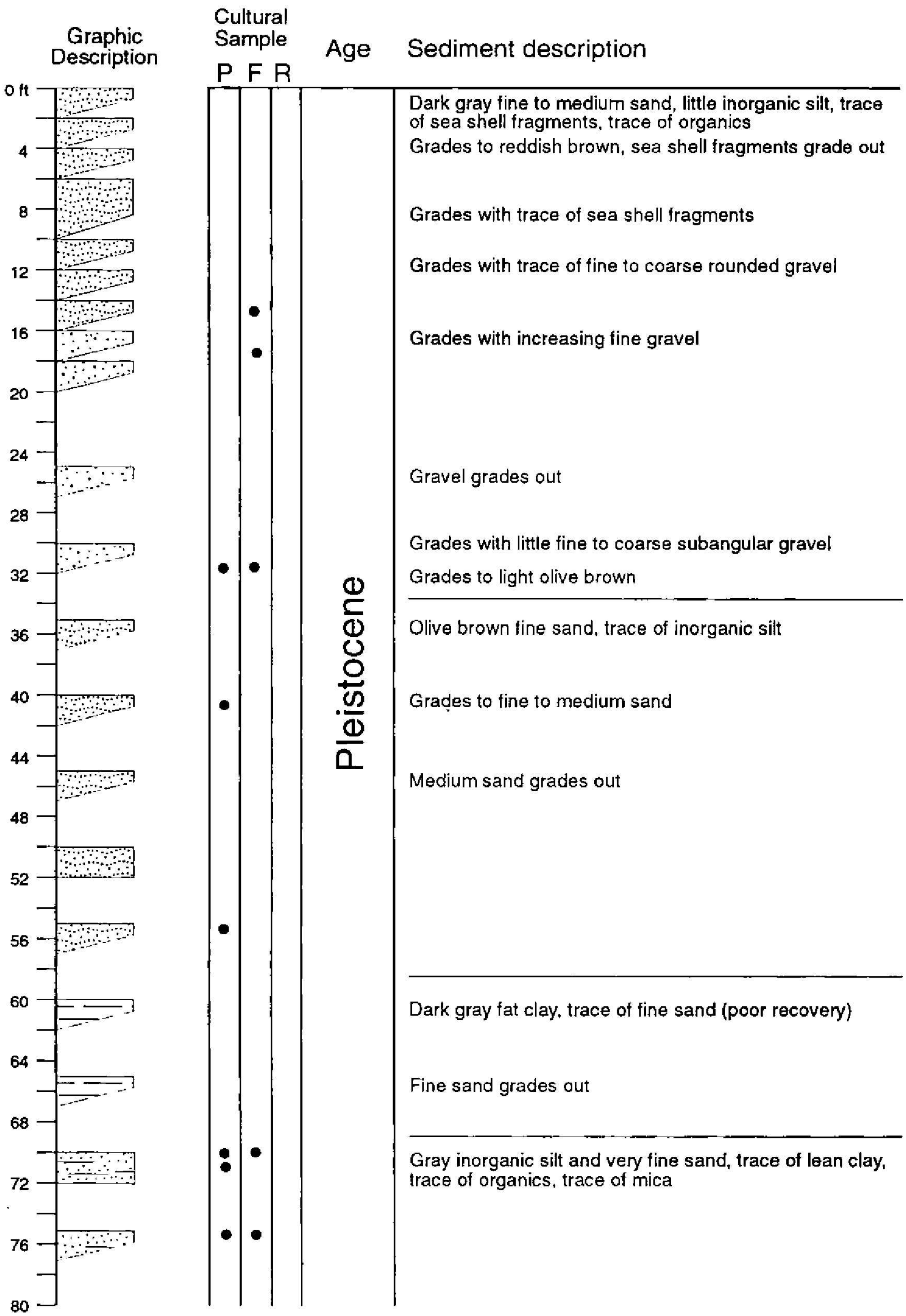
Age: Pleistocene

Sediment description

Yellowish brown fine sand, trace inorganic silt

(Boring completed at 105 ft)

BV-252 Zone 2 Lat. 40.529167° Lon. -74.066389°



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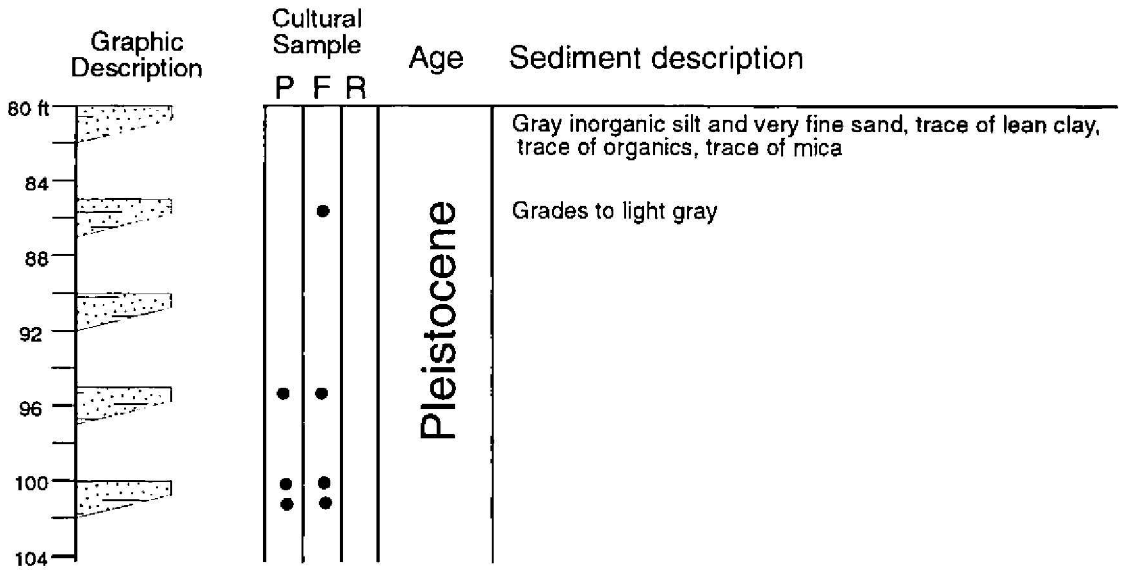
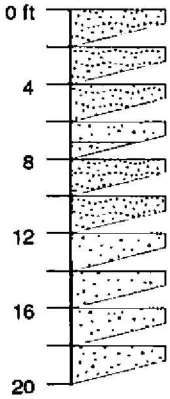
BV-252 Zone 2 Lat. 40.529167˚ Lon. -74.066389˚ (cont.)



(Boring completed at 102 ft)

BV-253 Zone 2 Lat. 40.512500° Lon. -74.079722°

Graphic Description



Cultural Sample P	F	R	Age	Sediment description
			Pleistocene	Brown fine to medium sand, trace of silt, grades to dark gray with little sea shell fragments and organics Grades to dark brown with trace of sea shell fragments Grades to reddish brown, then dark brown
				Reddish brown fine to coarse sand, trace of fine subrounded gravel Yellowish red fine to medium sand, trace of inorganic silt Grades with trace of fine rounded gravel
				Yellowish red fine to coarse sand, little inorganic silt, trace of fine rounded gravel Grades to reddish brown, increasing inorganic silt

(Boring completed at 20 ft)

APPENDIX 4

Palynology Studies of Marine Sediments from the Hudson-Raritan Estuarine System

by

Vaughn M. Bryant, Jr.
John Jones
Dawn Marshall
and
Melanie Glees

Palynology Laboratory
Texas A&M University
College Station, Texas

(Original report reproduced in its entirety. Note that original appendices 1, 2 and 3 are now consecutively numbered following the text)

PALYNOLOGY STUDIES OF MARINE SEDIMENTS FROM THE HUDSON-RARITAN ESTUARINE SYSTEM

by

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Dawn Marshall
and
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Palynology Laboratory
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College Station, Texas 77843-4352

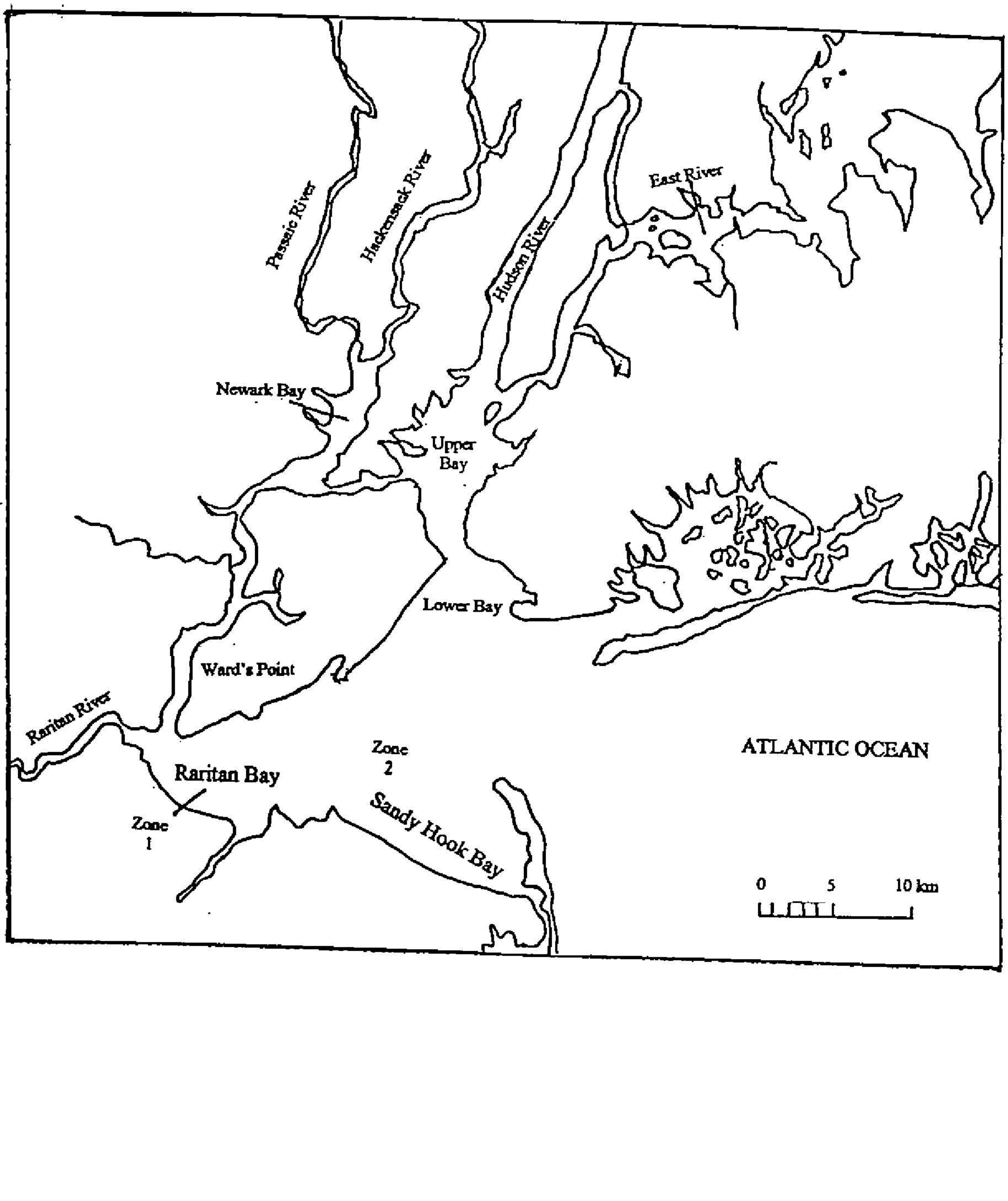
June, 1998

Palynological Study of the Hudson-Raritan Estuarine System

INTRODUCTION

As part of the New York District's Dredged Material Management Plan, 74 sediment samples were collected from 16 ocean cores located in the Hudson-Raritan estuarine system for pollen analysis. Of the 74 samples, only four indicated good to excellent preservation of late Pleistocene and Holocene pollen. These four samples had moderate to high fossil pollen concentration values and little to no reworked Tertiary or Cretaceous palynomorphs (pollen and spores). The majority of the remaining 70 samples contained either low concentrations of pollen, poor preservation of late Pleistocene and Holocene pollen, and/or significant amounts of reworked Tertiary and Cretaceous pollen and spores. All of the cores sampled were located either in riverine or estuary embayment environments and included the following areas: Newark Bay, Hudson River, Upper and Lower Bay, Raritan Bay and Sandy Hook Bay (see Figure 1). The sediments of the area consist of an outwash glacial till end moraine north of the study area with upper Cretaceous formations to the south and east. Changes in sea level, bay currents, river erosion, wind and weather patterns have all been factors causing the Cretaceous sand deposit to erode into the Raritan embayment carrying pollen that is then re-deposited into the more recent deposits as they form. During the Holocene, glacial till from the Wisconsin glaciation was eroded into the incipient rivers and those deposits, along with reworked fossil pollen and spores, were carried to the coastline and then into the bay. This continues today.

Figure 1. Map of the Hudson-Raritan estuarine system (taken from Bokuniewicz 1988).



GEOLOGY

A brief description of the geology of the area we are studying is outlined by Bokuniewicz (1988). The relevant portions of that report, as it relates to the fossil pollen record, consist of a description of the sediments of the bay floors and the nearby Cretaceous sands to the south and the Pleistocene tills to the north. The sampled area is considered an estuary or a coastal embayment which by definition is an area with a submerged unglaciated river valley that was inundated with seawater as the oceans advanced during times of sea level rise (Waters 1992: p.255). The Bay floors of the Raritan, Lower Bay, and Sandy Hook Bay consist of a mixture of muds and sands, as described by Nagel (1967), and are reflected in the sediments of the retrieved cores that we examined for fossil pollen. Muds and/or fine-grained silts and clays are found in those areas of lower energy in Raritan and Sandy Hook Bays. In the Lower Bay, sands dominate except where several barrow mud pits exist as a result of sand mining operations from the 1950's (Bokuniewicz 1988: p.53). In general, during and immediately after the end of the Wisconsin glacial period, coarser-grained outwash sediments tended to be deposited closer to shore, while the finer-grained clays and silts were washed further off shore (Waters 1992: p.122). South of the mud deposit, which currently extends from Raritan Bay to Sandy Hook Bay, lies another large sand deposit. The origin of these sand deposits appears to be eroding materials from the Cretaceous formations along the New Jersey shoreline. We suspect that these sands, and the Cretaceous pollen and spores they contain, represent the source of much of the reworked Cretaceous pollen and spores we found during the analysis of most of the samples we examined.

REWORKED PALYNOMORPHS

The Upper Cretaceous extends from 96 million years ago to 66.5 million years ago and includes the Cenomanian, Turonian, Coniacian, Santonian, Campanian and Masstrichtian stages. It is estimated that in what is now eastern North America the Cretaceous was a time of higher sea levels, with dry - warm to temperate climactic conditions. Many of the continents, as we know them today, were still connected and clustered together during the early part of the Upper Cretaceous until around 95 million years ago when the separation of Africa and South America became complete (Berggren 1982: p.124).

Pollen analysis from the Cretaceous period tends to be problematic, especially when it is used to attempt to correlate vegetational and climatic conditions over large regions of the landscape and when used to identify the origin and evolutional changes of the angiosperms. During the Upper Cretaceous several angiosperm groups have been identified for the Northern Hemisphere. Of these, the Normapolles group is of the most importance related to the reworked pollen and spores encountered during our present study (Vakhrameev 1991: p.234). The first major genera in this group appears in the middle to late Cenomanian in Bohemia and the Atlantic coast region of North America. Towards the end of the Cretaceous, these early types diversified into other genera including: *Choanopollenites*, *Minorpollis*, *Osculapollis*, *Plicapollis*, and *Pseudoplicapollis*. Although similar, there does seem to be some taxonomic differences in the vegetational composition between the North Atlantic coastal regions and areas further to the south (Vakhrameev 1991: p.234).

During our analysis we also found reworked Tertiary pollen types that are now extant; however, in general the occurrence of these Tertiary pollen types was rare.

The Quaternary deposits cover approximately the last two million years with the Pleistocene covering all but the last 10,000 years. The final period, the Holocene, began approximately 10,000 years ago.

FOSSIL PALYNOMORPHS

Palynomorphs are deposited and accumulate with eolian materials to form sediments that become part of the geologic record (Bradley 1985: p. 308). Because palynomorphs are formed from highly resistant organic materials, they generally preserve well and have been recovered in a variety of depositional settings including: terrestrial, lacustrine, and marine deposits. There are many important mechanisms that affect the deposition of modern pollen assemblages. For example, studies show that essential aspects of modern palynomorph deposition include pollen production, dispersion patterns, mode of deposition, and the environment of deposition.

Numerous studies of pollen dispersion, also known as the "pollen rain," have been carried out in various regions of the world. Some of the more important studies include those by Wright (1967), and Delacourt (1989). These studies note that some of the more important aspects that influence pollen dispersion include the size and mass of pollen grains, pollen surface ornamentation, grain morphology, the quantity of pollen produced, and the mode of dispersion (wind or insect). Insect-dispersed pollen types are limited to certain groups of angiosperms, and in general it is such an efficient mode of pollen dispersion that plants need to produce only very limited numbers of pollen grains. Thus, the low pollen production of these plants, coupled with their insect mode of dispersal, results in very little of these pollen types being dispersed into the atmosphere and thus deposited in the geologic record. One result of these low levels of production is that insect-pollinated flora is usually underrepresented in most fossil pollen assemblages.

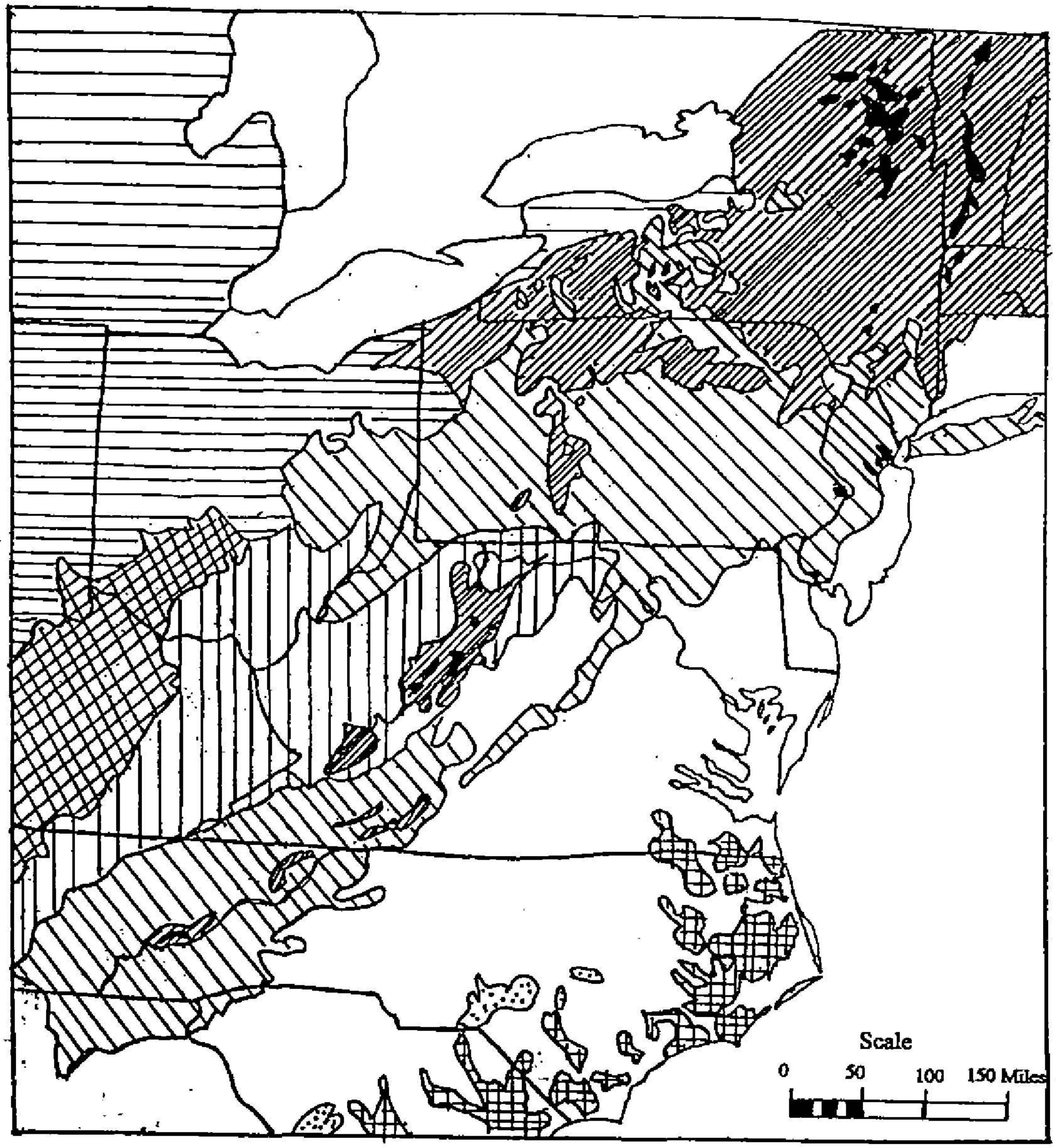
The majority of the fossil pollen recovered in any sedimentary environment comes from those plants that rely upon the wind to disperse their pollen. Wind dispersion is very inefficient; thus plants that rely upon this method of pollination may produce large amounts of pollen to ensure that pollination will occur. However, not all windborne pollen is the same size or shape and not all windborne types are produced in the same amount by the parent plants. Therefore, before a fossil pollen record can be correctly interpreted, one must have a clear understanding of the relationship between the morphological characteristics of each wind-dispersed pollen type and how those grains will be dispersed from their source. The final data interpretation becomes even more complicated because one must also be able to adjust for dispersion factors resulting from wind velocity, wind direction, topography, and the density of vegetation (Wright 1953; Tauber 1965; Janssen 1966; Shaw *et al.* 1980; Niklas 1985; Crane 1986; and Traverse 1994). For example, studies show that each wind-dispersed pollen type has a slightly different "sinking speed", or rate at which it will fall to the ground in still air. The sinking speed, combined with the direction and force of the wind will determine the potential distance that pollen will travel from its source before it is deposited. Many of these same factors also affect pollen that is deposited into water sources. In water a pollen grain's mass and its wetability become factors that determine how far it can travel on the surface of water before it sinks, and once it sinks these same factors will become important factors that determine how far the pollen will travel in water currents before it will settle and become part of a marine deposit. Light weight pollen grains that are small or have bladders (i.e., conifers) can often travel on the surface of water for weeks or months. If pollen is a wind-dispersed pollen type, then factors of wind velocity, direction, topography, and vegetation cover become important. For example, when a pollen grain becomes airborne, it can be carried over the vegetation (canopy component), through the vegetation (trunk component), or it can be removed from the atmosphere by precipitation (rain component) (Tauber 1965). One must recognize that long-distance transport of pollen grains occurs and that the presence of certain pollen grains in a deposit does not necessarily reflect its presence in the actual plant in the local vegetational composition.

MODERN VEGETATION

Broadly speaking, the modern vegetation of the eastern United States consists of 1) northern hardwood forests north and west of the study area; 2) an Appalachian oak forest to the southwest and in the study area; 3) an oak, hickory, and pine forest and a mixed deciduous forest south of the study area; and 4) a beech-maple forest and a mixed mesophytic forest with a small area of spruce and fir southwest of the study area (Figure 2).

At 18,000 yr. BP the Wisconsin glacier was at its maximum and covered the northern half of the study area (Figure 3). The vegetation cover at that time in the unglaciated areas of New Jersey consisted mainly of tundra that included sedges (Cyperaceae), grasses (Poaceae), ericads (*Ericaceae*), alder (*Alnus*), birch (*Betula*), and dwarf conifers (*Picea*). The area of tundra extended down the central Appalachian Mountains where cold-adapted grasses and small shrubs dominated the ecotonal regions near the tundra and regions immediately south of the glacial front (Watts 1979: p.427). As the Wisconsin glacial maximum came to a close and began to recede (15,000-13,000 BP),

Figure 2 Modern vegetation of the eastern United States (taken from Watts 1979



Spruce-Fir Forest

Northern Hardwoods

Apallachian Oak Forest

Beech-Maple Forest

Oak-Hickory Forest

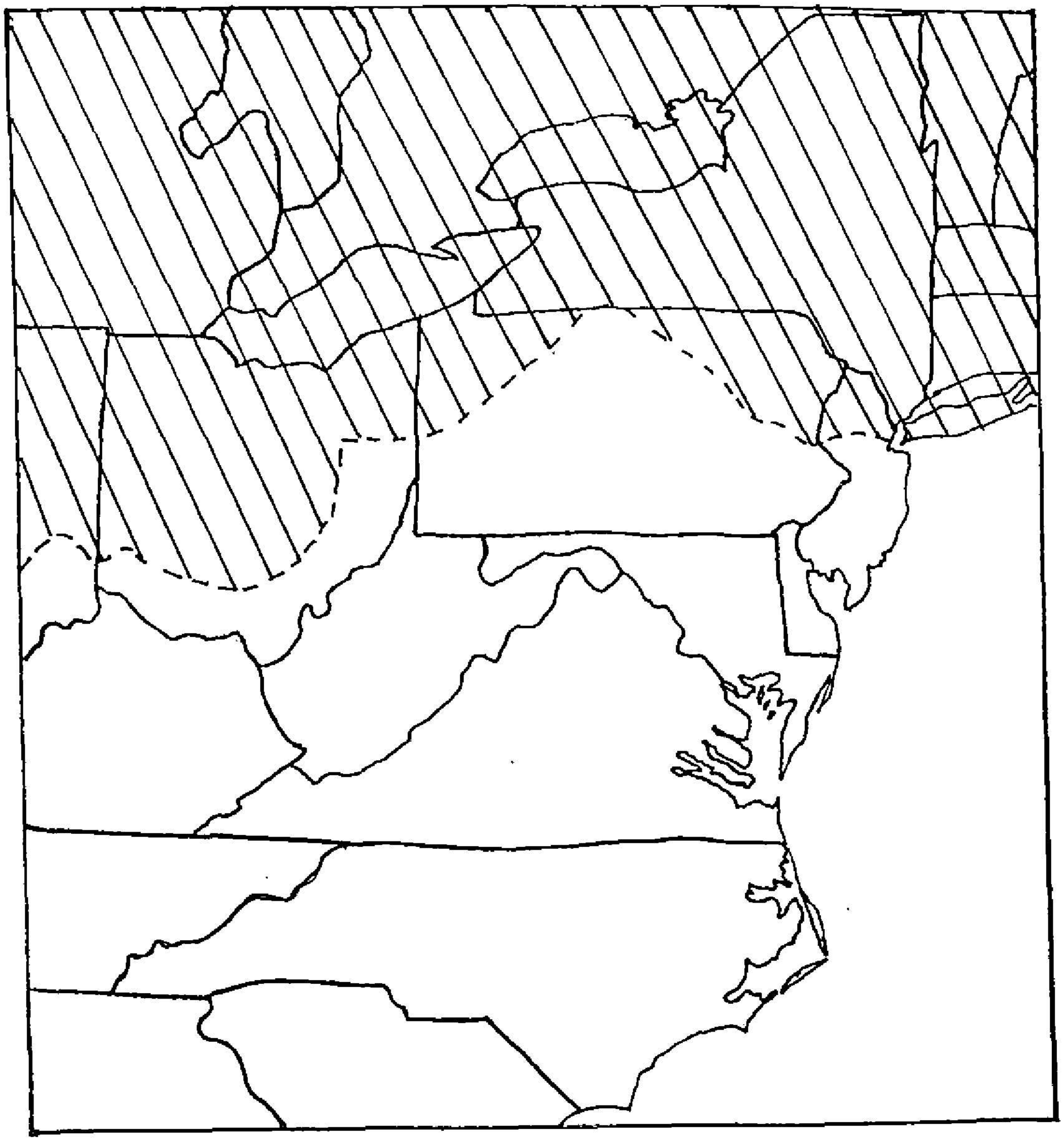
Mixed Mesophytic Forest

Southern Mixed Forest

Southern Floodplain Forest

Oak-Hickory-Pine Forest

Figure 3. Glacial maximum of the Laurentide ice sheet at 18,000 years B.P.(taken from Watts 1979).



the climate warmed. Birch (*Betula glandulosa*), and spruce (*Picea*) were among the first plant invaders into the newly exposed unglaciated areas. By 13,000 yr. BP the warming trend had increased the diversity of vegetation in the northeastern United States and now included invading species of pine (*Pinus baksiana*), fir (*Abies balsamea*), birch (*Betula populifolia*), and alder (*Alnus cf. rugosa*) (Watts 1979). Later, other serial species invaded the region including hemlock (*Tsuga*), chestnut (*Castanea*), and oak (*Quercus*).

In a pollen study of Roger's Pond, located in Connecticut, Davis (1967) reported finding low pollen deposition rates in sediments dated between 14,000-12,000 BP, indicating the presence of a tundra environment. By 12,000 years ago, the pollen composition of Roger's Pond changed and showed an increase in arboreal pollen types, suggesting the region was now being invaded by forest elements. At 9,000 BP, the region around Roger's Pond consisted of a mixed deciduous-coniferous forest and was reflected by the pollen record showing increases in the percentages of pine (*Pinus*) pollen, hemlock (*Tsuga*) pollen, poplar (*Populus*) pollen, oak (*Quercus*) pollen, and maple (*Acer*) pollen. Davis' study indicates that the percentages of pine pollen decreased around 8,000 BP, suggesting that pines were losing their dominance in the region and were being replaced by deciduous types. Two thousand years later Beech (*Fagus*) pollen becomes one of the important fossil markers (6,500 BP), followed by increases in hickory (*Carya*) pollen at 5,500 BP, and then chestnut (*Castanea*) pollen by 2,000 years ago (Davis 1967: p.409).

METHODOLOGY

Cores from Newark Bay, Hudson River, Upper Bay, East River, East Raritan Bay and Central Raritan Bay in the New York estuarine system were collected, using various coring methods. These cores were then sampled and sent to the Texas A&M Palynological Lab for fossil pollen studies (Table 1). We received a total of 74 samples for processing and analysis. The provenience of each sample is listed in Table 2. All samples were similar in sedimentary composition except for sample #74 that consisted of peat.

Each sample was placed in a 50 (cc) Nalgene test tube. For quantification purposes we added two tablets of *Lycopodium* spores, each containing 13,500±400 spores (Stockmarr 1971). *Lycopodium* is a fern and its spores are often used as an exotic marker in fossil pollen studies. By using an exotic marker type we are able to examine these spores throughout each step of the processing procedure to determine if any fossil pollen or marker spores are being damaged by the various chemicals we use. Later, we are able to use the tracer spores to determine a ratio between them and the fossil pollen and thus determine the fossil pollen concentration values for each sample. Concentration values are expressed as the number of pollen grains found per gram or per cubic centimeter of sample.

We added concentrated hydrochloric acid (HCl) to each sample to eliminate carbonates. Each sample was then sieved through a 150 micron mesh screen with distilled water. When present, silica in the form of sand was removed using the swirling method (Funkhouser and Evitt 1959). Once swirling was completed, the heavier silica particles settled quickly leaving the finer-grained particles and pollen in suspension (the liquid portion was saved and concentrated by centrifugation

Table 1

CORRESPONDING SAMPLE NUMBERS

A&M Sample Number	Core	Sample Number
1	B-4	12
2	B-4	13
3	B-4	14
4	B-5	15
5	B-5	19
6	B-5	23
7	B-6	14
8	B-6	15
9	B-6	19
10	B-6	20
11	B-106	11
12	B-106	13
13	B-106	16
14	B-106	17
15	B-106	19
16	B-106	21
17	B-106	24
18	B-106	25
19	B-8	12
20	B-8	15
21	B-8	17
22	B-8	19
23	B-8	21
24	B-13	6
25	B-13	8
26	B-13	11
27	B-13	12
28	B-13	13
29	B-13	15
30	B-13	21
31	B-110	8
32	B-110	14
33	B-110	16
34	B-110	22
35	B-112	12
36	B-112	14
37	B-111	15

A&M Sample Number	Core	Sample Number
38	B-112	21
39	B-112	22
40	BV252	14
41	BV252	17
42	BV252	20
43	BV252	21
44	BV252	25
45	B-110	Y1288
46	B-106	Y1287
47	B-13	Y1292
48	BV252	Y1280
49	B-6	Y1239
50	B-110	Y1289
51	*	Y1295
52	BV252	Y1278
53	BV252	Y1281
54	*	Y1298
55	BV252	Y1279
56	*	Y1296
57	*	Y1297
58	B-113	11
59	B-113	14
60	B-113	17
61	B-3	20
62	B-3	17
63	B-3	18
64	B-111	19
65	B-111	17
66	B-111	12
67	BV251	12
68	BV251	18
69	BV251	22
70	BV251	19
71	BV251	15
72	B-1	16
73	B-1	18
74	WP-V1	S-0

* Core designation not known

Table 2

Samples containing only Cretaceous reworked pollen grains

A&M Sample Number	Core	Sample Number
14	B-106	17
15	B-106	19
16	B-106	21
17	B-106	24
20	B-8	15
21	B-8	17
22	B-8	19
23	B-8	21
33	B-110	16
34	B-110	22
37	B-111	15
38	B-112	21
39	B-112	22
42	BV252	20
43	BV252	21
44	BV252	25
45	B-110	Y1288
46	B-106	Y1287
48	BV252	Y1280
50	B-110	Y1289
53	BV252	Y1281
54	*	Y1298
55	BV252	Y1279
56	*	Y1296
57	*	Y1297
58	B-113	11
59	B-113	14
60	B-113	17

* Core designation not known

using 50cc Nalgene test tubes.) After swirling, each sample was defloculated. Defloculation was followed by an overnight (approximately 12 hours) immersion in a solution of 60% hydrofluoric acid (HF) to remove any remaining silicates. After the addition of HF the samples were rinsed with distilled water, centrifuged, decanted and vortexed until the acidity in the sample was neutralized. Next the samples were sonicated for 20 seconds to disaggregate any remaining silts from the pollen grains. Sonication can occasionally be harmful to fossil pollen if done incorrectly, yet our procedure uses a Delta D-5 sonicator especially designed for pollen work. After sonication, we added 1% potassium hydroxide (KOH) to each sample to reduce the excess organic material which includes humates other than pollen. The samples were then reacidified using dilute (10%) HCl acid. This step is used to ensure that suspended pollen will settle properly during the remaining steps of processing. Next, each sample was centrifuged again, decanted and vortexed. We removed organic materials other than pollen with acetolysis (Erdtman 1960). Before we performed this step it was necessary to remove any water in the sample, so they were washed with glacial acetic acid. Acetolysis is an esterification process that removes extraneous organic matter but does not injure pollen.

Because silicates were endemic in each sample, swirling and HF were not able to remove all of the silica. Thus, to remove the remaining silicates, we used a heavy-density separation technique. We have found that zinc bromide ($ZnBr_2$) with a specific gravity of 2.00 is an excellent way to separate remaining fine-grained silicates and metals from samples (Funkhouser and Evitt 1959). Once the heavy-density separation process was completed, the remaining material in each sample was washed, centrifuged, decanted, vortexed, and placed in 2 dram glass vials. Glycerin was added as a mounting media.

Slides of each sample were prepared and counted. We attempted to count a minimum of 200 fossil pollen grains of Quaternary types for each sample as is recommended for statistical validity (Barkely 1934; Godwin 1934). Unfortunately, we discovered that for most of the samples, poor preservation of Quaternary pollen, low pollen concentration values, and a dominance of reworked fossil pollen made our task difficult. All pollen counting was done using a Jenna microscope at 400x and 1000x magnification.

ANALYSIS

The identification of pollen and spores in this study was based on comparisons with reference books and with reference slides in our extensive modern pollen collections at Texas A&M University. A list of all Quaternary pollen found during our analysis is listed in Appendix 1. During the analysis we noted if pollen grains were whole or partial fragments of grains. Pine pollen, which contains a body and two large bladders that frequently detach during deposition, were counted as a whole grain if the body contained at least one bladder. Individual bladders were counted as one-half a grain. All other pollen grains were counted as whole grains if they were distinguishable and had at least one-half or more of the grain visible. When we found fossil pollen grains that were not distinguishable, either because they were badly broken or damaged, or because they had become badly oxidized and degraded, we assigned them to the indeterminate category as recommended by Cushing (1967). Pollen grains that were whole but not identifiable were included in the total pollen count as unknowns. Pollen grain fragments smaller than one-half of the original grain was not counted except in the case of pine.

In the northeastern United States a number of airborne pollen types are similar in size and are inaperturate (having no openings in the wall of the pollen grain). These come mostly from gymnosperms and are usually designated by the initials TCT. Included in the TCT group are species of Cedar (*Taxodium*), Cypress (*Thuja*), and Juniper (*Juniperus*). The TCT group consist of fragile pollen types, and studies show that these grains are often subject to degradation at a faster rate than many other pollen types. Thus, due to the rapid degradation and lack of distinguishable characteristics, most of these grains are difficult to separate into precise genera and, therefore, are lumped into a single category called TCT.

Pollen coming from taxa in the family Chenopodiaceae and the genus *Amaranthus* all appear very similar in morphology and are nearly impossible to distinguish from one another at the genus level. Thus, they are similar to the TCT category in that they are lumped into a single group called Cheno-Ams.

All of the pollen types in the sedge family (Cyperaceae) and grass family (Poaceae) each look quite similar to one another; thus pollen in each of these families is generally identified only to the family level. Likewise, many of the pollen taxa in the composite family (Asteraceae) appear very similar in shape and morphology. As such, most are often lumped into the general category of Asteraceae, except for the taxon *Artemisia* and composites in the tribe Chichoreae which have a distinctive fenestrate morphology.

RESULTS

The majority of the sediments in the core samples we examined appear to represent sediments that have been reworked. We suspect that the source of these reworked sediments is from outwash filling, redeposit of dredged materials, or inflow of pollen from eroding Mesozoic and Tertiary sediments along shorelines and rivers that flow into the bay. The majority of the samples we examined contain reworked pollen taxa that originated from much earlier time periods and have no bearing on the reconstruction of vegetational sequences from late Quaternary. Only a few samples we examined that had no reworked Cretaceous or Tertiary fossil pollen are deemed to have any confidence for use in trying to reconstruct environmental sequences for any portion of the Late Pleistocene or Holocene periods.

To aid in the interpretation of these samples, we have selected to describe the samples we examined as units for each of the cores we received. These descriptions are listed below. Each sample is also described in Appendix 1.

Core B-1

Texas A&M Sample Numbers 72 & 73 (D&M corresponding sample numbers – 16 & 18): This core was taken from the Hudson River. **Sample Size**: Sediments consisted of a gray clay. We determined that 2cc of sediment was needed for processing from each of these samples. **Preservation**: Preservation of pollen ranged from very good at the 50-52 ft level to good at the 60-62 ft level. **Concentration of Quaternary Pollen**: Concentration values ranged from 4,972 pollen grains/cc for sample #72 to 7,698 pollen grains/cc in sample #73. However, these levels represent marginal Quaternary pollen concentration values for the region and we suspect differential pollen preservation may have occurred; thus any results derived from these samples are suspect. **Pollen Counts**: Both samples produced a minimum count of 200 grains with only sample #73 containing any reworked Cretaceous grains.

Core B-3

Texas A&M Sample Numbers 61, 62, & 63 (D&M corresponding numbers, respectively - 20, 17, & 18). This core was taken from the Hudson River. **Sample Size**: The sediments consisted of gray, silty/clay with fine-grained sand. From samples 62 and 63 we used 2cc of sediment for processing. In sample 61 the amount of sediment processed was 3cc. **Preservation:** Preservation varied from very good to variable. In sample 61 the preservation was very good and contained a few Cretaceous reworked pollen grains. Sample 62 yielded variable preservation and also contained a few reworked Cretaceous pollen grains. Sample 63 had good preservation and was the only sample that did not contain reworked Cretaceous pollen. Sample 63 also had the highest pollen concentration value in this core. **Concentration of Quaternary Pollen:** None of the samples from this core yielded excellent concentration values of Quaternary pollen. Each sample did contain moderate concentrations of Quaternary pollen. The pollen concentration ranged from 4,300 pollen grains/cc for sample 61, to 6,600 pollen grains/cc for sample 62, and 7,087 pollen grains/cc for sample 63. The sample with the highest confidence levels of Quaternary pollen is sample 63. It contained no reworked Mesozoic pollen grains. In sample 63 oak (*Quercus*) pollen comprises 42.9% of the sample. Second in value was pine pollen with 18.2%. **Pollen Counts:** All samples yielded a count of at least 200 fossil pollen grains.

Core B-4

Texas A&M Sample Numbers 1, 2, & 3 (Dames and Moore's samples 12,13, and 14). These samples were collected as part of Core B-4 The core came from the Upper Bay region at Constable Hook. **Sample Size:** For each of the samples from this core, 5cc of sediment was measured out and processed. These samples consisted mainly of silty, clay sediments that ranged from a light red clay to a light red-gray clay. **Preservation:** In the preliminary evaluation of this core we estimated a low concentration of fossil pollen. Later, during the complete analysis stage, we determined that the preservation was very good even though the concentration values remained low. We suspect that the low concentration values resulted from rapid sedimentation deposition or resulted from many of the lighter pollen grains being carried away by water currents, leaving behind only a fraction of the total pollen load in the water. **Concentration of Quaternary Pollen:** All of the samples from this core contain reworked pollen. We suspect that the reworked fossil pollen probably originated from nearby Cretaceous deposits. Because this core is not located near the Raritan embayment, where a primary source of suspected reworked pollen from the Upper Cretaceous material is found, we are not sure of the precise source of reworked pollen in this sample. Perhaps the reworked pollen may have been carried by another water source flowing into this area such as the Hudson or East Rivers, or from reworked pollen carried in suspension to this area by offshore water currents. Overall pollen concentration values were very low and ranged from 560 pollen grains/cc to 1,085 pollen grains/cc. These are marginal concentration levels at best and may reflect rapid deposition, swift currents, rapid pollen degradation, or low pollen dispersion rates from nearby onshore vegetation. **Pollen Counts:** A 200 grain count of Quaternary pollen types was achieved for all of the samples from this core.

Core B-5

Texas A&M Sample Numbers 15, 19, & 23 *(D&M corresponding sample numbers - 15, 19, & 23)*: This core was taken from Newark Bay. **Sample Size:** The sediment in these samples was a fine sand/silt. As a result, only 5cc of material was needed for processing each sample. **Preservation:** Only sample #5 (D&M #19) had good pollen preservation. This sample was collected at a reported depth of 60-62 ft and is bracketed on either side by the other two samples we examined from this core. **Concentration of Quaternary Pollen:** Although we were able to determine a concentration value for the Quaternary pollen types encountered, the concentration value was very low suggesting possible rapid deposition, significant degradation, or removal of palynomorph materials by swift-moving water currents. **Pollen Counts:** Sample #4 was the only sample for which we were able to obtain a 200 grain pollen count of Quaternary taxa. Minimal amounts of reworked Cretaceous palynomorphs appeared in sample # 4.

Core B-6

Texas A&M Sample Numbers 7, 8, 9, 10, & 49 (D&M corresponding sample numbers - 14, 15, 19, 20, & Y1239): This core was taken from the East River in Bowery Bay. **Sample Size:** The sediments showed a transition from the top to the bottom of a dark brown sandy/silt to a gray clay sandy/silt. The sand granules in the bottommost sample also increased in size. For sample #49 (D&M Y1239) 8cc of sediment was processed. For the remaining samples we deemed that only 5cc of sediment was needed for processing. We suspect that the increase in sand granule size at the bottom (sample #10) indicates a faster deposition rate and a swifter moving current when it was deposited. This assumption is supported by our finding no pollen in the sample. **Preservation:** Preservation ranged from poor to excellent. Preservation was the poorest in sample #10, which yielded no pollen. The remaining samples differed in preservation and concentration values as follows: #7 - poor preservation and marginal pollen concentration; #8 - fair to good preservation and marginal pollen concentration (nevertheless, we were able to derive a 200 grain pollen count); sample #49 - good preservation and marginal pollen concentration. Sample #9 (D&M Y1239) was the only sample that exhibited both excellent preservation and a good pollen concentration value. **Concentration of Quaternary Pollen:** The concentration of Quaternary pollen was not exceptional in sample #9; nevertheless, it did yield a concentration value of 11,382 pollen grains/cc of sediment. The highest percentage of Quaternary pollen found in that sample is oak at 29.8 %. Alder (*Alnus*) pollen was second at 13 %, followed by beech (*Fagus*) at 11.6 % and grass pollen at 11.2%. **Pollen Counts:** Overall, the composition of pollen in these samples appears to come from the Quaternary period and may represent original deposition because we found no evidence of reworked pollen from Cretaceous deposits, as was common in other samples.

Core B-8

Texas A&M Sample Numbers 19, 20, 21, 22,& 23 (D&M corresponding sample numbers – 12, 15, 17, 19, & 21). These samples came from zone 1 in Raritan Bay. **Sample size:** These samples consisted of a sand/clay fill that ranged from a mottled light to dark gray. Depending on the ratio of sand to clay, 2cc to 10cc of sediment was measured and processed for each sample. **Preservation:** During our preliminary examination of these samples we assumed that the preservation varied from low to high because we were recovering moderate to high amounts of fossil pollen. Nevertheless, during our later analysis phase, we realized that the preservation was poor because most of the fossil pollen we found is reworked pollen from earlier time periods. Most of the recovered pollen in these samples represent grains that appear to be re-deposited in this location by outwash filling, dredging, or from materials carried to the location by water current activity. **Concentration of Quaternary pollen:** We were unable to assign a precise Quaternary pollen concentration value to any of these samples because each sample contained so many reworked pollen taxa. Even though we found many fossil types that could be considered of possible Quaternary origin, the presence of so many reworked pollen grains leads us to suspect that most, if not all, of the possible Quaternary pollen might actually be from nearby eroded Tertiary deposits. Unfortunately, many of the conifer and angiosperm pollen types we found in these deposits have changed very little in shape or form during the Quaternary period. Therefore, it is nearly impossible to distinguish, with any degree of accuracy, which fossil grains may have come from the Tertiary and which are solely Quaternary in origin. Normally, this would not be a problem because one would know that the examined sediments were solely from one time period. However, because these samples also contained a number of reworked Cretaceous pollen and spore types we suspect that these sediments may be entirely reworked materials. **Pollen counts:** Although we believe these samples contain mostly or entirely reworked fossil pollen, we did examine each sample and we have included a listing of some of the major reworked pollen taxa we found in Appendix 3.

Core B-13

Texas A&M Sample Numbers 24, 25, 26, 27, 28, 29, 30 & 47 (D&M corresponding numbers, respectively - 6,8,11,12,13,15,21, & Y1292). This core was collected from Ward's Point in the Raritan Bay. **Sample Size:** The amount of sediment taken from each of these samples varied from 1cc to 5cc. The sediments tended to be uniform in these samples and consisted of a dark to medium gray silt/clay. **Preservation:** Sample 24 - very good; sample 25 - very good to excellent; Sample 26 - Excellent; Sample 27 - very good; Sample 28 - very good; Sample 29 - very good; Sample 30 - poor to fair; Sample 47 - very good. We believe that almost all of the pollen in these samples come mainly of Quaternary sources because unlike many of the other cores, this core contained very little evidence of reworked Cretaceous pollen grains. **Concentration of Quaternary Pollen:** Samples 28 and 47 have no Cretaceous reworked pollen and are deemed the most reliable samples from this core. Sample 47 had a Quaternary pollen concentration value of 24,700 pollen grains/cc and reflects a good concentration value for a marine deposit. Sample 28 has an even higher concentration value of 121,263 pollen grains/cc of sediment, which is exceptional for a marine deposit The primary pollen type recovered in sample 47 was oak at 28.7%, followed by spruce pollen at 27.1%, and pine pollen with 9.7%. In sample 28 the highest pollen values come from pine at 40.6%, followed by oak at 19.5%, and composite pollen at 9.8%. **Pollen Counts:** All samples yielded a minimum 200 grain count.

B-106

Texas A&M Sample Numbers 11, 12, 13, 14, 15, 16, 17, 18 & 46 (D&M corresponding numbers, respectively - 11, 13, 16, 17, 19, 21, 24, 25, Y1287). This core was collected from Zone 1 in Raritan Bay. **Sample Size:** The sediment ranges from a dark to medium gray silt/clay. **Preservation:** Preservation ranged from poor to excellent; however, only sample 11 had excellent preservation with a good pollen concentration value. Unfortunately, our confidence in the data, even from this sample, is not high because the sample contained reworked Cretaceous pollen suggesting a mixed deposition. All of the other samples from this core also contain significant levels of Cretaceous pollen and each sample has either no or very few pollen grains that are of Quaternary origin. **Concentration of Quaternary Pollen:** The pollen concentration value for sample 11 was 17,232 pollen grains/cc of sediment. We were unable to assign a Quaternary pollen concentration value to any of these samples because many of the recovered pollen grains represent taxa that have changed very little from the Tertiary through the Quaternary time periods and thus could be reworked material. As such, it is nearly impossible to distinguish, with any degree of accuracy, which fossil grains come from each time period. In addition, because these samples also contained a number of reworked Cretaceous pollen and spore types, we remain fairly convinced that these sediments all represent reworked material rather than original deposits. **Pollen Counts**: Samples 11,12, & 18 yielded a minimum of 200 grains.

Core B-110

Texas A&M Sample Numbers: 31, 32, 33, 34, 45, & 50 (D&M corresponding numbers respectively - 8, 14, 16, 22, Y1288, & Y1289). This core was taken from Raritan Bay in the Zone 1 area. **Sample Size:** The sediments from this core range from a gray clay in sample 31 at the top of the column at a depth of 45 ft to silts and sands in other samples nearer the bottom. Sample 32 is the next sample in depth and came from the 47 ft level. It consists of a light gray silt with fine-grained sand. At a depth of 57 ft sample 33 has a light gray coloring that is interspersed with black and orange lens and has a consistency of fine, silty clay. The composition of sample 34 is the same as sample 33. The final sample, number 50, consists of a black, sandy silt and comes from the 98 ft level. The amount of sediment used for our extraction ranged from 3cc to 10cc depending on the amount of silt and sand present in each sample. **Preservation:** The preservation of the pollen grains ranges from very good in sample 31 to poor in sample 32. The other four samples contained no Quaternary pollen and seem to consist entirely of reworked materials. **Concentration of Quaternary Pollen:** The pollen concentrations were very low and not considered high enough to represent statistically valid data. **Pollen Counts**: Only sample 31 yielded sufficient fossil pollen to obtain a minimum 200 grain count even though the concentration value was so low that the pollen data has a low degree of confidence.

Core B-111

Texas A&M Sample Numbers 37, 64, 65, & 66 (D&M corresponding numbers, respectively - 15, 19, 17 & 2). This core was taken from the central Lower Bay area in Zone 2. **Sample Size:** The sediments in this core were mostly of a coarse sand and silt mix. We deemed that from 5 to 20cc of sediment was needed for processing each sample. Unfortunately, we later found these samples are almost totally void of any fossil pollen. This absence may have resulted from very rapid sedimentation, severe pollen degradation and oxidation, or possible removal of pollen by swift-moving currents as the sediments were forming. **Preservation:**The pollen preservation in all of the samples was poor, adding further confirmation to our primary suspicion that the original pollen may have been oxidized. **Concentration of Quaternary Pollen:** No Quaternary pollen was found in this core so no concentration values could be determined. A few reworked Cretaceous pollen types were found but even these were minimal. **Pollen Counts**: None of the samples yielded a minimum 200 grain count.

Core B-112

Texas A&M Sample Numbers: 35, 36, 38, & 39 (D&M corresponding numbers, respectively - 12, 14, 21, & 22). **Sample Size:** This core was collected from the central Lower Bay area in Zone 2. The sediments in this core consisted mostly of a coarse sand and silt mix. **Preservation:** The pollen preservation for all of the samples was very poor. **Concentration of Quaternary Pollen**: Overall, these samples had a very low concentration of any pollen type. Absence of pollen in these deposits can be attributed to any of a number of possible causes including oxidation, rapid deposition, removal of pollen by swift-moving currents, etc. The presence of sand in these samples suggests rather rapid deposition in an area of high energy. Those two factors almost always result in marine deposits with little or no fossil pollen. Only two samples from this core contained any pollen that might have come from a Quaternary origin (samples 35 and 36). However, neither of these two samples produced either high concentration values or sufficient pollen to derive counts. **Pollen Counts:** None of the samples yielded a minimum 200 grain pollen count.

Core B-113

Texas A&M Sample Numbers: 58, 59, & 60 (D&M corresponding numbers, respectively - 11, 14, & 17). This core was collected from the Raritan Bay area in Zone 1. **Sample Size:** The sediments from this core ranged from a black clay at the 35-37 ft level, to dark gray, silty, fine-grained sand at the 55-57 and 70 ft levels. Since silt was present and the sand was fine-grained, we deemed that 2cc of sediment from each sample was sufficient for processing. **Preservation and Concentration of Quaternary Pollen and Pollen Count:** Overall, pollen preservation was very poor, concentration of Quaternary Pollen was nil, and we were unable to derive 200 grain pollen counts from any of the samples. Overall, we do not know the origin of these sediments because we found insufficient numbers of fossil pollen grains from Mesozoic, Tertiary, or Quaternary sources to derive a basis for a determination.

Core BV-251

Texas A&M Sample Numbers 67, 68, 69, 70, & 71 (D&M corresponding numbers, respectively - 12, 18, 22, 19, & 15). **Sample Size:** This core was collected from the central Lower Bay area in Zone 2. The sediments range from an orange, brown medium-grained sand containing tiny pebbles in sample 67, to a light to dark brown coarse-grained sand in the remaining samples. Because of the large granule size in these samples, we used 20cc of sediment for processing all samples. **Preservation:** The preservation ranged from very good in sample 67 collected at the 42-44 ft level, to various degrees of poor preservation for the remaining samples. We suspect that the poor preservation is mostly due to the area from which the core was collected. Zone 2 is virtually in the middle of the Lower Bay area, where sedimentation rates probably tend to be rapid and also where tides and current activity may play an active roll in moving pollen out of that area and into nearby shallower areas. The large size of the silica granules also suggests rather rapid sediment deposition. **Concentration of Quaternary Pollen:** The fossil pollen concentration values for deposits at this location are very low and indicate a low degree of confidence for any pollen data from this core. Reworked Cretaceous pollen was found in sample 67, indicating at least some contamination from an erosional source. **Pollen Counts:** None of the samples contained sufficient fossil pollen to yield a minimum count of 200 grains.

Core BV-252

Texas A&M Sample Numbers 40, 41, 42, 43, 44, 48, 52, 53, & 55 (D&M corresponding numbers, respectively - 14, 17, 20, 21, 25, Y1280, Y1278, Y1281, Y1279). This core was collected from the central Lower Bay area in Zone 2. **Sample Size:** The sediments begin at the 32 ft level with sample 52 characterized by coarse light-brown sands with tiny pebbles. Sample 40, collected at a depth of 40 ft, contained similar sediments with light gray sand and pebbles. These upper two samples are followed by sample 41 composed of medium to light-brown sand. Sample 42 had light-brown to gray fine-grained silty sand and came from a depth of 70 ft. At 75 ft, sample 43 contained medium gray fine-grained silty sand. Sample 44, at 95 ft, has similar sediments except that the color appears to be a lighter gray. This is also true for sample 48 at 100 ft--the color is a dark gray. The second sample in this core that was also taken at the 100 ft level is sample number 53. The sediments in that sample are similar in consistency with a medium gray to black color throughout. The amount of sediment we used from each sample during processing varied from 3cc to 10cc depending on the amount of silt and sand in each sample. **Preservation:** The fossil pollen preservation, similar to other samples collected from Zone 1 in this marine environment, is poor. **Concentration Quaternary Pollen:** Overall low fossil pollen concentration values confirm the very poor preservation environment of these deposits. None of the samples contained enough preserved fossil pollen to derive a minimal pollen count of 200 grains. **Pollen Counts:** No minimum counts of 200 were obtained due to the lack of pollen.

Core WP-V1

Texas A&M Sample Numbers 74 (D&M corresponding number - WP-V1). This sample was collected from Ward's Point in Raritan Bay. **Sample Size:** We examined only one sample from this core. The sedimentation consisted of a peat; thus only 1cc of material was needed for processing. Overall, peats are considered one of the best environments for the preservation of fossil pollen due to anaerobic conditions and the lack of reworked sediments. **Preservation:** The fossil pollen preservation in this sample is excellent. **Concentration of Quaternary Pollen:** The pollen concentration value for Quaternary pollen was moderate at 25,425 pollen grains/cc of sediment. The fossil pollen taxa in this sample, in order of percentage is: oak at 28.9%, grass at 28.3%, and composite pollen at 20.4%. **Pollen Counts:** The total number of Quaternary pollen grains counted in this sample was 226.

Unknown Core

Texas A&M Sample Numbers 51, 54, 56, & 57 (D&M corresponding numbers - Y1295, Y1298, Y1296, & Y1297). These samples were taken from Zone 2. However, we are not certain if all of these samples come from the same core. For the sake of reporting, we will assume that these did come from the same core. The sediments from this series of samples ranged from light-brown fine-grained sand in sample 51 at a depth of 30 ft to black to gray silty sand in samples 57 and 54 at 80.5 and 95 ft. We also found the same black sediments, with light-brown/orange silty clay, in sample 57 that came from a depth of 40-41 ft. **Sample Size:** Based on the sediment types, we deemed that

3 to 10cc of sediment would be needed for extraction for each sample. **Preservation:** The preservation overall was poor, even in the single sample (#51) that contained reworked fossil pollen. **Concentration of Quaternary Pollen:** Virtually no Quaternary pollen was recovered from any of these samples. **Pollen Counts:** None of the samples yielded a minimum count of 200 grains.

DISCUSSION

For all of the samples we examined, we attempted to conduct standard 200 grain fossil pollen counts. The reason palynologists rely upon a 200 grain pollen count is that its statistical accuracy in most situations has been confirmed (Barkley 1934; Martin 1963). Standard 200 grain counts exclude tracer spores, such as the *Lycopodium* marker grains we added to each sample. As reported in Appendix 3 and the results section, many of the samples we examined as part of this project did not contain a sufficient number of fossil pollen grains to permit the requisite 200 grain counts. Even when we could get 200 grain counts, those samples were often full of reworked pollen from earlier time periods suggesting that any counts would not be valid for paleoenvironmental interpretations. We did find that a few of the samples that contained 200 grain counts probably represented originally deposited Quaternary pollen grains.

The lack of fossil pollen in marine sediments could result from any of a variety of factors or from environmental conditions. Studies have shown that once fresh pollen is dispersed and deposited, the issue of preservation becomes the primary factor determining whether or not those pollen grains will be recovered at some future time. There are a number of published studies that address the issues of pollen preservation under various conditions. These include studies of pollen wall corrosion and differential pollen preservation (Havinga 1964, 1967, 1971, 1984); studies of the effects of mechanical degradation upon pollen grains (Duhoux 1982); studies that address the preservation potential of pollen in sediments of various alkalinity or pH (Dimbleby 1957, Martin 1963, Bryant 1969, and Hall 1981); studies of the Eh or oxidation potential of various types of sedimentary environments (Tschudy 1969); and studies on the types of microbes that feed on and destroy pollen (Goldstein 1960, Elsik 1966, and Holloway 1981). Of these, perhaps the two studies that have the most relevance for this project are a study conducted by Tschudy (1969) on marine sediments, and a report produced for the National Park Service (NPS) that was part of their search for factors that led to the preservation or destruction of organic materials in reservoirs. The second study, conducted by the NPS, looked at the chemical, microbial, and oxidation factors that led to the destruction of fossil pollen once it becomes part of sediments submerged in lakes. In the other study Tschudy (1969) examined the effect of Eh on pollen preservation in marine environments.

In the late 1970s the NPS asked Richard Holloway (1981) to study the effects of oxidation and degradation upon different types of fresh pollen that were submerged in newly-flooded reservoir lakes. Holloway selected 13 different types of fresh pollen and placed them in fine-meshed nylon bags that he sealed and suspended at various depths in a reservoir to determine how each pollen type would respond to chemical agents, alkalinity, and microbial activity in the water. Meanwhile, in a laboratory setting Holloway also tested the same types of fresh pollen to see what effect repeated periods of wetting and drying, and exposure to certain types of bacteria and fungi might have on the ability of pollen to remain preserved (Holloway 1981). His results confirmed earlier hypotheses that different types of pollen react differentially to different conditions and to different types of elements. For example, he found that certain types of pollen remained preserved better than others in alkaline deposits. Other pollen taxa were more susceptible to being destroyed by microbes, yet other types were most affected by repeated episodes of wetting and drying. His conclusion, based on this study, noted that pollen grains will remain preserved or will be destroyed depending on many different factors that include the pollen grain's ornamentation type, the thickness of the pollen wall, the size and shape of a pollen grain, and the percentage of a very durable organic substance found in all pollen grain walls called sporopollenin.

Holloway's study showed that pollen grains exposed to compounds containing chlorine, magnesium, potassium, sodium, and carbonates usually became degraded more rapidly than those exposed to other types of chemicals. His results also showed that, as the alkalinity of a deposit increases, pollen preservation tends to decrease. Previous studies (Dimbleby 1957; Martin 1963; Bryant 1969; and Hall 1981) had also noted a similar relationship in terrestrial deposits between the absence of preserved fossil pollen and the high alkalinity of the soils.

In Tschudy's 1969 study of Eh (oxidation potential) he noted that Eh should be considered as a major factor in determining the preservation potential of pollen in marine environments. He noted that a low Eh level is excellent for pollen preservation and that it is characteristic of a reducing marine environment where carbon dioxide and hydrogen sulfide are usually being released as by-products of microbial activity. These factors produce anaerobic conditions in the marine sedimentary environment that restricts the microbial activity of certain other bacteria and fungi known to attack pollen. Conversely, Tschudy (1969) noted that in marine areas with a high Eh, indicated by high levels of oxygen in the water and in sediments, pollen preservation is often minimal or non-existent. We are not certain what the Eh potential might be for the sediments (high or low Eh) in the cores we examined as part of this project. However, based on the low levels of preserved pollen in many of the samples, we suspect most of the cores came from sediments that would be rated as having a high Eh.

In 1977 a nautical archaeologist named Muckelroy (1977) noted that certain types of marine environments were ideal for the preservation of organic materials at sunken shipwreck sites, while other types of marine environments were detrimental to organic preservation. Although Muckelroy did not specifically address the question of pollen preservation in marine environments, his conclusions have served as a fairly accurate guide to where and under what types of conditions one should expect to find fossil pollen in marine sites. Of the various categories of marine deposits he examined, he determined that the most destructive environments for all forms of organic materials were those that included high levels of oxygen in the water, high water alkalinity, and high energy areas often found in shallow water and near shore lines where fast-moving currents and turbulent wave action occur. The validity of Muckelroy's hypotheses had recently been confirmed by our attempts to recover fossil pollen from deposits found at the location of Rene-Robert Cavaliar, Sieur de LaSalle's sunken flagship, *La Belle*, which ran aground and sank in Matagorda Bay, Texas during a storm in 1686 (Bryant and Dering 1998).

Aside from the chemical and environmental factors listed above, there are other possible reasons why fossil pollen might be absent from certain types of marine deposits. When dispersed pollen lands in water it sometimes is damaged by mechanical degradation. This is especially true of pollen that flows into marine environments from sheet runoff and from rivers. As pollen that is suspended in water travels through areas of high energy and water turbulence, individual pollen grains can become torn or broken and the bladders on conifer pollen grains are often torn loose. Once a pollen grain is cracked, torn, or broken, its durability and ability to remain preserved is compromised. Much like an egg that remains strong until cracked, a whole pollen grain has the best chance for becoming preserved as part of a fossil sediment when it remains whole. Likewise, as with an egg, when cracked a pollen grain becomes weakened and can be broken into tiny pieces that are no longer recognizable. Still other reasons why pollen may not be present in some marine deposits include factors related to pollen travel and deposition resulting from water currents. Water currents of different temperatures, salinity, and speeds each have a different ability to carry suspended pollen. Much like fine-grained sands and clay particles, pollen grains of different sizes and mass tend to settle out of water at different rates. As such, some areas are becoming almost devoid of deposited fossil pollen while other marine sediments contain prolific fossil pollen records. Studies by Muller (1959), Traverse and Ginsberg (1966), Brush and Davis (1984), and Traverse (1994) are among some of the best documented reports on what happens to pollen once it enters a marine environment as part of the water column. Each of these studies warns that, in order to interpret fossil pollen data with any degree of accuracy in a marine deposit, one must become familiar with what types of currents and conditions may have played a factor in the original deposition of pollen in a specific marine environment. As mentioned earlier, elements of the marine water column such as salinity, temperature, direction, and speed all become important factors that must be examined as part of understanding and then an interpretation of the origin of deposited pollen.

Some of the obstacles we encountered in trying to interpret the fossil pollen data from our current study revolve around our absence of information pertaining to potential water column conditions that may have existed in the areas where these core samples were collected. Without an understanding of those potential conditions we can only guess as to the potential origin of some of the fossil pollen materials we found in these samples. We know, for example, that for a majority of the samples we examined we found very little preserved fossil pollen, or we found that much of the pollen came from reworked source areas. As discussed earlier, we suspect that many of the samples we examined came from highly reworked sediments that may have originated in other areas and then become mixed with outwash or erosional flooding, harbor dredging, or from sediments in zones of high energy currents that may have existed during times when the sea levels were lower.

Another problem that we encountered during the analysis of these samples is that we have no clear knowledge of the age of any of the samples in these cores. The reports we were given noted that these sediments are suspected to be mostly from the Holocene and Late Pleistocene, but no precise dating for any of the cores was made available to us. If the actual age of the cores we examined is indeed Holocene and perhaps Late Pleistocene, then most of the fossil pollen, and by correlation the entire deposit may represent highly reworked sediments from earlier time periods that were redeposited during those later time periods.

SUMMARY AND CONCLUSIONS

In general, Quaternary pollen concentration levels that are lower than 2,500 grains/cc are considered too low to produce reliable data (Bryant et al. 1992; Bryant and Hall 1993). These rules, however, do not always apply to marine deposits, especially deposits that are formed some distance from shorelines. Most of the samples with pollen concentrations were not interpreted. Also, any samples with significant levels of reworked pollen grains were excluded from interpretation.

There were three cores that had one or more samples with adequate pollen preservation and concentration values. The first of these is Core B-6 and it had one good sample. This core was taken from the East River in Bowery Bay. Sample 9 from this core was taken from a depth of 65-66.4 feet in the core. The second core is B-13 and it had two samples that fulfilled the needed criteria for pollen preservation and concentration. Samples 28 and 47 yielded good preservation and concentration values, with sample 28 having the highest pollen concentration value of any sample we examined during this study. Core B-13 was collected from Ward's Point in Raritan Bay. This last sample in this group of good samples was also collected at Ward's Point using a vibracore. This last sample is sample WP-V1 and represents the only sample composed of peat.

Since none of the good samples were dated, it is difficult to say with any certainty what time scale we are dealing with. Broadly speaking, the pollen samples with the best preservation and concentration values are those we believe represent Quaternary deposits. We assume that those samples that exhibited high concentrations of reworked Cretaceous pollen came from deposits that were eroding into the bay. In those samples with reworked Cretaceous pollen it was difficult to assign a Quaternary pollen concentration value because many of the recovered pollen grains represent taxa that have changed very little from the Tertiary through the Quaternary time periods. In all of the good samples, except sample 28, the pollen taxa with the highest percentage is oak. In sample 28 the highest pollen is from pine. These samples may indicate environmental changes or they may represent pollen types that preserve the best, are the easiest to identify, and/or are produced in high numbers. Both oak and pine are high pollen producers and both tend to be overrepresented in the pollen record. These two pollen taxa are also the easiest types to recognize even if degraded. Today all of the Quaternary pollen types we found during this study are still present in the area and may be found to varying degrees in past sediments as well.

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Appendix 1

Taxanomic List

Family	Genus	Common Name
Aceraceae	*Acer*	Maple
Apiaceae		Carrot or Parsley Family
Aquifoliaceae	*Ilex*	Holly
Asteraceae	*Centaurea*	Star Thistle
Asteraceae	*Artemesia*	Wormwood
Asteraceae	*Cirsium*	Common or Plumed Thistle
Balsaminaceae	*Impatiens*	Balsam, Jewelweed, Snapweed, or Touch-Me-Not
Berberidaceae		Barberry Family
Betulaceae	*Alnus*	Alder
Betulaceae	*Betula*	Birch
Betulaceae	*Corylus*	Hazelnut
Betulaceae	*Ostrya*	Hop-hornbeam, Ironwood
Betulaceae	*Carpinus*	Hornbeam, Ironwood
Brassicaceae		Mustard Family
Caprifoliaceae	*Sambucus*	Elder
Caprifoliaceae	*Lonicera*	Honeysuckle
Caryophyllaceae		Pink Family
Cheno-Am		Goosefoot-Pigweed Families
Cornaceae	*Cornus*	Dogwood
Cyperaceae		Sedge Family
Ericaceae		Heath Family
Fabaceae		Bean Family
Fabaceae	*Robinia*	Locust
Fagaceae	*Castanea*	Chestnut
Fagaceae	*Fagus*	Beech
Fagaceae	*Quercus*	Oak
Geraniaceae		Geranium Family
Hamamelidaceae	*Liquidambar*	Sweet Gum
Juglandaceae	*Carya*	Hickory
Juglandaceae	*Juglans*	Walnut
Juncaceae	*Juncus*	Bog rush, Rush
Lamiaceae		Mint Family
LS Asteraceae		Sunflower or Aster Family
Myricaceae	*Myrica*	Wax Myrtle
Nyssaceae	*Nyssa*	Tupelo or Sour Gum
Nyssaceae	*Nyssa aquatica*	Cotton Gum
Nyssaceae	*Nyssa sylvatica*	Black Gum
Oleaceae	*Fraxinus*	Ash
Pinaceae	*Picea*	Spruce
Pinaceae	*Pinus*	Pine
Pinaceae	*Tsuga*	Hemlock
Platanaceae	*Platanus*	Sycamore, Buttonwood, Planetree
Poaceae		Grass Family
Polygonaceae		Buckwheat, Smartweed, or Knotweed Family
Rosaceae		Rose Family
Rubiaceae	*Cephalanthis*	Buttonbush
Salicaceae	*Salix*	Willow
Sparganiaceae	*Sparganium*	Bur Reed
TCT	*Thuja, Taxodium, and Juniperus*	Cypress, Cedar, and Juniper
Tiliaceae	*Tilia*	Basswood
Typhaceae	*Typha latifolia*	Common Cat-Tail
Ulmaceae	*Celtis*	Hackberry or Sugarberry
Ulmaceae	*Ulmus*	Elm
Urticaceae		Nettle Family

Appendix 2

#1 **Core B-4, #12** **40°39.6013'N 74°05.0379'W** **Upper Bay** **Pollen Type**	**Count**	**%**	**Cretaceous/Reworked Pollen**	**Count**
Apiaceae	1	0.5%	cf. *Trudopollis* (group)	1
Asteraceae	2	1.0%	Unknown Spore	2
Betulaceae *Alnus*	6	3.0%		
Betulaceae *Betula*	2	1.0%		
Betulaceae *Ostrya*	3	1.5%		
Caprifoliaceae *Sambucus*	1	0.5%		
Cyperaceae	5	2.5%		
Fagaceae *Castanea*	2	1.0%		
Fagaceae *Fagus*	3	1.5%		
Fagaceae *Quercus*	11	5.5%		
Hamamelidaceae*Liquidambar*	1	0.5%		
Oleaceae *Fraxinus*	1	0.5%		
Pinaceae *Picea*	16	8.0%		
Pinaceae *Pinus*	118	59.0%		
Pinaceae *Tsuga*	1	0.5%		
Plantanaceae *Platanus*	1	0.5%		
Poaceae	13	6.5%		
Salicaceae *Salix*	1	0.5%		
TCT	5	2.5%		
Ulmaceae *Ulmus*	1	0.5%		
Urticaceae	1	0.5%		
Indeterminate	5	2.5%		
Total	200	100%		
Lycopodium	1005			
Pollen Concentration 1,085 Pollen grains/cm^3				

#2				
Core B-4, #13				
40°39.6013'N 74°05.379'W				
Upper Bay				
Pollen Type	**Count**	**%**	**Cretaceous/Reworked Pollen**	**Count**
Asteraceae	6	3.0%	cf. *Trudopollis (group)*	1
Asteraceae *Artemesia*	2	1.0%	*Momipites*	2
Asteraceae *Cirsium*	1	0.5%		
Betulaceae *Betula*	3	1.5%		
Betulaceae *Ostrya*	4	2.0%		
Corylaceae *Alnus*	9	4.5%		
Cyperaceae	11	5.5%		
Fagaceae *Castanea*	8	4.0%		
Fagaceae *Fagus*	3	1.5%		
Fagaceae*Quercus*	37	18.5%		
Oleaceae *Fraxinus*	1	0.5%		
Pinaceae *Picea*	8	4.0%		
Pinaceae *Pinus*	53	26.5%		
Platanaceae *Platanus*	1	0.5%		
Poaceae	18	9.0%		
Rosaceae	1	0.5%		
Rubiaceae *Cephalanthus*	1	0.5%		
Salicaeae *Salix*	12	6.0%		
Sparganiaceae *Sparganium*	1	0.5%		
TCT	6	3.0%		
Urticaceae	2	1.0%		
Indeterminate	12	6.0%		
Total	200	100.0%		
Lycopodium	1927			
Pollen Concentration				
560 Pollen grains/cm^3				

#3
Core B-4, #14
40°39.6013'N 74°05.0379'W
Upper Bay

Pollen Type	Count	%	Cretaceous/Reworked Pollen	Count
Aceraceae *Acer*	2	1.0%	*Cicatricosisporites*	1
Apiaceae	1	0.5%	*Momipetes*	2
Asteraceae	7	3.4%	cf. *Trudopollis* (group)	1
Betulaceae *Alnus*	9	4.4%		
Betulaceae *Betula*	3	1.5%		
Betulaceae *Ostrya*	8	3.9%		
Chenopodium/Amaranthu	1	0.5%		
Cyperaceae	5	2.4%		
Ericaceae	1	0.5%		
Fagaceae *Castanea*	4	1.9%		
Fagaceae *Fagus*	3	1.5%		
Fagaceae *Quercus*	30	14.6%		
Juglandaceae *Carya*	3	1.5%		
Oleaceae *Fraxinus*	2	1.0%		
Pinaceae *Picea*	8	3.9%		
Pinaceae *Pinus*	79	38.3%		
Platanaceae *Platanus*	1	0.5%		
Poaceae	16	7.8%		
Rubiaceae *Cephalanthus*	1	0.5%		
Salicaceae *Salix*	3	1.5%		
TCT	4	1.9%		
Ulmaceae *Ulmus*	2	1.0%		
Indeterminate	13	6.3%		
Total	206	100.0%		
Lycopodium	1585			

Pollen Concentration
702 Pollen grains/cm^3

#4
Core B-5, #15
40°41.2023'N 74°07.4833'W
Newark Bay

Pollen Type	Count	%	Cretaceous/Reworked Pollen	Count
Asteraceae	1	9.1%	*Tricolporopollenites*	1
Pinaceae *Picea*	2	18.2%		
Pinaceae *Pinus*	6	54.5%		
Indeterminate	2	18.2%		
Total	11	100.0%		
Lycopodium	355			
Pollen Concentration				
167 Pollen grains/cm^3				

#5
Core B-5, #19
40°41.2023'N 74°07.4833'W
Newark Bay

Pollen Type	**Count**	**%**	**Cretaceaous/Reworked Polle**	**Count**
Aceraceae *Acer*	1	0.5%	*Momites*	1
Asteraceae	7	3.5%	*Striatopollis*	1
Betulaceae *Alnus*	2	1.0%	*Tricolporoidites*	2
Betulaceae *Betula*	2	1.0%	Unknown	1
Betulaceae *Ostrya*	4	2.0%		
Chenopodium/Amarathus	3	1.5%	Total	5
Cyperaceae	9	4.5%		
Ericaceae	1	0.5%		
Fabaceae	1	0.5%		
Fagaceae *Castanea*	4	2.0%		
Fagaceae *Fagus*	2	1.0%		
Fagaceae *Quercus*	44	21.8%		
Geraniaceae	1	0.5%		
Juglandaceae *Carya*	5	2.5%		
Juncaceae *Juncus*	1	0.5%		
Oleaceae *Fraxinus*	1	0.5%		
Pinaceae *Pinus*	71	35.1%		
Pinaceae *Tsuga*	1	0.5%		
Pinus *Picea*	9	4.5%		
Platanaceae *Platanus*	1	0.5%		
Poaceae	13	6.4%		
Rosaceae	1	0.5%		
Salicaceae *Salix*	4	2.0%		
TCT	4	2.0%		
Ulmaceae *Ulmus*	3	1.5%		
Indeterminate	7	3.5%		
Total	202	100.0%		
Lycopodium	2445			

Pollen Concentration
446 Pollen grains/cm^3

#6	
Core B-5, #23	
40°41.2023'N 74°07.4833'W	
Newark Bay	
PollenType	**Count**
Betulaceae *Betula*	2
Pinaceae *Pinus*	3
Indeterminate	1
Total	6
Lycopodium	305
Pollen Concentration	
106 Pollen grains/cm^3	

#7	
Core B-6, #14	
40°46.6696'N 74°53.2301'W	
Bower Bay	
Pollen Type	**Count**
Betulaceae *Alnus*	1
Fagaceae *Quercus*	2
Pinceae *Pinus*	2
Lycopodium	320
Pollen Concentration	
84 Pollen grains/cm^3	

#8 Core B-6, #15 40°46.6696'N 74°53.2301'W Bowery Bay Pollen Type	Count	%
Aceraceae *Acer*	2	1.0%
Asteraceae	2	1.0%
Betulaceae *Alnus*	7	3.5%
Betulaceae*Betula*	14	7.0%
Betulaceae*Ostrya*	6	3.0%
Chenopodium/Amarnthus	7	3.5%
Cyperaceae	4	2.0%
Ericaceae	1	0.5%
Fabaceae	1	0.5%
Fagaceae *Castanea*	2	1.0%
Fagaceae *Fagus*	7	3.5%
Fagaceae *Quercus*	55	27.5%
Hamamelidaceae *Liquidambar*	4	2.0%
Juglandaceae *Carya*	8	4.0%
Oleaceae *Fraxinus*	3	1.5%
Pinaceae *Picea*	5	2.5%
Pinaceae *Pinus*	35	17.5%
Poaceae	24	12.0%
Polygonaceae	1	0.5%
Rosaceae	1	0.5%
Sparganiaceae *Sparganium*	1	0.5%
Tiliaceae *Tilia*	1	0.5%
Ulmaceae *Uimus*	1	0.5%
Urticaceae	1	0.5%
Indeterminate	7	3.5%
Total	200	100.0%
Lycopodium	2458	
Pollen Concentration 439 Pollen grains/cm^3		

#9 **Core B-6, #19** **40°46.6696'N 74°53.2301'W** **Bowery Bay**		
Pollen Type	**Count**	**%**
Aceraceae *Acer*	2	0.9%
Aquifoliaceae *Ilex*	2	0.9%
Asteraceae	4	1.9%
Betulaceae *Alnus*	28	13.0%
Betulaceae *Betula*	12	5.6%
Betulaceae *cf. Carpinus*	1	0.5%
Betulaceae *Ostrya*	16	7.4%
Ericaceae	1	0.5%
Fabaceae	1	0.5%
Fagaceae *Castanea*	2	0.9%
Fagaceae *Fagus*	25	11.6%
Fagaceae *Quercus*	64	29.8%
Hamamelidaceae *Liquidambar*	2	0.9%
Juglandaceae *Carya*	1	0.5%
Nyssaceae *Nyssa aquatica*	1	0.5%
Oleaceae *Fraxinus*	4	1.9%
Pinaceae *Picea*	1	0.5%
Pinaceae *Pinus*	12	5.6%
Platanaceae *Platanus*	1	0.5%
Poaceae	24	11.2%
Salicaceae *Salix*	3	1.4%
TCT	4	1.9%
Ulmaceae *Ulmus*	1	0.5%
Indeterminate	3	1.4%
Total	215	100.0%
Lycopodium	102	
Pollen Concentration 11,382 Pollen grains/cm^3		

#10 **Core B-6, #20** **40°46.6696'N 74°53.2301'W** **Bowery Bay**	
Lycopodium	285
No pollen	

#11
B-106, #11
40°29.6683'N 74°11.5416'W
Raritan Bay (Zone 1)

Pollen Type	Count	%	Cretaceaous/Reworked Pollen	Count
Aceraceae *Acer*	6	2.8%	*Cicatricosisporites*	1
Betulaceae *Ostrya type*	1	0.5%	*Liliacidites/Arecipites Type*	2
Betulaceae*Betula*	7	3.2%	cf. *Trudopollis*	3
Cornaceae *Cornus*	1	0.5%		
Cyperaceae	1	0.5%	Total	6
Fagaceae *Castanea*	9	4.1%		
Fagaceae *Fagus*	7	3.2%		
Fagaceae *Quercus*	17	7.8%		
Liliaceae	1	0.5%		
Oleaceae *Fraxinus*	1	0.5%		
Pinaceae *Picea*	41	18.9%		
Pinaceae *Pinus*	50	23.0%		
Pinaceae *Tsuga*	35	16.1%		
Platanaceae *Platanus*	12	5.5%		
Poaceae	1	0.5%		
Salicaceae *Salix*	24	11.1%		
TCT	1	0.5%		
Indeterminate	2	0.9%		
Total	217	100.0%		
Lycopodium	68			

Pollen Concentration
17,232 Pollen grains/cm^3

#12
B-106, #13
40°29.6683'N 74°11.5416'W
Raritan Bay (Zone 1)

Pollen Type	**Count**	**%**	**Cretaceaous/Reworked Pollen**	**Count**
Aceraceae *Acer*	1	0.5%	*Cicatricosisporites*	1
Betulacaceae *Betula*	4	1.9%	*Liliacidites/Arecipites*	1
Cyperaceae	1	0.5%	*Porocolpopollenites*	6
Fagaceae *Castanea*	27	12.5%	*Retitricolpites*	1
Fagaceae *Fagus*	9	4.2%	*Tricolpites*	3
Fagaceae *Quercus*	12	5.6%	cf. *Trudopollis groups*	8
Nyssaceae *Nyssa sylvatica*	3	1.4%		
Pinaceae *Picea*	47	21.8%	Total	12
Pinaceae *Pinus*	34	15.7%		
Salicaceae *Salix*	32	14.8%		
TCT	2	0.9%		
Indeterminate	3	1.4%		
Total	216	100.0%		
Lycopodium	71			
Pollen Concentration				
16,428 Pollen grains/cm^3				

#13 **Core B-106, #16** **40°29.6683'N 74°11.5416'W** **Raritan Bay (Zone 1)**			
Pollen Types	**Count**	**Cretaceaous/Reworked Pollen**	**Count**
No mod. pollen - only KT grains observed,		*Appendicisporites*	1
These poorly preserved		*Tricolpites*	2
		Tricolporopollenites	1
Lycopodium	313		
		Total	4

#18	
Core B-106, #25	
40°29.6683'N 74°11.5416'W	
Raritan Bay (Zone 1)	
Cretaceaous/Reworked Pollen	**Count**
cf *Trudopollis group*	22
cf. *Complexiopollis*	4
cf. *Pseudoplicapollis*	1
cf. *Tricolpopollenites or Retitri*	3
Cicatricosisporites	11
Cornetopollis	1
Faveotricolpites	3
Liliacidites/Arecipites type	3
Porocolpopollenites	48
poss. Caryapollenites	1
Prob. Several genera incl. Retitricolpit	22
Tricolpites	4
Tricolpopollenites	17
Tricolporoidites	22
Tricolporopollenites	25
Unknown	1
Indeterminate	32
Total	220
Lycopodium	326
Possible Tertiary Grains	
poss. Magnolia or Laevigatospo	1
Total	1

#19 Core B-8, #12 40°28.5585'N 74°10.0056'W Raritan Bay (Zone 1) Pollen Types	Count	Cretaceous/Reworked Pollen	Count
Aceraceae *Acer*	1	*cf. Trudopollis*	1
Betulaceae *Alnus*	2		
Cyperaceae	2		
Oleaceae *Fraxinus*	1		
Pinaceae *Pinus*	4		
Pinaceae *Tsuga*	3		
Total	13		
Lycopodium	345		
Pollen Concentration 102 Pollen grains/cm^3			

#20 B-8, #15 40°28.5585'N 74°10.0056'W Raritan Bay (Zone 1) No modern pollen **Cretaceous Pollen Type**	**Count**
cf. Pseudoplicapollis	8
cf. Trudopollis	124
Cicatricosisporites	3
Cornetopollis	1
Liliacidites/Arecipites	11
Momipites	6
Nyssaceae *Nyssa*	1
Bisaccates	52
Porocolpopollenites	2
TCP,RET, Triang.	16
TCT	6
Tricolpites	8
Tricolporopollenites Type	4
Indeterminate	10
Total	252
Lycopodium	41

#23
Core B-8, #21
40°28.5585'N 74°10.0056'W
Raritan Bay (Zone 1)
No modern pollen

Cretacous Pollen Type	Count	Poss. Tertiary Grains	Count
Appendicisporites	1	*poss. Nyssa*	4
cf. Atlantopollis	1		
cf. Heidelbergipollis	1		
cf. Intratriporopollenites	1		
cf. Pseudoplicopollis	9		
cf. Tricolpopollenites or Retitricolpites	5		
cf. Trudopollis	15		
Cicatricosisporites	4		
Cornetopollis	2		
Fagaceae *Quercus*	10		
Liliacidites/Arecipites Type	25		
Momipites	4		
Bisaccates	65		
Striatopollis	1		
Tricolpites	7		
Tricolpopollenites	11		
Tricolporoidites	12		
Tricolporopollenites	6		
Unknown	3		
Indeterminate	12		
Total	195		
Lycopodium	69		

#24
Core B-13, #6
40°29.5997'N 74°15.1974'W
Ward's Point

Pollen Type	**Count**	**%**	**Cretaceous/Reworked Pollen**	**Count**
Aceraceae *Acer*	2	1.0%	*Cornetopollis*	1
Asteraceae	14	7.0%		
Betulaceae *Alnus*	19	9.5%		
Betulaceae *Betula*	11	5.5%		
Betulaceae *Carpinus*	1	0.5%		
Betulaceae *Ostrya*	1	0.5%		
Chenopodium/Amaranthus	3	1.5%		
Cornaceae *Cornus*	1	0.5%		
Cyperaceae	7	3.5%		
Fagaceae *Castanea*	3	1.5%		
Fagaceae *Quercus*	76	38.0%		
Juglandaceae *Carya*	5	2.5%		
Juglandaceae *Juglans*	1	0.5%		
Oleaceae *Fraxinus*	4	2.0%		
Pinaceae *Pinus*	16	8.0%		
Pinaceae *Tsuga*	10	5.0%		
Platanaceae *Platanus*	1	0.5%		
Poaceae	20	10.0%		
Rosaceae	1	0.5%		
Spaganiaceae *Sparganium*	1	0.5%		
TCT	2	1.0%		
Tiliaceae *Tilia*	1	0.5%		
Total	200	100.0%		
Lycopodium	28			

Pollen Concentration
64,286 Pollen grains/cm^3

#25 Core B-13, #8 40°29.5997'N 74°15.1974'W Ward's Point **Pollen Types**	**Count**	**%**	**Cretaceous/Reworked Pollen**	**Count**
Aceraceae *Acer*	2	0.8%	*cf. Trudopollis*	1
Asteraceae	13	5.4%		
Betulaceae *Alnus*	6	2.5%		
Betulaceae *Betula*	5	2.1%		
Betulaceae *Corylus*	1	0.4%		
Betulaceae *Ostrya*	2	0.8%		
Chenopodium/Amaranthus	3	1.2%		
Cyperaceae	4	1.7%		
Fagaceae *Fagus*	2	0.8%		
Fagaceae *Quercus*	83	34.4%		
Juglandaceae *Carya*	1	0.4%		
Lamiaceae	1	0.4%		
Oleaceae *Fraxinus*	1	0.4%		
Pinaceae *Pinus*	25	10.4%		
Pinaceae *Tsuga*	3	1.2%		
Platanaceae *Plantanus*	2	0.8%		
Poaceae	71	29.5%		
Rosaceae	1	0.4%		
Salicaceae *Salix*	5	2.1%		
TCT	3	1.2%		
Tiliaceae *Tilia*	1	0.4%		
Ulmaceae *Ulmus*	2	0.8%		
Uricaceae	2	0.8%		
Indeterminate	2	0.8%		
Total	241	100.0%		
Lycopodium	23			
Pollen Concentration 142,630 Pollen grains/cm^3				

#26 Core B-13, #11 40°29.5997'N 74°15.1974'W Ward's Point Pollen Type	Count	%	Cretaceous/Reworked Pollen	Count
Apiaceae	1	0.5%	*cf. Pterocarya*	1
Asteraceae	12	5.9%		
Betulaceae *Alnus*	1	0.5%		
Betulaceae *Betula*	5	2.5%		
Betulaceae *Ostrya*	2	1.0%		
Cyperaceae	34	16.8%		
Fagaceae *Quercus*	77	38.1%		
Pinaceae *Picea*	1	0.5%		
Pinaceae *Pinus*	29	14.4%		
Pinaceae *Tsuga*	6	3.0%		
Poaceae	30	14.9%		
Salicaceae *Salix*	2	1.0%		
Urticaceae	1	0.5%		
Indeterminate	1	0.5%		
Total	202	100.0%		
Lycopodium	31			
Pollen Concentration 175,934 Pollen grains/cm^3				

#27
Core B-13, #12
40°29.5997'N 74°15.1974'W
Ward's Point

Pollen Types	**Count**	**%**	**Cretaceous/Reworked Pollen**	**Count**
Aceraceae *Acer*	3	1.3%	*Liliacidites/Arecipites* Type	1
Asteraceae	8	3.4%	*Tricolporopollenites*	1
Betulaceae *Alnus*	3	1.3%		
Betulaceae *Betula*	4	1.7%		
Betulaceae *Ostrya*	4	1.7%		
Brassicaceae	1	0.4%		
Caryophyllaceae	1	0.4%		
Chenopodium/Amaranthus	1	0.4%		
Cyperaceae	9	3.8%		
Ericaceae	2	0.8%		
Fagaceae *Fagus*	1	0.4%		
Fagaceae *Quercus*	86	36.3%		
Juglandaceae *Carya*	1	0.4%		
Juncaceae *Juncus*	2	0.8%		
Oleaceae *Fraxinus*	3	1.3%		
Pinaceae *Picea*	5	2.1%		
Pinaceae *Pinus*	76	32.1%		
Pinaceae *Tsuga*	6	2.5%		
Platanaceae *Platanus*	3	1.3%		
Poaceae	13	5.5%		
Salicaceae *Salix*	2	0.8%		
TCT	1	0.4%		
Ulmaceae *Ulmus*	2	0.8%		
Total	237	100.0%		
Lycopodium	15			

Pollen Concentration
142,200 Pollen grains/cm^3

#28 Core B-13, #13 40°29.5997'N 74°15.1974'W Ward's Point Pollen Type	Count	%
Aceraceae *Acer*	4	1.6%
Aquifoliaceae *Ilex*	1	0.4%
Asteraceae	25	9.8%
Asteraceae *Artemisia*	2	0.8%
Berberioaceae	1	0.4%
Betulaceae *Alnus*	5	2.0%
Betulaceae *Betula*	10	3.9%
Betulaceae *Ostrya*	3	1.2%
Chenopodium/Amaranthus	4	1.6%
Cyperaceae	3	1.2%
Ericaceae	2	0.8%
Fagaceae *Fagus*	2	0.8%
Fagaceae *Quercus*	50	19.5%
Oleaceae *Fraxinus*	3	1.2%
Pinaceae *Picea*	4	1.6%
Pinaceae *Pinus*	104	40.6%
Pinaceae *Tsuga*	10	3.9%
Plantanaceae *Platanus*	1	0.4%
Poaceae	14	5.5%
Salicaceae *Salix*	5	2.0%
Indeterminate	3	1.2%
Total	256	100.0%
Lycopodium	19	
Pollen Concentration 121,263 Pollen grains/cm^3		

#29 Core B-13, #15 40°29.5997'N 74°15.1974'W Ward's Point **Pollen Types**	**Count**	**%**	**Cretaceous/Reworked Pollen**	**Count**
Asteraceae	1	0.4%	*Tricolporopollenites*	1
Betulaceae *Alnus*	7	2.8%		
Betulaceae *Betula*	11	4.5%		
Betulaceae *Ostrya*	4	1.6%		
Caryophyllaceae	1	0.4%		
Chenopodium/Amaranthus	6	2.4%		
Cyperaceae	7	2.8%		
Ericaceae	1	0.4%		
Fagaceae *Quercus*	63	25.5%		
Juglandaceae *Carya*	1	0.4%		
Juncaceae *Juncus*	1	0.4%		
Lamiaceae	1	0.4%		
Oleaceae *Fraxinus*	3	1.2%		
Pinaceae *Picea*	2	0.8%		
Pinaceae *Pinus*	98	39.7%		
Pinaceae *Tsuga*	13	5.3%		
Platanaceae *Platanus*	1	0.4%		
Poaceae	19	7.7%		
Rosaceae	1	0.4%		
Salicaceae *Salix*	3	1.2%		
TCT	1	0.4%		
Ulmaceae *Ulmus*	1	0.4%		
Indeterminate	1	0.4%		
Total	247	100.0%		
Lycopodium	20			
Pollen Concentration 111,150 Pollen grains/cm^3				

#30
Core B-13, #21
40°29.5997'N 74°15.1974'W
Ward's Point

Pollen Type	Count	%	Cretaceous/Reworked Pollen	Count
Aceraceae *Acer*	1	0.5%	*cf. Ajatipollis or Dicotetrides*	6
Asteraceae	6	3.0%	*cf. Caryapollenites*	1
Asteraceae *Artemisia*	2	1.0%	*cf. Tricopopollenites or Tetitricolpites*	1
Betulaceae *Alnus*	11	5.5%	*cf. Trudopollis group*	1
Betulaceae *Betula*	9	4.5%	*Cicatricosisporites*	4
Cornaceae *Cornus*	1	0.5%	*Foveotricolpites*	2
Cyperaceae	12	6.0%	*Liliacidites/Arecipites Type*	4
Ericaceae	1	0.5%	*Porocolpopollenites*	1
Fagaceae *Castanea*	8	4.0%	*Probably several genera, incl Tetitricolpites*	3
Fagaceae *Fagus*	2	1.0%	*Tricolpites*	7
Fagaceae *Quercus*	15	7.5%	*Tricolpites*	1
Pinaceae *Picea*	5	2.5%	*Tricolpopollenites*	37
Pinaceae *Pinus*	73	36.5%	*Tricolporoidites*	13
Pinaceae *Tsuga*	4	2.0%	*Tricolporopollenites*	2
Platanaceae *Platanus*	1	0.5%	Unknown	2
Poaceae	6	3.0%		
Salicaceae *Salix*	18	9.0%	Total	85
TCT	8	4.0%		
Indeterminate	17	8.5%	**Possible Tertiary Grains**	
			poss.Myrtaceidites	1
Total	200	100.0%	*poss. Nyssa*	1
Lycopodium	148		Total	2
Pollen Concentration				
7,297 Pollen grains/cm^3				

#31
B-110, #8
40°28.2604'N 74°13.1135'W
Central Raritan Bay

Pollen Type	**Count**	**%**	**Cretaceous/Reworked Polle**	**Count**
Aceraceae *Acer*	4	1.7%	*Porocolpopollenites*	1
Asteraceae	8	3.5%	*Tricolpites*	1
Betulaceae *Alnus*	4	1.7%	*Tricolporoidites*	1
Betulaceae *Betula*	17	7.4%	cf. *Trudopollis*	1
Betulaceae *Ostrya*	6	2.6%		
Caryophyllaceae	1	0.4%	Total	4
Cheno-Am	4	1.7%		
Cyperaceae	5	2.2%		
Fabaceae	1	0.4%		
Fagaceae *Castanea*	4	1.7%		
Fagaceae *Fagus*	3	1.3%		
Fagaceae *Quercus*	105	45.7%		
Juglandaceae *Carya*	9	3.9%		
Oleaceae *Fraxinus*	2	0.9%		
Pinaceae *Picea*	5	2.2%		
Pinaceae *Pinus*	28	12.2%		
Pinaceae *Tsuga*	4	1.7%		
Platanaceae *Platanus*	1	0.4%		
Poaceae	11	4.8%		
Rosaceae	2	0.9%		
Rubiaceae *Cephalanthus*	1	0.4%		
Salicaceae *Salix*	1	0.4%		
TCT	1	0.4%		
Ulmaceae *Ulmus*	1	0.4%		
Indeterminate	2	0.9%		
Total	230	100.0%		
Lycopodium	69			
Pollen Concentration				
3,000 Pollen grains/cm^3				

#32 Core B-110, #14 40°28.2604'N 74°13.1135'W Central Raritan Bay Pollen Type	Count
Fagaceae *Quercus*	1
Pinaceae *Pinus*	3
Poaceae	1
Total	5
Lycopodium	301
Pollen Concentration 11 Pollen grains/cm^3	

#35			
Core B-112, #12			
40°29.6964'N 74°03.7612'W			
Central Lower Bay			
Pollen Type	**Count**	**Cretaceous/Reworked Pollen**	**Count**
Poaceae (most probably contamination)	1	*Tricolporopollenites*	1
Lycopodium	310		
Pollen Concentration 14 Pollen grains/cm^3			

#36 **B-112, #14** **40°29.6964'N 74°03.7612'W** **Central Lower Bay**		
Pollen Types	**Count**	
Pinaceae *Tsuga*	1	Probably contaminated at the source.
Lycopodium	362	
Pollen Concentration 6 Pollen grains/cm^3		

#40 **Core BV 252, #17** **40°31.7524'N 74°3.9849'W** **Central Lower Bay (Zone 2)**		
Pollen Types	**Count**	
Fagaceae *Quercus*	1	Modern contamination at the source suspected
Pinaceae *Pinus*	1	1 broken bladder fragment.
Lycopodium	322	
Pollen Concentration 1 Pollen grain/cm^3		

#41	
Core BV 252, #20	
40°31.7524'N 74°°3.9849'W	
Central Lower Bay (Zone 2)	
Pollen Type	**Count**
No pollen	
Lycopodium	379

#47
Core B-13 Y1292
40°29.5997'N 74°15.1974'W
Ward's Point

Pollen Type	Count	%
Aceraceae *Acer*	4	1.6%
Apiaceae	1	0.4%
Asteraceae	1	0.4%
Asteraceae *Artemisia*	15	6.1%
Asteraceae *Centaurea*	1	0.4%
Betulaceae *Alnus*	1	0.4%
Betulaceae *Ostrya*	3	1.2%
Cheno-Am	1	0.4%
Cyperaceae	7	2.8%
Fagaceae *Castanea*	5	2.0%
Fagaceae *Quercus*	71	28.7%
Hamamelidaceae *Liquidambar*	1	0.4%
Juglandaceae *Carya*	2	0.8%
Pinaceae *Picea*	67	27.1%
Pinaceae *Pinus*	24	9.7%
Pinaceae *Tsuga*	3	1.2%
Ulmaceae *Ulmus*	1	0.4%
Indeterminate	39	15.8%
Total	247	100.0%
Lycopodium	9	

Pollen Concentration
24,700 Pollen grains/cm^3

#49 **Core B-6, #Y1239** **40°46.6696'N 74°53.2301'W** **Bowery Bay**		
Pollen Type	**Count**	**%**
Betulaceae *Otsrya*	1	4.5%
Fagaceae *Fagus*	1	4.5%
Fagaceae *Quercus*	13	59.1%
Juglandaceae *Carya*	1	4.5%
Pinaceae *Pinus*	4	18.2%
Poaceae	1	4.5%
Indeterminate	1	4.5%
Total	22	100.0%
Lycopodium	370	
Pollen Concentration 20 Pollen grains/cm^3		

#51 Y 1295 Zone 2 Pollen Type	Count	%	Cretaceous/Reworked Pollen	Count
Indeterminate	1		*Tricolpites*	1
			Porocolpopollenites	1
Lycopodium	341			

#52		
Core BV252, Y1278		
40°31.7524'N 74°03.9849'W		
Central Lower Bay (Zone 2)		
Pollen Type	**Count**	**%**
Juglandaceae *Carya*	1	100.00%
Total	1	100.00%
Lycopodium	367	
Pollen Concentration		
1 Pollen grain/cm^3		

#61
Core B-3, #20
40°43.1612'N 74°01.3938'W
Hudson River

Pollen Type	Count	%	Cretaceous/Reworked Pollen	Count
Aceraceae *Acer*	2	0.9%	*Foveotricolpites*	1
Asteraceae	4	1.9%	*Tricolpites*	1
Betulaceae *Alnus*	4	1.9%	*Tricolporopollenites*	1
Betulaceae *Betula*	8	3.7%		
Betulaceae *Ostrya*	1	0.5%		
Cheno-Am	2	0.9%		
Cyperaceae	6	2.8%		
Fagaceae *Castanea*	2	0.9%		
Fagaceae *Quercus*	96	44.7%		
Juglandaceae *Carya*	8	3.7%		
Oleaceae *Fraxinus*	1	0.5%		
Pinaceae *Pinus*	59	27.4%		
Pinaceae *Tsuga*	7	3.3%		
Platanaceae *Platanus*	1	0.5%		
Poaceae	7	3.3%		
Tiliaceae *Tilia*	1	0.5%		
Ulmaceae *Ulmus*	4	1.9%		
Indeterminate	2	0.9%		
Total	215	100.0%		
Lycopodium	45			

Pollen Concentration
4,300 Pollen grains/cm^3

#62
Core B-3, #17
40°43.1612'N 74°01.3938+A22'W
Hudson River

Pollen Type	Count	%	Cretaceous/Reworked Polle	Count
Aceraceae *Acer*	2	0.9%	*Porocolpopollenites*	1
Asteraceae	1	0.5%	*Tricolpites*	1
Asteraceae *Artemisia*	1	0.5%		
Betulaceae *Alnus*	3	1.4%		
Betulaceae *Betula*	7	3.2%		
Betulaceae Ostrya	5	2.3%		
Cheno-Am	1	0.5%		
Cornaceae *Cornus*	1	0.5%		
Cyperaceae	3	1.4%		
Fagaceae *Castanea*	2	0.9%		
Fagaceae *Quercus*	94	42.7%		
Hamamelidaceae *Liquidambar*	1	0.5%		
Juglandaceae *Carya*	20	9.1%		
Oleaceae *Fraxinus*	5	2.3%		
Pinaceae *Picea*	2	0.9%		
Pinaceae *Pinus*	47	21.4%		
Pinaceae *Tsuga*	9	4.1%		
Platanaceae *Platanus*	2	0.9%		
Poaceae	6	2.7%		
Tiliaceae *Tilia*	2	0.9%		
Ulmaceae *Ulmus*	1	0.5%		
Indeterminate	5	2.3%		
Total	220	100.0%		
Lycopodium	45			

Pollen Concentration
6,600 Pollen grains/cm^3

#63 Core B-3, #18 40°43.1612'N 74°01.3938W Hudson River **Pollen Type**	**Count**	**%**
Aceraceae *Acer*	4	1.7%
Asteraceae	3	1.3%
Asteraceae *Artemisia*	1	0.4%
Betulaceae *Alnus*	2	0.9%
Betulaceae *Betula*	12	5.2%
Betulaceae *Ostrya*	1	0.4%
Cheno-Am	2	0.9%
Cyperaceae	4	1.7%
Fagaceae *Castanea*	4	1.7%
Fagaceae *Fagus*	6	2.6%
Fagaceae *Quercus*	99	42.9%
Juglandaceae *Carya*	15	6.5%
Juncaceae *Juncus*	2	0.9%
Myricaceae *Myrica*	1	0.4%
Oleaceae *Fraxinus*	2	0.9%
Pinaceae *Picea*	2	0.9%
Pinaceae *Pinus*	42	18.2%
Pinaceae *Tsuga*	16	6.9%
Platanaceae *Platanus*	1	0.4%
Poaceae	4	1.7%
Salicaceae *Salix*	1	0.4%
Ulmaceae *Ulmus*	2	0.9%
Indeterminate	5	2.2%
Total	231	100.0%
Lycopodium	44	
Pollen Concentration 7,087 Pollen grains/cm^3		

#64 Core B-111, #19 40°30.0396'N 74°04.5542'W Central Lower Bay (Zone 2)				
Pollen Type	**Count**	**%**	**Cretaceous/Reworked Pollen**	**Count**
No Pollen			*Foreotricolpites*	1
			Retitricolpites	1
Lycopodium	74		*Tricolporopplenites*	2
			Indeterminate	1

#65
Core B-111, #17
40°30.0396'N 74°04.5542'W
Central Lower Bay (Zone 2)

Pollen Type	**Count**	**%**	**Cretaceous/Reworked Pollen**	**Count**
Fagaceae *Quercus*	1	50.00%	cf. *Trudopollis*	1
Poaceae	1	50.00%	*Striatopollis*	1
			Tricolpites	1
Total	2	100.00%	*Tricolpopollenites* type	2
			Tricolporopollenites type	4
Lycopodium	143			
			Total	9
Pollen Concentration				
3 Pollen grains/cm^3				

#66 Core B-111, #12 40°30.0396'N 74°04.5542'W Central Lower Bay (Zone 2) Pollen Type	Count	%
Pinaceae *Pinus*	1	50.0%
Poaceae	1	50.0%
Total	2	100.0%
Lycopodium	306	

#67
Core BV251, #12
40°31.7796'N 74°06.0960'W
Central Lower Bay (Zone 2)

Pollen Type	Count	%	Cretaceous/Reworked Pollen	Count
Aceraceae *Acer*	1	0.4%	Nyssaceae *Nyssa*	1
Asteraceae	2	0.8%	*Tricolpites*	1
Betulaceae *Alnus*	5	2.0%	*Tricolpopollenites*	1
Betulaceae *Betula*	4	1.6%	*Tripopollis* Group	1
Betulaceae *Ostrya*	2	0.8%		
Caryophyllaceae	1	0.4%		
Cheno-Am	1	0.4%		
Cyperaceae	8	3.2%		
Fagaceae *Fagus*	17	6.9%		
Fagaceae *Quercus*	65	26.3%		
Hamamelidaceae *Liquidambar*	7	2.8%		
Juglandaceae *Carya*	26	10.5%		
Oleaceae *Fraxinus*	2	0.8%		
Pinaceae *Picea*	7	2.8%		
Pinaceae *Pinus*	65	26.3%		
Pinaceae *Tsuga*	9	3.6%		
Platanaceae *Platanus*	2	0.8%		
Poaceae	13	5.3%		
Salicaceae *Salix*	2	0.8%		
Ulmaceae *Ulmus*	3	1.2%		
Indeterminate	5	2.0%		
Total	247	100.0%		
Lycopodium	97			

Pollen Concentration
381 Pollen grains/cm^3

#68		
Core BV251, #18		
40°31.7796'N 74°06.0960'W		
Central Lower Bay (Zone 2)		
Pollen Type	**Count**	**%**
Aceraceae *Acer*	1	10.0%
Betulaceae *Betula*	1	10.0%
Cyperaceae	1	10.0%
Fagaceae *Quercus*	3	30.0%
Pinaceae *Tsuga*	1	10.0%
Poaceae	3	30.0%
Total	10	100.0%
Lycopodium	311	
Pollen Concentration		
4 Pollen grains/cm^3		

#69 Core BV 251, #22 40°31.7796'N 74°06.0960'W Central Lower Bay (Zone 2) Pollen Type	Count	%
Aceraceae *Acer*	1	9.1%
Asteraceae	1	9.1%
Betulaceae *Betula*	2	18.2%
Fagaceae *Quercus*	2	18.2%
Pinaceae *Pinus*	5	45.5%
Total	11	100.0%
Lycopodium	325	
Pollen Concentration 4 Pollen grains/cm^3		

#70		
Core BV251, # 19		
40°31.7796'N 74°06.0960'W		
Central Lower Bay (Zone 2)		
Pollen Type	**Count**	**%**
Apiaceae	1	7.1%
Betulaceae *Betula*	1	7.1%
Cyperaceae	2	14.3%
Fagaceae *Quercus*	4	28.6%
Juglandaceae *Carya*	1	7.1%
Pinaceae *Picea*	1	7.1%
Pinaceae *Pinus*	2	14.3%
Pinaceae *Tsuga*	1	7.1%
Poaceae	1	7.1%
Total	14	100.0%
Lycopodium	313	
Pollen Concentration		
6 Pollen grains/cm^3		

#71		
Core BV251, #15		
40°31.7796'N 74°06.0960'W		
Central Lower Bay (Zone 2)		
Pollen Type	**Count**	**%**
Betulaceae *Betula*	1	16.7%
Pinaceae *Picea*	1	16.7%
Fagaceae *Quercus*	1	16.7%
Pinaceae *Pinus*	3	50.0%
Total	6	100.0%
Lycopodium	303	
Pollen Concentration		
2 Pollen grains/cm^3		

#72 **Core B-1, #16** **40°46.0964'N 74°00.3952'W** **Hudson River** **Pollen Type**	**Count**	**%**
Aceraceae *Acer*	4	1.8%
Asteraceae	4	1.8%
Asteraceae *Artemisia*	1	0.5%
Betulaceae *Alnus*	1	0.5%
Betulaceae *Betula*	6	2.7%
Betulaceae *Ostrya*	2	0.9%
Cheno-Am	2	0.9%
Cyperaceae	5	2.3%
Ericaceae	1	0.5%
Euphorbiaceae	2	0.9%
Fagaceae *Fagus*	5	2.3%
Fagaceae *Quercus*	106	48.0%
Juglandaceae *Carya*	16	7.2%
Nyssaceae *Nyssa aquatica*	1	0.5%
Oleaceae *Fraxinus*	1	0.5%
Pinaceae *Picea*	2	0.9%
Pinaceae *Pinus*	28	12.7%
Pinaceae *Tsuga*	19	8.6%
Platanaceae *Platanus*	2	0.9%
Poaceae	5	2.3%
Tiliaceae *Tilia*	1	0.5%
Ulmaceae *Celtis*	1	0.5%
Ulmaceae *Ulmus*	2	0.9%
Indeterminate	4	1.8%
Total	221	100.0%
Lycopodium	60	
Pollen Concentration 4972 Pollen grains/cm^3		

#73
Core B-1, #18
40°46.0964'N 74°00.3952'W
Hudson River

Pollen Type	Count	%	Cretaceous/Reworked Pollen	Count
Pinaceae *Tsuga*	12	5.7%	*Complexiopollenites*	1
Aceraceae *Acer*	9	4.3%	*Porocolpopollenites*	1
Asteraceae	6	2.8%		
Asteraceae *Artemesia*	1	0.5%		
Betulaceae *Alnus*	1	0.5%		
Betulaceae *Betula*	8	3.8%		
Betulaceae Ostrya	6	2.8%		
cf. Fabaceae *Robinia*	1	0.5%		
Cheno-Am	1	0.5%		
Cyperaceae	6	2.8%		
Fagaceae *Castanea*	1	0.5%		
Fagaceae *Fagus*	10	4.7%		
Fagaceae *Quercus*	72	34.1%		
Hamamelidaceae *Liquidambar*	2	0.9%		
Juglandaceae *Carya*	13	6.2%		
Juglandaceae *Juglans*	1	0.5%		
Myricaceae *Myrica*	2	0.9%		
Oleaceae *Fraxinus*	1	0.5%		
Pinaceae *Pinus*	28	13.3%		
Platanaceae *Platanus*	3	1.4%		
Poaceae	16	7.6%		
Tiliaceae *Tilia*	1	0.5%		
Ulmaceae *Ulmus*	2	0.9%		
Indeterminate	8	3.8%		
Total	211	100.0%		
Lycopodium	37			

Pollen Concentration
7698 Pollen grains/cm^3

#74
Core WP-V1

Ward's Point

Pollen Type	**Count**	**%**
Asteraceae	46	20.4%
Balsaminaceae *Impatiens*	1	0.4%
Betulaceae *Alnus*	1	0.4%
Betulaceae *Ostrya*	1	0.4%
Caprifoliaceae *Lonicera*	1	0.4%
Cheno-Am	4	1.8%
Cyperaceae	2	0.9%
Fagaceae *Castanea*	1	0.4%
Fagaceae *Fagus*	1	0.4%
Fagaceae *Quercus*	65	28.8%
Nyssaceae *Nyssa*	1	0.4%
Pinaceae *Pinus*	21	9.3%
Pinaceae *Tsuga*	7	3.1%
Platanaceae *Platanus*	2	0.9%
Poaceae	64	28.3%
Typhaceae *Typha latifolia*	4	1.8%
Ulamaceae *Celtis*	1	0.4%
Ulmaceae *Ulmus*	1	0.4%
Indeterminate	2	0.9%
Total	226	100.0%
Lycopodium	24	

Pollen Concentration
25,425 Pollen grains/cm^3

Appendix 3

Core B-1
Location 40°46.0964'N 74°00.3952'W
Hudson River

Sample #	#16
Depth	50-52 ft.
Amt.of Sediments processed	2cc
Pollen Concentration	4,972 Pollen grains/cm^3
Pollen Preservation	Very Good
Total # of Grains counted	221
Indeterminates	4
Lycopodium counted	60
Total # of Cretaceous Grains	0

Sample #	#18
Depth	60-62 ft.
Amt.of Sediments processed	2cc
Pollen Concentration	7,698 Pollen grains/cm^3
Pollen Preservation	Good
Total # of Grains counted	211
Indeterminates	8
Lycopodium counted	37
Total # of Cretaceous Grains	2

Core B-3
Location 40°43.1612'N 74°01.3938'W
Hudson River

Sample #	#17
Depth	50-52 ft.
Amt.of Sediments processed	2cc
Pollen Concentration	6,600 Pollen grains/cm^3
Pollen Preservation	Variable, mostly good
Total # of Grains counted	220
Indeterminates	5
Lycopodium counted	45
Total # of Cretaceous Grains	2

Sample #	#18
Depth	55-57cc
Amt.of Sediments processed	2cc
Pollen Concentration	7,087 Pollen grains/cm^3
Pollen Preservation	Good
Total # of Grains counted	231
Indeterminates	5
Lycopodium counted	44
Total # of Cretaceous Grains	0

Sample #	#20
Depth	65-67 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	4,300 Pollen grains/cm^3
Pollen Preservation	Very Good
Total # of Grains counted	215
Indeterminates	2
Lycopodium counted	45
Total # of Cretaceous Grains	3

Core B-4
Location 40°39.6013'N 74°05.0379'W
Upper Bay

Sample #	#12
Depth	35-37 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	1,085 Pollen grains/cm^3
Pollen Preservation	Very Good
Total # of Grains counted	200
Indeterminates	0
Lycopodium counted	1005
Total # of Cretaceous Grains	0

Sample #	#13
Depth	40-42 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	560 Pollen grains/cm^3
Pollen Preservation	Excellent
Total # of Grains	200
Indeterminates	12
Lycopodium counted	1927
Total # of Cretaceous Grains	3

Sample #	#14
Depth	45-47 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	702 Pollen grains/cm^3
Pollen Preservation	Fair
Total # of Grains	206
Indeterminates	13
Lycopodium counted	1585
Total # of Cretaceous Grains	4

Core B-5
Location 40°42.2620'N 74°07.4833'W
Newark Bay

Sample #	#15
Depth	40-42 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	167 Pollen grains/cm^3
Pollen Preservation	Poor to fair
Total # of Grains counted	11
Indeterminates	2
Lycopodium counted	355
Total # of Cretaceous Grains	1

Sample #	#19
Depth	60-62 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	446 Pollen grains/cm^3
Pollen Preservation	Fair
Total # of Grains	202
Indeterminates	7
Lycopodium counted	2445
Total # of Cretaceous Grains	4

Sample #	#23
Depth	80-82 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	106 Pollen grains/cm^3
Pollen Preservation	Very poor
Total # of Grains	6
Indeterminates	1
Lycopodium counted	305
Total # of Cretaceous Grains	0

Core B-6
Location 40°46.6696'N 74°53.02301'W
Bowery Bay

Sample #	#14
Depth	30-32 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	84 Pollen grains/cm^3
Pollen Preservation	Poor
Total # of Grains counted	5
Indeterminates	0
Lycopodium counted	320
Total # of Cretaceous Grains	0

Sample #	#20
Depth	60-60 ft.
Amt.of Sediments processed	5cc/
Pollen Concentration	No Pollen
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#15
Depth	35-37 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	439 Pollen grains/cm^3
Pollen Preservation	Fair to good
Total # of Grains counted	200
Indeterminates	7
Lycopodium counted	2458
Total # of Cretaceous Grains	0

Sample #	#Y1239
Depth	20-22 ft.
Amt.of Sediments processed	8cc
Pollen Concentration	20 Pollen grains/cm^3
Pollen Preservation	Very good
Total # of Grains counted	22
Indeterminates	1
Lycopodium counted	370
Total # of Cretaceous Grains	0

Sample #	#19
Depth	55-55 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	11,382 Pollen grains/cm^3
Pollen Preservation	Excellent
Total # of Grains counted	215
Indeterminates	3
Lycopodium counted	102
Total # of Cretaceous Grains	0

Core B-8
Location 40°28.5585'N 74°10.0056'W
Raritan Bay (Zone 1)

Sample #	#12
Depth	25-27 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	102 Pollen grains/cm^3
Pollen Preservation	Poor
Total # of Grains counted	13
Indeterminates	0
Lycopodium counted	345
Total # of Cretaceous Grains	1

Sample #	#19
Depth	60-62 ft.
Amt.of Sediments processed	2cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#15
Depth	40-45 ft.
Amt.of Sediments processed	2cc
Pollen Concentration	no pollen
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	41
Total # of Cretaceous Grains	368

Sample #	#21
Depth	70-72 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	no pollen
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	69
Total # of Cretaceous Grains	317

Sample #	#17
Depth	50-52 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Core B-13
Location 40°29.5997'N 74°15.1974'W
Ward's Point

Sample #	#6
Depth	10-12 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	64,286 Pollen grains/cm^3
Pollen Preservation	Very good
Total # of Grains counted	200
Indeterminates	0
Lycopodium counted	28
Total # of Cretaceous Grains	1

Sample #	#13
Depth	30-32 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	121,263 Pollen grains/cm^3
Pollen Preservation	Very good
Total # of Grains counted	256
Indeterminates	3
Lycopodium counted	19
Total # of Cretaceous Grains	0

Sample #	#8
Depth	14-16 ft.
Amt.of Sediments processed	2cc
Pollen Concentration	142,630 Pollen grains/cm^3
Pollen Preservation	very good-excellent
Total # of Grains	243
Indeterminates	2
Lycopodium counted	23
Total # of Cretaceous Grains	142,630 Pollen grains/cm^3

Sample #	#15
Depth	40-42 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	111,150 Pollen grains/cm^3
Pollen Preservation	Very good
Total # of Grains	247
Indeterminates	1
Lycopodium counted	20
Total # of Cretaceous Grains	1

Sample #	#11
Depth	20-22
Amt.of Sediments processed	1cc
Pollen Concentration	175,934 Pollen grains/cm^3
Pollen Preservation	Excellent
Total # of Grains counted	202
Indeterminates	1
Lycopodium counted	31
Total # of Cretaceous Grains	1

Sample #	#21
Depth	70-72 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	0
Pollen Preservation	
Total # of Grains counted	0
Indeterminates	
Lycopodium counted	148
Total # of Cretaceous Grains	105

Sample #	#12
Depth	25-27 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	142,200 Pollen grains/cm^3
Pollen Preservation	Very good
Total # of Grains counted	237
Indeterminates	0
Lycopodium counted	15
Total # of Cretaceous Grains	2

Sample #	#Y1292
Depth	22 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	24,700 Pollen grains/cm^3
Pollen Preservation	Very good
Total # of Grains counted	247
Indeterminates	39
Lycopodium counted	9
Total # of Cretaceous Grains	0

Core B-106 (Page 1)
Location 40°29.6683'N 74°11.5416'W
Raritan Bay (Zone 1)

Sample #	#11
Depth	23-25 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	17,232 Pollen grains/cm3
Pollen Preservation	Excellent
Total # of Grains counted	217
Indeterminates	2
Lycopodium counted	68
Total # of Cretaceous Grains	6

Sample #	#13
Depth	33-35
Amt.of Sediments processed	5cc
Pollen Concentration	16,428 Pollen grains/cm3
Pollen Preservation	Excellent
Total # of Grains counted	216
Indeterminates	3
Lycopodium counted	71
Total # of Cretaceous Grains	21

Sample #	#16
Depth	48-50 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	no pollen
Pollen Preservation	
Total # of Grains	
Indeterminates	
Lycopodium counted	313
Total # of Cretaceous Grains	4

Sample #	#17
Depth	53-55 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#19
Depth	63-65 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Core B-106 (Page 2)
Location 40°29.6683'N 74°11.5416'W
Raritan Bay (Zone 1)

Sample #	#21
Depth	73-75 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#25
Depth	93-94 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	169 Pollen grains/cm^3
Pollen Preservation	Very poor
Total # of Grains counted	204
Indeterminates	32
Lycopodium counted	326
Total # of Cretaceous Grains	188

Sample #	#24
Depth	88-89 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#Y1287
Depth	64 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Core B-110
Location 40°28.2604'N 74°13.1135'W
Central Raritan Bay

Sample #	#8
Depth	17-19 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	3,000 Pollen grains/cm^3
Pollen Preservation	Very good
Total # of Grains counted	230
Indeterminates	2
Lycopodium counted	69
Total # of Cretaceous Grains	4

Sample #	#22
Depth	87-89 ft.
Amt.of Sediments processed	8cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#14
Depth	47-49 ft.
Amt.of Sediments processed	4cc
Pollen Concentration	11 Pollen grains/cm^3
Pollen Preservation	Poor
Total # of Grains counted	5
Indeterminates	0
Lycopodium counted	301
Total # of Cretaceous Grains	0

Sample #	#Y1288
Depth	31 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#16
Depth	57-59 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#Y1289
Depth	98 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Core B-111
Location 40°30.0396'N 74°04.5542'W
Central Lower Bay (Zone 2)

Sample #	#12
Depth	2-4 ft
Amt.of Sediments processed	20cc
Pollen Concentration	1 Pollen grains/cm3
Pollen Preservation	Poor
Total # of Grains counted	2
Indeterminates	0
Lycopodium counted	306
Total # of Cretaceous Grains	0

Sample #	#15
Depth	54-55 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#17
Depth	64-66 ft
Amt.of Sediments processed	10cc
Pollen Concentration	3 Pollen grains/cm3
Pollen Preservation	Poor
Total # of Grains counted	2
Indeterminates	0
Lycopodium counted	143
Total # of Cretaceous Grains	9

Sample #	#19
Depth	74-76 ft.
Amt.of Sediments processed	6cc
Pollen Concentration	no pollen
Pollen Preservation	no pollen
Total # of Grains counted	0
Indeterminates	0
Lycopodium counted	74
Total # of Cretaceous Grains	5

Core B-112
Location 40°29.6964'N 74°03.7612'W
Central Lower Bay

Sample #	#12
Depth	37-39 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	14 Pollen grains/cm3
Pollen Preservation	Poor
Total # of Grains counted	1
Indeterminates	0
Lycopodium counted	310
Total # of Cretaceous Grains	1

Sample #	#14
Depth	47-49 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	6 Pollen grains/cm3
Pollen Preservation	Poor
Total # of Grains counted	1
Indeterminates	0
Lycopodium counted	362
Total # of Cretaceous Grains	0

Sample #	#21
Depth	82-83 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#22
Depth	87-88 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Core B-113

Location 40°28.5563'N 74°09.9997'W

Raritan Bay Area (Zone 1)

Sample #	#11
Depth	35-37 ft.
Amt.of Sediments processed	2cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#17
Depth	70-72 ft.
Amt.of Sediments processed	2cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#14
Depth	55-57 ft
Amt.of Sediments processed	2cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Core BV251
Location 40°31.7796'N 74°06.0960'W
Central Lower Bay (Zone 2)

Sample #	#12
Depth	42-44 ft.
Amt.of Sediments processed	20cc
Pollen Concentration	381 Pollen grains/cm^3
Pollen Preservation	Very Good
Total # of Grains counted	247
Indeterminates	5
Lycopodium counted	97
Total # of Cretaceous Grains	4

Sample #	#19
Depth	75-77 ft.
Amt.of Sediments processed	20cc
Pollen Concentration	6 Pollen grains/cm^3
Pollen Preservation	Poor to Good
Total # of Grains counted	14
Indeterminates	0
Lycopodium counted	313
Total # of Cretaceous Grains	0

Sample #	#15
Depth	57-59 ft.
Amt.of Sediments processed	20cc
Pollen Concentration	2 Pollen grains/cm^3
Pollen Preservation	Poor
Total # of Grains counted	6
Indeterminates	0
Lycopodium counted	303
Total # of Cretaceous Grains	0

Sample #	#22
Depth	92-94 ft.
Amt.of Sediments processed	20cc
Pollen Concentration	4 Pollen grains/cm^3
Pollen Preservation	Poor
Total # of Grains counted	11
Indeterminates	0
Lycopodium counted	325
Total # of Cretaceous Grains	0

Sample #	#18
Depth	72-74 ft.
Amt.of Sediments processed	20cc
Pollen Concentration	4 Pollen grains/cm^3
Pollen Preservation	Poor to Fair
Total # of Grains counted	10
Indeterminates	0
Lycopodium counted	311
Total # of Cretaceous Grains	0

Core BV252 (Page 1)
Location 40°31.7524'N 74°03.9849'W
Central Lower Bay (Zone 2)

Sample #	#14
Depth	40-42 ft
Amt.of Sediments processed	10cc
Pollen Concentration	1 Pollen grains/cm3
Pollen Preservation	Poor
Total # of Grains counted	2
Indeterminates	0
Lycopodium counted	322
Total # of Cretaceous Grains	0

Sample #	#21
Depth	75-77 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#17
Depth	55-57 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	1 Pollen grains/cm3
Pollen Preservation	poor
Total # of Grains counted	2
Indeterminates	0
Lycopodium counted	379
Total # of Cretaceous Grains	0

Sample #	#25
Depth	95-97 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	1

Sample #	#20
Depth	70-72 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	no pollen
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Core BV252 (Page 2)
Location 40°31.7524'N 74°03.9849'W
Central Lower Bay (Zone 2)

Sample #	#Y1278
Depth	32 ft.
Amt.of Sediments processed	10cc
Pollen Concentration	1 Pollen grains/cm3
Pollen Preservation	Poor
Total # of Grains counted	1
Indeterminates	0
Lycopodium counted	367
Total # of Cretaceous Grains	0

Sample #	#Y1279
Depth	70 ft
Amt.of Sediments processed	3cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#Y1280
Depth	100 ft.
Amt.of Sediments processed	5cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#Y1281
Depth	100 ft
Amt.of Sediments processed	5cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Core WP-V1
Location
Ward's Point

Sample #	#S-0
Depth	16.2 ft.
Amt.of Sediments processed	1cc
Pollen Concentration	25,425 Pollen grains/cm^3
Pollen Preservation	Excellent
Total # of Grains counted	226
Indeterminates	2
Lycopodium counted	24
Total # of Cretaceous Grains	0

Zone 2

Sample #	#Y1295
Depth	30 ft
Amt.of Sediments processed	10cc
Pollen Concentration	no pollen
Pollen Preservation	Poor
Total # of Grains counted	0
Indeterminates	1
Lycopodium counted	341
Total # of Cretaceous Grains	2

Sample #	#Y1296
Depth	40-41 ft
Amt.of Sediments processed	3cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#Y1297
Depth	80.5 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

Sample #	#Y1298
Depth	95 ft.
Amt.of Sediments processed	3cc
Pollen Concentration	
Pollen Preservation	
Total # of Grains counted	
Indeterminates	
Lycopodium counted	
Total # of Cretaceous Grains	

APPENDIX 5

Foraminiferal Analyses of Boring and Vibracore Samples

by

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(Original report reproduced in its entirety.)

07/01/98

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cc Philip LaPorta
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Enclosed please find our final report for the analysis of New York/New Jersey harbor and offshore boring samples. We sampled, washed and microscopically examined 58 samples with an average processed weight of 22.8 grams. Sample sizes ranged between 6.5 to 39 grams. Although relatively sizeable and therefore representative samples were used for our analysis, only 4 of 58 samples contained calcareous foraminifera and one contained arenaceous species. All foraminifera enumerated were of the size range greater than 150 micrometers.

In general, the samples that contained benthic foraminifera were low in coarse fraction (< 12%) and contained mollusk shells. The most prevalent species of benthic foraminifera found in this suite of samples was *Elphidium excavatum*, a species well-adapted to extreme fluctuations in salinity and temperature found in estuarine environments (Miller et al, Journal of Foraminiferal Research, v. 12, no. 2, 1982).

Regards,

Kathryn L. Elder
Kathryn L. Elder

C. Eben Franks
C. Eben Franks

Sample Identification:	B8 Zone-1 12 25-27
Weight of Sample Processed:	33.6500 (g)
Weight > 63 µ	31.8884 (g)
Percent Coarse Fraction	94.8 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of tan/black/white well-sorted sand.

Sample 1 of 58

07/01/98

Sample Identification:	B8 Zone-1 14 35-37
Weight of Sample Processed:	23.4251 (g)
Weight > 63 μ	2.0804 (g)
Percent Coarse Fraction	8.9 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 90% black organic material, 10% quartz sand.

Sample 2 of 58

07/01/98

Sample Identification:	B8 Zone-1 15 40-45
Weight of Sample Processed:	29.1257 (g)
Weight > 63 μ	3.3850 (g)
Percent Coarse Fraction	11.6 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 50% black organic material, 50% quartz sand.

Sample 3 of 58

07/01/98

Sample Identification:	B8 Zone-1 17 50-52
Weight of Sample Processed:	36.8436 (g)
Weight > 63 µ	1.0593 (g)
Percent Coarse Fraction	2.9 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 50% black organic material, 50% unsorted sand and fossilized worm-holes(?).

Sample 4 of 58

07/01/98

Sample Identification:	B8 Zone-1 19 60-62
Weight of Sample Processed:	24.9919 (g)
Weight > 63 µ	11.6907 (g)
Percent Coarse Fraction	46.8 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material, 95-100% well-sorted fine-grained quartz sand and mica.

Sample 5 of 58

07/01/98

Sample Identification:	B8 Zone-1 21 70-72
Weight of Sample Processed:	28.1795 (g)
Weight > 63 μ	11.5696 (g)
Percent Coarse Fraction	41.1 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material, 95-100% well-sorted fine-grained quartz sand and mica.

Sample 6 of 58

07/01/98

Sample Identification:	B8 Zone-1 23 80-82
Weight of Sample Processed:	12.0927 (g)
Weight > 63 μ	1.0012 (g)
Percent Coarse Fraction	8.3 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 25-35% black organic material, 65-75% sand and mica.

Sample 7 of 58

07/01/98

Sample Identification:	B8 Zone-1 24 85-87
Weight of Sample Processed:	22.7870 (g)
Weight > 63 µ	2.4320 (g)
Percent Coarse Fraction	10.7 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material, 95-100% sand and mica.

Sample 8 of 58

07/01/98

Sample Identification:	B106 Zone-1 11
Weight of Sample Processed:	26.0907 (g)
Weight > 63 μ	13.0951 (g)
Percent Coarse Fraction	50.2 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 2-5% black organic material, 98-95% well-sorted fine-grained quartz sand and mica.

Sample 9 of 58

07/01/98

Sample Identification:	B106 Zone-1 13
Weight of Sample Processed:	17.7633 (g)
Weight > 63 μ	6.7927 (g)
Percent Coarse Fraction	38.2 %
Foraminiferal Content/species:	*not present*
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 2-5% black organic material, 98-95% well-sorted fine-grained quartz sand and mica.

Sample 10 of 58

07/01/98

Sample Identification:	B106 Zone-1 17
Weight of Sample Processed:	33.5309 (g)
Weight > 63 μ	27.7010 (g)
Percent Coarse Fraction	82.6 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of well-sorted quartz sand and mica, very few organic peices.

Sample 11 of 58

07/01/98

Sample Identification:	B106 Zone-1 19
Weight of Sample Processed:	25.8143 (g)
Weight > 63 μ	14.6221 (g)
Percent Coarse Fraction	56.6 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material, 95-100% well-sorted fine quartz sand and mica.

Sample 12 of 58

07/01/98

Sample Identification:	B106 Zone-1 21
Weight of Sample Processed:	34.1967 (g)
Weight > 63 µ	30.2619 (g)
Percent Coarse Fraction	88.5 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material (including a large chunkof black wood), 95-100% well-sorted coarser sand and mica.

Sample 13 of 58

07/01/98

Sample Identification:	B106 Zone-1 26
Weight of Sample Processed:	39.0799 (g)
Weight > 63 µ	21.9967 (g)
Percent Coarse Fraction	56.3 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 2-5% black organic material, 98-95% sand and mica.

Sample 14 of 58

07/01/98

Sample Identification:	B106 Zone-1 27
Weight of Sample Processed:	29.6882 (g)
Weight > 63 µ	26.0249 (g)
Percent Coarse Fraction	87.7 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 2-5% black organic material, 98-95% sand and mica.

Sample 15 of 58

07/01/98

Sample Identification:	B113 Zone-1 11 35-37
Weight of Sample Processed:	12.7563 (g)
Weight > 63 μ	1.2860 (g)
Percent Coarse Fraction	10.1 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 95% black organic material, 5% sand and mica.

Sample 16 of 58

07/01/98

Sample Identification:	B113 Zone-1 14 55-57
Weight of Sample Processed:	22.7091 (g)
Weight > 63 μ	3.3821 (g)
Percent Coarse Fraction	14.9 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 25-35% black organic material, 65-75% very fine-grained sand and mica.

Sample 17 of 58

07/01/98

Sample Identification:	B113 Zone-1 17 70-72
Weight of Sample Processed:	28.2454 (g)
Weight > 63 µ	8.6631 (g)
Percent Coarse Fraction	30.7 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material, 95-100% well-sorted fine-grained quartz sand and mica.

Sample 18 of 58

07/01/98

Sample Identification:	B113 Zone-1 20 85-87
Weight of Sample Processed:	13.1291 (g)
Weight > 63 µ	4.1932 (g)
Percent Coarse Fraction	31.9 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 10-15% black organic material, 85-90% sand and mica.

Sample 19 of 58

07/01/98

Sample Identification:	B113 Zone-1 23 100-102
Weight of Sample Processed:	14.9897 (g)
Weight > 63 μ	1.5947 (g)
Percent Coarse Fraction	10.6 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 90% black organic material, 10% quartz sand.

Sample 20 of 58

07/01/98

Sample Identification:	BU-252-Zone 2 14
Weight of Sample Processed:	29.5249 (g)
Weight > 63 μ	26.8107 (g)
Percent Coarse Fraction	90.8 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of not well-sorted sand, no organic matter.

Sample 21 of 58

07/01/98

Sample Identification:	BU-252-Zone 2 17
Weight of Sample Processed:	20.4215 (g)
Weight > 63 µ	18.8678 (g)
Percent Coarse Fraction	92.4 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of well-sorted multi-colored sand.

Sample 22 of 58

07/01/98

Sample Identification:	BU-252-Zone 2 21 75-77
Weight of Sample Processed:	22.0043 (g)
Weight > 63 µ	15.9631 (g)
Percent Coarse Fraction	72.5 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 2-5% black organic material, 98-95% well-sorted fine-grained quartz sand and mica.

Sample 23 of 58

07/01/98

Sample Identification:	BU-252-Zone 2 23 85-87
Weight of Sample Processed:	25.7860 (g)
Weight > 63 µ	17.9041 (g)
Percent Coarse Fraction	69.4 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 1-2% black organic material, 98-99% well-sorted white quartz sand and mica.

Sample 24 of 58

07/01/98

Sample Identification: BU-252-Zone 2 25 95-97

Weight of Sample Processed: 20.3624 (g)

Weight > 63 µ 16.2238 (g)

Percent Coarse Fraction 79.7 %

Foraminiferal Content/species: not present

Total # Foraminifera per gram: 0.0/g

Observations: Sample composed of approximately <1% black organic material, 99% well-sorted white quartz sand and mica.

Sample 25 of 58

07/01/98

Sample Identification:	B110 Zone-1 8 17-19
Weight of Sample Processed:	10.2422 (g)
Weight > 63 µ	0.7201 (g)
Percent Coarse Fraction	7.0 %
Foraminiferal Content/species:	benthic forams
	33 Elphidium excavatum
Total # Foraminifera per gram:	3.2/g

Observations: Sample composed of unsorted quartz sands including mica and gastropod shells.

Sample 26 of 58

07/01/98

Sample Identification:	B110 Zone-1 10 27-29
Weight of Sample Processed:	22.2253 (g)
Weight > 63 µ	20.0470 (g)
Percent Coarse Fraction	90.2 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of unsorted iron-stained sand including pebbles and mica.

Sample 27 of 58

07/01/98

Sample Identification:	B110 Zone-1 14 47-49
Weight of Sample Processed:	20.9698 (g)
Weight > 63 µ	17.1165 (g)
Percent Coarse Fraction	81.6 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 1-2% black organic material, 98-99% well-sorted white quartz sand and mica.

Sample 28 of 58

07/01/98

Sample Identification:	B110 Zone-1 18 67-69
Weight of Sample Processed:	22.1550 (g)
Weight > 63 µ	0.4007 (g)
Percent Coarse Fraction	1.8 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 20-30% black and brown organic material, 70-80% angular fine-grained sand and mica.

Sample 29 of 58

07/01/98

Sample Identification: B110 Zone-1 22 87-89

Weight of Sample Processed: 18.9948 (g)

Weight > 63 µ 17.0164 (g)
Percent Coarse Fraction 89.6 %

Foraminiferal Content/species: not present

Total # Foraminifera per gram: 0.0/g

Observations: Sample composed of approximately 1-2% black organic material, 98-99% well-sorted white quartz sand and mica.

Sample 30 of 58

07/01/98

Sample Identification:	B110 Zone-1 24 97-99
Weight of Sample Processed:	33.0881 (g)
Weight > 63 µ	27.5289 (g)
Percent Coarse Fraction	83.2 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 1-2% black organic material, 98-99% well-sorted white quartz sand and mica.

Sample 31 of 58

07/01/98

Sample Identification:	B111 Zone-1 12 34-36
Weight of Sample Processed:	32.3646 (g)
Weight > 63 μ	20.7463 (g)
Percent Coarse Fraction	64.1 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 1-2% black organic material, 98-99% well-sorted white quartz sand and mica.

Sample 32 of 58

07/01/98

Sample Identification:	B111 Zone-1 15 54-55
Weight of Sample Processed:	20.6861 (g)
Weight > 63 μ	16.5011 (g)
Percent Coarse Fraction	79.8 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 10-15% black organic material, 85-90% angular sand and mica.

Sample 33 of 58

07/01/98

Sample Identification:	B111 Zone-1 20 79-81
Weight of Sample Processed:	19.3109 (g)
Weight > 63 µ	13.0378 (g)
Percent Coarse Fraction	67.5 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 10-15% black organic material, 85-90% angular sand and mica.

Sample 34 of 58

07/01/98

Sample Identification:	B111 Zone-1 22 89-91
Weight of Sample Processed:	27.9832 (g)
Weight > 63 µ	21.7182 (g)
Percent Coarse Fraction	77.6 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material, 95-100% sand and mica.

Sample 35 of 58

07/01/98

Sample Identification:	B13 WP 21 65-67
Weight of Sample Processed:	20.8962 (g)
Weight > 63 μ	9.5441 (g)
Percent Coarse Fraction	45.7 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 15-20% black and brown organic material, 80-85% sand and mica.

Sample 36 of 58

07/01/98

Sample Identification:	B13 WP 22 70-72
Weight of Sample Processed:	18.9469 (g)
Weight > 63 µ	0.4572 (g)
Percent Coarse Fraction	2.4 %
Foraminiferal Content/species:	arenaceous forams
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately <1% black organic material, 40% well-sorted white quartz sand and mica, 60% >150 micron arenaceous forams.

Sample 37 of 58

07/01/98

Sample Identification:	B-112 Zone 2 12 37-39
Weight of Sample Processed:	31.3950 (g)
Weight > 63 µ	9.9011 (g)
Percent Coarse Fraction	31.5 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of very fine well-rounded, well-sorted multi-colored sand.

Sample 38 of 58

07/01/98

Sample Identification:	B-112 Zone 2 14 47-49
Weight of Sample Processed:	29.6606 (g)
Weight > 63 μ	27.2491 (g)
Percent Coarse Fraction	91.9 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of well-sorted multi-colored sand.

Sample 39 of 58

07/01/98

Sample Identification:	B-112 Zone 2 21 82-83
Weight of Sample Processed:	26.4213 (g)
Weight > 63 µ	22.1870 (g)
Percent Coarse Fraction	84.0 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 1-2% black organic material, 98% sand (mostly fine but some pebbles) and mica.

Sample 40 of 58

07/01/98

Sample Identification:	B-112 Zone 2 22 87-88
Weight of Sample Processed:	31.5798 (g)
Weight > 63 µ	28.5082 (g)
Percent Coarse Fraction	90.3 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 1-2% black organic material, 98% quartz sand (mostly fine but some colored pebbles) and mica.

Sample 41 of 58

07/01/98

Sample Identification:	B-6 Y-1239 20-22
Weight of Sample Processed:	22.2432 (g)
Weight > 63 μ	17.7014 (g)
Percent Coarse Fraction	79.6 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of coarse multicolored sand with small pebbles.

Sample 42 of 58

07/01/98

Sample Identification:	V252 Y-1278 32
Weight of Sample Processed:	30.5355 (g)
Weight > 63 µ	28.8963 (g)
Percent Coarse Fraction	94.6 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of coarse multicolored sand with small pebbles.

Sample 43 of 58

07/01/98

Sample Identification:	V252 Y-1279 70
Weight of Sample Processed:	12.5169 (g)
Weight > 63 µ	6.6940 (g)
Percent Coarse Fraction	53.5 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 75% black organic material (some larger peices), 25% angular sand with iron staining and mica.

Sample 44 of 58

07/01/98

Sample Identification:	V252 Y-1280 100
Weight of Sample Processed:	24.8464 (g)
Weight > 63 μ	14.6087 (g)
Percent Coarse Fraction	58.8 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material, 95-100% well-sorted fine quartz sand and mica.

Sample 45 of 58

07/01/98

Sample Identification:	V252 Y-1281 100
Weight of Sample Processed:	23.7690 (g)
Weight > 63 μ	14.5266 (g)
Percent Coarse Fraction	61.1 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 20% black organic material, 80% well-sorted fine quartz sand with iron staining and mica.

Sample 46 of 58

07/01/98

Sample Identification:	B106 Y-1287 64
Weight of Sample Processed:	22.6039 (g)
Weight > 63 µ	12.1503 (g)
Percent Coarse Fraction	53.8 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 5-10% black organic material, 95-100% well-sorted fine quartz sand and mica.

Sample 47 of 58

07/01/98

Sample Identification:	B110-Z-1 Y-1288 33
Weight of Sample Processed:	24.5594 (g)
Weight > 63 µ	21.1426 (g)
Percent Coarse Fraction	86.1 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 2% black organic material, 98% well-sorted fine-grained quartz sand.

Sample 48 of 58

07/01/98

Sample Identification:	B110-Z-1 Y-1289 98
Weight of Sample Processed:	12.1602 (g)
Weight > 63 µ	7.4612 (g)
Percent Coarse Fraction	61.4 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 90% black organic material, 10% quartz sand and mica.

Sample 49 of 58

07/01/98

Sample Identification:	B13 Y-1292 22
Weight of Sample Processed:	6.4984 (g)
Weight > 63 µ	3.9287 (g)
Percent Coarse Fraction	60.5 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 100% brown-black organic material.

Sample 50 of 58

07/01/98

Sample Identification: Zone-2 Y-1295 30

Weight of Sample Processed: 31.7965 (g)

Weight > 63 μ 24.7880 (g)

Percent Coarse Fraction 78.0 %

Foraminiferal Content/species: not present

Total # Foraminifera per gram: 0.0/g

Observations: Sample composed of very well-sorted fine quartz sand and mica.

Sample 51 of 58

07/01/98

Sample Identification: Zone-2 Y-1296 40-41

Weight of Sample Processed: 13.3301 (g)

Weight > 63 µ 7.9458 (g)

Percent Coarse Fraction 59.6 %

Foraminiferal Content/species: not present

Total # Foraminifera per gram: 0.0/g

Observations: Sample composed of approximately 90% black organic material, 10% quartz sand and mica.

Sample 52 of 58

07/01/98

Sample Identification:	Zone-2 Y-1297 80.5
Weight of Sample Processed:	16.5844 (g)
Weight > 63 μ	12.0804 (g)
Percent Coarse Fraction	72.8 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 90% black organic material, 10% quartz sand and mica.

Sample 53 of 58

07/01/98

Sample Identification:	Zone-2 Y-1298 95
Weight of Sample Processed:	29.7523 (g)
Weight > 63 μ	17.2388 (g)
Percent Coarse Fraction	57.9 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 90% black organic material, 10% quartz sand and mica.

Sample 54 of 58

07/01/98

Sample Identification:	Zone 1 B111 2 2-4
Weight of Sample Processed:	24.6069 (g)
Weight > 63 μ	22.8507 (g)
Percent Coarse Fraction	92.9 %
Foraminiferal Content/species:	not present
Total # Foraminifera per gram:	0.0/g

Observations: Sample composed of approximately 2-5% carbonate shell material (molluscs, balanus), 98-95% unsorted, sub-rounded multicolored sand.

Sample 55 of 58

07/01/98

Sample Identification:	Z-1 V-1 sec 0
Weight of Sample Processed:	12.6656 (g)
Weight > 63 μ	0.3897 (g)
Percent Coarse Fraction	3.1 %
Foraminiferal Content/species:	benthic forams
	343 Elphidium excavatum
Total # Foraminifera per gram:	27.1/g

Observations: Sample composed of approximately 2-5% carbonate shell material, 20% organic matter and 75% unsorted, angular quartz sand and mica.

Sample 56 of 58

07/01/98

Sample Identification:	Z-1 V-2 sec 0
Weight of Sample Processed:	15.6348 (g)
Weight > 63 µ	0.6965 (g)
Percent Coarse Fraction	4.5 %
Foraminiferal Content/species:	benthic forams 306 Elphidium excavatum, 17 Epistominella exigua, 1 Globobulimina auriculata
Total # Foraminifera per gram:	20.7/g

Observations: Sample composed of approximately 2-5% carbonate shell material, 20% organic matter and 75% unsorted, angular quartz sand and mica.

07/01/98

Sample Identification: Z-1 V-3 sec 0

Weight of Sample Processed: 12.2441 (g)

Weight > 63 µ 1.4291 (g)

Percent Coarse Fraction 11.7 %

Foraminiferal Content/species: benthic forams

39 Elphidium excavatum

Total # Foraminifera per gram: 3.2/g

Observations: Sample composed of approximately 2-5% carbonate shell material, 20% organic matter and 75% unsorted, angular quartz sand and mica.

Sample 58 of 58

07/01/98

APPENDIX 6

Qualifications of La Porta & Associates Personnel

PHILIP C. La PORTA
Curriculum Vitae

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EDUCATION

Ph.D. (geology/archaeological geology), City University of New York, 1999
M.Phil. (geology), The Graduate Center of the City University of New York, 1996
M.A. (geology), Queens College of the City University of New York, 1990
B.A. (geology/anthropology), Rutgers University, New Brunswick, New Jersey, 1977
Attended graduate program in anthropology, State University of New York at Binghamton, 1977-79

Dissertation title: The Stratigraphy and Structure of the Cambrian and Ordovician Carbonates of the Wallkill River Valley: The Nature of the Diagenesis of Chert and Its Archaeological Potential

Research interests: *archaeology:* Northeastern United States hunter/gatherer prehistory, prehistoric quarries and quarry technology, trade and exchange systems, lithic provenance studies, Paleolithic of southern India; *geology:* Cambro-Ordovician carbonates, nodular and bedded cherts, Appalachian structural geology and stratigraphy, carbonate diagenesis and reef growth through time, economic ore deposits, history and philosophy of geology

PROFESSIONAL EXPERIENCE

1993-present	President, La Porta & Associates, Inc., Geological Consultants - Lithic analysis, regional geological studies, geomorphology and sedimentology of archaeological sites
1997	Mapping Geologist/Archaeologist, Smithsonian Institution Archeological Expedition, Southern India
1983-1984	Laboratory Archaeologist, Louis Berger & Associates, East Orange, New Jersey
1979-1980	Archivist, Bergen County, New Jersey - Native American studies, contact, and proto-historic relations in Metropolitan New York region
1977-1979	Geologist and illustrator, Public Archaeology Facility, SUNY at Binghamton

TEACHING EXPERIENCE

1995-1997	Co-director, Archaeological Field School, Montclair State University, Montclair, New Jersey
1995	Adjunct Lecturer in geology, Lehman College of the City University of New York
1989-1994	Adjunct Lecturer in geology, Hunter College of the City University of New York
1987	Adjunct Lecturer in geology, Queensborough Community College of the City University of New York
1986-1989	Adjunct Lecturer in geology, Queens College of the City University of New York
1982-1984	Lecturer in anthropology/geology, Newark Museum, Newark, New Jersey
1981-1983	Teaching Assistant in geology, Rutgers University, New Brunswick, New Jersey

PUBLICATIONS AND ABSTRACTS

Most recent publications and works in progress:

Brewer, M.C., and La Porta, P.C., 1999, The prehistoric quarry landscape in the eastern Appalachians [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

Funk, R., and La Porta, P.C., ms. in prep., "Settlement Patterns and Stone-working Technology": Popular Brochure for Iroquois Pipeline Study, prepared by Hartgen Archaeological Associates, Inc., Troy, New York for Iroquois Gas Company.

La Porta, P.C., ms. in prep., Bedrock Geology and Lithic Resources, *in* Grumet, R.S., ed., The Archaeology of Great American Cities: New York: Washington, D.C., National Park Service.

La Porta, P.C., 1999, The organization of prehistoric mining technology in the Wallkill River Valley of northwestern New Jersey [abs.]: Geological Society of America, Abstracts with Programs.

La Porta, P.C., 1999, Recent approaches to provenance studies and raw material analysis, from classical methods to modern technology: Middle Atlantic Archaeological Conference, Session Organizer and Chair, April 9-11, 1999.

La Porta, P.C., 1999, The role of rock fabric in lithic selection for diagnostic stone tools recovered from the Whitehurst Freeway Project, Washington, D.C. [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

La Porta, P.C., Petraglia, M., and Korisettar, R., ms. in prep., Lakhmapur Quarry, peninsular India: A 500,000-year-old, Lower Paleolithic manufacturing center: to be submitted to Antiquity.

Petraglia, M., La Porta, P.C., and Paddayya, K., in press, Isampur, an Acheulian quarry in India and its implications for assessing the meaning of stone tool morphology: Journal of Archeological Research.

Sohl, L.E., and La Porta, P.C., 1999, Fundamental criteria for prehistoric quarry development [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

Other publications:

Bergman, C.A., Doershuk, J.F., La Porta, P.C., and Schuldenrein, J., 1996, An introduction to the Early and Middle Archaic occupations at Sandt's Eddy: Pennsylvania Archaeologist.

Bergman, C.A., La Porta, P.C., Doershuk, J.F., Fassler, H., Rue, D., and Schuldenrein, J., 1993, The Padula Site (36Nm15) and chert resource exploitation in the Middle Delaware River Valley: Archaeology of Eastern North America, v. 20, p. 39-66.

Brewer, M.C., and La Porta, P.C., 1998, Geological catchments for lithic provenance research: Case studies from eastern North America [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

La Porta, P.C., 1998, The chemical characterization of ferruginous cherts: A case study from Lums Pond archaeological site, Iron Hill, Delaware [abs.]: Geological Society of America, Abstracts with Programs, v. 30(1), p. 31.

La Porta, P.C., 1998, Chertification processes and silica sources: Examples from the Central Appalachians [abs.]: Geological Society of America, Abstracts with Programs, v. 30(7), p. A-333.

La Porta, P.C., 1998, Diagenesis of Cambro-Ordovician cherts [abs.]: Geological Society of America, Abstracts with Programs, v. 30(1), p. 31.

La Porta, P.C., 1998, Geological catchment and lithic source identification for diagnostic stone tools recovered from Whitehurst [abs.]: Middle Atlantic Archaeological Conference, Programs and Abstracts, April 2-5, 1998, Cape May, New Jersey.

La Porta, P.C., 1998, The prehistoric mining landscape and evolution of ore exploitation [abs.]: Eastern States Archaeological Federation, Annual Meeting Abstracts.

La Porta, P.C., 1997, A geological framework for lithic provenance studies: A case study from Lums Pond at Iron Hill, Delaware [abs.]: Eastern States Archaeological Federation, Annual Meeting Abstracts.

La Porta, P.C., 1997, The prehistoric mining technology of the Cambro-Ordovician carbonates of the Wallkill River Valley of northwestern New Jersey [abs.]: Geological Society of America, Abstracts with Programs, v. 29(6), p. A-146.

La Porta, P.C., 1996, Raw Material, Lithics, and Quarry Workshop [abs.]: Canadian Archaeological Association Meeting, hosted by Dr. Stephen Davis, St. Mary's University, chaired by Dr. David Black, University of New Brunswick.

La Porta, P.C., 1996, Lithostratigraphic models and the geographic distribution of prehistoric chert quarries within the Cambro-Ordovician lithologies of the Great Valley Sequence, Sussex County, New Jersey and Orange County, New York: Annual Field Conference - Geological Association of New Jersey, v. 13, p. 47-70.

La Porta, P.C., 1996, Lithostratigraphy as a predictive tool for prehistoric quarry investigations: Examples from the Dutchess Quarry Site, Orange County, New York, *in* Lindner, C., ed., A Golden Chronograph for Robert E. Funk: Occasional Papers in Northeastern Anthropology No. 15: Bethlehem, Connecticut, Archaeological Services, p. 73-84.

La Porta, P.C., 1996, Lithic analysis and databases for the Middle Atlantic states [abs.]: Society for American Anthropology, Annual Meeting Abstracts, v. 61.

La Porta, P.C., 1995, Petrographic identification of lithic sources [abs.]: Geological Society of America, Abstracts with Programs, v. 27(1), p. 62.

La Porta, P.C., 1994, Lithostratigraphic models and the geographic distribution of prehistoric chert quarries within the Cambro-Ordovician lithologies of the Great Valley Sequence, Sussex County, New Jersey, *in* Bergman, C.A. and Doershuk, J.F., eds., Recent Research into the Prehistory of the Delaware Valley, Journal of Middle Atlantic Archaeology, v. 10, p. 47-66.

La Porta, P.C., 1994, Prehistoric chert quarries within the Lower Ordovician Halcyon Lake Group: The elucidation of a prehistoric mining district in Orange County, New York [abs.]: New York State Archaeological Association, Annual Meeting Program and Abstracts, p. 15.

La Porta, P.C., 1994, The Lewis M. Haggerty Collection [abs.]: Eastern States Archaeological Federation, Annual Meeting Abstracts, p. 16.

La Porta, P.C., 1993, Prehistoric chert exploitation in the Cambro-Ordovician lithologies of the Wallkill River Valley [abs.]: Society of American Archaeology, Annual Meeting Abstracts, p. 81.

La Porta, P.C., 1993, The application of cognitive models for lithic resource exploitation: Folk geology within the Wallkill River Valley [abs.]: New York State Archaeological Association, Annual Meeting Program and Abstracts, p. 11.

La Porta, P.C., 1992, Nodular cherts of the Cambro-Ordovician Kittatinny Supergroup: Their diagenesis, stratigraphic relevance and archaeological potential [abs.]: Materials Research Society, Annual Meeting (abstract).

La Porta, P.C., 1991, A chert stratigraphy for the Cambro-Ordovician carbonates of the Kittatinny Supergroup: Their geological and human geographic potential: Association of American Geographers, Middle States Division, 1991 Annual Meeting.

La Porta, P.C., 1990, The Stratigraphic Relevance and Archaeological Potential of the Cambro-Ordovician Kittatinny Supergroup of the Wallkill River Valley of Northern New Jersey: M.A. thesis, Queens College of the City University of New York, 50 p.

La Porta, P.C., 1989, The stratigraphic relevance and archaeological potential of the chert-bearing carbonates within the Kittatinny Supergroup, in New York State Geological Association Field Trip Guidebook, 61st Annual Meeting, Middletown, New York.

La Porta, P.C., 1987, Prehistoric resource analysis: field observations and petrographic characteristics of Cambrian-Ordovician chert [abs.]: Geological Society of America, Abstracts with Programs, v. 19(1), p. 24-25.

La Porta, P.C., 1986, The archaeological potential of the Leithsville Formation: a Lower Cambrian chert-bearing carbonate in New Jersey [abs.]: Geological Society of America, Abstracts with Programs, v. 18(1), p. 28-29.

La Porta, P.C., and Petraglia, M.D., 1998, Geological controls on Acheulian quarries and artifact forms [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

La Porta, P.C., Szekielda, K., and Brewer, M.C., 1994, Prehistoric Late-Middle Archaic to Transitional Mining Practices in the Wallkill River Valley [abs.]: Eastern States Archaeological Federation, Annual Meeting Abstracts, p. 16.

Lozny, L.R., and La Porta, P.C., 1995, Patterns of chert exploitation in the northeastern U.S.A. [abs.]: VII International Flint Symposium, Warsaw, Poland, September 4-8, 1995.

Roberston, V., Shields, C., and La Porta, P.C., 1998, Early to Late Woodland Ceramic Industries [abs]: Middle Atlantic Archaeological Conference, Programs and Abstracts, April 2-5, 1998, Cape May, New Jersey.

Sohl, L.E., and La Porta, P.C., 1998, Models for quarry development in a prehistoric mining district [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

CONTRIBUTIONS TO CULTURAL RESOURCE MANAGEMENT REPORTS

1998 Contributions to *Data Recovery and Excavations of the Whitehurst Freeway, Sites 51NW103, 51NW104 and 51NW117,* including a) The Geological Catchment for the Capitol District, b) Petrographic Atlas of Quartzite Textures, and c) Petrographic Atlas of Woodland Ceramics: Report submitted by Parsons Engineering Science, Inc., Fairfax, Virginia for National Park Service, Washington, D.C.

1998 "A Geomorphological and Archaeological Analysis of Potential Dredged Material Management Alternative Sites in the New York Harbor-Apex Region": Report submitted to Battelle Research Corp. for the Army Corps of Engineers - New York District.

1998 "Lithic Analysis for Long Valley Project 2163, Morris County, New Jersey": Report submitted to Louis Berger & Associates, Inc., East Orange, New Jersey.

1997 "Lithic Analysis of Materials Recovered during Phase III Excavations of the Bennett Site (36 Sq 109), Susquehanna County, Pennsylvania": Report submitted to Louis Berger & Associates, Inc., East Orange, New Jersey.

1997 "Petrographic and Hand Sample Analysis of Lithic Materials Recovered from Site 18 PR 119, Sherwood-3 Project, Prince Georges County, Maryland": Report submitted to R. Christopher Goodwin & Associates, Frederick, Maryland.

1997 "Geomorphological Assessment of the Surficial Deposits within a Transgressive Estuarine Complex, Bridgeport Municipal Airport, Stratford, Connecticut": Report submitted to URS Greiner, Inc., Florence, New Jersey.

1997 "Geologic Catchment and Lithic Analysis for Phase II of the Iroquois Compressor Project, West Athens Hill, New York": Report submitted to Hartgen Archeological Associates, Inc., Troy, New York for Iroquois Gas Company.

1997 "Geologic Reconnaisance for Phase IB of the Sprint Telecommunications Line Study, New Baltimore Township, New York": Report submitted to Hartgen Archeological Associates, Inc., Troy, New York.

1996 "Technical Report for Lums Pond, Delaware Archeological Investigation: A Chemical Characterization of Jasper Artifacts Originating from New Jersey, Pennsylvania and Delaware": Report submitted as part of *The Prehistory of the Lums Pond Site, Newcastle County, Delaware*, prepared by Parsons Engineering Science, Inc., Fairfax, Virginia for Delaware Department of Transportation, Newark, Delaware.

1996 "Technical Report for Site PS 56R, Staten Island": Report submitted to Historical Perspectives, Inc., Westport, Connecticut.

1996 "Technical Report for Veteran's Administration National Cemetery, Site 731, Town of Stillwater, Saratoga County, New York: Phase II Archeological Investigation": Report submitted to Hartgen Archeological Associates, Troy, New York.

1995 "The Saxtant Site, C7537.02: Rathbone, Steuben County, New York: Part I, Lithic Catchment; Part II, Geomorphology and Soils Classification": Report submitted to 3D/ESI, Inc., Cincinnati, Ohio for CNG Transmission Corporation, Clarksburg, West Virginia.

1995 "Geological Catchment for Central Hudson Utility Line Project (P and MK Line, Ulster County), Phase IB Report": Report submitted to Hartgen Archeological Associates, Inc., Troy, New York for Central Hudson Power and Gas, Albany, New York.

1995 "Geological Catchment for Kingston Business Park, Kingston, New York, Project No. 426, Phase II Report": Report submitted to Hartgen Archeological Associates, Inc., Troy, New York for the City of Kingston, New York.

1995 "Soil Study for Tenneco Pipeline, Project No. C7373.02, Morgan County, Ohio": Report submitted to 3D/ESI, Inc., Cincinnati, Ohio.

1995 "Lithic Analysis of the Catskill Quarry Collection, Project No. 347, Phase IB Report": Report submitted to Hartgen Archeological Associates, Inc., Troy, New York.

1995 "Lithic Analysis and Geologic Catchment for the New Hampshire Wal*Mart RDC Site, Phase II Report": Report submitted to Hartgen Archeological Associates, Inc., Troy, New York.

1995 "Lithic Analysis of the Wood's Edge Collection, Phase I Report": Report submitted to Kittatinny Archaeological Research, Inc., Stroudsburg, Pennsylvania.

1995 "Lithic Analysis of the Richfield Site, Phase II Collection": Report submitted to Kittatinny Archaeological Research, Inc., Stroudsburg, Pennsylvania.

1995 "Geological Catchment for Site C7477.01 Along the Tejas Transmission Line, Northern Tioga County, Pennsylvania, Phase IB Report": Report submitted to 3D/ESI, Inc., Cincinnati, Ohio for Tejas Gas Corporation, Houston, Texas.

1994 "Phase III Survey and Testing Along the CNG Natural Gas Pipeline, Kettle Creek Sites (36-Cn-165 and 36-Cn-199), Clinton County, Pennsylvania": Report submitted as part of *Archaeological Excavations on Kettle Creek: Investigations at 36CN165 and 36CN199, Clinton County, Pennsylvania,* prepared by Engineering Science, Washington, D.C. for CNG Transmission Corporation, Clarksburg, West Virginia.

1994 "Catchment Geology for Prehistoric Sites Located within the Chilhowee and Glade Springs Quadrangles, Roanoke, Virginia, Phase 2 Report": Report submitted to 3D/Environmental Services, Inc., Cincinnati, Ohio for National Park Service, Washington, D.C.

1994 Contributions to Chapters 2, 6 and 7 (covering regional geology and lithic analysis) submitted as part of *Archaeological Data Recovery for Transcontinental Gas Pipe Line Corporation's 6.79 Mile Leidy Natural Gas Pipeline Expansion, Sandt's Eddy Site (36-Nm-12), Northhampton County, Pennsylvania,* prepared by 3D/Environmental Services, Inc., Cincinnati, Ohio for Transcontinental Gas Pipe Line Corporation, Houston, Texas.

1994 Contributions to Chapters 2, 7, 9 and 10 (covering regional geology, predictive models for prehistoric quarry locations, and lithic analysis) submitted as part of *An Archaeological Survey of the Wallpack Valley Portion of the Delaware Water Gap National Recreation Area, Sussex County, New Jersey, Project No. C7228.01:* Report prepared by 3D/Environmental Services, Inc., Cincinnati, Ohio for National Park Service, Washington, D.C.

1993 "Phase III Survey and Testing Along the CNG Natural Gas Pipeline (TL-400 Extension 1), Beaver, Butler and Armstrong Counties, Pennsylvania": Report submitted as part of *Archaeological Data Recovery in the Upper Ohio Valley: Investigations at 36BV292, A Prehistoric Site on Connoquenessing Creek, Beaver County, Pennsylvania,* prepared by

Engineering Science, Washington, D.C. for CNG Transmission Corporation, Clarksburg, West Virginia.

1993 "Geological Report for the Chapel Farm Estate Quartz Quarries, Phase II Report": Report submitted to CityScape, Inc., Brooklyn, New York for New York City Landmark Division.

1993 "Predictive Model for Quarry Locations, Delaware Water Gap National Recreational Area, Phase I Report": Report submitted to 3D/Environmental Services, Inc., Cincinnati, Ohio for National Park Service, Washington, D.C.

1993 "Lithic Analysis of the Minisceongo Site, Site Nos. 177 and 195, Rockland County, New York": Report submitted to Hartgen Archeological Associates, Inc., Troy, New York.

1992 "Geological Reconnaissance for the Kerr Estates, Site No. 224, Ulster County, New York": Report submitted to Hartgen Archeological Associates, Inc., Troy, New York.

1992 "The Padula Geological Catchment Area and Prehistoric Lithic/Mineral Resource Procurement" and "Analysis of the Prehistoric Lithic Assemblage": Report submitted as part of *Archaeological Data Recovery for Transcontinental Gas Pipe Line Corporation's 6.79 Mile Leidy Natural Gas Pipeline Expansion, Padula Site (36-Nm-15), Northhampton County, Pennsylvania,* prepared by 3D/Environmental Services, Inc., Cincinnati, Ohio for Transcontinental Gas Pipe Line Corporation, Houston, Texas.

1992 "Phase II Testing at the Dutchess Quarry Site, Orange County, New York": Report submitted as part of *Dutchess Quarry & Supply Co., Inc. Cultural Resources Survey, Stages 1 and 2, Goshen Quarry Future Mining Area, Town of Goshen, Orange County, New York,* prepared by Dunn Geoscience, Inc. and Hartgen & Associates, Inc., Troy, New York for the Dutchess Quarry & Supply Co., Goshen, New York.

1992 "Geological Reconnaissance for the Sussex County Sewer Project, Borough of Sussex, Sussex County, New Jersey, Phase IA Report": Report submitted to Kittatinny Archaeological Research, Inc., Stroudsburg, Pennsylvania for the County of Sussex, New Jersey.

1990 "Geological Reconnaissance Study of the Sharkey Landfill Superfund Site, Rockaway Neck, Morris County, New Jersey, Phase I Report": Report submitted to Joel Grossman & Associates, Inc., New York, for Burns & Roe Industrial Services Co.

OPEN FILE REPORTS

For the Archaeological Facility, State University of New York at Binghamton, on file with the New York State Department of Transportation in Syracuse, New York

1979 Bedrock Geology, Structural History and Stream Patterning in Cayuga Creek, Tioga County, New York, 15 p.

1979 Glacial History of the Manlius-Lafayette-Cicero Swamp Area, East Syracuse, New York, 15 p.

1979 Bedrock Geology and Glacial History of the Lafayette-Cicero Swamp Area, East Syracuse, New York, 16 p.

1979 Bedrock Geology, Physiography [Geomorphology] and Glacial History of the Manlius-Baldwinsville Quadrangle, Onondaga County, New York, 25 p.

1979 Bedrock Geology and Glacial History of the Watkins Glen-Horseheads Area, Cayuga and Schuyler Counties, New York, 37 p.

1978 Bedrock Geology, Structural History and Physiography [Geomorphology] of Broome County, New York: A Summary, 35 p.

Other:

1978 Soil Subdivisions and their Prehistoric Implications, Acadia National Park, Bar Harbor, Maine, 4 p.

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

Society of American Archaeology, Eastern States Archaeological Federation, Middle Atlantic Archaeological Conference, Archaeological Society of New Jersey, Archaeological Society of New York, Professional Archaeologists of New York City, United States Geological Survey Volunteer Staff, Geological Society of America, Society of Economic Paleontologists and Mineralogists, Geological Association of Canada, New York Academy of Science, American Association of Petroleum Geologists, Geological Association of New Jersey, Sigma Xi

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Curriculum Vitae

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Date and Place of Birth: August 9, 1966; Yonkers, New York

EDUCATION:

Ph.D. Columbia University, New York, 1999 (expected)
(M.A., 1995; M.Phil., 1998)
Dissertation title: Paleoclimate of the Mid- to Late Neoproterozoic (~650-590 Ma): Evidence from the Stratigraphy, Sedimentology and Paleomagnetism of the central Flinders Ranges, South Australia
Ph.D. Advisor: Nicholas Christie-Blick

B.A. Hunter College of the City University of New York, 1993 (geology)
(magna cum laude)

B.A. Fordham University, Bronx, New York, 1987 (communications)

RESEARCH EXPERIENCE:

For my dissertation, I am employing stratigraphic, sedimentologic, and paleomagnetic techniques to the reconstruct the paleoclimatic evolution of the Neoproterozoic interglacial to Marinoan glacial succession (~650-590 Ma) in Australia. This unusual time period includes the probable occurrence of extensive glaciation at sea level in low paleolatitudes; an explanation for this event should help to clarify the processes controlling climatic trends on geologic time scales. Aside from my dissertation research, I have also served as sedimentologist for Ocean Drilling Program Leg 174A - Continuing the New Jersey Mid-Atlantic Sea Level Transect (summer 1997), and as an undergraduate I completed an honors project on the stratigraphy of Cambro-Ordovician carbonates in northwestern New Jersey (1992-1993). My research experiences have given me a strong foundation in field mapping, siliciclastic and carbonate stratigraphy and sedimentology, paleoclimate reconstruction, time series analysis, and paleomagnetism.

MEMBERSHIPS IN PROFESSIONAL SOCIETIES:

American Association of Petroleum Geologists
American Geophysical Union
Geological Society of America
Sigma Xi
Society for Sedimentary Geology (SEPM)
Society of American Archaeology

SELECTED ACADEMIC AWARDS AND HONORS:

1993-99 Faculty Fellowship, Columbia University
1995 Outstanding Student Proposal Award, Sedimentary Geology Division, Geological Society of America
1995 Estwing Award (Columbia University Dept. of Earth and Environmental Sciences award for outstanding geology student)
1994 Outstanding Student Research Award, Geological Society of America
1994 National Science Foundation Graduate Fellowship (Honorable Mention)
1990-93 Dean's List, Hunter College
1991 Angelo Tagliacozzo Memorial Scholarship, American Institute of Professional Geologists, Northeastern Section
1983-87 Dean's Scholarship, Fordham University

OTHER WORK EXPERIENCE:

1989-93 Writing Associate, Matthew Bender & Co., New York, New York (legal publisher)
- Copy Editor, 1988-89

1985-87 Assistant Manager, Sam Goody's, Inc., Yonkers, New York (music retail)
- Salesperson/Administrative Assistant, 1982-1985

PUBLICATIONS AND ABSTRACTS:

Chandler, M.A. and Sohl, L.E., in preparation. Climate Forcings Required to Initiate Low Latitude Ice Sheets During the Varanger Glaciation. In Christie-Blick, N. and Narbonne, G.M., eds., Trends and Events in Terminal Proterozoic Earth History, SEPM (Society for Sedimentary Geology) Special Publication.

Chandler, M.A. and Sohl, L.E., 1997. Global climate model simulations of a Neoproterozoic ice age: Potential forcings of the Varanger glaciation (~610-590 Ma). *Geological Society of America Abstracts with Programs,* 29(6):A-195.

Christie-Blick, N., Kennedy, M.J., and Sohl, L.E., 1998, Proposed location of a Terminal Proterozoic GSSP: Nuccaleena Formation, Flinders Ranges, South Australia. Geological Society of Australia (South Australian Division) Inaugural Sprigg Symposium: The Ediacaran Revolution, *Geological Society of Australia Abstracts* No. 51, p. 16-17.

Sohl, L.E., 1997. Paleomagnetic and stratigraphic implications for the duration of low-latitude glaciation in the late Neoproterozoic of Australia. *Geological Society of America Abstracts with Programs,* 29(6):A-195.

Sohl, L.E., 1993. The Stratigraphy of the Limeport Member of the Allentown Formation: An Upper Cambrian Carbonate within the Kittatinny Supergroup. *Geological Society of America Abstracts with Programs,* 25(2):81.

Sohl, L.E., and Christie-Blick, N., 1995. Equatorial glaciation in the Neoproterozoic: New evidence from the Marinoan glacial succession of Australia. *Geological Society of America Abstracts with Programs*, 27(6):A-204.

Sohl, L.E., Christie-Blick, N., and Kent, D.V., in press. Paleomagnetism of the Neoproterozoic interglacial and Marinoan glacial succession of Australia: Implications for the duration of low-latitude glaciation. *Geological Society of America Bulletin.*

Sohl, L.E., and La Porta, P.C., 1999, Fundamental criteria for prehistoric quarry development [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

Sohl, L.E., and La Porta, P.C., 1998, Models for quarry development in a prehistoric mining district [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

Vita
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Biographical Information

Date and Place of Birth: August 5, 1970, Wichita, Kansas
Citizenship: U.S.A.

Education

Ph.D., Geology, University of Kentucky, expected date of graduation May, 2001.
Dissertation topic: Geometry, Kinematics and Controls of the Bessemer Transverse Zone, Appalachian Thrust Belt, Alabama.

M.S., Geology, University of Kentucky, December, 1997.
Thesis topic: Stratigraphy and Structure of an Ancient Rifted Continental Margin in the Southern Appalachian of Tennessee and North Carolina.

B.A., honors, Geology, Anthropology, Hunter College of the City University of New York, May, 1994.

Research Experience

Department of Geological Sciences, University of Kentucky
December, 1997 to present

Current research involves the investigation of stratigraphic and structural controls of the geometry and kinematics of transverse zones in orogenic fold and thrust belts. Detailed geologic mapping in one such transverse zone near Bessemer, Alabama, along with the analysis of seismic profiles across the Bessemer transverse zone, will permit the creation of three-dimensional models of transverse zones. This project is being supervised by Dr. William A. Thomas (University of Kentucky) and is being funded in part by the United States Geological Survey and the University of Kentucky Department of Geological Sciences.

Department of Geological Sciences, University of Kentucky
September, 1994 to December, 1997

Research concluded for M.S. thesis under the supervision of Dr. William A. Thomas (University of Kentucky). This project documented the presence of normal faults and sedimentary rock assemblages associated with Neoproterozic continental rifting of southeastern Laurentia. Geologic field mapping for this project was conducted in the Blue Ridge of North Carolina and Tennessee. This research was funded by the University of Kentucky Department of Geological Sciences, the University of Kentucky Graduate School, the North Carolina Geological Survey, and the Geological Society of America.

Professional Experience

August, 1998 to present: Research Assistant: Lamont Doherty Earth Observatory of Columbia University

Worked under the direction of Dr. Klaus Jacob on the New York City HAZUS Project. Compiled seismic profiles and maps for bedrock and overlying soil distribution south of 59th Street, Manhattan, New York City. The maps and profiles will be used by engineering firms to code buildings in New York to account for ground movement due to seismic activity.

June, 1993 to present: Research Assistant, LaPorta and Associates, Inc., Geological Consultants

I been employed by LaPorta and Associates in the past as an archivist and library researcher. I have also worked as an on-site investigator conducting geomorphological and sedimentological studies pertaining to the stratigraphic analysis and interpretation of archaeological sites. I have laboratory experience in the analysis of deep tests and cores from archaeological sites associated with coastal estuaries, and also have experience in lithic analysis. In recent years, I have become acquainted with many issues concerning chert diagenesis and its role as a provenance indicator, and this has led to more recent investigations in source analysis and prehistoric quarry technology. I have also been involved in the preparation of geological background studies, and report writing for cultural resource management.

Selected publications

Brewer, Margaret C., and LaPorta, P.C., 1999, The prehistoric quarry landscape in the eastern Appalachians [abs.]: Society for American Archaeology, Annual Meeting Abstracts.

Brewer, Margaret C., and Thomas, William A., 1998, Late Precambrian two-phase rifting of southeastern Laurentia [abs.]; Geological Society of America, Annual Meeting Abstracts.

LaPorta, Philip C., Sohl, Linda E., and **Brewer, Margaret C.**, 1998, A Geomorphological and Archaeological Analysis of Potential Dredged Material Management Alternative Sites in the New York Harbor-Apex Region: Report submitted to Battelle Research Corp. for the Army Corps of Engineers - New York District.

Brewer, Margaret C., and LaPorta, Philip C., 1997, Geological catchments for lithic provenance research: Case studies from eastern North America [abs.]; Society for American Archaeology, Annual Meeting Abstracts.

Brewer, Margaret C., Thomas, William A., and Whiting, Brian M., 1996, Structure of an ancient rifted continental margin along the Blue Ridge of Tennessee, North Carolina, and Virginia [abs.]: Geological Society of America Abstracts with Programs, v. 28 p. 2.

Howell, Paul D., Neihaus, Ronald, and **Brewer, Margaret C.**, 1995, Let's Get Physical: Lab Manual for GLY 111, Physical Geology Lab, University of Kentucky, Department of Geological Sciences: Custom Academic Publishing, Oklahoma City, Oklahoma, 188 p.

LaPorta, Philip C., Szekielda, Karl, and **Brewer, Margaret C.**, 1994, Prehistoric Late-Middle Archaic to Transitional mining practice in the Wallkill River Valley: Eastern States Archaeological Federation, Annual Meeting Abstracts, p. 16.

Brewer, Margaret C., 1993, The Lower and Middle Cambrian Leithsville Formation within the Wallkill River Valley, Sussex County, New Jersey: Its stratigraphy and archaeological relevance [abs.]: Geological Society of America Abstracts with Programs, v. 25, p. 7.

Research and professional honors and awards

1998 University of Kentucky, Department of Geological Sciences
McFarlund Award

1996 University of Kentucky, Department of Geological Sciences
McFarlund Award

1996 University of Kentucky, Graduate School
Graduate School Assistantship

1996 North Carolina Geological Survey
Student Research Award

1995 Geological Society of America, Southeastern Section
Student Research Award

1995 University of Kentucky, Department of Geological Sciences,
Sigma Gamma Epsilon, Chi Chapter, Member

1988 Hunter College of the City University of New York
New York State Regents Scholarship

1988 Ceiba-Geigy Science Education Award

1988 New York State Science Supervisors Association
Earth Science Award
1988 National Science Olympiad
Earth Science Award

Teaching Experience

September, 1994 to present: Teaching Assistant, Department of Geological Sciences, University of Kentucky

Stuctural Geology (Spring, 1998): Assisted with lecture material and laboratory exercises covering brittle and ductile deformation mechanisms, geologic map and cross-section construction, and stereographic projection exercises.

Environmental Geology (Spring, 1998): Assisted with lecture material covering mass movement, water contamination and conservation, earthquake and volcanic hazards, landfill mediation, and resource sustainability.

Engineering Geology (Spring, 1996 to Fall, 1997): Independently prepared laboratory materials and associated lectures concerning rock identification and mechanics, flood control, earthquake hazards, and shallow seismic profile utilization in engineering studies.

Introduction to Geology Laboratory (Fall, 1994 to Fall, 1995): Independently taught laboratories covering mineral and rock identification, topographic and geologic map construction, stratigraphic and structural principles, earthquake hazards, groundwater contamination. Also served as head teaching assistant in which I coordinated labs and managed laboratory materials. During this time I was also responsible for producing a laboratory manual that continues to be published and used for the introductory labs.

Computer Skills

Working knowledge of HTML.

Proficiency in MS-DOS and Macintosh-based software packages, including MS-Word, MS-Excel, MS-Powerpoint, MS-Access, Wordperfect, Adobe Illustrator, Adobe Photoshop, Canvas, Mapinfo, HAZUS.

Working knowledge of common operating systems, including MS-D0S, MS-Windows, UNIX, and Macintosh.

Continuing Education

Three-Dimensional Seismic Interpretation: A Primer for Geologists, Directed by Bruce S. Hart, 1998 Geological Society of America Annual Meeting, Toronto, Canada, CEU's: 1.6.

Extracurricular Service

University of Kentucky, Department of Geological Sciences, Departmental Chair Recruitment Committee, Faculty-elected member, Spring, 1997.

University of Kentucky, Department of Geological Sciences, Undergraduate Curriculum Committee, Faculty-elected member, Spring, 1995, Fall, 1996.

University of Kentucky, Department of Geological Sciences, President of Kentucky Geological Student Association, Student-elected, Spring, 1995, Fall, 1996.

Professional Memberships

Geological Society of America
American Association of Petroleum Geologists
Society of Economic Paleontologists and Mineralogists
Kentucky Society of Professional Geologists
New York Academy of Sciences
American Association for the Advancement of Science
Society of American Archaeology