RESULTS OF GEOARCHAEOLOGICAL SOIL BORINGS
AND PROPOSED PHASE IB ARCHAEOLOGICAL SURVEY
Report #7

NEW JERSEY-NEW YORK EXPANSION PROJECT
ROUTE VARIATIONS 58 AND 76
PORT AUTHORITY PROPERTY
STATEN ISLAND, NEW YORK

FERC Docket No. CP11-56-000
New York SHPO No. 09PR05949

Prepared for

SPECTRA ENERGY TRANSMISSION, LLC
150 WARREN STREET
JERSEY CITY, NEW JERSEY 07304

Prepared by

Suzanne G. Cherau

The Public Archaeology Laboratory, Inc.
210 Lonsdale Avenue
Pawtucket, Rhode Island 02860

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ATTACHMENTS

INTRODUCTION

Spectra Energy Corp (Spectra Energy) is proposing to expand its pipeline systems in the New Jersey-New York region to meet the immediate and future demand for natural gas in the largest United States metropolitan area. The New Jersey-New York Expansion Project (NJ-NY Project) will create a new transportation path for 800,000 decatherms per day (Dth/d) of natural gas from multiple receipt points on the Spectra Energy systems to new delivery points in New Jersey and New York. The Project consists of approximately 19.8 miles of multi-diameter pipeline, associated pipeline support facilities, and six new metering and regulating (M&R) stations. The proposed facilities are located in New Jersey, New York, and Connecticut (Figure 1).

Previous Investigations

The Public Archaeology Laboratory, Inc. (PAL) completed Phase IA archaeological overview surveys for the New York portion of the Project in August and December 2010 (Elquist et al. 2010a and b). Since that time additional Phase IA archaeological assessments have been conducted for pipeline route variations in the New York portion of the project (Elquist and Cherau 2011a, b, and c). The Phase IA archaeological assessment recommendations for the Project alignment and route variations include a program of geoarchaeological soil borings in sensitive areas where modern fill deposits associated with heavy industrialization and urbanization land uses have occurred. A total of 52 soil borings has been proposed to date for the archaeologically sensitive areas of the Staten Island portion of the Project pipeline route where subsurface soil conditions are unknown and/or considered too deep for conventional hand testing. Of these, two soil borings were completed in December 2010 (see separate PAL report, Cherau 2011a) and 29 soil borings were completed from July to November 2011 (see separate PAL report, Cherau 2011b). Ten soil borings were also completed along Route Variation 87 on property owned by 380 Development on Staten Island, New York in February-March 2012 (see separate PAL report, Cherau 2012, and are the subject of the current report.

The ongoing goal of the soil borings program is to determine the presence and depth of ground disturbances, fill and/or marsh deposits, and of any sediments or buried landscapes containing potentially significant archaeological resources below these deposits. The Project area is dominated by industrial and commercial facilities, but the possibility remains that intact archaeological resources may be preserved within and below historically deposited fill. Additionally, large areas along the Project area of potential effect (APE) consist of former or current tidal marsh that may have been previously available for human occupation prior to marine transgression.

The following report presents the need for and scope of proposed Phase IB archaeological survey for Route Variation 76 and a portion of Route Variation 58 on the Staten Island portion of the project where nine (9) soil borings were completed in April 2012. The proposed Phase IB archaeological survey methodology has been formulated based on the results of these most recent geoarchaeological investigations that included the excavation and analysis of the nine borings located on property belonging to the Port Authority of New Jersey and New York on the east side of Western Avenue (Figure 2). The nine borings are offset approximately 17 meters (m) (55 feet [ft]) to the east of a parallel set of geoarchaeological soil borings conducted for the Western Avenue study area (RCH-4H-ARC" series) presented in a separate PAL report (Cherau 2011B). The soil borings typically extended to a depth of 610 centimeters (20 ft), with isolated exceptions, and encountered complex stratigraphic sequences of fill, possible pre-contact period surfaces, and underlying natural unconsolidated geological deposits. The results of the geoarchaeological investigations for this portion of the Project were prepared by Geoarcheology Research Associates (GRA), under subcontract to PAL, the cultural resources consultants to Spectra Energy. The GRA report is provided as Attachment A.

PROJECT AREA OF POTENTIAL EFFECT (APE)

The APE is the "geographic area or areas within which an undertaking may directly or indirectly cause changes in the character of or use of historical properties, if any such properties exist" (36 CFR 800.16[d]). The APE is defined based upon the *potential* for effect, which may differ for aboveground resources (historic structures and landscapes) and subsurface resources (archaeological sites). The APE includes all areas where ground disturbances are proposed, where land use (i.e., traffic patterns, drainages, etc.) may change, or any locations from which the undertaking may be visible.

For archaeological resources associated with the pipeline component of the Project, the APE consists of any areas of ground disturbance for the proposed pipeline trench and associated temporary workspace. In general, the horizontal APE for the proposed pipeline trench is anticipated to be a maximum of 4.5 m (15 ft) at the top and 3 m (10 ft) wide at the bottom; the vertical APE for the proposed pipeline trench is 2.2-2.4 m (7-8 ft) below surface, except in areas where existing utilities are present or the pipeline needs to be deeper for road and railroad crossings or other landowner concerns. The proposed Phase IB testing methodology presented in this report encompasses the horizontal and vertical APE for the pipeline trench.

SCOPE AND AUTHORITY

The Spectra Energy NJ-NY Project requires approvals and permits from federal, state, and local entities. One of the primary Project approval requirements at the federal level is a Certificate of Public Convenience and Necessity under Section 7(c) of the Natural Gas Act issued by the Federal Energy Regulatory Commission (FERC). Consequently, the Project is being reviewed under Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended. Prior to authorizing an undertaking (e.g., the issuance of a FERC approval or Certificate), Section 106 of the NHPA requires federal agencies, including the FERC, to take into account the effect of that undertaking on cultural resources listed or eligible for listing in the National Register of Historic Places (36 CFR §60). The agency must also afford the Advisory Council on Historic Preservation (ACHP) the opportunity to comment on the undertaking. The Section 106 process is coordinated at the state level by the State Historic Preservation Officer (SHPO), represented in New York by the New York State Office of Parks, Recreation, and Historic Preservation. The issuance of a federal agency certificate or approval depends, in part, on obtaining comments from the SHPO. In accordance with Section 106, FERC, as the lead federal agency for the Project, must consult with the New Jersey SHPO regarding the effects of the Project on historic properties.

The primary goals of cultural resource investigations conducted as part of the Section 106 review process are to:

- locate, document, and evaluate buildings, structures, objects, landscapes, and archaeological sites that are listed, or eligible for listing, in the National Register of Historic Places (National Register);
- assess potential impacts of the Project on those resources; and

- provide recommendations for subsequent treatment, if necessary, to assist with compliance with Section 106.

In addition to Section 106, the additional cultural resources investigation will be conducted for this portion of the Project in accordance with FERC's Office of Energy Project's *Guidelines for Reporting on Cultural Resources Investigations* (2002); the Secretary of the Interior's *Standards and Guidelines for Archaeology and Historic Preservation* (NPS, 48 Fed. Reg. 44716-42, Sept. 29, 1983); and the standards and guidelines set forth in the *Standards for Cultural Resource Investigations and the Curation of Archaeological Collections in New York State* (NYAC 1994) and *Landmarks Preservation Commission Guidelines for Archaeological Work in New York City* (NYC LPC 2002). Because of the sensitive nature of some of the material contained in this proposal, the covers and any applicable pages are labeled "CONTAINS PRIVILEGED INFORMATION – DO NOT RELEASE" in accordance with FERC guidelines and 36 CFR 800.11(c)(1).

RESULTS AND RECOMMENDATIONS

Port Authority Property

A total of nine geoarchaeological soil borings (the RCH-4-ARC series) were excavated on this single property in Staten Island, a borough of New York City. This section of pipeline route encompasses the northern portion of Route Variation 58 and the entire Route Variation 76, described and assessed in a separate PAL addendum report (Elquist and Cherau 2011c). Route Variation 58 extends the pipeline route about 200 ft east of the 2010 FERC filing route, which was sensitized as having high sensitivity for pre-contact resources and moderate to low sensitivity for post-contact resources (Elquist et al. 2010a) (Figure 3). This route variation extends from approximately STA 248+50 to STA 255+50, although only the northern portion from STA 252+75 to STA 255+50 is on the Port Authority Property and included in this report. Pre-contact sites recorded in the immediate area include the Old Place Site (A08501.0134 and A08501.2366), and the Mariner's Harbor Site area first reported by Skinner (Boesch 1994:No. 105; STD-MH), and Site 8505 (NYSM site files). Skinner additionally noted finds of projectile points (possibly related to Site 8505) along Western Avenue (Skinner 1898-1909). Post-contact sites documented south of the Staten Island Railroad Crossing include Revolutionary War Period burials related to a skirmish associated with the former Reverend Kinney property (documented as Site A085-01-2375) (Payne and Baumgardt 1986; Skinner 1909). North of the rail crossing, the route overlaps with the southernmost limit of the Proctor and Gamble Port Ivory Plant complex that by the 1920s occupied both sides of Western Avenue. The 1907 Robinson map indicates that a "Milliken Station" was present along a rail spur just north of the Staten Island rail line, which appears to have been torn down by 1937 (Bromley 1907, 1917; Sanborn 1937). By 1962, a manufactory building of the Proctor and Gamble complex for cake mixes was present near the former location of the rail station and appears on Sanborn maps as late as 1996, but is no longer present Sanborn 1962, 1977, 1981, 1983, 1986, 1987, 1988, 1989, 1990, 1992, 1993, 1994, 1995, 1996). However, neither the rail station or the Proctor and Gamble manufactory building lie within the direct alignment of Route Variation 58. The presence of previously recorded pre-contact archaeological sites and artifact finds along Western Avenue indicated that Route Variation 58 has high sensitivity for pre-contact cultural resources in intact sediments that may lie below expected deposits of marsh sediments, fill and/or disturbed soils in this area. Expected pre-contact resources could consist of campsite or village components dating to the Archaic through contact periods. The portion of the route north of the rail crossing, currently subjected to geoarchaeological soil borings on Port Authority property was assessed as having low sensitivity for any significant post-contact period resources.

Route Variation 76 reflects a very minor deviation from the FERC pre-filing route (Elquist et al. 2010b). The pre-filing route was largely contained within the Western Avenue roadbed, while the currently proposed route runs adjacent to the eastern edge of Western Avenue to the intersection with Richmond Terrace (Figures 4 and 5). This Route Variation extends from approximately STA 253+75 to STA 278+00. It was concluded in the Pre-filing report that this area contained high sensitivity for pre-contact resources given the presence of Archaic through Woodland finds associated with the Mariner's Harbor site area (Boesch 1994:No. 105; STD-MH), artifact finds along Western Avenue/Site 8505 (NYSM site files; Skinner 1898-1909), and deposits associated with the Bowman's Brook (NYSM 4594 and 7921) and Bowman's Brook North (A085-01-2364) sites to the north and east (Payne and Baumgardt 1986; Skinner 1909). The Pre-filing route was not assessed as having any sensitivity for post-contact resources as no structures, buildings, or other features associated with the above-noted Proctor and Gamble complex are documented within or along the Western Avenue roadbed (Elquist et al. 2010b:84 and 86).

The nine geoarchaeological soil borings conducted on Port Authority Property off Western Avenue are organized into three groups based on their stratigraphic associations. The Group 1 borings are located in the northern half of Route Variation 76 (see Figures 4 and 5). The four cores in this group (RCH-4-ARC-18, RCH-4-ARC-19, RCH-4-ARC-20, and RCH-4-ARC-21) are dominated by fills accreted on glacial till. All four borings contained 30-60 cm (1-2 ft) of asphalt, capping a loose, gray or dark brown sandy gravel fill, and a substrate of loose, reddish brown to red sandy fill to depths of 90-120 cm (3-4 ft). Fill and basal till were present from depths of 120 to 610 cm (4-20 ft) at the limit of soil borings. Pristine shore facies were absent from all four borings, although it is considered possible that thin veneers of shoreline sands were locally reworked into the sandy fill that lies between the modern asphalt and the intact Pleistocene Till (GRA 2012:19). The fill deposits and reworked till are likely the result of earthmoving from the twentieth-century Proctor and Gamble complex, a large building of which was constructed between 1950 and 1962 near the intersection of Western Avenue and Richmond Terrace, adjacent and near to the Group 1 borings. The absence of a preserved shore facies prevents an identification of any original Pleistocene till-based landform in this area (GRA 2012:30). There is no potential for pre-contact period deposits, and previous assessments did not indicate any sensitivity for potentially significant post-contact period resources. No further archaeological investigations are recommended for the Group 1 borings segment of Route Variation 76.

The Group 2 borings are located in the southern half of Route Variation 76 (see Figures 3 and 4). The three cores in this group (RCH-4-ARC-15, RCH-4-ARC-16, and RCH-4-ARC-17) contain post-contact period fills accumulated above till with an intervening shore facies. All three borings contained 120-240 cm (4-8 ft) of dark brown to black loose and heterogeneous gravelly to sandy fill soils, with dense to diffuse concentrations of brick and wood fragments. The fill overlays shoreline sands and clays including a probable fill transition zone of grayish-brown clays and brown medium-fine sand. This complex extends from 230-440 cm (7.5-14.5 ft) and overlies a reddish-brown sandy till facies to 490-720 cm (16-23.8 ft) below ground surface (GRA 2012:20-21). No Holocene paleosols horizons were identified in these soil borings, and the only pristine (unweathered Holocene matrices are of depositional origin (shoreline facies). The fill to till interface marks a historic to Pleistocene contact, such that any Holocene preservation context would be registered as an overprinted Cambic soil (GRA 2012:21). In sum, there are no preserved paleosols in the Group 2 borings, so pre-contact period surfaces relating to recorded sites in the area have been removed or reworked into the post-contact/modern period fill deposits (GRA 2012:30). There is no potential for intact pre-contact period cultural deposits and previous assessments did not indicate any sensitivity for potentially significant post-contact period resources. No further archaeological investigations are recommended for the Group 2 borings segment of Route Variation 76.

The Group 3 borings are located in the northern half of Route Variation 58 (see Figure 3). The two cores in this group (RCH-4-ARC-13 and RCH-4-ARC-14) contain differentiated Holocene age-sequences with fill overlying peat, which in turn seals in a shore facies. The peats in Group 3 were radiocarbon dated since these contain elements of intact pre-contact period environments. These two cores are located between two sets of railroad tracks, east of Western Avenue. Drainage ditches adjacent to the railroad tracks indicate that the pristine and early post-contact period terrain was a wetland area. The former wetland landscape was confirmed in the stratigraphy of the two cores placed in this area. The cores both contain an upper stratum of artificial fill over intact peat and matted anaerobic vegetation complexes. Peats and sediments recovered from depths of 270-610 cm (9-20 ft) produced radiocarbon dates between 13,700 and 160 B.P. (years before present) (GRA 2012:21).

Specifically, RCH-4-ARC-13 contained a sandy loam fill with brick and metal fragments from ground surface to a depth of 150 cm (4.9 ft). A lower fill is present from 150-210 cm (4.9-6.9 ft) below surface. At 210 cm (6.9 ft) the fill tapers to a silty loam preserving matted marsh vegetative structures. An intact, black peat horizon with visible vegetation structures and leaves was present between 230-300 cm (7.5-9.8 ft). Peat from 290 m (9.5 ft) produced a radiocarbon date of 630±30 B.P. (Beta-320523), and sediment from the same sample was dated to 3910±50 B.P. (Beta-320840). The bottom of this peat layer at 305 cm (10 ft) produced an anomalous date of 160±30 (Beta-320525). That peat was underlain by another organic matted layer at 390 cm (12.8 ft), dated to 1730±30 B.P. (Beta-320524) at 335 cm (11 ft) below surface. The bottom of the core to 610 cm (20 ft) contained loose, gray well-sorted sands. An organic sample obtained at 549 cm (18 ft) was cross-dated at 6530±40 B.P. (Beta-320526) for plant remains and at 13,700±60 B.P. (Beta-320841) for organic sediment (GRA 2012:22).

RCH-4-ARC-14 contained sandy loam fill with gravel from ground surface to 180 cm (5.9 ft), underlain by silty clay that transitioned abruptly to a black peat at 270 cm (8.9 ft). A peat sample at this depth produced a radiocarbon date of 1310±30 B.P. (Beta-320527). The peat layer covered a reddish-brown organic-rich sandy clay with organics, which yielded a radiocarbon date of 720±30 B.P. (Beata-320528). Plant material from the bottom of the clay layer at 320 cm (10.5 ft) was dated to 1340±30 B.P. (Beta-320529). A reddish-brown sand extended to the bottom of the boring at 610 cm (20 ft) where it interfaces with a brown matted peat, which produced a radiocarbon date of 11,760±50 B.P. (Beta-320530) (GRA 2012:22).

In sum, the two cores (RCH-4-ARC-13 and RCH-4-ARC-14) document the development of the wetland in this area beginning in the mid-Holocene period. Between the surface and 320 cm (10.5 ft) the radiocarbon date inversions suggest that there appears to have been post-contact period disturbances to the natural wetlands development sequence. However, the record of peat formation appears intact below that depth based on the peat and sediment radiocarbon dates obtained from both borings. The dated peat strata reflect and intact sequence of peat deposition from ca. 6500 to 1350 B.P. spanning the Middle Archaic to Woodland periods (GRA 2012:23-24; 30-31). This area is assigned a high sensitivity for intact pre-contact period marsh surfaces that could contain significant archaeological deposits. The vertical pipeline APE is anticipated to reach depths of 245-365 cm (8-12 ft) below grade because of the presence of the two railroad easements in this area. Phase IB deep testing is recommended for the Group 3 borings segment of Route Variation 58. The vertical APE in this segment of the pipeline trench route ranges from 12-14 ft at the locations of the bore pits for the railroad crossings (STA 252+75 and STA 254+00) to 7 ft in the grassy area between the railroad crossings. The vertical APE at the bore pits will extend through the upper portions of the sensitive pre-contact period strata that begin at 320 cm (10.5 ft). The vertical pipeline trench APE in between the bore pits will extend to approximately 7 ft below existing grade, above the sensitive pre-contact period strata.

Two (2) trenches, each measuring 2.5 m (8 ft) wide by 4.5 m (15 ft) long (to accommodate the shoring box), are proposed at each of the bore pit locations for the railroad crossing (see Figures 3 and 6). Both trenches will extend to at least 320 (10.5 ft) to the extent possible (safety and ground water considerations) through the sensitive archaeological strata within the vertical bore pit APE. The testing methodology for the machine-assisted trenches is described in more detail below.

TESTING METHODOLOGY

PAL's Phase IB archaeological survey testing methodology has been formulated according to the standards and guidelines set forth in the *Standards for Cultural Resource Investigations and the Curation of Archaeological Collections in New York State* (NYAC 1994); and *Landmarks Preservation Commission Guidelines for Archaeological Work in New York City* (LPC 2002).

The Phase IB archaeological field investigations will consist of subsurface testing in the form of machine-assisted trenches to locate and identify potentially significant belowground resources within the vertical APE of the pipeline trench. The exact on-the-ground placement and size of the machine-assisted trenches will need to be determined in the field at the time of the survey, pending any utilities issues with NY Dignet (which will be contacted prior to the fieldwork) and other ground surface or subsurface factors or obstructions that constrict the trench size and placement. Depending on the results of the first two trenches, additional trenches (trench extensions) may need to be excavated and their dimensions will be approximately eight feet wide by 31 feet long on the surface to depths varying from 6 to 15 feet (see Figure 6). The need for and placement of the additional trenches is TBD pending the results of the first round of trenches. The proposed and additional trenching will be sufficient to characterize and evaluate the significance of identified archaeological deposits.

A combination of machine-assisted and shovel scraping techniques will be used to investigate the nature and integrity of any identified structural remains and cultural strata encountered in the trenches. All machine-excavated soils will be examined for cultural materials and a sample of these soils will be hand screened through ¼-inch hardware mesh. Any cultural material (or a representative sample) remaining in the screen and collected from the excavated unscreened soils will be bagged and tagged by trench and level. Soil stratigraphy will be recorded for each machine trench and plans and profiles will be measured and drawn. Cultural material and samples will be bagged and labeled with provenience information. Digital photographs will be taken of all trenching locations and any identified belowground cultural remains. All cultural remains will be mapped in plan using compass and tape measure onto current existing conditions topographic site plans. Measured detailed drawings (plans, cross sections) will be done for any identified structural remains in the trenches.

All trenches will be excavated in accordance with Occupational Health and Safety Administration (OSHA) regulations for benching, sloping, and/or mechanical shoring devices at depths that exceed 3-4 ft. Dewatering of the trenches will also be conducted as needed depending on the anticipated/actual depth of the water table at the time of the excavations. A site-specific HASP that specifies air monitoring and PPE including tyvek suits and ½ face respirators may be needed for the proposed archaeological investigations pending review of the environmental testing results for soil contaminant exceedances. PAL's Certified Industrial Hygienist (CIH) subconsultant, in consultation with the TRC environmental staff, will develop the necessary HASP, which will be reviewed by Spectra Energy's Environmental Health and Safety (EHS) group. Mobile lighting devices may also be needed for recordation in trenches below these depths.

Upon completion of testing and recordation, all archaeological trenches will be backfilled and restored to their original ground contour surface.

LABORATORY PROCESSING AND ANALYSES

All cultural materials recovered from the Project during the Phase IB field investigations will be returned to the PAL facility for laboratory processing and analyses. These activities will include:

- cleaning, identification, and cataloging of any recovered cultural materials;
- preliminary analysis of spatial distributions of cultural materials;
- map and graphics production.

CURATION

Any recovered cultural materials and related documentation (e.g., field forms and notes, maps, photographs, report) will be organized and stored in acid-free Hollinger boxes with box content lists and labels printed on acid-free paper. These boxes will be temporarily stored at PAL according to curation guidelines established by the Secretary of Interior Standards 36 CFR 79, and with *Standards for Cultural Resource Investigations and the Curation of Archaeological Collections in New York State* (NYAC 1994) and LPC guidelines (2002), and until such time as a permanent repository can be determined in consultation with the New York SHPO.

WORK PRODUCTS

Upon completion of the fieldwork, and laboratory processing and analysis, PAL will prepare Phase IB archaeological survey report(s). The reports will follow the guidelines established by FERC (2002) and the New York SHPO (2005) and the New York City LPC (2002). Draft copies of the report(s) will be submitted to appropriate agencies, Native American groups, and other consulting parties for review. The final report(s) will follow the draft review. Appropriate SHPO archaeological site forms will also be completed and submitted, if necessary.

PROJECT SCHEDULE

Fieldwork for the Phase IB archaeological investigations will take approximately two weeks, weather and logistics dependant, and can begin as soon as landowner permissions are obtained. A technical report will be submitted within 45 days after the completion of the fieldwork.

PROJECT PERSONNEL

The archaeological investigations will be overseen by a Principal Investigator. The fieldwork will be supervised by a Project Archaeologist. All PAL project personnel meet the qualifications set by the National Park Service (36 CFR Part 66, Appendix C) and the NY SHPO.

REFERENCES CITED

Boesch, Eugene J.

1994 *Archaeological Evaluation and Sensitivity Assessment of Staten Island, New York.* Prepared for the New York City Landmarks Preservation Commission, New York, NY. Report on File at NY State Historic Preservation Office, Waterford, NY.

Bromley, G.W.

1907 *Atlas of Richmond County, New York.* G.W. Bromley and Company, New York, NY.

1917 *Atlas of Richmond County, New York.* G.W. Bromley and Company, New York, NY.

Cherau, Suzanne G.

2011a *Results of Geoarchaeological Soil Borings and Proposed Phase IB Archaeological Surveys, New Jersey-New York Expansion Project, Staten Island, New York and Linden, Bayonne, and Jersey City, New Jersey.* PAL Report 2367.02, April 2011. Submitted to Spectra Energy Transmission, LLC, Jersey City, NJ.

2011b *Results of Geoarchaeological Soil Borings and Proposed Phase IB Archaeological Surveys, Report #3, New Jersey-New York Expansion Project, Staten Island, New York.* PAL Inc. Report No. 2367.03. Submitted to Spectra Energy Transmission, LLC, Jersey City, NJ.

2012 *Results of Geoarchaeological Soil Borings, Report #6, New Jersey-New York Expansion Project, Route Variation 87, 380 Development Property, Staten Island, New York.* PAL Inc. Report No. 2367.04. Submitted to Spectra Energy Transmission, LLC, Jersey City, NJ.

Elquist, Ora, Suzanne Cherau, Nichole Gillis, and Gregory R. Dubell

2010a *Archaeological Overview Survey, Texas Eastern Transmission, LP, New Jersey-New York Expansion Project, Pre-Filing FERC Docket No. PF10-17-000, Staten Island, Manhattan, and Ramapo, New York.* PAL Inc. Report No. 2367.01, August 2010. Submitted to Spectra Energy Transmission, LLC, Jersey City, NJ.

2010b *Archaeological Overview Survey, Texas Eastern Transmission, LP, New Jersey-New York Expansion Project, FERC Docket #CP11-56-000, Staten Island, Manhattan, and Ramapo, New York.* PAL Report No. 2367.01B, December 2010. Submitted to Spectra Energy Transmission, LLC, Jersey City, NJ.

Elquist, Ora and Suzanne Cherau

2011a *Archaeological Overview Survey, Addendum #1 to Technical Report, New Jersey-New York Expansion Project, Staten Island, New York.* Submitted by PAL, Inc. to Spectra Energy Transmission, LLC, Jersey City, NJ.

2011b *Archaeological Overview Survey, Addendum #2 to Technical Report, New Jersey-New York Expansion Project, Staten Island and Manhattan, New York.* Submitted by PAL, Inc. to Spectra Energy Transmission, LLC, Jersey City, NJ.

2011c *Archaeological Overview Survey, Addendum #3 to Technical Report, New Jersey-New York Expansion Project, Staten Island and Manhattan, New York*. Submitted by PAL, Inc. to Spectra Energy Transmission, LLC, Jersey City, NJ.

2011d *Phase IB Archaeological Identification Survey, M&R 058 Additional Temporary Workspace and Phase II Archaeological Site Evaluation, Old Place Neck Site (OPRHP #A08501.002971), Goethals Bridge HDD Workspace, Staten Island, Richmond County, New York.* Submitted by PAL, Inc. to Spectra Energy Transmission, LLC, Jersey City, NJ.

Federal Energy Regulatory Commission (FERC)
2002 *Guidelines for Reporting on Cultural Resources Investigations for Pipeline Projects.* Office of Energy Projects, Washington, D.C.

Landmarks Preservation Commission (LPC)
2002 *Landmarks Preservation Commission Guidelines for Archaeological Work in New York City*. Landmarks Preservation Commission, New York, NY.

National Park Service (NPS)
1983 Archaeology and Historic Preservation: Secretary of the Interior's Standards and Guidelines. *Federal Register* 48(190). National Park Service, Department of the Interior, Washington, D.C.

New York Archaeological Council (NYAC)
1994 *Standards for Cultural Resource Investigations and the Curation of Archaeological Collections in New York State.* Adopted by the New York State Office of Parks, Recreation and Historic Preservation. New York Archaeological Council, NY.

Payne, Ted M., and Kenneth Baumgardt
1986 *Howland Hook Marine Terminal Expansion Cultural Resources Reconnaissance.* Prepared by MAAR Associates, Inc., Newark, DE. Prepared for International Technologies, Edison, NJ.

Sanborn Map Company
1937 *Insurance Maps of New York, Richmond Boro*. Sanborn Map Co., New York, NY.

1950-1996 *Insurance Maps of New York, Richmond Boro*. Updated to 1996. Sanborn Map Co., New York, NY.

Skinner, Alanson
1898–1909 *Catalogue of the Skinner Collection of Staten Island*. Compilation of original notes by Alanson Skinner. Division of Anthropology Archives, American Museum of Natural History, New York, NY.

1909 The Lenape Indians of Staten Island. In *The Indians of Greater New York and the Lower Hudson*. Anthropological Papers of the American Museum of Natural History, Vol. III (Clark Wissler, ed.). Hudson-Fulton Publication, New York, NY.

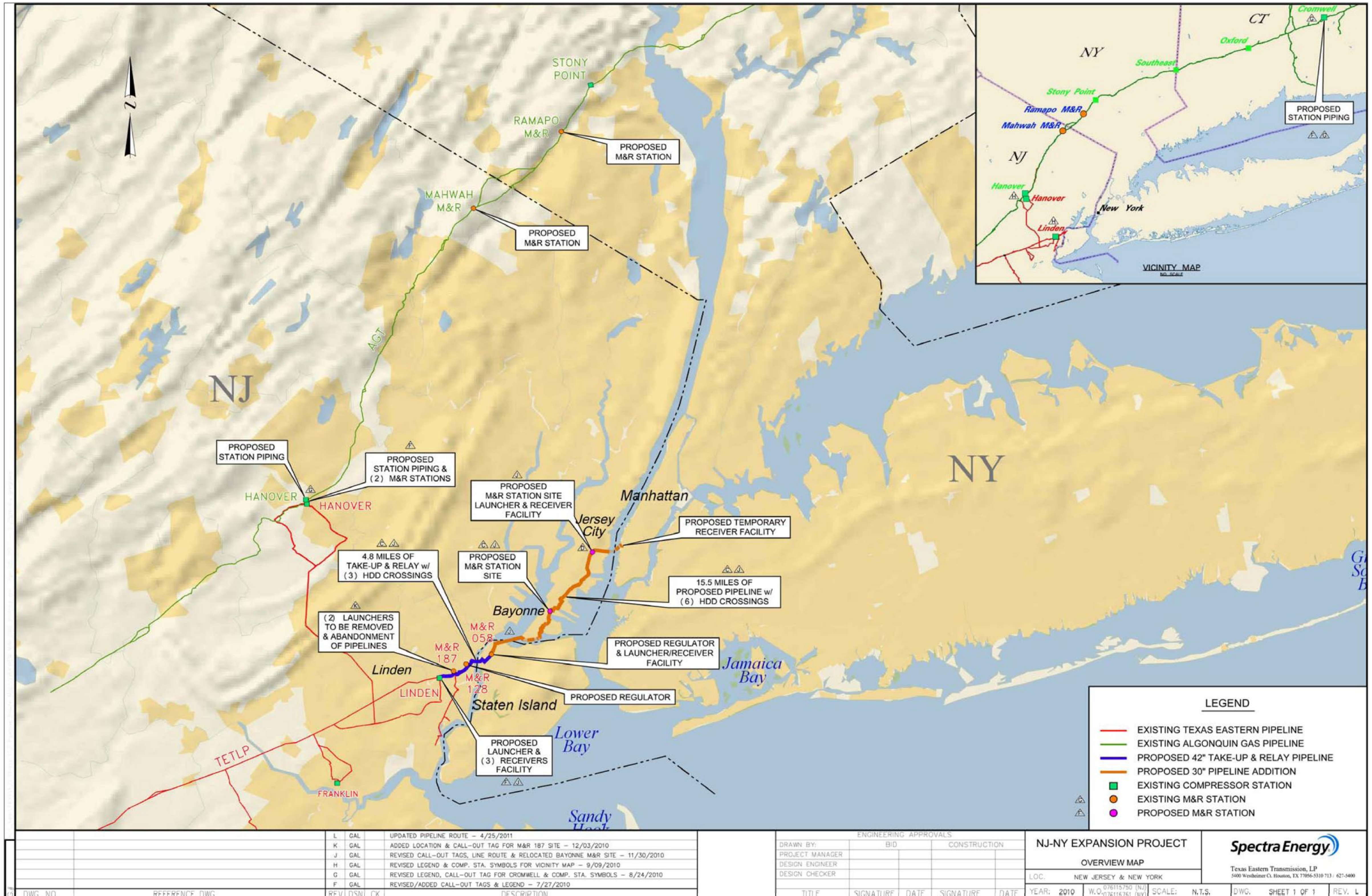

Figure 1. Overview map showing the various locations of the NJ-NY Project.

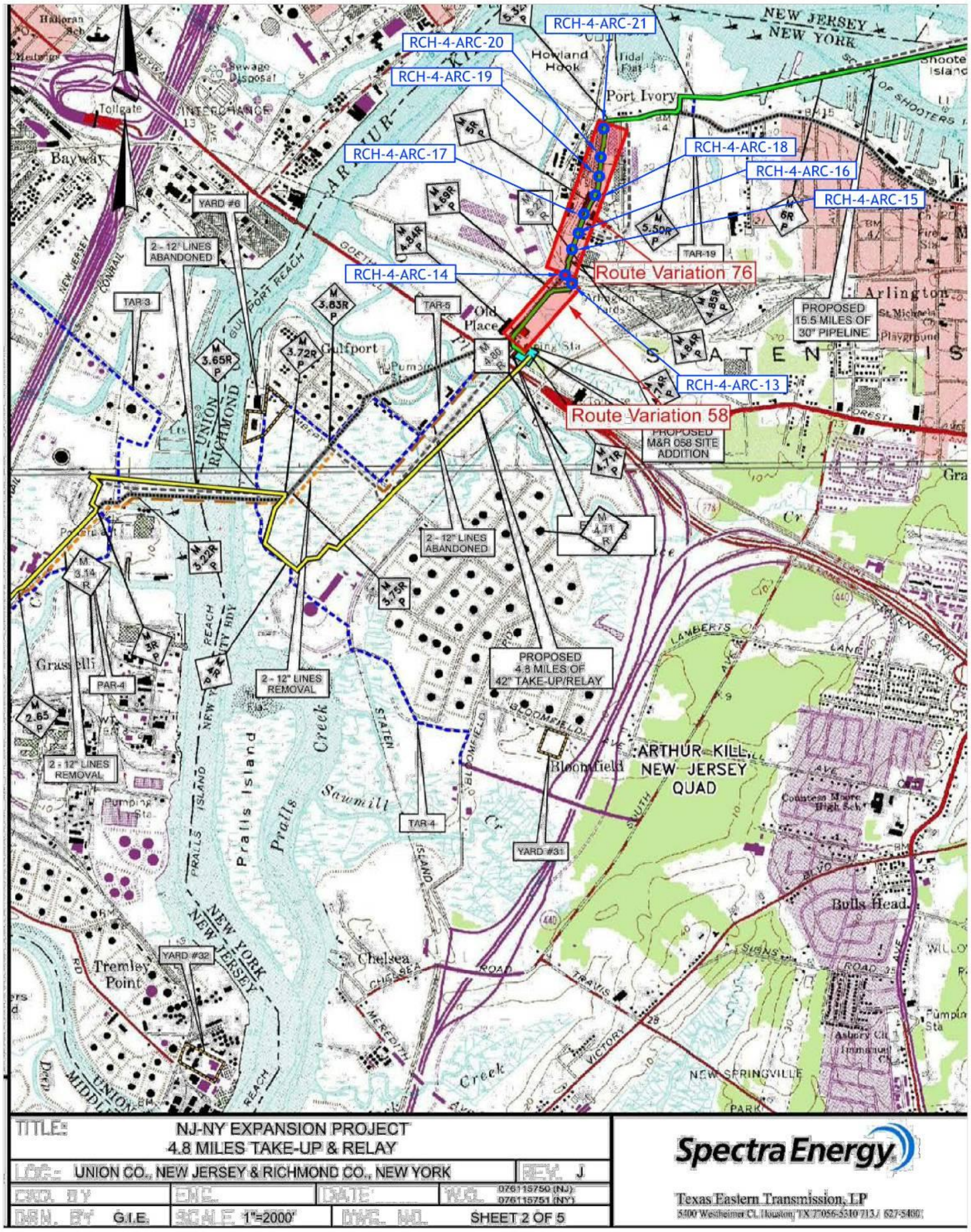

Figure 2. NJ-NY Expansion Project, showing the locations of completed geoarchaeological soil borings within the Port Authority Property, Staten Island, NY, on the Arthur Kill NJ USGS quadrangle, 7.5 minute series .

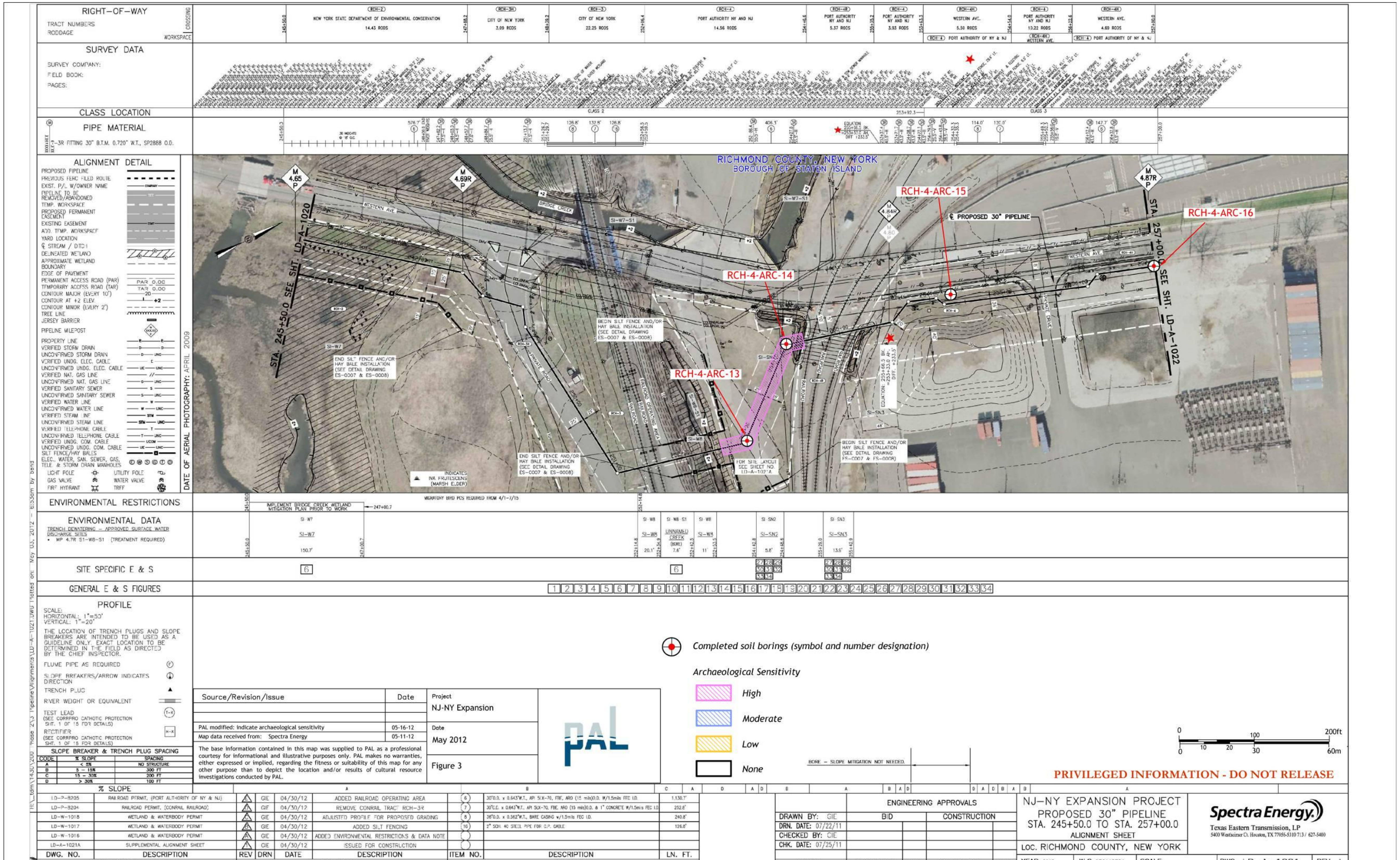

Figure 3. Revised archaeological sensitivity assessment for STA 252+75 to STA 257+00 on Port Authority Property, Staten Island, NY, NJ-NY Expansion Project.

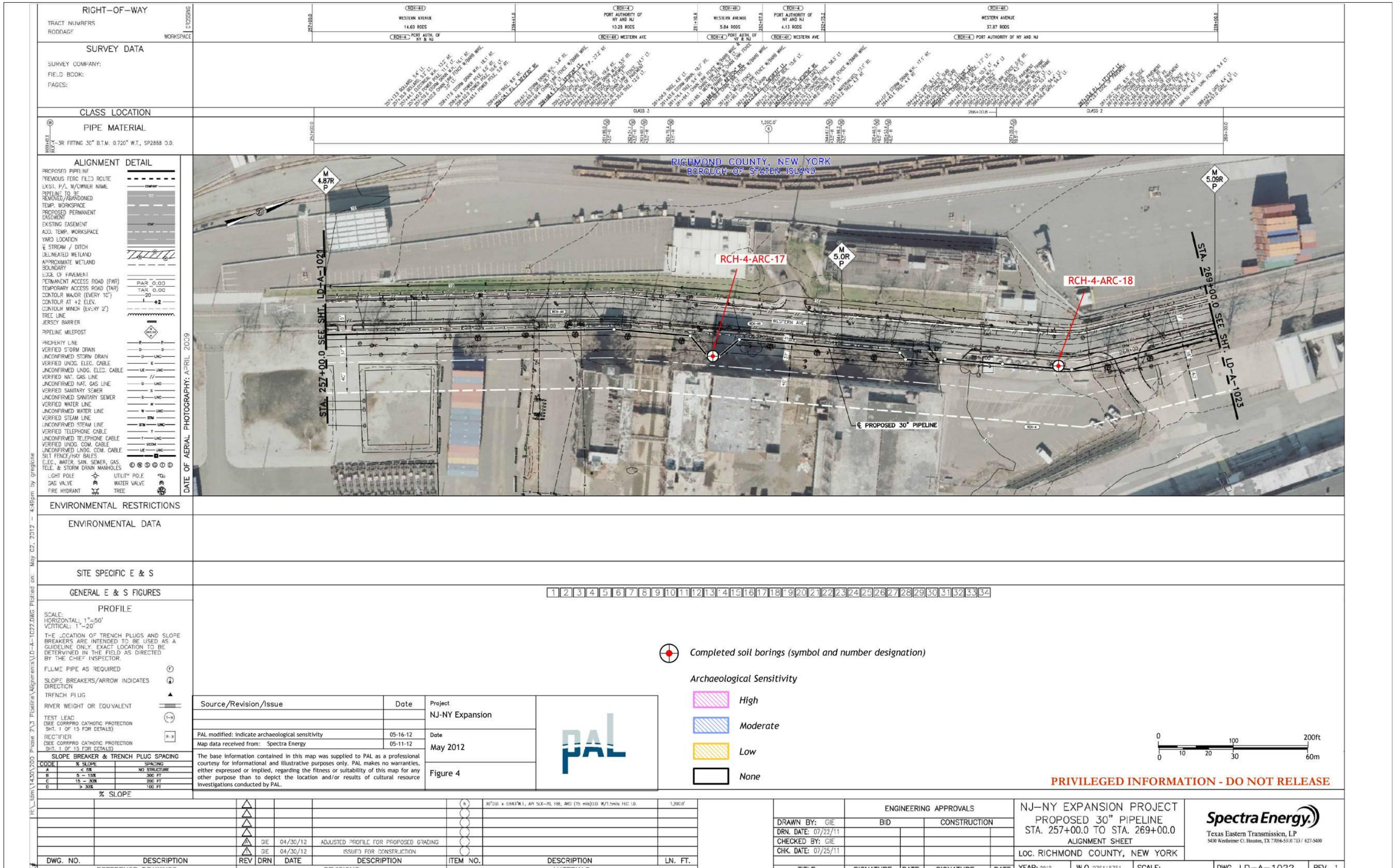

Figure 4. Revised archaeological sensitivity assessment for STA 257+00 to STA 269+00 on Port Authority Property, Staten Island, NY, NJ-NY Expansion Project.

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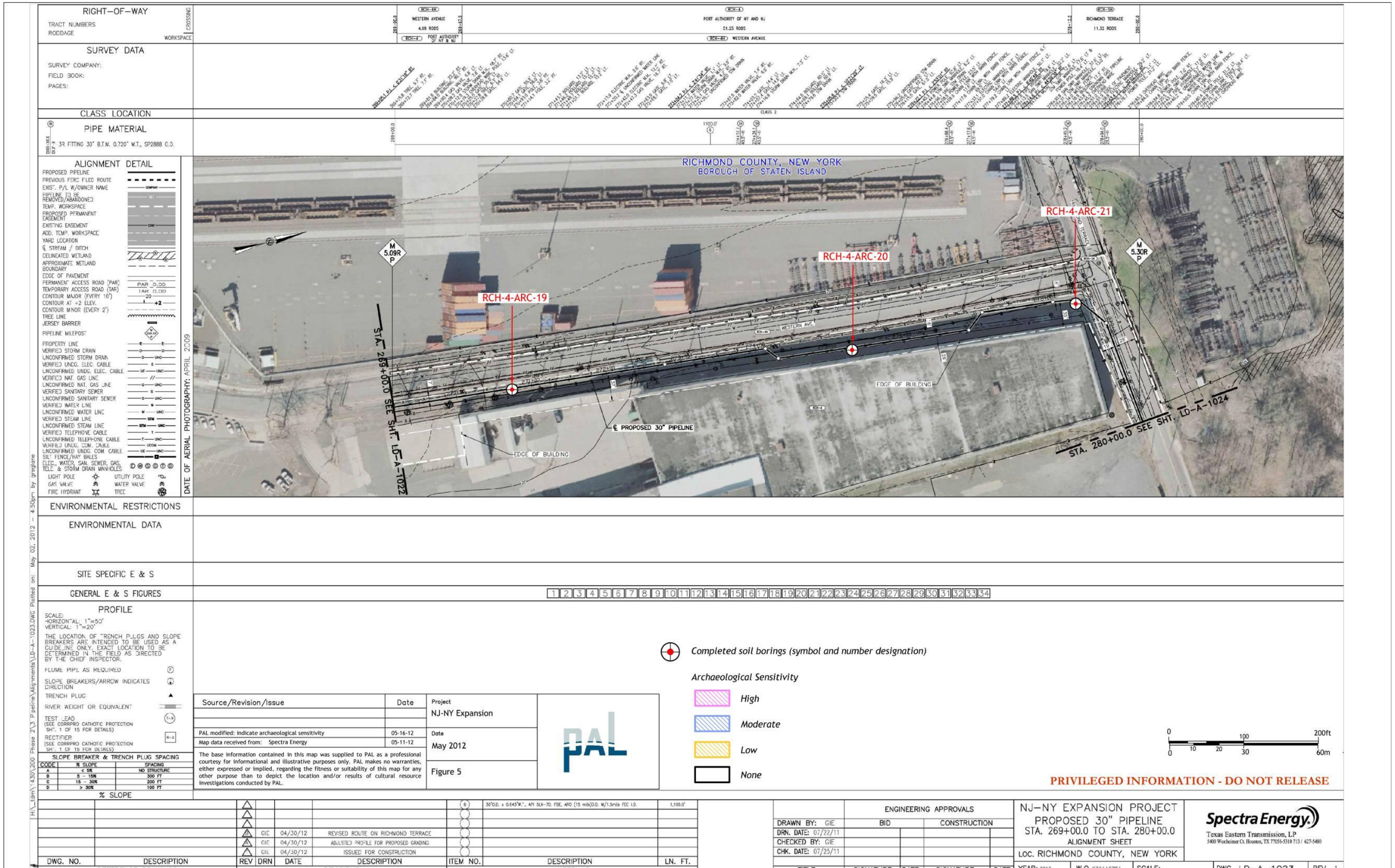

Figure 5. Revised archaeological sensitivity assessment for STA 269+00 to STA 278+00 on Port Authority Property, Staten Island, NY, NJ-NY Expansion Project.

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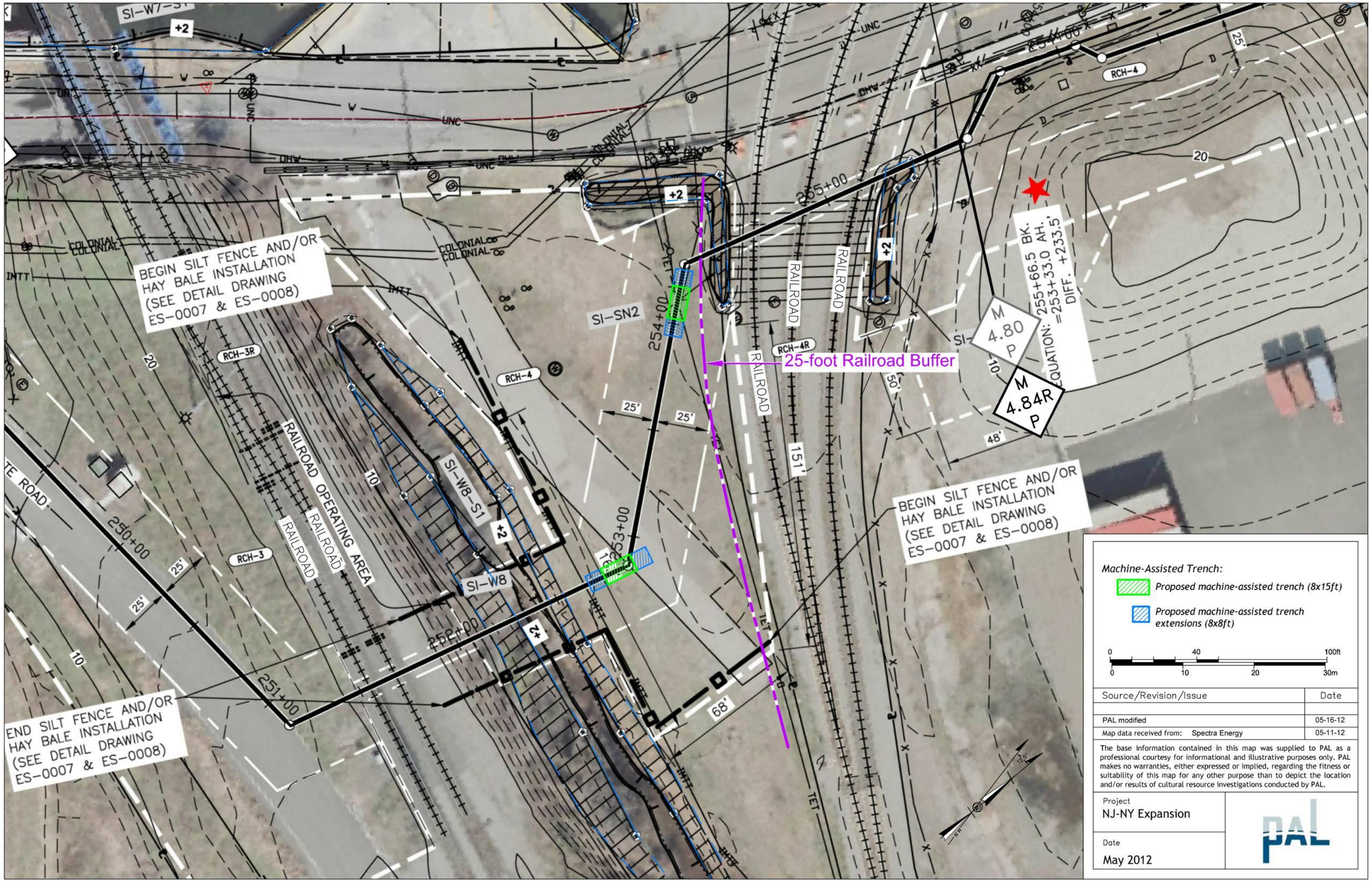

Figure 6. Proposed deep testing locations between STA 252+75 and STA 254+50 on Port Authority Property, Staten Island, NY, NJ-NY Expansion Project.

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ATTACHMENT A

GEOARCHEOLOGY RESEARCH ASSOCIATES – SOIL BORING REPORT #7

PRELIMINARY REPORT: "PRE-ANALYSIS" RESULTS OF GEOARCHAEOLOGICAL INVESTIGATIONS PHASE 1A, NJ-NY EXPANSION PROJECT ROUND 7 APRIL 2012

STATEN ISLAND, RICHMOND COUNTY, NEW YORK

Prepared for:

Public Archaeology Lab
210 Lonsdale Ave
Pawtucket, Rhode Island 02860

Assembled by:

Geoarcheology Research Associates
92 Main Street
Suite 207
Yonkers, NY 10701

Joseph Schuldenrein, Ph.D.
Principal Investigator

with

Eva Hulse, Ph.D.
Project Geoarchaeologist

Andrew Nesheim, M.S.
Project Geoarchaeologist

Johnathan Garland, M.Sc.
Project Geoarchaeologist

May 11, 2012

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1. INTRODUCTION

This report presents the preliminary results of field investigations conducted during April 2012 for the NJ-NY Expansion Project. Geoarcheology Research Associates (GRA) of Yonkers, New York was contracted by Public Archaeology Laboratory (PAL) of Pawtucket, Rhode Island to conduct a geoarchaeological study along a proposed pipeline corridor for Spectra Energy Transmission, LLC. This study presents a summary of a seventh round of fieldwork and preliminary results for the project area. A first round produced a comprehensive report of the first thirty-two (32) cores examined for geoarchaeological purposes (GRA, 2011a). The second round documented the findings of an additional fourteen (14) cores (GRA, 2011b) and the third round examined thirty (30) cores (GRA, 2011c). The fourth round initiated reporting efforts for 2012 and provides the results of four (4) cores (GRA, 2012a) while the fifth round reported on three (3) additional cores (GRA, 2012b). The sixth round reported on ten (10) cores (GRA, 2012c). The present effort documents core retrieval at nine (9) new locations. As in the case of the earlier reports, this document is a "pre-analysis" report that assembles the stratigraphy of subsurface deposits to the degree that technical field studies permit. The geoarchaeological study is being undertaken to develop a probability model for the Phase IB archaeological survey. By conducting a systematic survey involving comprehensive sub-surface exploration, GRA is providing a working schema of subsurface stratigraphic relations in this project's areas of potential effects (APE). The project impact area spans urban areas known for dense, complex, and deep archaeological and historical deposits.

The locations tested and reported herein are distributed exclusively in Staten Island (Richmond County), a borough of New York City. The pipeline route currently extends over 20.3 miles and the locales sampled in this seventh round of fieldwork were selected because they traverse terrain of potentially high archaeological sensitivity. The project alignment is straight (Figure 1). The transect of nine (9) archaeological cores runs from southwest to northeast along a 2,700 ft. (0.82 km) segment adjacent to the eastern side of Western Avenue on one (1) property belonging to Port Authority of New Jersey and New York. This linear portion of the line covers ca. 2.5% of the total pipeline route. The nine (9) borings are offset approximately 55 ft. (17 m) to the east from a parallel set of testing locations reported for the Western Avenue study area ("RCH-4H-ARC" series; see GRA 2011c) (Figure 2). The presented cores are identified as the "RCH-4-ARC" series.

Preliminary hand augering typically preceded machine (Geoprobe™) drilling for the uppermost six feet (180 cm). Cores typically extended to a depth of 20 feet (610 cm), with isolated exceptions, and encountered complex stratigraphic sequences of fill, buried historical surfaces, possible prehistoric surfaces, and underlying natural, unconsolidated geological deposits. A critical objective of the study was the identification of the range of Late Quaternary environments associated with the prehistoric and historic settings of potential sites along the length of line. In this connection, we report on the results of eleven (11) radiocarbon dates for particularly critical locations with strong potential for recovering information on historic and prehistoric settlement and paleoenvironments.

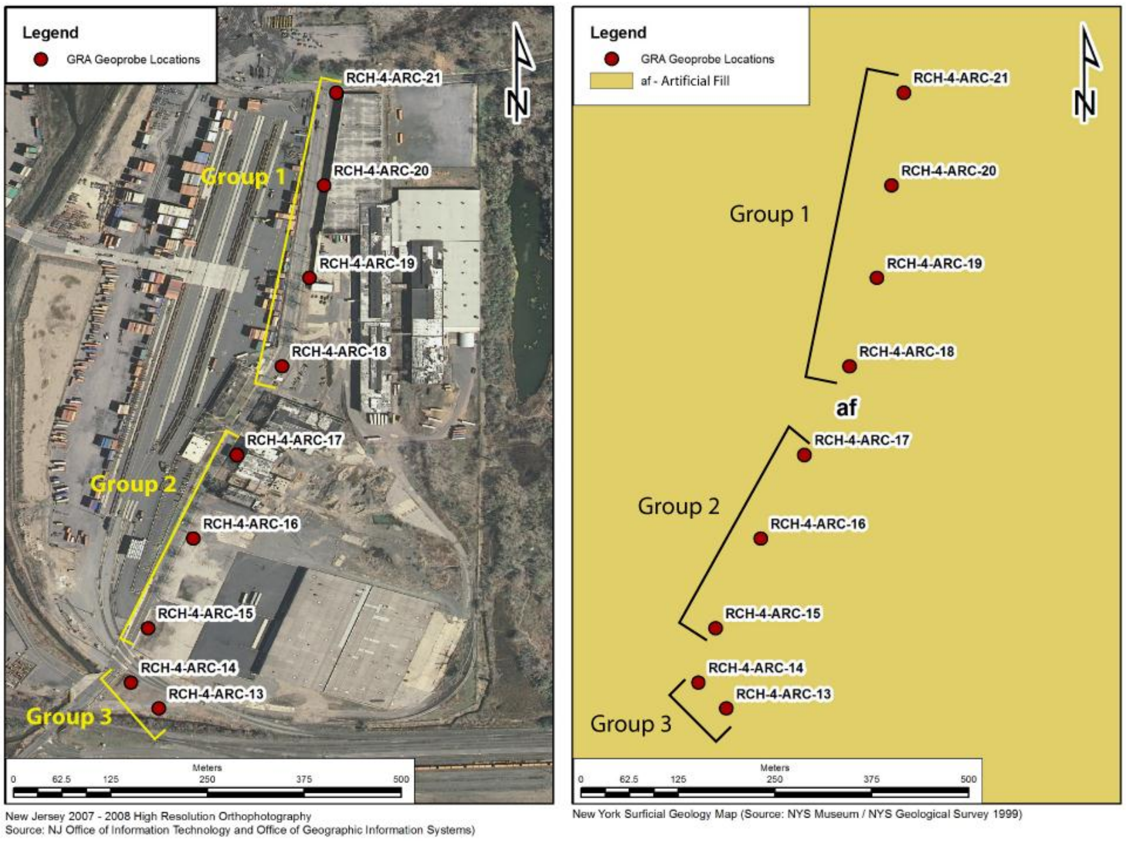


Figure 1. Aerial imagery alongside surficial geology map of project area.

Figure 2. Locations of cores in this report, relative to cores collected in July-November 2011 (see GRA 2011c).

This preliminary report presents baseline results of this initial investigation. A thorough overview of the geological setting of the region is presented, with a particular focus on landscape history along the project corridor. A methods section follows, which details both field and laboratory techniques. Particular attention is accorded to the interpretive potential of deep coring for the development of paleolandscape reconstructions and models of archaeological probability.

Appendix A is a map of the surface geology of Staten Island. It serves as a baseline reference for the geoarchaeological contexts of the sediments that were penetrated by the Geoprobe. The detailed sedimentology for each core is presented in Appendix B along with photo mosaics of the opened cores. Results of the radiocarbon assay are documented in Appendix C. More generalized descriptions of the cores are detailed in the results chapter. Preliminary recommendations of the potential for buried archaeological deposits conclude the document.

The recommendations include a protocol for specialized laboratory studies that should be undertaken in support of developing a paleolandscape model that underpins a robust model of archaeological sensitivity. It should be noted that no special analyses (with the exception of the eleven radiocarbon dates) have been conducted to date. As such, the interpretations presented in this preliminary report lack refinements made possible by such analyses.

Finally, it is cautioned that the recommendations presented in this study represent follow-up work that would enhance the interpretive potential for reconstructing paleoenvironment, site formation histories, and the development of a model of buried site preservation. For this pipeline segment in particular, the possibility of formulating a comprehensive landscape history relevant to well-documented prehistoric complexes in northwest Staten Island (see GRA 2011c) is facilitated by paleoenvironmental studies. That potential was partially confirmed in this study by the radiocarbon results (Appendix C). The results of this report and our earlier studies suggest that a comprehensive follow-up analysis design should be based on a representative sampling of the entire pipeline corridor to maximize information yield and to develop a scientifically sound and cost-effective mitigation strategy.

2. PROJECT GEOMORPHIC BACKGROUND

The entire proposed pipeline corridor, as well as the segment under consideration, is located along urbanized segments of near-shore, tidal, and offshore settings in Upper New York Bay in New Jersey and New York. The Late Quaternary landform history of the New York Bay is a function of bedrock geology and events associated with regional glacial history. The end of the Pleistocene (after 18,000 B.P.) is almost exclusively registered in the surface and subsurface deposits of the coast and near-shore settings of metropolitan New York City and adjacent New Jersey and New York. Variable accumulations of sediment record the region's history of glaciation and deglaciation, and corresponding marine based submergence and emergence. Related terrestrial and marine histories reflect the dynamic balance along the glacial margins and shorelines over the course of the past million years.

Regional geological and palaeoenvironmental studies are extensive. Relevant research has focused on bedrock geology (Isachsen et al. 1991; Schuberth 1968); late Pleistocene and (to a lesser degree) Holocene surficial deposits (Antevs 1925; Averill et al. 1980; Lovegreen 1974; Merguerian & Sanders 1994; Rampino & Sanders 1981; Reeds 1925, 1926; Salisbury 1902; Salisbury & Kummel, 1893; Sirkin 1986; Stanford 1997; Stanford 2010, Stanford & Harper 1991; Widmer 1964), as well as postglacial vegetation change (Peteet et al. 1990; Rue & Traverse 1997; Thieme et al. 1996) and sea level rise (Newman et al. 1969; Weiss 1974). More recently, there have been detailed studies of archeological preservation potential for the Holocene surficial deposits (GRA 1996a, 1996b; Schuldenrein 1995a, 1995b, 2000; Schuldenrein et al., 2007; Thieme & Schuldenrein 1996, 1998; Larsen et al., 2010) and estuarine sediments (GRA 1999; LaPorta et al. 1999; Wagner & Siegel 1997).

Physiography and Bedrock Geology

The Upper New York Bay is an estuary formed within a valley deepened and widened by the advance and retreat of the Laurentide continental ice sheet of the last Ice Age. Mesozoic-age Newark Group rocks underlie most of the New York Harbor region in New Jersey and extend up the west side of the Hudson River. The Triassic-age Palisades Sill marks the western shore of the Hudson in the New York City area. The sill is an igneous intrusion into the Newark Group sedimentary rocks. These sedimentary rocks contrast with the Cambrian to Ordovician metamorphic rocks of the New York Group east of the Hudson River. Quaternary-age glacial deposits rest unconformably on the Newark Group sedimentary rocks as well as those of the New York Group.

Pleistocene Glaciation, Chronology, and Landform Development

The unique landscape configurations of the Upper New York Bay are attributable to large-scale geological processes of the last ice age. Until recently, generic landscape chronologies served as the only basis for geoarchaeologically-oriented cultural resources assessments (such as 3DI 1992). Currently, however, the combination of regional geologic mapping by the New Jersey Geological Survey (Stanford 1995, 2002 and Stone et al. 2002), as well as older regional mapping by the New York State Geological Survey (Cadwell 1989), palaeoenvironmental studies (e.g., Carbotte et al. 2004, Maenza-Gmelch, 1997), and geoarcheological investigations (e.g. Schuldenrein et al. 2007, Thieme 2003, Schuldenrein and Aiuvalasit 2011) provide a significantly more refined and chrono-stratigraphically accurate understanding of the late Quaternary geologic history and archeological potential of the Upper New York Bay.

Prior to the terminal Wisconsinan, glaciers advanced across the region at least twice during the Pleistocene (Stanford, 1997; Sirkin, 1986). Both Illinoisan, ca. 128,000-300,000 B.P. (radiocarbon years before present), and pre-Illinoisan (> 300,000 B.P.) terminal moraines are mapped in northern New Jersey, and these ice advances may be represented by still earlier tills on Long Island (Rampino and Sanders, 1981; Merguerian and Sanders, 1994). Older tills have a "dirty" appearance and can be distinguished from late Wisconsinan deposits by the presence of unweathered mudstone, sandstone, and igneous rock clasts in the late Wisconsinan deposits (Stanford, 1997).

The Hudson-Mohawk Lobe of the latest or Wisconsinan ice sheet advanced to its Harbor Hills terminal moraine by 20,000 B.P. (Sirkin, 1986; Sirkin and Stuckenrath, 1980). The extensive and arcuate shaped Harbor Hills landform marks the final position of the ice advance, links Long Island with Staten Island, and is dated by postglacial radiocarbon dates from northwestern New Jersey of 19,340±695 B.P. in a bog on Jenny Jump Mountain (Stanford, 1997) and 18,570±250 B.P. in Francis Lake (Cotter, et al., 1986). Thieme and Schuldenrein (1998) obtained a similar date of 19,400±60 B.P. from a loamy sediment overlying glacial till along Penhorn Creek in the Hackensack Meadowlands.

During the later phases of the Pleistocene, the hydrography at the glacial margin was dynamic and resulted in a glaciolacustrine landscape that involved cyclic retreats and transgressions of linear lakes that approximated the morphologies of structural valleys. Lakes Passaic, Hackensack, Hudson, and Flushing variously occupied the terrain between Long Island and east-central New Jersey as well as the Hudson valley. In Newark Bay and the lower reaches of the Hackensack and Passaic River valleys, subsurface stratigraphy revealed uniform lake bed sequences beginning with deep, classically-varved pro-glacial sediments (Antevs, 1925; Lovegreen, 1974; Reeds, 1925, 1926; Salisbury, 1902; Salisbury and Kummel, 1893; Stanford, 1997; Stanford and Harper, 1991; Widmer, 1964). Reddish brown muds derived from Mesozoic-age Newark Group rocks form thicker winter layers, while more sandy sediment layers were deposited as the ice melted during the summer. The top of the glaciolacustrine sediment sequence is typically an unconformable contact from 12-30 feet below the present land surface in the Hackensack Meadowlands (Lovegreen, 1974). These same varved silts and clays fill the deeper parts of the incised Hudson valley and are overlain by riverine sands and gravel, which are, in turn, capped by thick marine estuarine muds.

Deglaciation of the Mohawk River lowland between 13,000 and 12,000 B.P. is a key event in the geologic history of the New York Harbor area. Proglacial Lake Iroquois, which occupied the Lake Ontario basin, subsequently drained directly to the Hudson River valley via the Mohawk lowland and added to the volume of pro-glacial Lake Hudson. Researchers disagree on the mechanism, but an outlet through the Harbor Hills moraine at the Narrows was opened at about this same time, emptying Lake Hudson and forming the present Hudson River drainage pattern. Newman, et al. (1969) noted that marine and brackish water filled the -27 m (-89 ft)-deep channel of the Hudson River at 12,500 +/- 600 B.P. (14,830 cal yrs B.P.) as evidenced by marine and brackish marine microfossils preserved at the base of organic silts beneath peat bogs at Iona Island. It is unclear as to whether the erosion of the outlet through the Harbor Hills moraine was gradual, or catastrophic as proposed by Uchupi et al. (2001) and Thieler et al. (2007). Nevertheless, evidence suggests that flow from the Hudson River eroded a channel and valley across the exposed continental shelf to drain and deposit a delta on the outer shelf at a lowered sea level stand.

Most challenging to our understanding of the Hudson River history is the lack of a clear explanation for a direct marine connection between contemporaneous sea level at the edge of the continental shelf and the upper Hudson River valley. More generally, we consider the shelf to have been sub-aerially exposed at this time. Differential isostatic adjustment of the earth's crust following deglaciation is the most reasonable explanation accounting for down-warping and depression of the crust beneath glacier ice in the north and commensurate uplift of the continental shelf, thereby raising sea level in line with the upper Hudson River channel. Evidence for differential uplift of the crust along the upper Hudson Valley (relative to the New York Harbor area) is based on historic tide gauge data by Fairbridge and Newman (1968), although the complete relationship remains unclear.

The present study relies on an accurate record of relative sea level rise developed for the New York Harbor area by Schuldenrein et al. (2007) for determining the submerged locations of probable prehistoric human habitation areas in the Hudson River channel. That study proposed a model for archaeological sensitivity that would help guide plans to minimize impacts on cultural resources by future marine construction. The attendant construct for sea level rise (Figure 3) is derived from radiocarbon analyses of nearby submerged environmental settings acquired during baseline New York Harbor and related GRA studies. Our new model differs markedly from that presented by Newman et al. (1969) and is proposed herein as a more accurate construct. GRA (Schuldenrein et al. 2007) presented a relative sea level history consistent with "far field" eustatic sea level studies (Fleming et al., 1998). We show a rapid rise in relative sea level at a rate of approximately 9 mm/yr (0.5 inches/yr) from at least 9000 cal yrs B.P. until about 8000 cal yrs B.P. when the rate of rise diminished to a consistent 1.5 – 1.6 mm/yr (0.06 inches/yr), from 7000 cal yrs B.P. until the present. This sea level model is consistent with studies by Bloom and Stuiver (1963) for the Connecticut shore; Redfield and Rubin (1964) for Barnstable, Massachusetts; Belknap and Kraft (1977); and Nikitina et al. (2000) for Delaware Bay as reexamined by Larsen and Clark (2006).

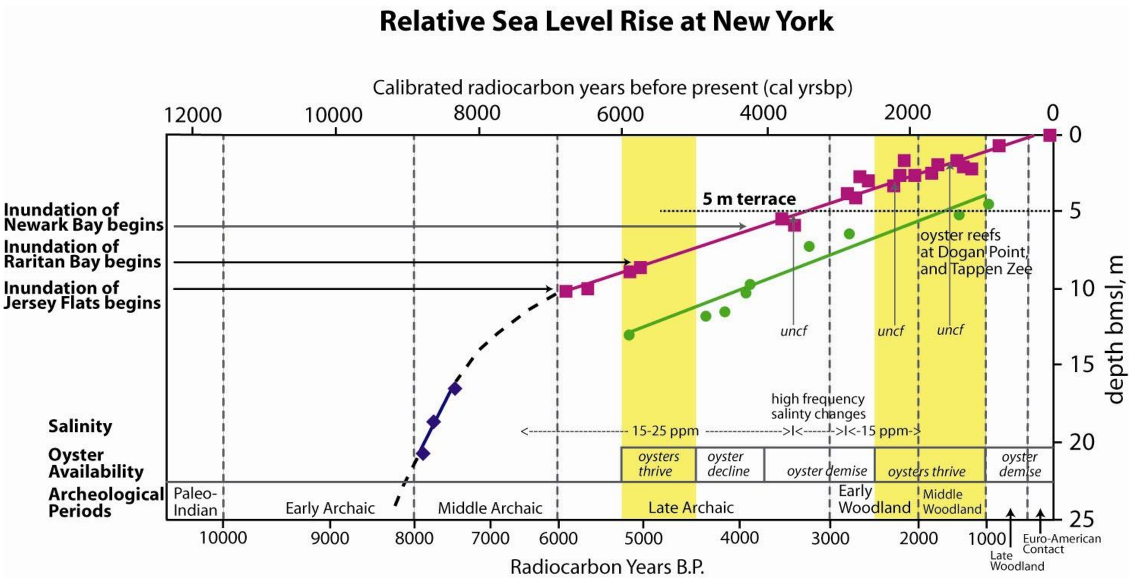


Figure 3. Sea level rise model for New York Harbor (from Schuldenrein et al. 2007).

In general terms, the new relative sea level model can be retrofitted to account for reflooding of the incised Hudson channel and Upper New York Bay as described by Thieler et al. (2007) for the Narrows at ca. 12,000 B.P. (13,875 cal yrs B.P.), as well as for the marine incursion of the upper Hudson Valley and consequent deposition of brackish estuarine sediments. It cannot, however, resolve the differential positions of the incised channel at the Narrows with the proposed delta at the edge of the continental shelf. We show progressive flooding of the main Hudson channel culminating in its present configuration. The area currently known as the New Jersey Flats was initially subject to inundation about 7,000 cal yrs B.P. Oyster reefs formed upriver at Tappan Zee at this time as well, and spread at successively shallower depths following the rising sea level (Carbotte et al., 2004). The latter record of oyster reef growth is consistent with sea level rise as demonstrated by the data points (in green) in Figure 3. The common depth range for the eastern oyster Crassostrea virginica is 8 to 24 feet (2.5-7.2 m). This explains the Tappan Zee oyster growth history which parallels but falls beneath our calculated and contemporaneous sea level curve. Marine water entered and progressively flooded Raritan Bay and Newark Bay about 6,000 cal yrs B.P. Marshes upstream from the present mouth of the Raritan River as well as the nearby Hackensack marshes became increasingly saline after 3,000 cal yrs B.P. and they subsequently evolved into salt marshes.

The estuaries and shorelines along the Upper Bay became the focus of historical Dutch settlement, and eventually blossomed into the sprawling metropolis of New York City. In general, the natural tidal zones and immediate near-shore settings through which the proposed pipeline corridor runs have been wholly reworked throughout the historic period and into the present day. The background literature review for this project conducted by PAL provides a thorough overview of the historical development of the project area with numerous archival maps that show the successive land use of the project area (Elquiest et al., 2010a and 2010b).

Expected Geological Sequence within the Project Area

For the initial reports on the NJ-NY Expansion project (ie., GRA 2011a) the assessment of the age and archaeological potential within the geological sequences drew extensively from the detailed surface geology maps of New Jersey (Stone et al., 2002). The present Staten Island segment is in New York State and that state's surface geology map is structured on different mapping units (NYGS 1989; see GRA 2011c). In general, however, the units and, more significantly, the ages of the attendant surface and upper sub-surface deposits are broadly correlative between the two states. For present purposes we draw directly from the digitized New York State surface geology map (NYGS 1989). Data for the map has been generated from two traditional mapping sources: first, the state-wide surface geology map (1:250,000 scale; Cadwell, 1989) and second, a traditional Quaternary map of the Hudson Quadrangle (4° x 6°) (Fullerton et al., 1992).

The area described in this Round 7 report is located to the north of the elevated Staten Island Railroad railbed. The wetlands of Mariners Marsh are 1500 feet (<0.5 km) east of Western Avenue. The Western Avenue street gradient is approximately level to the Mariners Marsh Park wetlands, indicating that this area may not contain deep or extensive fill deposits, and that the current roadway may represent part of an original landform (GRA 2011c; Elquiest et al. 2010: 78). Soils within this location are mapped as: Pavements and Buildings, wet substratum Laguardia-Ebbets Complex, 0-8 percent slopes and Pavement & buildings-Windsor-Verrazano complex, 0 to 8 percent slopes (NRCS 2005).

The project area traverses an area previously characterized by GRA (2011c) as consisting of relatively deep and recent fills, often resting unconformably on Pleistocene till and Pleistocene-to-Holocene shoreline deposits (Stone et al, 2002). As part of Round 3, 14C dating organic sediment from shore facies revealed a date of 16,940±70 B.P. (Beta-309857). This date is consistent with the regional chrono-stratigraphy associated with the emergence of the Staten Island shoreline during the late Wisconsinan (GRA 2011c).

Studies by GRA (2011c) determined that moderately thin Holocene deposits beneath historic fills may not be indicative of deeply stratified prehistoric sites. However, the depth and discrete composition of these historic fills indicate that the likelihood of intact historic resources along this section of the proposed route is relatively high.

There is only one surficial deposit mapped formally mapped within the project alignment corridor (Figure 1 and Appendix A). This is the Artificial Fill itself ("af" in Figure 1) and it is the most pervasive surface sediment actually registered in the impact zone, as detailed in our results section. Nevertheless, three pre-disturbance units are relevant to the subsurface investigations as these are likely to be encountered in immediate sub-surface contexts (Appendix A and per NYGS, 1999). The two most prominent New York-based surficial units of relevance are Lacustrine Sands ("ls") and Till ("t"), both of late Pleistocene (glacial) age and formally mapped to the east and south of the core-testing alignment (Appendix A). The third, Peat Muck ("pm") is a Holocene to historic age Swamp Deposit, effectively a salt-marsh and estuarine matrix, that underlies or interdigitates with anthropogenic fill along much of the alignment. It is stressed that these units must be considered as fundamental basal sediments that can be expected to underlie most core locations. They should not be used to infer either the age or composition of the sediments retrieved from individual cores. This is because of the pervasiveness of fill caps whose depth, composition, and lateral extent were not and could not have been mapped with requisite accuracy, despite the best efforts of the New York Geological Survey (NYGS,1999).

In general the Till deposits represent deposition beneath the ice, with sediment sizes ranging from boulder to silt. They are described as "variably textured…..usually poorly sorted sand-rich diamict" (NYGS, 1999). Permeability of the matrices varies with compaction thicknesses ranging from 1 to 50 meters. As is the case in New Jersey, till complexes in Staten Island are non-stratified. Basins carved out by glacial ice resulted in the hummocky to variably graded topography which gave rise to the succession of lakes that emerged after the glaciers retreated.

The category Lacustrine Sands describes well-sorted quartz sand complexes, often stratified and usually laid down in pro-glacial lakes. However, the sands may also have been accreted on remnant ice as a near-shore facies, or even near a sand source. Matrices are permeable and thicknesses are highly variable (2-20 meters). Exceptions to classic lake basin sedimentation proliferated, with deltas registering on the margins of the previously described pro-glacial lakes. While the lake basins infilled with fine grained sediments, coarser deposits of sands and silts were laid down along the peripheries. Undifferentiated marine and lacustrine sand bodies have also been identified (NYGS 1999) as near-shore deposits at or below the highest marine levels, where they may include fossil shells. Finer grained sediments, silts and clays may also proliferate along the margins of the pro-glacial lakes; the fines are often calcareous. Delta sediment bodies have been recognized as coarse to fine gravel and sand depositional strata, stratified and well-sorted along the ancient lake shoreline, again with variable thicknesses (3-15 m).

Finally, the Swamp Deposits, equivalent to the Salt-Marsh and Estuarine deposits utilized in the New Jersey reports (GRA 2011a, b; per Stone et al., 2002) are dominantly organic silts and sands in poorly drained reaches (along the coastal edge to the west). They are characteristically unoxidized, and will often overlie marl and lake silt with thicknesses of 2-10 m. It remains unclear as to whether or not these underlying "marl-type" complexes represent Holocene basins or, as is probably the case, they represent primary or reworked depositions of Pleistocene antiquity.

3. METHODS

Designated sampling intervals for baseline core placements were agreed upon by the State Historic Preservation Officer (SHPO) of New York. For New York the sampling interval was set at one test boring every 300 ft (90 m). An underlying hypothesis is that for any comparative study this interval should accommodate comprehensive project-wide reconstructions.

On the ground, spacing intervals had to be modified because of logistical concerns. In some cases boring locations were judgmentally re-spaced to evaluate settings and substrate associated with particular features, known locations of critical archaeological sites, and palaeoenvironmental settings that were both rich and varied, despite their burial beneath significant accumulations of fill. The primary archaeological sites in the area are the Mariner's Harbor Site, the Bowman's Brook Site, Bowman's Brook North, NYSM Archaeological Site #8505, and the Richmond Terrace Historical Archaeological Site. These sites are described in more detail in Section 4.

Additional considerations for the coring strategy included questions of representative sampling and in-field circumstances such as accessibility and presence of buried contaminants. In all cases of re-spacings, resolution was obtained through negotiations with Spectra Energy and PAL. The boring locations and precise placements were mapped by a team of surveyors contracted by Spectra Energy. Most in-field adjustments to boring proveniences resulted in locational modification of no more than 5-10 feet (1.5-3 m) from the originally designated placements. Remote sensing for buried utilities or obstructions was conducted at testing localities by Spectra Subsurface Imaging, LLC of Latham, NY. Their surveys augmented background subsurface map reviews by utility companies, property owners, and utility identifications by the One-Call Service. Remote sensing provided an additional control delimiting the presence and orientation of subsurface utilities and features. For this segment of line, seven (7) of the nine (9) cores emplaced along the 0.51 mile (0.82 km) traverse were spaced at an interval of 400 ft (122 m). The remaining two (2) cores (RCH-4-ARC-13 and RCH-4-ARC-14) were placed 140 ft (42.5 m) from one another. This spacing deviates from the recommended 300 ft interval because the Round 3 study (GRA 2011c) covered the same area in greater detail. The present study provides supplementary data to the findings from Round 3 (GRA 2011c), given the proximity of the two sets of cores (see Figure 2).

Subsurface excavation for the GRA study was performed by a Geoprobe™ boring device, operated by LAWES, Inc. of Center Moriches, NY. The Geoprobe™ is a hydraulically driven, mechanical track-mounted device that extracts cores that can be collected in stratigraphically intact sections within plastic sleeves (Figure 3). These sections are examined in the field and/or sealed, collected, and described under controlled laboratory conditions at a later date.

For this project, cores of approximately 2 ½ inch (6 cm) diameter were collected in 5 foot sections (145 cm) to depths of up to 20 feet (6 m) below ground surface. During the investigations, the upper 1-6 feet (0.3-1.8 m) of each boring was extracted with the use of a hand auger and soil-sediment descriptions were made directly. Hand augering for upper deposits resulted in more precise recovery and more detailed observations. More precise inspections of the soil and sediment properties enabled the geoarchaeologists to preview the composition of the topmost historic sediments.

Safety gear included the use of protective eye-wear, hard-hats, steel-toed boots, nitrile gloves, and reflective safety vests. A trained environmental geologist employed by TRC, Inc. took sediment samples for characterization of contaminants, and ran a photo ion detection (PID) meter over the samples to test for volatile organic compounds. The in-field examinations of the cores were guided by health and safety procedures regarding the handling and collection of the cores.

Standard protocol calls for the core sleeves to be sealed in the field and transported to GRA's lab facilities. The Port Authority Property cores often contained significant levels of contaminants, such that much of the inspection of the Geoprobe cores was done in the field, together with photographic documentation and initial soil and sediment characterizations. Sampling for special analysis was performed under field conditions, although key specimens for dating and related analyses were identified, recorded, sampled and taken to the laboratory for detailed inspection and preparation for shipping to appropriate outside laboratory facilities. The cores were described using standardized pedo- and litho-stratigraphic terminology (ISSC 1994; USDA 1994). Samples of historical artifacts as well as soil samples for possible age determinations by radiometric analysis were collected. Upon full documentation of the cores and sample collection, the discarded sediment and soil fractions were either bulked in 55-gallon drums (when taken to the GRA facility) or transferred into the core hole. Upon completion of the project any bulked and stored specimens are sampled and characterized for contaminants, and transported to a disposal facility.

Finally, it should be noted that full recovery from individual core segments was rarely achieved. This is typical, as highly variable conditions of the substrate can result in inadvertent sediment loss upon recovery. These conditions include the presence of an elevated water table, uniquely unconsolidated sediments, and dramatic changes in sediment texture. Based on GRA's general experience working with this technique (Schuldenrein 2006, 2007), as well as regional conditions, the team has developed a method for extrapolating both the thicknesses and depths of deposits.

Figure 4. Field collection of cores

4. PRELIMINARY RESULTS

The nine (9) cores from this round of field investigations (April 2012) extend along a single extended segment. On stratigraphic grounds, the cores can be segregated into three groups (Figure 1). Cores in Group 1 are dominated by fills accreted on glacial till. Cores in Group 2 feature fills accumulated above till with an intervening shore facies. Finally, cores from Group 3 preserve the best differentiated Holocene age-sequences with fill overlying peat, which in turn seals in a shore facies. The peats in Group 3 were radiocarbon dated since these contain elements of intact prehistoric environments.

Previous cultural resource assessments and Environmental Impact Statements have identified areas sensitive for pre-contact and twentieth century cultural resources associated with the former Proctor and Gamble site that dominates the Port Authority property (GRA 2011c; NYCEDC 2004; HAA 2002:23-24). Additionally, the proposed pipeline route spans an offset approximately 500 ft (152 m) from a previously proposed pipeline extension considered highly sensitive for pre-contact resources beneath fill (Elquiest et al., 2010). The area surrounding Richmond Terrace may also be sensitive for pre-twentieth farmsteads and domestic sites, and 20th century industrial remains (Elquiest et al. 2010; Flagg 1991a, 1991b; Kerns et al 1991a; Payne and Baumgardt 1986).

No archaeological sites have been identified along the proposed pipeline Right of Way, but several pre-contact sites have been recorded in the vicinity. Archaeological studies along the northwestern coastline of Staten Island have long established the region's potential for prehistoric archaeological loci. A local study by Historical Perspectives Inc. (1991) reported the presence of fourteen (14) archaeological sites within a 1.25 mile (2.0 km) radius of the central portion of the pipeline route.

The project route's immediate proximity to four known prehistoric archaeological sites and one historic site is shown in Figure 5. The prehistoric sites include the Mariner's Harbor Site (No. 105 and STD-MH) (Boesch 1994; Elquiest et al. 2010); the Bowman's Brook Site (NYSM 4594 and 7321) (Elquiest et al. 2010; Skinner 1909); Bowman's Brook North Site (A085-01-2364); and NYSM Archaeological Site #8505 (Elquiest et al. 2010). The historic site is documented as the Richmond Terrace Historical Archaeological Site (Elquiest et al. 2010, 86), and there are other historic structures in the vicinity. The archaeological complexes are described in greater detail below and the cited archaeological locations are within <.40 kilometers (less than .25 miles), of the proposed project centerline (GRA 2011c; Elquiest et al. 2010).

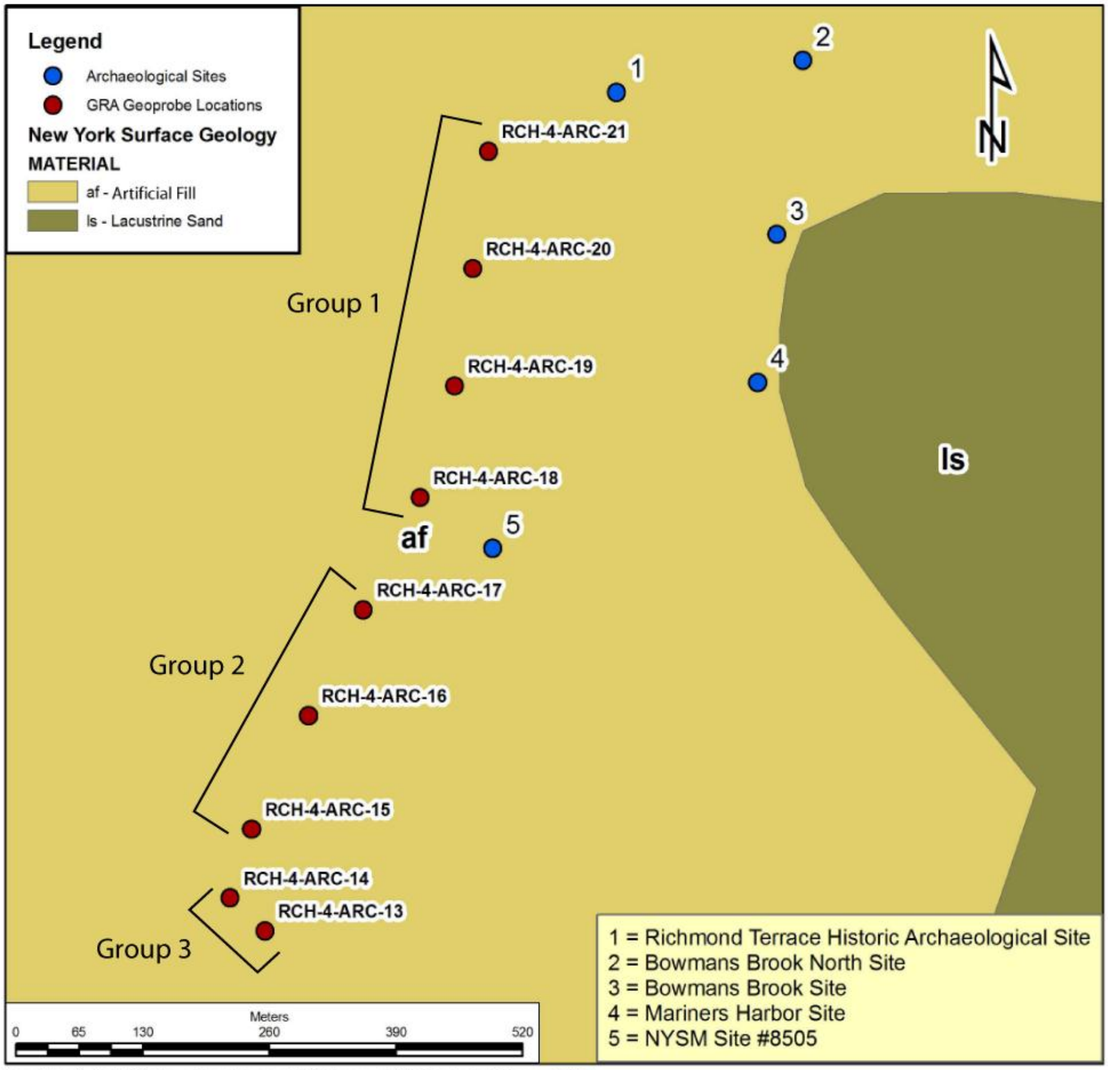


Figure 5. Core locations on Port Authority of New York & New Jersey property in relation to known archaeological sites in the immediate vicinity of the project area.

The basis for this geoarchaeological assessment is grounded on three sets of observations: (1) in-field landform and topographic observations; (2) preliminary inspection and classification of sediment properties and stratigraphy: and (3) radiocarbon dating of plant material and/or sediment recovered from key organic pedo-sedimentary contexts. The local conditions that factor into assessing buried site potential in the substrate include contextual integrity, previously documented regional stratigraphies, and finally design plans specifying depths of proposed impact.

Lithostratigraphic descriptions of the individual cores with accompanying photographic documentation are presented in Appendix B. The following account details the observations for the set of borings by core alignments and groupings.

Port Authority Property – *Staten Island, NY*
(Group 1: RCH-4-ARC-18, RCH-4-ARC-19, RCH-4-ARC-20, RCH-4-ARC-21)

Cores in Group 1 are characterized by an asphalt surface capping 1-2 ft (0.30-0.60 m) of loose, gray (10YR 5/1) or dark brown (7.5YR 3/3) sandy gravel fill, and a substrate of 3-4 ft (0.91-1.2 m) of loose, reddish-brown (5YR 4/4) to red (2.5YR 4/6) sandy fill. The latter ranges in composition from sand to sandy loam and sandy clay. At between 6-10.5 ft (1.8-3.2 m) bgs, there is a basal matrix of dark reddish-brown (2.5YR 3/3) firm, sub-angular blocky clay till with subangular gravels interspersed within the matrix. Core RCH-4-ARC-21 featured discrete layers of fill above the basal till. At depths of 4-8 ft (1.2-2.4 m) bgs a historic fill contained a parent matrix of black granular to loamy sand with slag, glass, and wood fragments. Beneath 8 ft (2.4 m) a 1 in (2.5 cm) thick layer of white, medium-grained sand sealed in a clay-rich till facies that extended to the base of the core. This core disclosed the best differentiated historic fill sequence for group. The Group 1 cores were distinguished by the fact that pristine shore facies were absent. It is possible that thin veneers of shoreline sands were locally reworked into the sandy fill that between the modern asphalt and the intact Pleistocene till.

Historic resources within the immediate vicinity of the Group 1 cores include the Richmond Terrace Historical Archaeological Site, and the remains of mid to late-nineteenth century domestic structures, to the north and south of Richmond Terrace. The Richmond Terrace Historic Archaeological Site consists of buried remains of residences predating 1845 (Elquiest et al. 2010, 86). There are also numerous slab foundations of earlier nineteenth century dwellings along the north side of Richmond Terrace (Elquiest et al. 2010; Payne and Baumgardt 1986).

The area south of Richmond Terrace remained largely underdeveloped until the Proctor and Gamble Plant expanded to the eastern side of Western Avenue in the 1920s (Elquiest et al. 2010). By 1937, the Sanborn maps depict a long rectangular warehouse associated with soap and vegetable shortening manufacturing along the eastern edge of the project area (Sanborn 1937). Much of the currently proposed route passes along the eastern edge of Western Avenue, roughly 200 ft (61 m) west of the former Proctor and Gamble warehouse. Much of the area along the western margins of the warehouse lot is littered with broken concrete and semi-continuous asphalt stretches associated with sub-recent paving for parking lots.

Cores RCH-4-ARC-20 and RCH-4-ARC-21 are situated next to a building on the corner of Western Avenue and Richmond Terrace. This structure and an adjacent facility remain from the Proctor and Gamble complex constructed between 1950 and 1962. The former facility currently serves as a warehouse (Elquiest et al. 2010).

Before the area was industrially developed, the only known historic structures were directly south of Richmond Terrace, where landholders constructed domestic quarters (Beers 1874; Elquiest et al. 2010). By 1917 many tracts were subdivided and additional structures were constructed between Richmond Terrace and Omaha Street (Elquiest et al. 2010). Housing tracts are no longer depicted on Sanborn Maps after 1950 (Sanborn 1910, 1917, 1937, 1950, 1962). Later nineteenth century developments along Richmond Terrace included “Sailor’s Row”, a series of residences for retired sailors (Elquiest et al. 2010, 85). An additional historic resource of note is the Phillip Post farmstead, along the south side of Richmond Terrace (Payne and Baumgardt (1986). The Post homestead was largely destroyed by construction of a gas pipeline right-of-way (ROW) (Elquiest et al. 2010: 86).

Despite the extensive reworking of the sediments above the till, Payne and Baumgardt (1986: III-6) determined that the farmstead site should be considered highly sensitive for archaeological resources beneath levels of disturbance. Three documented prehistoric sites lie to the east of the industrial structures: the Bowman’s Brook Site, Bowman’s Brook North, and the Mariner’s Harbor Site. The Bowman’s Brook North Site (A085-01-2364), first identified during surveys for the Howland Hook Marine Terminal Expansion, extends north along Richmond Terrace and has an extensive prehistoric component (Elquiest et al. 2010, 82, Payne and Baumgardt1986).

The Mariner’s Harbor Site, initially reported by Alanson Skinner in the early twentieth century (Boesch 1994; Elquiest et al. 2010), was a locus of extensive Archaic and Late Woodland Period occupation. Historic resources dating to the Contact period have also been found in the vicinity (Skinner 1909; Elquiest et al. 2010). Artifacts include projectile points, blades, scrapers manufactured out of materials such as argillite, jasper and flint, a possible gorget, steatite sherds, and potsherds (Skinner 1909; Elquiest et al. 2010).

The Bowman’s Brook Site is perhaps one of the most extensive prehistoric settlement sites in the area, dating between the Archaic and Late Woodland period (Ritchie 1980; Skinner 1909). Recorded artifacts include pottery sherds, antler and bone tools, clay pipes, projectile points and grooved axes. A wide range of floral and faunal remains have also been recorded (Skinner 1909). Pit features and multiple prehistoric burials indicate that this setting was either near or within the boundaries of a former village (Skinner 1909; Ritchie 1980; Elquiest et al. 2010). Despite the historic development of the area, isolated pockets of the Bowman’s Brook site may remain preserved (Elquiest et al. 2010).

The primary sources of disturbance in the project area include localized excavation and construction on individual housing lots in the mid to late 18th century and the development and construction of the Proctor and Gamble facilities. While previous investigations of the project area were not able to identify the overall depths of these disturbances, the extent of historic landscaping and regrading is presumed to be extensive. However, local regarding would have been more confined potentially resulting in the preservation of intact sediments (Elquiest et al. 2010).

(Group 2: RCH-4-ARC-15, RCH-4-ARC-16, RCH-4-ARC-17)

The three (3) cores in Group 2 feature largely uniform stratigraphies. The upper horizons are 4-8 ft (1.2-2.4 m) fills of dark brown (10YR 3/3) to black (10YR 2/1) loose and heterogeneous gravelly to sandy loams with dense to diffuse concentrations of brick and wood fragments. This fill rests unconformably on shoreline sands and clays. The shore sediments include a probable fill transition zone-- sub-blocky grayish-brown (10YR 5/2) clays—that coarsen with depth to a loose, friable, and well-sorted brown (10YR 4/3) medium-fine sand. The depth of this complex is 7.5-14.5 ft (2.3-4.4 m) bgs. The shoreline sands disconformably overlie a reddish-brown (2.5 YR 4/3) sandy till facies. The till was not registered at the 20 ft (6.1 m) length of RCH-4-ARC-17. In RCH-4-ARC-16 the till was recognized at 16 ft (4.9 m) bgs, and at RCH-4-ARC-15 it was encountered at 23.8 ft (7.2 m).

The cores in Group 2 are in the immediate vicinity of NYSM Site #8505, although the latter's site boundaries are not clearly defined. The site is near Western Avenue--most likely between Richmond Terrace to the north, and the Staten Island Rail Road line to the south—and along the east side of Western Avenue (Elquiest et al. 2010,79). Grooved axes, scrapers, argillite blades, pottery, projectile points of various lithic materials, and a pewter kettle fragment have been formally recorded at NYSM Site #8505. The artifacts and assemblages are suggestive of long-term occupation between the Archaic and Contact period.

Accordingly, it is possible that fill deposits buried and sealed in intact paleosols, cultural materials from NTSM Site #8505, or occupation horizons at Bowman's Brook, Bowman's Brook North, or Mariner's Harbor. Preliminary indications, however, were that no Holocene paleosol horizons were in evidence and that the only pristine (unweathered) Holocene matrices are of depositional origin (shoreline facies). The fill to till interface marks a historic to Pleistocene contact, such that any Holocene preservation context would be registered as an overprinted Cambic soil.

(Group 3: RCH-4-ARC-13, RCH-4-ARC-14)

The two (2) cores in Group 3 are located between two sets of railroad tracks, east of the road, at the south end of the tested area. The drainage ditches adjacent to the train track complex indicate that the pristine and early historic terrain was a wetland area. The former wetland landscape was confirmed in the stratigraphy of the cores, that consist of an upper stratum of artificial fill over intact peat and matted anaerobic vegetation complexes. Radiometrically dated peats and sediments were recovered from depths ranging from 9.0-20.1 ft. (2.7-6.1 m) and produced ages between 13,700-160 BP. As discussed below, the peat complexes were structurally intact, even though there are instances of inverted stratigraphy. More significantly, organic sediments that contained the peats themselves invariably produced determinations on the order of 2 to 5 times older than the peats themselves. Beneath the peat and associated (organic) sediment layers are shore facies of well-sorted sands with organic inclusions. The stratigraphies of the individual cores are described in detail below.

RCH-4-ARC-13 is capped by 4.9 ft (1.5 m) of loose, brown (10YR 4/3) sandy loam fill containing gravels and sands, with fragments of brick and metal, as well as dark, product-rich finer matrix with no recorded volatile organics. This upper matrix grades into a lower fill up to 2 ft (0.6 m) thick, with a similar parent sediment of gravelly, sandy loam. At 6.9 ft (2.1 m) the fill fines downward to a silty loam preserving matted marsh vegetation structures. The basal matrix is a slightly sticky, dark yellowish-brown (10YR 4/4) sandy clay. An intact, black (10YR 2/1) peat horizon with visible vegetation structures and leaves was identified between 7.5-9.8 ft (2.3-3 m). Peat from 9.5 ft (2.9 m) produced dates of 630±30 BP (Beta-320523), while sediment from the same sample dates to 3910±50 BP (Beta-320840). The bottom of this peat layer, at 10 ft (3.05 m), produced an anomalous determination of 160±30 BP (Beta-320525). That peat was underlain by a dark grayish-brown (10YR 3/2) sandy clay that coarsened downward into black (Munsell 10YR 2/1) well-sorted sands with fibrous organic inclusions whose structure was matted at 12.8 ft (3.9 m). The matting was dated to 1730±30 BP (Beta-320524) at 11 ft (3.35 m) below surface. Immediately beneath the mat organic structures and fabrics diminished to the base of the core at 20 ft (6.1 m). Loose, gray (10YR 5/1) well-sorted sands marked the lower limit of the probe. The deepest (organic) sample obtained from RCH-4-ARC-13, at 18 ft (5.49 m), was cross dated at 6530±40 BP for plant remains (Beta-320526) and 13,700±60 BP for organic sediment (Beta-320841).

RCH-4-ARC-14 is sealed by 5.9 ft (1.8 m) of loose, gray (10YR 3/2) sandy loam fill with gravel and increasing concentrations of rounded pebbles and chert fragments. The matrix fines downward to an increasingly plastic, reddish-brown (5YR 4/4) silty clay with subangular gravel inclusions, which transitions abruptly to black (10YR 2/1) peat at 8.9 ft (2.7 m). A peat sample from 8.9 ft (2.7 m), directly below the transition, produced a determination of 1310±30 BP BP (Beta-320527). The peat layer rests atop a slightly friable, reddish-brown (2.5YR 5/4) organic-rich sandy clay. A sample of organic matrix from this layer, at 9.8 ft (3 m), yielded a date of 720±30 BP (Beta-320528). Plant material from the bottom of this clay layer, at 10.5 ft (3.2 m), was dated to 1340±30 BP (Beta-320529). The base of that horizon is a reddish-brown (2.5YR 5/3) well-sorted sand at 10.5 ft (3.2 m). As in core RCH-4-ARC-13, the organic sediment equivalent to the peat is substantially older at 3140±30 BP (Beta-320842). This sand extends to the end of the core at 20 ft (6.1 m), where it interdigitates with a brown (7.5YR 4/2) matted peat. This lowermost organic matrix dates to 11760±50 BP (Beta-320530).

Table 1 summarizes the depths and proveniences of the peat and sediment complexes for RCH-4-ARC-13 and RCH-4-ARC-14 respectively.

	RCH-4-ARC-13		RCH-4-ARC-14	
depth	**peat**	**sediment**	**peat**	**sediment**
2.70 m			1310±30 BP (Beta-320527)	
2.90 m	630±30 BP (Beta-320523)	3910±50 BP (Beta-320840)		
3.00 m			720±30 BP (Beta-320528)	
3.05 m	160±30 BP (Beta-320525)			
3.20 m			1340±30 BP (Beta-320529)	3140±30 BP (Beta-320842)
3.35 m	1730±30 BP (Beta-320524)			
5.49 m	6530±40 BP (Beta-320526)	13700±60 BP (Beta-320841)		
6.10 m			11760±50 BP (Beta-320530)	

Table 1. Proveniences of 14C Determinations

The surfaces of both cores are at elevations of ±10 ft (3 m) above sea level. Accordingly, topo-stratigraphic relationships permit both lateral and vertical correlations between the peats and allow for a comprehensive chrono-stratigraphy (see Figure 6). The following relationships are in evidence.

1. Below 10.5 ft (3.2 m), the peat dates reflect an intact sequence of peat deposition from ca. 6500 to 1350 B.P.

2. Between the surface and 10.5 ft, there appears to have been disturbance, which, while not reflected in the homogeneous structure (and apparent integrity) of the matted peat complex, is signified by radiometric inversions. An anomalous older date at 2.7 m (1310±30 B.P.) and a significantly younger date at 3.05 m (160±30 B.P.) may represent mobilization of younger or older organic components by percolation or aqueous transport of sediment. These dates may also be explained by incorporation of residual organics during the core extraction process.

3. The integrity of the chrono-sequence beneath 10.5 ft., coupled with our provisional interpretations for sources of contamination for the upper (<10.5) sequence, allows us to infer that the peat dates of 600-700 B.P. are reliable at depths of ±3.0 m. Thus, the record of peat formation is continuous up until Euro-american Contact times. Above that level, historic filling has effectively destroyed the evidence that would chronicle the end of marsh formation along the near-shore margins of Staten Island.

4. Cross correlation of dates between identically provenienced peats and sediments yields older dates for the latter, by an order of magnitude factor of 2 to 5. These discrepancies are a function of the incorporation of “old

carbon" within the parent sediment matrix. Carbon sources in aqueous (marsh and near-shore settings) are multiple in an open system and may include long-term transport of older vegetation through wave action and long distance transport.

5. Accordingly, the largely intact vertical sequences for peat succession should be taken as evidence for continuous Middle to Late Holocene accretion of peats in the near shore environments at the shoreline fringe at a time that spans well over 6000 years and accommodates all post-Middle Archaic prehistoric periods. The sequence is near continuous, extending through the Woodland and Euro-American contact times.

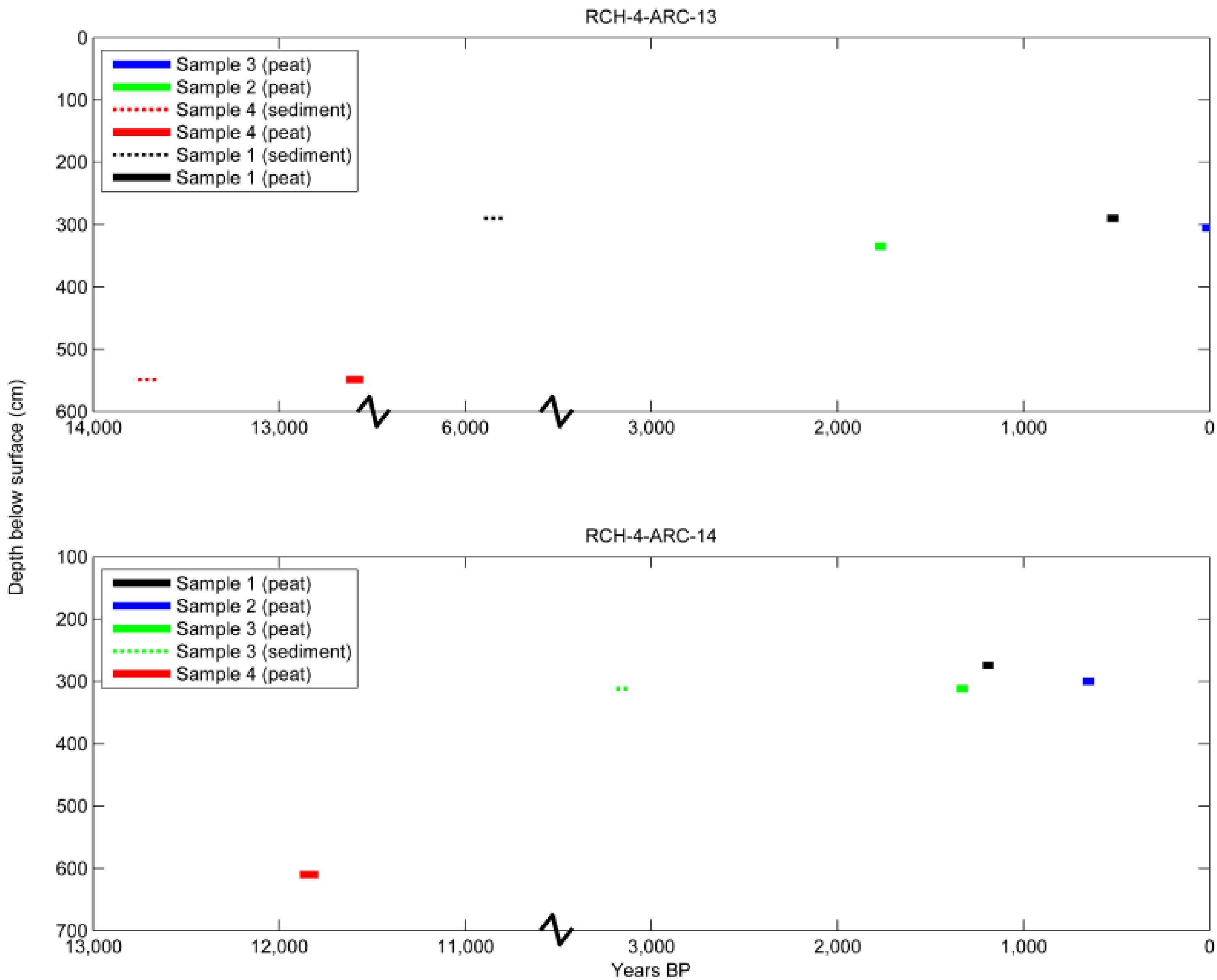


Figure 6. Chart of Radiocarbon Dates

5. GEOARCHAEOLOGICAL INTERPRETATIONS AND RECOMMENDATIONS

This seventh round of GRA investigations is an assessment of the potential for locations in northwestern Staten Island to house deeply buried archaeological sites. The approach applied for this assessment is unique for two reasons. First, it examines subsurface potential for an alignment segment that spans only 0.51 miles (0.82 km). Second, this portion of the alignment traverses terrain that, while disturbed, is nevertheless in close proximity to some of the most sensitive archaeological terrain in New York City. The latter concern is especially true for the prehistoric component of the cultural resources, since Staten Island generally, and this (northwest) portion of the island in particular, houses intact and stratified alluvial successions that are among the oldest in the Northeast. Towards this end we have generated archaeological sensitivity assessments based both on our interpretations of subsurface geological integrity and antiquity (Tables 1 and 2) as well as proximity of core locations to the more prominent prehistoric sites in the vicinity of the alignment. For historic components, guidelines for sensitivity are based on known cultural resources (see Elquiest et al. 2010a) bolstered by evaluations of discrete fill components that conform to debris types that would be expected from the documented historic properties.

As in the case of earlier studies (GRA 2011a, b, c; GRA 2012 a, b, c) it is emphasized that these recommendations are relevant to the immediate vicinities of the coring locations, and they should not be extrapolated to adjoining properties or tracts beyond the sampling interval of the boring program. The recommendations are based on close-interval sampling schemes and it is expected that the reliability of these recommendations is high. As noted, for New York State that interval is 300 ft (90 m). Nevertheless, the recommendations are proposed largely without the benefit of additional laboratory analyses. For this study, radiocarbon dating was undertaken in eleven (11) contexts and we have established a reliable sequence for peat sedimentation in the project area. Moreover, we are confident that we have established a working absolute chronology for the lower-lying terrain in this segment of the pipeline traverse. That terrain is of prehistoric age and its aquatic micro-environments would have been exploited by the Archaic peoples of Staten Island. By the same token we do not have unequivocal evidence for reconstructing conclusive depositional histories for the extent of the pipeline alignment, nor for that matter for the high ground overlooking the local marshes, on which prehistoric peoples may have settled. To do so would require additional analysis bearing on landform origins (sedimentology and micromorphology), and reconstructing vegetation and climate (palynology and stable isotope studies). Such analyses will be performed at locations deemed palaeoenvironmentally sensitive, pending protocols determined in agreements between PAL and the New York State Office of Parks and Recreation & Historic Preservation (NYSOPRHP).

For the greater project area, as well as for individual project tracts, the formulation of a chronology of deeply buried sequences would refine our archaeological sensitivity model. In many cases, there is not enough difference in the physical characteristics of deposits—as manifest in the limited exposure furnished by cores—to differentiate between sediments with archaeological sensitivity and deposits which pre-date human arrivals. We do know, for example, that there is a significant gap between the end of Pleistocene sedimentation in the project area and the known period of human activity in this part of the world. In yet other situations, refinement of depositional environments (through palaeoecological analysis techniques) would allow for reconstructions with sufficient data to establish the types of sites that might be expected in certain settings.

In practical terms assessments of sensitivity were determined by planned depth of impact, per project design, and specifically the depth of pipe installation. Towards that end, "historic fill" columns that extend beyond 15 ft. preclude a location from further testing. Additional considerations in sensitivity assessments include investigator familiarity with the age and type of the natural substrate. Thus, locally the immediate subsurface beneath the fill is a thick peat at one major location. This peat registers the uninterrupted presence of an aqueous subsistence landscape at the margins of the Staten Island shore from the Middle Archaic through Euroamerican contact times. These local marshes and ponds were clearly associated with the archaeological sites documented for the area (Figure 5). However, potential for recovering prehistoric or contact area materials would more likely be associated with higher settings, here weathered tills formed on moraines. There is a moderate to high potential that small sites might be found on the margins of the marshes.

Thus, the following provisional assessments of archaeological preservation along this alignment are based on the coring program and the stratigraphies preserved at the three core groups under consideration.

Tables 1 and 2 summarize the recommendations for follow-up work for each of the three groups along the alignment. These tables justify our recommendations on the strength of preliminary examinations of core sequences.

Table 1 presents general assessments of archaeological sensitivity on a core-by-core basis. Historic and prehistoric resource potentials are considered separately for each core. Rankings are assessed on a relative basis, according to "high", "medium", and "low" levels of sensitivity (column 3). Stratigraphic and sedimentological evidence in support of the rankings are presented in the last column.

Table 2 specifies the locations in which follow-up work is recommended on the basis of formal geoarchaeological criteria. These geoarchaeological criteria are structured around baseline stratigraphies and chronologies. Accordingly, columns 3 through 8 detail the six (6) geological units that accommodate the sequences recorded in the entire population of cores. As shown, these units grade from youngest to oldest (left to right) and include: (1) Deep/Mixed Fill; (2) Discrete Fill; (3) Buried Soil; (4) Estuarine/Peats; (5) Shore facies; and (6) Till. The units have unique properties in determining archaeological potential for Historic and Prehistoric sites respectively. We consider each.

Historic Units. Units (1) and (2), the fills, represent historic deposits associated with land clearing activities and can extend from the 17^{th} through 21^{st} centuries. Most large scale clearance dates to the late 19^{th} century and subsequent. While fill is widely considered to have limited archaeological potential, we separate category (2), Discrete fill, as indicating degradation of a particular feature or episode of destruction that can be linked to a known historic structure. In that sense the Discrete Fill may represent a context favorable for yielding intact archaeological remains.

Prehistoric Units. Units (3), (4), and possibly (5) are contemporaneous with prehistoric occupations and resource environments. Thus they will invariably date to the last 10,000-12,000 years (Holocene). Buried soils (3) are considered likely to contain prehistoric surfaces because they register stable environments of the Holocene. The category classed as Estuarine/Peats (4) are rich biotic settings which functioned as subsistence environments that would have attracted prehistoric peoples. Shore facies (5) are not well dated in Staten Island and may be of Pleistocene or Holocene age. Thus, they have some potential for containing prehistoric deposits. Till (6) is of late Pleistocene age and probably pre-dates prehistoric occupation.

In sum, it follows that sealed geological deposits of an age contemporaneous with human occupation are excellent indicators of buried cultural resource potential. For historic sites the optimal geological unit is (2) as it contains evidence for unique historic activities in a sealed sediment matrix. For prehistoric sites primary preservation contexts for archaeological materials include units (3) and (4).

In addition to sealed geological deposits, the archaeological sensitivity of a core location is enhanced by its proximity to known archaeological sites (column 9). Finally, the absolute dating of buried soils and sediments, through the radiocarbon method, confirms the age of a deposit and it too is an excellent measure of buried site potential (column 10).

Table 2 is a matrix that charts the set of cores by geological unit (columns 3-8) and additional measures of archaeological preservation potential—proximity to known sites (column 9) and radiocarbon dates (column 10)--to develop a measure of **archaeological potential** (column 11) that guides our recommendation for follow-up work. The key element for determining archaeological potential for each core is the age of the geological units preserved within the composite core column. A core that contains several units of prospective archaeological age, noted in Table 2 by “Yes” in the appropriate age column, would be a likely candidate for follow up testing. Proximity to archaeological sites and Radiocarbon Dates at the core location would further underscore the productivity of testing.

In general, cores for which 3 to 4 “Yes” responses are checked were considered viable candidates for prospective follow-up work. For example, if a single core preserved three geological units of archaeological age and was in proximity of a site, it would be selected for further testing. It is noted, of course, that while all the cores were in proximity of archaeological sites in this uniquely sensitive (northwestern) section of

Staten Island, individual core locations would **not** be tested unless they fulfilled at least two other criteria, most typically containing at least two deposits of Holocene age. Following these guidelines a total of two (2) core locations were selected for additional work.

Specific recommendations and guidelines for such work were dictated by the particular core stratigraphies. The following discussion presents the specific strategies proposed for each group of cores.

Port Authority Property – *Staten Island, NY*

Group 1:

The four (4) cores at the north end of the transect document approximately 6 ft (1.8 m) of historic fill over Pleistocene till, with a likelihood of disturbed shoreline deposits. Historic resources have been extensively documented in the immediate area, and structures from the 1920s Proctor and Gamble development are still extant. Prehistoric resources in the same area have probably been disturbed by historic processes, as historic fill is the dominant component in this area. The Proctor and Gamble development is the most likely source of the buried debris in RCH-4-ARC-21, although additional analysis of the fill would be needed in order to eliminate another source. Absence of a preserved shore facies (possibly re-worked into the local fills) makes it impossible to isolate the contours of the original surface of the Pleistocene, till-based landform.

> *Historic fill horizons were present at RCH-4-ARC-21. These have a high likelihood of dating to the 1920s or later. This core warrants additional testing, as a firm chronology should be established. Pedestrian shovel testing would provide diagnostic materials to date the deposit. The remaining cores in the group do not have unique historic fill horizons, and they do not warrant additional testing. In all locations, potential for palaeoenvironmental reconstruction is minimal.*

Group 2:

These three (3) cores document 4-8 ft (1.2-2.4 m) of historic fill over transgressive shoreline facies (with sediments fining upwards), indicating a relatively intact record of the development of the coastal environment during the Holocene. The surface of the underlying till (or possibly reworked lacustrine sands) appears undisturbed. For example, the absence of this Pleistocene sediment complex in core RCH-4-ARC-17 despite intact shore facies suggests that the original landform surface dips down here. Extensive gravel, wood, and brick fragments in the fill suggest that the primary cultural contributions to the sediment cover were historic, although these cores are adjacent to NYSM Site #8505. There are no preserved paleosols in this group of cores, so prehistoric surfaces relating to either #8505 or the other prehistoric sites in the area have been removed or reworked into the historic fill layer. Intact prehistoric contexts are unlikely. This area preserves both fairly undifferentiated historic resources and prehistoric landforms.

> *No unique historic fill horizons were recognized. There is minimal potential for buried historic or prehistoric surfaces at this location. Potential for palaeoenvironmental reconstruction is minimal. The Pleistocene till landform is below the 15 ft-deep footprint of the project. These cores do not warrant additional testing.*

Group 3:

These cores document the development of the wetland beginning in the mid-Holocene, and provide an important environmental chronology for the area. The strata in RCH-4-ARC-13 suggest at least two episodes where still water allowed clay particles to settle and support marsh vegetation. The final episode of marsh was buried by artificial fill, although the area remains a wetland with artificial drainage ditches. RCH-4-ARC-14 does not display identical episodes of mid-to-late-Holocene marsh growth as registered at RCH-4-ARC-13. In the former, there appears to be a single episode of coarsening downwards from late-Holocene vegetation to sand to clay, terminating with a deeply-buried mat of vegetation at 20 ft (6.1 m) which provides the very early date for wetland development of 11840±50 BP. Partial loss of RCH-4-ARC-14 below the top layer of peat may have obscured an additional episode of mid-Holocene marsh development that parallels the one in RCH-4-ARC-13. The inversion of dates above 320 cm probably resulted from disturbance or reworking of the uppermost peat, when the wetlands were being filled in.

Taken together, however, the continuity of marsh sedimentation is confirmed between the two cores. Marsh formation extends as far back as the Middle Holocene and was near continuous for all prehistoric periods and extended through to Euroamerican times. The record of peat sedimentation was only truncated stratigraphically because of the intrusion of filling activity during historic times. There is no question but that that the persistence of these marshes since the Middle Archaic accounts for the proliferation of prehistoric sites in this part of Staten Island.

> *A comprehensive deep testing program is proposed for this setting. Historic and palaeoenvironmental data should be procured from each horizon, and complete stratigraphic columns should be sampled. A suite of palaeoenvironmental tests should be performed together with radiometric dating. This is one of the most diagnostic stratigraphic successions for the entire length of line. It is critical to establish the ages of the beach, marsh, and underlying lacustrine/marine shoreline deposits.*
>
> *Palaeoenvironmental reconstructions should focus on sedimentology, micromorphology, pollen studies, and palaeobotanical identification of plant remains. It is proposed that at least one trench be excavated to a depth of 6 m. This trench should be centered in the vicinity of RCH-4-ARC-14, in order to establish the actual sequence of marsh formation and to obtain further data about the deep, early-Holocene peat layer. Limited testing of the historic fill should also be initiated.*

Table 2. Summary of Recommendations

Property	Core No.	Sensitivity Assesment	Preliminary Analysis Information			Comments
			Contamination (No Further Work)	Modern Fill = 15 ft BS (No Futher Work)	Modern Fill/ Historic Strata = 15 ft BS (Further Work)	
Port Authority	RCH-4-ARC-13	moderate for prehistoric and historic resources.				Sandy fill transitioning to apparently natural organic-rich deposits 213 cm. Natural deposits consist of peats, organic-rich sands and shorefacies. RC dates at 290 cm: 520±30 BP (Beta-320523, peat), 3850±50 BP (Beta-320840, sediment); RC date at 305 cm 10±30 BP (Beta-320525, peat); RC date at 335 cm: 1770±30 BP (Beta-320524, peat); RC date at 549 cm: 6590±40 BP (Beta-320526, peat); 13720±60 BP (Beta-320841, sediment)
Port Authority	RCH-4-ARC-14	moderate for prehistoric and historic resources.				Sandy fill transitioning to natural deposits below 274 cm. Natural deposits consist of peats/marsh deposits and shorefacies. RC date at 274 cm: 1190±30 BP (Beta-320527, peat); RC date at 300 cm 650±30 BP (Beta-320528, peat); RC dates at 312 cm 1330±30 BP (Beta-320529, peat); 3160±30 BP (Beta-320842, sediment); RC date at 610 cm: 11840±50 BP (Beta-320530, peat)
Port Authority	RCH-4-ARC-15	low for prehistoric and historic resources.		present		Note: core extends to 760 cm below ground surface. Gravelly surface fill and sandy fill transitioning to reworked till facies below 610 cm, till sands below 732 cm.
Port Authority	RCH-4-ARC-16	low for prehistoric resources and historic resources.				Surface and sandy fill transitioning to till sands below 457 cm.
Port Authority	RCH-4-ARC-17	low for prehistoric resources and historic resources				Concrete and sandy fill transitioning to apparent natural deposits below 396 cm. Natural horizons consists of sandy clay overlying compacted shorefacies.
Port Authority	RCH-4-ARC-18	low for prehistoric resources and historic resources				Gravelly/sandy fill to 270 cm, till (clay and sand) to base
Port Authority	RCH-4-ARC-19	low for prehistoric resources and historic resources				Sandy fill to 305 cm, till (clay/gravel) to base
Port Authority	RCH-4-ARC-20	low for prehistoric resources and historic resources				Sandy fill to 183 cm, till to base
Port Authority	RCH-4-ARC-21	low for prehistoric resources and historic resources				Sandy fill over till (clay) at 240 cm

Table 3. Assessments of Archaeological Significance and Follow up Testing

Core	RELATIVE AGE YOUNGEST ⟹ OLDEST POTENTIALLY ARCHAEOLOGICALLY SENSITIVE									
		HOLOCENE								
Core	Deep/Mixed Fill	Discrete Fill	Buried Soil	Marsh/ Peat	Shore facies	Till	Proximity to known Arc sites*	RC Dates	SIGNIFICANT (x/-)	COMMENTS
RCH-4-ARC-13[1]	NO	NO	NO	YES	YES	NO	YES	YES	x	Sandy fill, organic-rich deposits at 213 cm
RCH-4-ARC-14[1]	NO	NO	NO	YES	YES	NO	YES	YES	x	Sandy fill, peats/shorefacies below 274 cm.
RCH-4-ARC-15	YES	NO	NO	NO	YES	YES	YES	NO	-	Gravel/sand fill, reworked till facies below 610 cm.
RCH-4-ARC-16	NO	NO	NO	NO	YES	YES	YES	NO	-	Surface and sandy fill transitioning to till sands below 457 cm.
RCH-4-ARC-17	NO	NO	NO	NO	YES	NO	YES	NO	-	Concrete and sandy fill with natural deposits below 396 cm
RCH-4-ARC-18	NO	NO	NO	NO	NO	YES	YES	NO	-	Gravelly/sandy fill to 270 cm, till (clay and sand) to base
RCH-4-ARC-19	NO	NO	NO	NO	NO	YES	YES	NO	-	Sandy fill to 305 cm, till (clay/gravel) to base
RCH-4-ARC-20	NO	NO	NO	NO	NO	YES	YES	NO	-	Sandy fill to 183 cm, till to base
RCH-4-ARC-21	NO	YES	NO	NO	NO	YES	YES	NO	-	Sandy fill over till (clay) at 240 cm

[1]sampled for radiocarbon date

*within ~1.0 km

REFERENCES

3DI. (1992). *Paleoecological and geomorphological studies for Transcontinental Gas Pipe Line Corporation's 0.75 mile Carlstadt Loop project in Bergen County, New Jersey*. Houston, Texas.

Antevs, E.V. (1925). Conditions of Formation of the Varved Glacial Clay. *Geological Society of America Bulletin* (36).

Averill, S.P., Pardi, R.R., Newman, W.S., & Dineen, R.J. (1980). Late Wisconsin-Holocene History of the Lower Hudson Region: New Evidence from the Hackensack and Hudson River Valleys. In W. Manspeizer (Ed.), *Field Studies of New Jersey Geology and Guide to Field Trips: 52nd Annual Meeting of the New York Geological Survey*.

Belknap, D.F., & J.C., K. (1977). Holocene Relative Sea-Level Changes and Coastal Stratigraphic Units on the Northwest Flank of the Baltimore Canyon through Geosyncline. *Journal of Sedimentary Petrology*, 47, 610-629.

Boesch, E. (1994). *Archaeological Evaluation and Sensitivity Assessment of Staten Island, New York*. Prepared for the New York City Landmarks Preservation Commission, New York, NY. Report on File at NY State Historic Preservation Office.

Cadwell, D.H. (1989). *Surficial Geologic Map of New York, Lower Hudson 1:250,000 Sheet*. Albany: New York State Geological Survey.

Carbotte, S.M., Bell, R.E., W.B.F., R., McHugh, C., Slagle, A., Nitsche, F., et al. (2004). Environmental Change and Oyster Colonization within the Hudson River Estuary Linked to Holocene Climate. *Geo-Mar Lett*, 24, 212-224.

Cotter, G.C., Ridge, J.C., Everson, E.B., Sevon, W.D., L., S., & Stuckenrath, R. (1986). The Wisconsinan History of the Great Valley, Pennsylvania, and New Jersey, and the Age of the "Terminal Marine" in the Wisconsinan Stage of the First Geological District, Eastern New York. *New York State Museum Bulletin*, 455.

Elquiest, O., Cherau, S., N., G., & Dubell, G.R. (2010a). *Archaeological Overview Survey, Texas Eastern Transmission, LP, New Jersey-New York Expansion Project, FERC Docket No. CP-___-000, Staten Island, Manhattan, and Ramapo*: *Report prepared for Spectra Energy Transmission, LLC, New Jersey*. Pawtucket, Rhode Island.

Elquiest, O., Cherau, S., N., G., & Dubell, G.R. (2010b). *Archaeological Overview Survey, Texas Eastern Transmission, LP, New Jersey-New York Expansion Project, Linden Bayonne, Jersey City, Hanover, and Mahwah, New Jersey, Volume I: Report prepared for Spectra Energy Transmission, LLC, New Jersey*. Pawtucket, Rhode Island.

Fairbridge, R.W., & Newman, W.S. (1968). Postglacial Crustal Subsidence of the New York Area. *Zeitschrift fur Geomorphologie*, 3, 296-317.

Flagg, T. R. (1991a). *Cultural Resources Survey, Newark Bay Site: Main Parcel and Pier Parcel, Staten Island, NY. New York City Long Range Sludge Management Plan GEIS III*. Prepared for the New York City Department of Environmental Protection, Roosevelt Island, NY.

Flagg, T. R. (1991b). *Cultural Resources Evaluation, Newark Bay Site: Main Parcel and Pier Parcel, Staten Island, NY*. Prepared by Historical Documentation Services. Report on File at NY State Historic Preservation Office, Waterford, NY.

Fleming, K., Johnston, P., D., Z., Yokoyama, Y., Lambeck, K., & Chappell, J. (1998). Refining the Eustatic Sea-Level Curve since the Last Glacial Maximum using Far- and Intermediate-Field Sites. *Earth and Planetary Science Letters*, 163, 327-342.

GRA. (1996). *Enhancement Project, Phase 1B, Geomorphological Analysis, Final Report of Field Investigations*. New York, New York.

GRA. (2000). *Geomorphological and Archaeological Study Northeast of Shooters Island, Hudson and Union Counties, New Jersey, in Connection with the Arthur Kill - Howland Hook Marine Terminal Channel Project*. Report prepared for the U. S. Army Corps of Engineers, New York District. New York, New York.

GRA. (2011a). *Preliminary Report: "Pre-Analysis" Results of the December, 2010 Phase IA Geoarcheological Investigations for the NJ-NY Expansion Project. Linden, Union County, New Jersey; Bayonne and Jersey City, Hudson County, New Jersey; Staten Island, Richmond County, New York: Report prepared for Public Archaeology Laboratory, Pawtucket, Rhode Island*. New York, New York.

GRA. (2011b). *Preliminary Report: "Pre-Analysis" Results of Geoarchaeological Investigations, Phase IA Round 2, June-October 2011 NJ-NY Expansion Project. Bayonne and Jersey City, Hudson County, New Jersey: Report prepared for Public Archaeology Laboratory, Pawtucket, Rhode Island*. New York, New York.

GRA. (2011c). *Preliminary Report: "Pre-Analysis" Results of Geoarchaeological Investigations, Phase IA, NJ-NY Expansion Project, Round 3, July-November 2011 Staten Island, Richmond County, New York: Report prepared for Public Archaeology Laboratory, Pawtucket, Rhode Island*. New York, New York.

GRA. (2012a). *Preliminary Report: "Pre-Analysis" Geoarchaeological Investigations, Phase IA Round 4, October-November 2011 NJ-NY Expansion Project. Jersey City, Hudson County, New Jersey: Report prepared for Public Archaeology Laboratory, Pawtucket, Rhode Island*. New York, New York.

GRA. (2012b). *Preliminary Report: "Pre-Analysis" Geoarchaeological Investigations, Phase IA Round 5, March 2012, NJ-NY Expansion Project. Bayonne, Hudson County, New Jersey: Report prepared for Public Archaeology Laboratory, Pawtucket, Rhode Island*. New York, New York.

GRA. (2012c). *Preliminary Report: "Pre-Analysis" Results of Geoarchaeological Investigations, Phase 1A, NJ-NY Expansion Project, Round 6, February-April 2012, Staten Island, Richmond County, New York: Report prepared for Public Archaeology Laboratory, Pawtucket, Rhode Island*. New York, New York.

Harten Archaeological Associates, Inc. (HAA). (1995). *Report of Archaeological Potential, Goethals Bridge Expansion, Staten Island Bridges Program, Richmond County, New York and Union County, New Jersey*. Prepared for Hartgen Archaeological Associates, Inc. Troy, NY. Submitted to Parsons Brinckerhoff, New York, NY.

Harten Archaeological Associates, Inc. (HAA). (2002). *Phase 1A Literature Review and Archaeological Sensitivity Assessment, Cross Harbor Freight Movemement Project, Port Ivory Yard, Arlington Yard, Eleven Railroad Crossings and Proposed Tunnel, Staten Island, Richmond County, New York*. Prepared for Hartgen Archaeological Associates, Inc. Troy, NY. Submitted to Allee King Rosen and Fleming, Inc., New York, NY.

Henn, R.E. (1985). *Preliminary Assessment of Cultural Resources, Port Jersey, Hudson County, New Jersey*. Environmental Analysis Branch, New York District, U.S. Army Corps of Engineers. New York, New York.

Isachsen, Y.W., Landing, E., Lauber, J.M., Rickard, L.V., & Rogers, W.B. (1991). *Geology of New York: A Simplified Account*. New York State Museum, Albany.

ISSC. (1994). *International Stratigraphic Guide, Second Edition*. Boulder, Colorado: The Geological Society of America.

Kearns, B., Kirkorian, C., Schneiderman-Fox, F. (1991a). *The New York City Long Range Sludge Management Plan, Generic Environmental Impact Statement III, Newark Bay, Staten Island, Phase IA Archaeological Assessment*. Prepared by Historical Perspectives, Inc., Riverside, CT. Prepared for Allee King Rosen and Fleming, Inc., New York, NY.

LaPorta, P.C., Sohl, L.E., M.C., B., Elder, K.L., Franks, C.E., Bryant Jr., V.M., et al. (1999). *Cultural Resource Assessment of Proposed Dredged Material Management Alternative Sites in the New York Harbor-Apex Region: Report prepared for U. S. Army Corps of Engineers, New York District*.

Larsen, C.E., & Clark, I. (2006). A Search for Scale in Sea Level Studies. *Journal of Coastal Research*, 22(4), 788-800.

Larsen, C.E., Smith, M.A., & Schuldenrein, J. (2010). *Geoarcheological Study of Cores for the Tappan Zee Bridge Hydrographic Survey, I-287 Corridor*. New York.

Lawrence, J.W. (1998). *City of Bayonne, Hudson County, New Jersey, Interim Report on the Phase II Combined Sewer Overflow Floatable/Solids Control Facilities Planning Study, NJPDES Permit No. NJ0105023, Individual Authorization No. 0109240, Volume III Stage IA Cultural Resources Study*. Whitehouse, NJ.

Lewis Berger Group. (2007). *Goethals Bridge Replacement, Richmond County, New York and The City of Elizabeth, Union County, New Jersey, Phase I Archaeological Report. Prepared by the Louis Berger Group Inc., East Orange, New Jersey. Prepared for the United States Coast Guard*. Report on File at NY State Historic Preservation Office. Waterfod, NY.

Lovegreen, J.R. (1974). *Paleodrainage History of the Hudson Estuary*. Columbia University, New York.

Maenza-Gmelch, T.E. (1997). Vegetation, Climate, and Fire during the Late-Glacial-Holocene Transition at Spruce Pond, Hudson Highlands, Southeastern New York. *The Holocene*, 7(1), 25-37.

Merguerian, C., & Sanders, J.E. (1994). *Field Trip 33 - Staten Island and Vicinity*. New York: New York Academy of Sciences.

Newman, W.S., Thurber, D., Weiss, H., Rokach, A., & Musich, L. (1969). *Late Quaternary Geology of the Hudson River Estuary: A Preliminary Report*. Transaction Series. New York: Academy of Sciences.

New York City Economic Development Corporation (NYCEDC) (2004). *Cross Harbor Freight Movement Project, Draft Environmental Impact Statement*. Prepared in cooperation with the United States Department of Transportation, the Federal Highway Administration, and the Federal Railroad Administration. New York, New York.

New York State Office of Parks, Recreation and Historic Preservation. (2010). *New York State Historic Preservation Office. GIS – Public Access*. Retrieved June 3, 2010 from the world wide web:http://www.oprhp.state.ny.us/nr/main.asp.

Nikitina, D.L., Pizzuto, J.E., Schwimmer, R.A., & Ramsey, K.W. (2000). An Updated Sea Level Curve for the Delaware Coast. *Marine Geology*, 171, 7-20.

Payne, T.M. and Baumgardt, K. (1986). *Howland Hook Marine Terminal Expansion Cultural Resources Reconnaisance*. Prepared by MAAR Associates, Inc., Newark, DE. Prepared for International Technologies, Edison, NJ.

Peteet, D.M., Vogel, J.S., Netson, D.E., Southon, J.R., Nickman, R.J., & Heusser, L.E. (1990). Younger Dryas Climatic Reversal in Northeastern USA? AMS Ages for an Old Problem. *Quaternary Research*, 33, 219-230.

Raber, M.S., Flagg, T., Weinstein, G., Weigand, E. and Brouwer, N. (1996). *Reconnaissance Cultural Resource Investigation, Arthur Kill New York Reach, Richmond County, New York,* *New York Harbor Collection and Removal of Drift Project, U.S. Army Corps of Engineers, New York District.* Prepared by Raber Associates, South Glastonbury, CT. Prepared for Fredrick R. Harris, Inc., New York, NY.

Rampino, M.R., & Sanders, J.E. (1981). Upper Quaternary Stratigraphy of Southern Long Island, New York. *Marine Geology*, 171, 7-20.

Redfield, A.C., & Rubin, M. (1962). *The age of salt marsh peat and its relation to recent changes in sea level in Barnstable, Massachusetts*. Transaction Series. National Academy of Sciences.

Reeds, C.A. (1925). Glacial Lake Hackensack and Adjacent Lakes. *Geological Society of America Bulletin,* 36(155).

Reeds, C.A. (1926). The Varved Clays at Little Ferry, New Jersey. *American Museum Novitiates*, 209, 1-19.

Ritchie, W. (1980). *The Archaeology of New York State*. Revised edition. Harbor Hill Books. New York: NY.

Robinson, W.F. (1961). *Bayonne Centennial Historic Revue, 1861-1961*. Bayonne, NJ: Centennial Committee.

Rue, D.J., & Traverse, A. (1997). Pollen Analyses of the Hackensack, New Jersey Meadowlands Tidal Marsh. *Northeastern Geology and Environmental Notes*, 19(3), 211-215.

Salisbury, R.D. (1902). *The Glacial Geology of New Jersey Annual Report of the State Geologist of New Jersey.*

Salisbury, R.D., & Kummel, H.B. (1893). *Lake Passaic: An Extinct Glacial Lake Annual Report of the State Geologist of New Jersey (Section VI).*

Sanborn Map Company. (1910). *Insurance Maps of New York, Manhattan and Bronx Boros.* Sanborn Map Co., New York, NY.

Sanborn Map Company. (1917). *Insurance Maps of New York, Manhattan and Bronx Boros.* Sanborn Map Co., New York, NY.

Sanborn Map Company. (1937). *Insurance Maps of New York, Manhattan and Bronx Boros.* Sanborn Map Co., New York, NY.

Sanborn Map Company. (1950). *Insurance Maps of New York, Manhattan and Bronx Boros.* Sanborn Map Co., New York, NY.

Sanborn Map Company. (1962). *Insurance Maps of New York, Manhattan and Bronx Boros.* Sanborn Map Co., New York, NY.

Schuberth, C.J. (1968). *The Geology of New York City and Environs.* Garden City: Natural History Press.

Schuldenrein, J. (1995). *Geoarcheological Observations for the Arthur Kill Factory Outlet Center (AKFOC) Project, Staten Island*. Riverdale, NY. Riverdale, NY.

Schuldenrein, J. (1995). Geoarcheological Overview of Bellman's Creek, Hackensack Meadowlands, New Jersey. In J. Geismar (Ed.), *A Stage 1A Cultural Resources Survey of the Impact Area of the New Jersey Turnpike Secaucus Interchange Project, Hudson County, New Jersey*. New York.

Schuldenrein, J. (2000). *Geoarcheological Investigations of the Collect Pond Borings, Report prepared for Joan Geismar, Inc*. Riverdale, NY.

Schuldenrein, J. (2006). Emergence of Geoarchaeology in Research and Cultural Resource Management: Part I. *The SAA Archaeological Record*, 6(5), 11-14.

Schuldenrein, J. (2007). Emergence of Geoarchaeology in Research and Cultural Resource Management: Part II. *The SAA Archaeological Record*, 7(1), 16-24.

Schuldenrein, J., & Aiuvalasit, M.J. (2011). Urban Geoarchaeology and Sustainability: A Case Study from Manhattan Island, New York, U.S.A. In A.G. Brown, L.S. Basell & K.W. Butzer (Eds.), *Geoarchaeology, Climate Change, and Sustainability* Denver, CO.: Geological Society of America.

Schuldenrein, J., Larsen, C.E., Aiuvalasit, M., Smith, M.A., & Malin-Boyce, S. (2007). *Geomorphology/Archeological Borings and GIS Model of the Submerged Paleoenvironment in the New York/New Jersey Harbor and Bight in Connection with the New York and New Jersey Harbor Navigation Project*. New York.

Sirkin, L. (1986). *Pleistocene Stratigraphy of Long Island, New York. In The Wisconsinan Stage of the First Geological District, eastern New York*. Albany: New York State Museum.

Sirkin, L., & Stuckenrath, R. (1980). The Post-Washingtonian Warm Interval in the Northern Atlantic Coastal Plain. *Geological Society of America Bulletin*, 91:332-336.

Skinner, A. (1909). The Lenape Indians of Staten Island. In *The Indians of Greater New York and the Lower Hudson*. Edited by Clark Wissler. Anthropological Papers of the Museum of Natural History, vol. III.

Stanford, S.D. (1997). Pliocene-Quaternary Geology of Northern New Jersey-An Overview. In S.D. Stanford & R.W. Witte (Eds.), *Pliocene-Quaternary Geology of Northern New Jersey-Guidebook for the 60th Annual Reunion of the Northeastern Friends of the Pleistocene, New Jersery Geological Survey*. New Jersey: New Jersey Geological Survey.

Stanford, S.D. (2002). *Surficial Geology of the Elizabeth Quadrangle, Essex, Hudson, and Union Counties, New Jersey, Open-File (Map 42 ed.)*. Department of Environmental Protection / New Jersey Geological Survey.

Stanford, S.D. (2010). Onshore Record of Hudson River Drainage to the Continental Shelf from the Late Miocene through the Late Wisconsinan Deglaciation, USA: synthesis and revision. *Boreas*, 39(1), 1-17.

Stanford, S.D., & Harper, D.P. (1991). Glacial Lakes of the Lower Passaic Hackensack, And Lower Hudson Valleys, New Jersey and New York. *Northeastern Geology*, 13(4), 277-286.

Stone, B.D., Stanford, S.D., & White, R.W. (2002). *Surficial Geological Map of Northern New Jersey, Miscellaneous Investigations Series Map I-2540-C*. U.S. Geological Survey.

Thieler, E.R., Butman, B., Schwab, W.C., Allison, M.A., Discoll, N.W., Donnelly, J.P., et al. (2007). A Catastrophic Meltwater Flood Event and Formation of the Hudson Shelf Valley. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 246, 120-136.

Thieme, D.M. (2003). Archaeological Site Formation in Glaciated Settings, Southern New York and New Jersey. In J. Hart & D. Cremeens (Eds.), *Geoarchaeology in the Glaciated Northeast* (pp. 163-179). Albany: New York State Museum.

Thieme, D.M., & Schuldenrein, J. (1996). *Quaternary Paleoenvironments in the Hackensack Meadowlands: A Geological and Palynological Study of Borings for the Proposed North Arlington Force Main and Pumping Station, North Arlington, N.J.: prepared for Neglia Engineering Associates, Lyndhurst, N.J.* New York.

Thieme, D.M., & Schuldenrein, J. (1998). *Paleoenvironmental Analysis of the Combined Sewer Overflow Planning Study, Planning Area 1A, North Bergen (West), Hudson County, New Jersey, prepared for Richard Grubb and Associates, Inc., Cranbury, N.J.* New York.

Thieme, D.M., Schuldenrein, J., & Maenza-Gmelch, T. (1996). *Abstracts of the American Quaternary Association 14th Biennial Meeting.* Flagstaff.

TRC Companies, Inc. (2010) *Site Review Summary Tables: TRD ID Nos, 3-8, 11-17,19-25.* Prepared by TRC Companies, Inc. Millburn, New Jersey.

Uchupi, E., Driscoll, N., Ballard, R.D., & Bolmer, S.T. (2001). Drainage of Late Wisconsin Glacial Lakes and the Morphology and Late Quaternary Stratigraphy of the New Jersey-Southern New England Continental Shelf and Slope. *Marine Geology*, 172, 117-145.

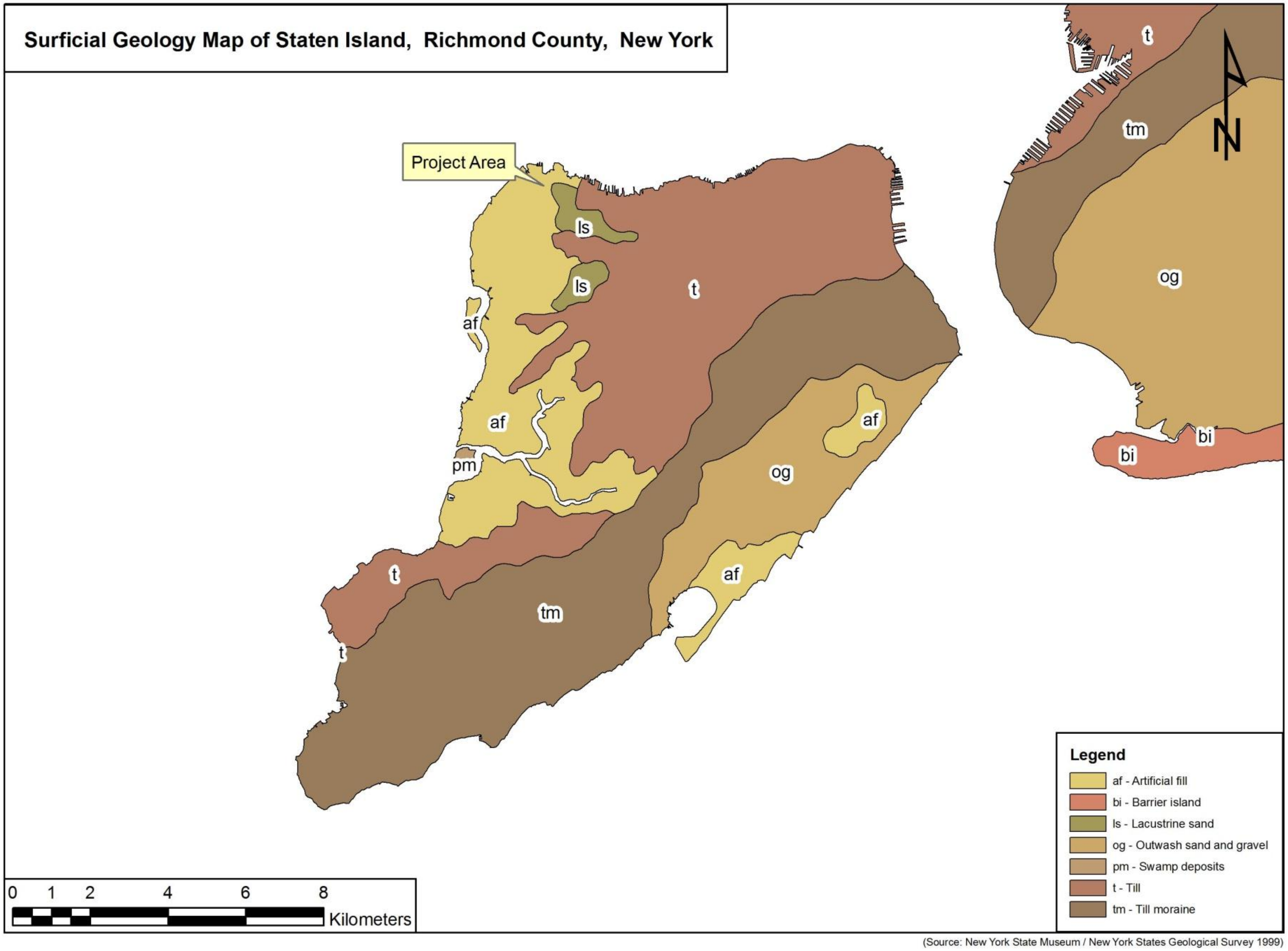
USDA. (1994). *Keys to Soil Taxonomy* (6 ed.). Blacksburg, Virginia:Pocahontas Press.

Wagner, D.P., & Siegel, P.E. (1997). *A Geomorphological and Archeological Analysis of the Arthur Kill-Howland Hook Marine Terminal Channel, Richmond County, New York, and Union County, New Jersey, prepared for the New York District, U.S. Army Corps of Engineers*.

Weiss, D. (1974). Late Pleistocene Stratigraphy and Paleoecology of the Lower Hudson River Estuary. *Geological Society of America Bulletin*, 85, 1561-1580.

Widmer, K. (1964). *The Geology and Geography of New Jersey*. Princeton, New Jersey: Van Nostrand.

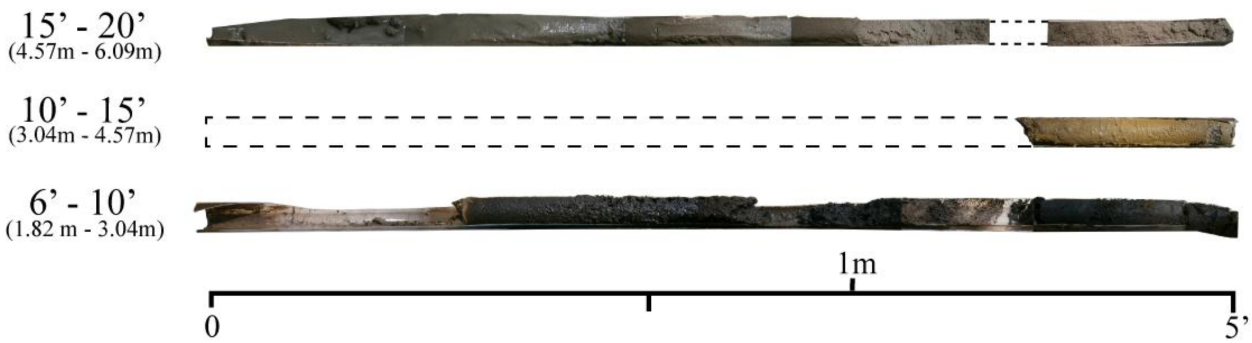
Appendix A: Surficial Geology Map



Surficial Geology Map of Staten Island, Richmond County, New York (Source: NYSGS 1999)

Appendix B: Core Photographs and Descriptions

RCH-4-ARC-13



RCH-4-ARC-13

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consist.	Boundary	Comments
FILL	0-61	61	Ap1	10YR 4/3	SL	dist	l-fri	g	common gravel, brick and metal material; some coal present
FILL	61-183	122	Ap2	10YR 2/1	SiL	dist	l-sl.st	n/a	waste material with oily sheen and petrol smell (PID=0); iron nail at 122 cm, wood below 213 cm
MISSING	183-198	15	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FILL	198-247	49	Ap3	10YR 4/4	SCL	gr	l-sl.st	c	some gravel present
FILL	247-250	3	Ap4	10YR 2/1	O	2sbk	sl.pl	c	peat - well-preserved organic material (reeds)
FILL	250-259	9	Ap5	10YR 3/2	S-CS	gr	l	c	poorly sorted sand with no visible inclusions

(continued on next page)

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure

Consist: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky

Boundary Distinct: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp

Boundary Topo: w=wavy; s=smooth; a=abrupt

Misc: n/a=not applicable, n/r=not recorded

RCH-4-ARC-13 (continued)									
Unit	**Depth (cm)**	**Thickness (cm)**	**Soil Horizon**	**Munsell Color**	**Texture**	**Structure**	**Consistence**	**Boundary**	**Comments**
FILL/ REWORK-ED MARSH	259-305	46	Ap6	10YR 2/1	O	2sbk	fi	g	well-preserved fibrous organics, color lightens with depth. RC dates at 290 cm: 520±30 BP (Beta-320523, peat), 3850±50 BP (Beta-320840, sediment); RC date at 305 cm 10±30 BP (Beta-320525, peat)
SHORE FACIES	305-335	30	2C	2.5Y 5/4	CS-SC	gr	sl.pl	n/a	well-sorted sandy matrix with variable clay content and organics present. RC date at 335 cm: 1770±30 BP (Beta-320524, peat)
MISSING	335-457	122	n/r	n/r	n/r	n/r	n/r	n/a	n/r
SHORE FACIES	457-549	92	2C2	10YR 5/1	S	gr	l	g	homogenous well-sorted sand with some clay, well-preserved organic inclusions
SHORE/ MARSH	549-564	15	3C	10YR 5/1 - 2.5Y 5/1	S-O	gr-2sbk	fi-sl.l	g	densely packed sand with plentiful organics RC date at 549 cm: 6590±40 BP (Beta-320526, peat); 13720±60 BP (Beta-320841, sediment)
SHORE FACIES	564-610	46	3C2	10YR 5/1	S	gr	l	n/a	few-no organics below 564 cm; low clay fraction
Texture:	Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:								
Struct:	1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse								
	gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic								
	pl=platy; dist=disturbed/no structure								
Consist:	fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky								
Boundary Distinct:		a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp							
Boundary Topo:		w=wavy; s=smooth; a=abrupt							

RCH-4-ARC-14

RCH-4-ARC-14

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consistence	Boundary	Comments
FILL	0-61	61	Ap1	10YR 3/2 - 7.5YR 4/4	SL	dist	l-fri	g	<20% gravel, some organics (roots) present; distinct color transition (gray redddish) below 30 cm
FILL	61-91	30	Ap2	5YR 4/4	SCL	dist	sl.fri	g	few cobbles
FILL	91-183	92	Ap3	7.5YR 4/1 - 5YR 4/3	SL	gr	sl.l	g	rounded pebbles, matrix mottled with 10YR 6/4; chert fragments present throughout, variable clay fraction increasing below 152 cm, very small shell fragments present below 122 cm
FILL	183-267	84	Ap4	7.5YR 4/2	SCL	1sbk	fi-sl.fi	c	silt present in matrix, common subangular claystone fragments, some chert; increasingly firm with depth

(continued on next page)

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure

Consist.: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky

Boundary Distinct.: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp

Boundary Topo.: w=wavy; s=smooth; a=abrupt

Miscellaneoı n/a=not applicable, n/r=not recorded

RCH-4-ARC-14 (continued)								
FILL/ REWORK-ED PEAT	267-305	38	Ap5	10YR 2/1	O	2sbk	fi	n/a	organic material RC date at 274 cm: 1190±30 BP (Beta-320527, peat); RC date at 300 cm 650±30 BP (Beta-320528, peat)
MARSH PEAT	305-320	15	2C	2.5Y 5/4	SC-O	gr-1sbk	sl.fri	g	sandy clay with some organics RC dates at 312 cm 1330±30 BP (Beta-320529, peat); 3160±30 BP (Beta-320842, sediment)
SHORE FACIES	320-358	38	3C	10YR 4/3	SC	gr	sl.l	c	well-sorted sand with some clay
SHORE FACIES	358-364	6	3C2	2.5 6/1	S	gr	sl.fri	c	light gray cemented sand layer
SHORE FACIES	364-594	230	3C3	2.5Y 5/3 - 10YR 4/2	S	gr	l-fri	a	well-sorted fine-medium sand with no visible inclusions; slight darkening to gray with depth
MARSH PEAT	594-610	16	4C	7.5YR 4/2	O-S	2sbk	sl.fri	n/a	decomposed reeds and marsh organics, some sand RC date at 610 cm: 11840±50 BP (Beta-320530, peat)

Texture:	Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:
Structure:	1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
	gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
	pl=platy; dist=disturbed/no structure
Consist.:	fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky
Boundary Distinct.:	a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp
Boundary Topo.:	w=wavy; s=smooth; a=abrupt
Miscellane	n/a=not applicable, n/r=not recorded

RCH-4-ARC-15

RCH-4-ARC-15

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consistence	Boundary	Comments
FILL	0-76	76	Ap1	10YR 3/3	SL	dist	l	g	glass, brick, coal, lumber, whiteware; >50% gravel/cobble
FILL	76-152	76	Ap2	5YR 4/6 - 10YR 3/3	SL	dist	l	g	>50% gravel, no cultural remains
FILL	152-244	92	Ap3	10YR 2/1	SiC-S	2sbk	sl.fri	n/a	<50% rounded gravels, wood pulp present
FILL	244-305	61	Ap4	10YR 4/3	SC-S	1sbk	sl.fri	n/a	wet, few rootlets
MISSING	305-325	20	n/r	n/r	n/r	n/r	n/r	n/r	n/r
FILL	325-381	56	Ap5	10YR 4/4	SC-S	1sbk	sl.fri	g	wet
FILL	381-386	5	Ap6	10YR 5/2	SiC	2sbk	st	c	distinct silty layer
SHORE FACIES	386-587	201	2C	10YR 4/3 - 2.5Y 4/2	S	gr	l	c	well-sorted sand, no visible inclusions, some clay present in matrix, gradual color transition
SHORE FACIES	587-620	33	2C2	10YR 4/1	S-SiC	1sbk	sl.st	c	some organics present, possible oxidation
SHORE FACIES	620-724	104	2C3	5Y 4/1	S	gr	l	c	fine moderately-sorted to coarse poorly-sorted sand, very wet
TILL	724-762	38	3C	2.5YR 4/3	S	gr	l	n/a	fine very well-sorted sand

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure

Consist.: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky

Boundary Distinct.: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp

Boundary Topo.: w=wavy; s=smooth; a=abrupt

Miscell.: n/a=not applicable, n/r=not recorded

RCH-4-ARC-16

RCH-4-ARC-16

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consistence	Boundary	Comments
FILL	0-91	91	Ap1	10YR 4/4	SL	dist	l-fri	g	<30% subangular gravel, few rootlets
FILL	91-229	138	Ap2	2.5YR 4/3	SCL	dist	gr	g	sandy loam with clumps of decomposing wood and clay
SHORE FACIES	229-259	30	Ap3	10YR 4/1	SC	1sbk	sl.st	g	silt present, some mottling
SHORE FACIES	259-457	198	2C	10YR 4/3	S	gr	l	n/a	single grain well-sorted sand, no visible inclusions; color transition to 10YR 5/4
MISSING	457-488	31	n/r	n/r	n/r	n/r	n/r	n/r	n/r
TILL	488-610	122	3C	7.5YR 5/4	S	gr	l	n/a	sand, reddish till colored, no visible

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure

Consist: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky

Boundary Distinct: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp

Boundary Topo: w=wavy; s=smooth; a=abrupt

RCH-4-ARC-17

RCH-4-ARC-17

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consistence	Boundary	Comments
FILL	0-5	5	Ap1	n/a	n/a	n/a	n/a	n/a	concrete pavers
FILL	5-15	10	Ap2	10YR 6/4	S-G	dist	gr	g	concrete, <50% gravel
FILL	15-122	107	Ap3	10YR 2/1 - 10YR 4/2 - 7.5YR 4/4	SL	gr	sl.l	g	mottled sandy loam with some large gravels and few organics (roots)
FILL	122-305	183	Ap4	2.5Y 4/3	S	gr	l	n/a	well-sorted sand, no visible inclusions; mottling at 213 cm
MISSING	305-351	46	n/r	n/r	n/r	n/r	n/r	n/r	n/r
FILL	351-396	45	Ap5	7.5YR 4/2	S	gr	l	c	gravel at 396 cm
FILL	396-442	46	Ap6	5YR 4/3	SC	2sbk	fi	a	common gravel inclusions
SHORE FACIES	442-457	15	2C	5YR 3/4	S	gr	l	n/a	no visible inclusions, well-sorted sand
MISSING	457-503	46	n/r	n/r	n/r	n/r	n/r	n/r	n/r
SHORE FACIES	503-610	107	2C2	5YR 3/4	S	gr	fri	n/r	single grain, very well-sorted, compacted

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure

Consist.: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky

Boundary Distinct.: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp

Boundary Topo.: w=wavy; s=smooth; a=abrupt

RCH-4-ARC-18

RCH-4-ARC-18

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consistence	Boundary	Comments
FILL	0-10	10	Ap1	n/a	n/a	n/a	n/a	a	asphalt cap
FILL	10-30	20	Ap2	10YR 5/1	G-SL	dist	l	g	few organics present
FILL	30-61	31	Ap3	2.5YR 4/6	S	gr	l	g	<50% gravel, mottled with 7.5YR 3/3
FILL	61-274	213	Ap4	2.5YR 4/3	S	gr	l	g	homogeneous well-sorted sand with occasional organics from 61-152 cm
TILL	274-488	214	2C	5YR 4/4	C-G	3sbk	v.fi	g	clay with common subangular gravel inclusions
TILL	488-610	122	3C	2.5YR 3/3	S	gr	l	n/a	fine very well-sorted wet sand with some clay

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure
Consist.: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky
Boundary Distinct.: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp
Boundary Topo.: w=wavy; s=smooth; a=abrupt
Misc: n/a=not applicable, n/r=not recorded

RCH-4-ARC-19

RCH-4-ARC-19

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consistence	Boundary	Comments
FILL	0-30	30	Ap1	n/a	G	dist	l	g	asphalt and gravel
FILL	30-244	214	Ap2	2.5YR 3/4	S-C	dist	l	g	variable gravel content (<50% gravel)
FILL	244-305	61	Ap3	2.5YR 4/3	C-G	3sbk	v.fi	g	plentiful medium gravel, no organics
FILL/TILL	305-320	15	2C1	2.5YR 4/6	C-G	gr	l	c	wet, soupy consistence
TILL	320-457	137	2C2	2.5YR 4/3	C-G	3sbk	v.fi	g	plentiful medium gravel, no organics
MISSING	457-482	25	n/r	n/r	n/r	n/r	n/r	n/r	n/r
TILL	482-610	128	2C3	2.5YR 4/3	C-G	3sbk	v.fi	g	homongeneous, variable subuangular gravel fraction

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure

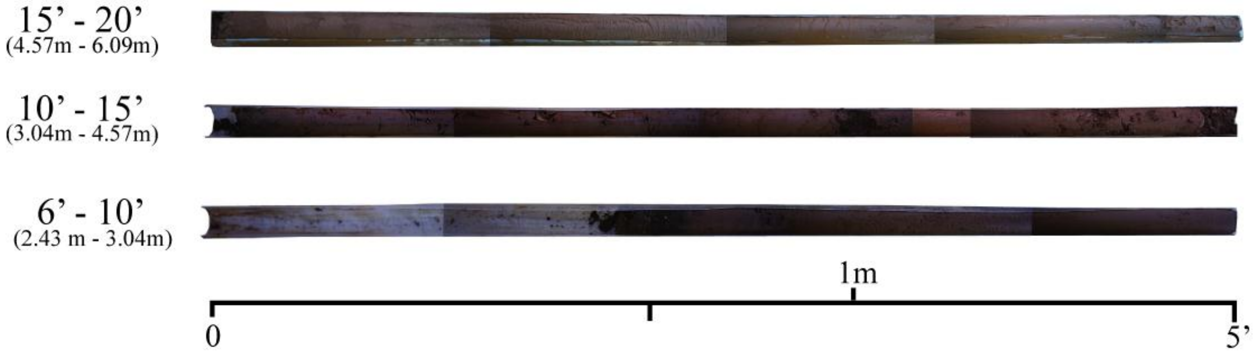
Consist.: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky

Boundary Distinct.: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp

Boundary Topo.: w=wavy; s=smooth; a=abrupt

Miscell.: n/a=not applicable, n/r=not recorded

RCH-4-ARC-20



RCH-4-ARC-20

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consistence	Boundary	Comments
FILL	0-30	30	Ap1	7.5YR 3/3	SL	dist	l	g	>50% large gravel and cobbles
FILL	30-137	107	Ap2	5YR 3/3	SL	dist	l	g	some 5YR 2.5/1 inclusions, 50% small-medium gravel
FILL	137-183	92	Ap3	2.5YR 4/4	S-C	gr	l-sl.fri	g	some organics present, <10% gravel
TILL	183-610	427	2C	2.5YR 4/4 - 7.5YR 4/4	C	2sbk	sl.fri	n/a	homogeneous, variable gravel/sand fraction

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure
Consist: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky
Boundary Distinct: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp
Boundary Topo: w=wavy; s=smooth; a=abrupt
Misc: n/a=not applicable, n/r=not recorded

RCH-4-ARC-21

RCH-4-ARC-21

Unit	Depth (cm)	Thickness (cm)	Soil Horizon	Munsell Color	Texture	Structure	Consistence	Boundary	Comments
FILL	0-30	30	Ap1	7.5YR 5/1	G-SL	dist	l	g	aspalt cap, no organics present
FILL	30-91	61	Ap2	5YR 4/4	SL	dist	l	g	variable gravel content, large subangular rock fragments below 60 cm; few roots
FILL	91-122	31	Ap3	5YR 3/3	SL	dist	l	c	relatively high clay fraction, medium rock fragments
FILL	122-183	61	Ap4	7.5YR 2/1	SL	dist	l	n/a	slag present, some larger lumber fragments, few concrete inclusions
MISSING	183-224	41	n/r	n/r	n/r	n/r	n/r	n/r	n/r
FILL	224-234	10	Ap5	5YR 2.5/1	SL	gr	l	c	some orange mottling
FILL	234-239	5	Ap6	10YR 7/2	S	gr	l	a	white single grain sand, no inclusions
TILL	239-411	172	2C	2.5YR 4/4	C	3sbk	v.fi	a	few subangular gravel inclusions
TILL	411-427	16	2C	n/a	Rock	n/a	n/a	a	very large rock inclusion
TILL	427-610	183	2C	2.5YR 4/4	C	3sbk	v.fi	n/a	few subangular gravel inclusions

Texture: Si=silt; L=loam; C=clay; S=sand; F=fine; V=very; G=gravel; O=organic:

Structure: 1=weak; 2= moderate; 3=strong; f=fine; m=medium; c=coarse
gr=granular; mass=massive; strat=stratified; sbk=subangular blocky; ab=angular blocky; pr=prismatic
pl=platy; dist=disturbed/no structure

Consist: fri=friable; sl=slightly; v=very; l=loose; fi=firm; h=hard; st=sticky; ss=strongly sticky

Boundary Distinct: a=abrupt; c=clear; d=diffuse; g=gradual; s=sharp

Boundary Topo: w=wavy; s=smooth; a=abrupt

Misc: n/a=not applicable, n/r=not recorded

Appendix C: Radiocarbon Testing Results for Peat Samples

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www.radiocarbon.com

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

April 27, 2012

Dr. Joseph Schuldenrein
Geoarcheology Research Associates
92 Main Street
Suite 207
Yonkers, NY 10701
USA

RE: Radiocarbon Dating Results For Samples RCH-4-ARC-13 Sample 1, RCH-4-ARC-13 Sample 2, RCH-4-ARC-13 Sample 3, RCH-4-ARC-13 Sample 4, RCH-4-ARC-14 Sample 1, RCH-4-ARC-14 Sample 2, RCH-4-ARC-14 Sample 3, RCH-4-ARC-14 Sample 4

Dear Joe:

Enclosed are the radiocarbon dating results for eight samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA

BETA ANALYTIC INC.

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

4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Joseph Schuldenrein — Report Date: 4/27/2012

Geoarcheology Research Associates — Material Received: 4/18/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 320523	520 +/- 30 BP	-18.0 o/oo	630 +/- 30 BP
SAMPLE : RCH-4-ARC-13 Sample 1			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 1280 to 1400 (Cal BP 660 to 550)			
Beta - 320524	1770 +/- 30 BP	-27.2 o/oo	1730 +/- 30 BP
SAMPLE : RCH-4-ARC-13 Sample 2			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 240 to 390 (Cal BP 1710 to 1560)			
Beta - 320525	10 +/- 30 BP	-15.9 o/oo	160 +/- 30 BP
SAMPLE : RCH-4-ARC-13 Sample 3			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 1660 to 1710 (Cal BP 290 to 240) AND Cal AD 1720 to 1830 (Cal BP 230 to 120) Cal AD 1830 to 1890 (Cal BP 120 to 60) AND Cal AD 1910 to post 1950 (Cal BP 40 to post 1950)			
Beta - 320526	6590 +/- 40 BP	-28.8 o/oo	6530 +/- 40 BP
SAMPLE : RCH-4-ARC-13 Sample 4			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 5550 to 5470 (Cal BP 7500 to 7420)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

BETA

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Joseph Schuldenrein

Report Date: 4/27/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 320527	1190 +/- 30 BP	-17.5 o/oo	1310 +/- 30 BP
SAMPLE : RCH-4-ARC-14 Sample 1			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 660 to 730 (Cal BP 1290 to 1220) AND Cal AD 740 to 770 (Cal BP 1210 to 1180)			
Beta - 320528	650 +/- 30 BP	-20.5 o/oo	720 +/- 30 BP
SAMPLE : RCH-4-ARC-14 Sample 2			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 1260 to 1290 (Cal BP 690 to 660)			
Beta - 320529	1330 +/- 30 BP	-24.4 o/oo	1340 +/- 30 BP
SAMPLE : RCH-4-ARC-14 Sample 3			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 650 to 690 (Cal BP 1300 to 1260) AND Cal AD 750 to 760 (Cal BP 1200 to 1190)			
Beta - 320530	11840 +/- 50 BP	-29.7 o/oo	11760 +/- 50 BP
SAMPLE : RCH-4-ARC-14 Sample 4			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 11790 to 11510 (Cal BP 13740 to 13460)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-18:lab. mult=1)

Laboratory number: **Beta-320523**

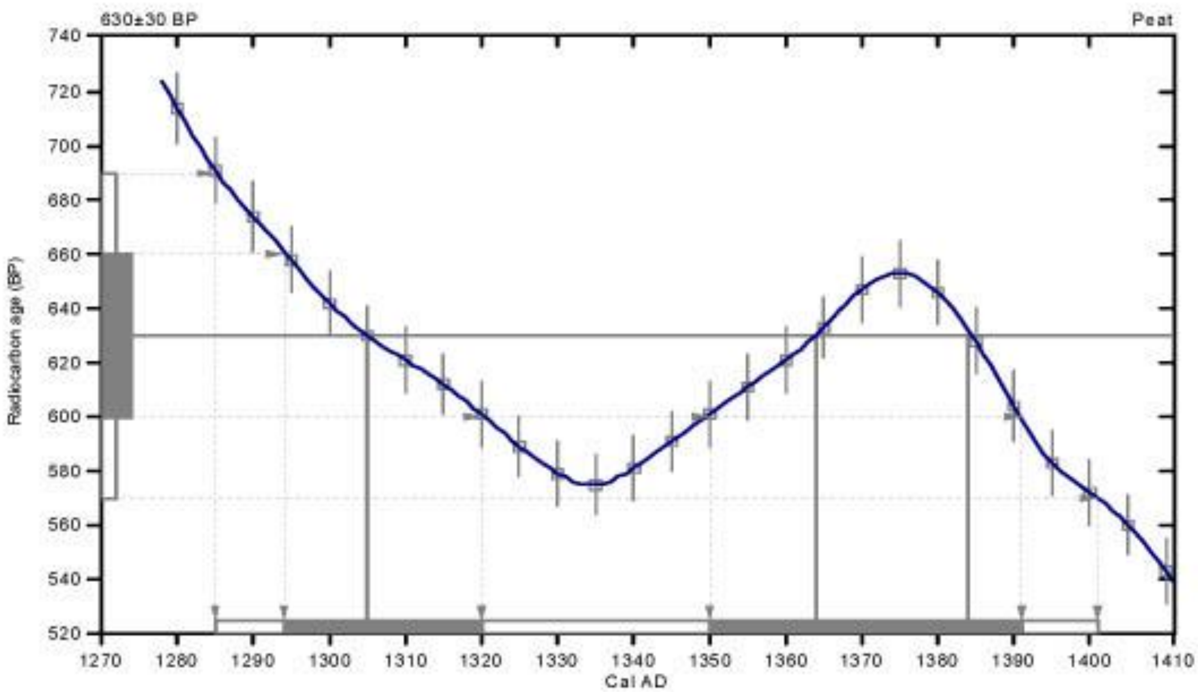
Conventional radiocarbon age: **630±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1280 to 1400 (Cal BP 660 to 550)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1300 (Cal BP 640) and
Cal AD 1360 (Cal BP 590) and
Cal AD 1380 (Cal BP 570)

1 Sigma calibrated results: (68% probability) Cal AD 1290 to 1320 (Cal BP 660 to 630) and
Cal AD 1350 to 1390 (Cal BP 600 to 560)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.2:lab. mult=1)

Laboratory number: **Beta-320524**

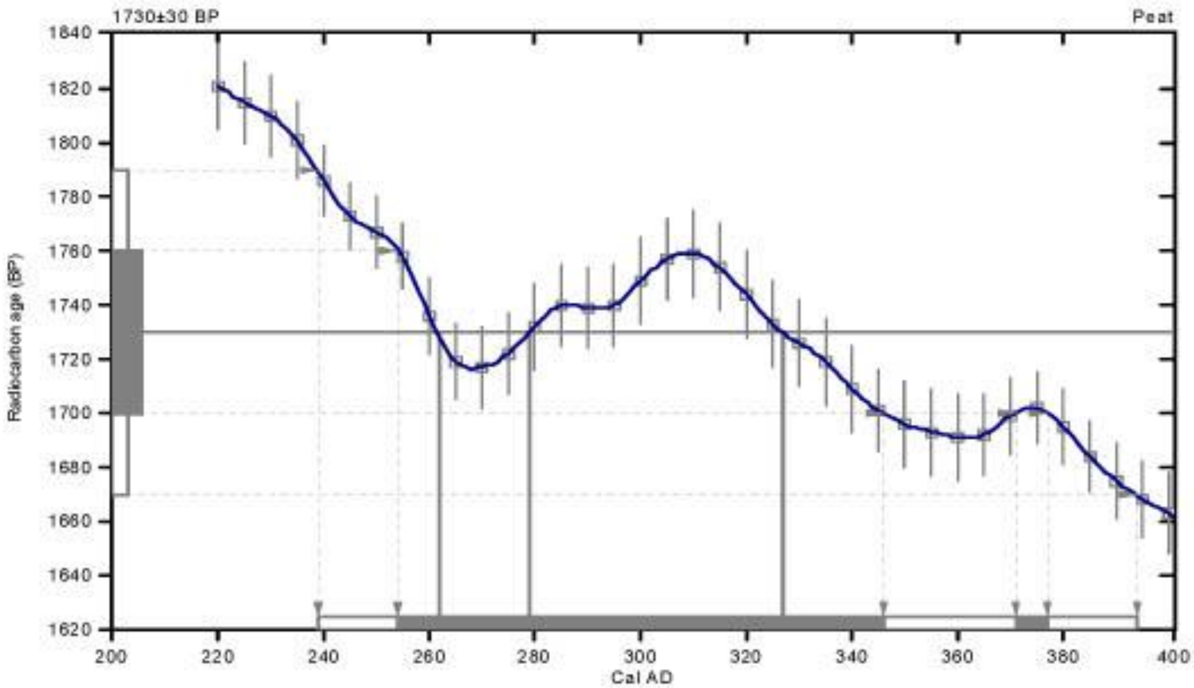
Conventional radiocarbon age: **1730±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 240 to 390 (Cal BP 1710 to 1560)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 260 (Cal BP 1690) and
Cal AD 280 (Cal BP 1670) and
Cal AD 330 (Cal BP 1620)

1 Sigma calibrated results: (68% probability) Cal AD 250 to 350 (Cal BP 1700 to 1600) and
Cal AD 370 to 380 (Cal BP 1580 to 1570)



References:

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INTCAL09

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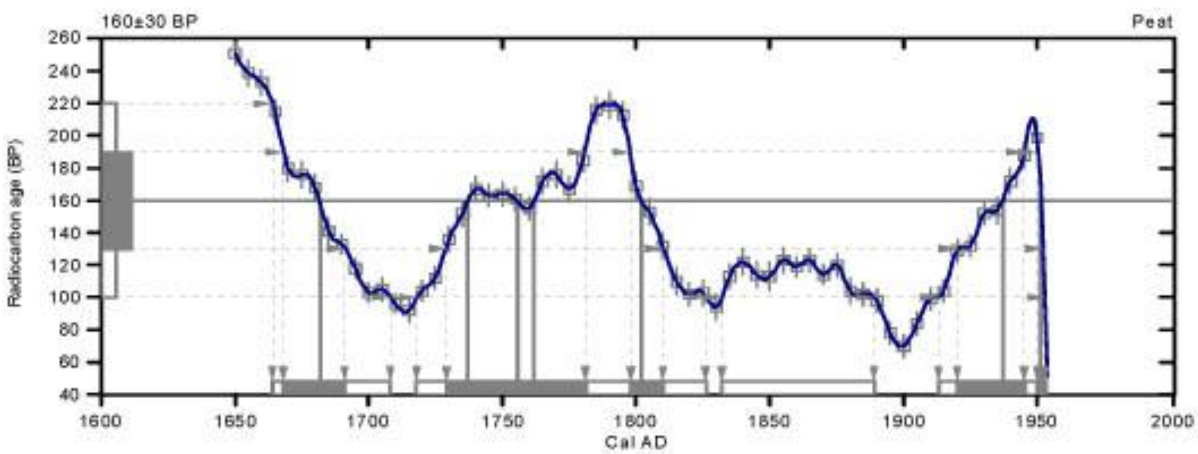
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-15.9:lab. mult=1)

Laboratory number:	**Beta-320525**
Conventional radiocarbon age:	**160±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 1660 to 1710 (Cal BP 290 to 240) and** **Cal AD 1720 to 1830 (Cal BP 230 to 120) and** **Cal AD 1830 to 1890 (Cal BP 120 to 60) and** **Cal AD 1910 to post 1950 (Cal BP 40 to post 1950)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 1680 (Cal BP 270) and Cal AD 1740 (Cal BP 210) and Cal AD 1760 (Cal BP 190) and Cal AD 1760 (Cal BP 190) and Cal AD 1800 (Cal BP 150) and Cal AD 1940 (Cal BP 10) and Cal AD Post 1950
1 Sigma calibrated results: (68% probability)	Cal AD 1670 to 1690 (Cal BP 280 to 260) and Cal AD 1730 to 1780 (Cal BP 220 to 170) and Cal AD 1800 to 1810 (Cal BP 150 to 140) and Cal AD 1920 to 1940 (Cal BP 30 to 0) and Cal AD 1950 to post 1950 (Cal BP 0 to post 1950)



References:

Database used
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References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-28.8:lab. mult=1)

Laboratory number: **Beta-320526**

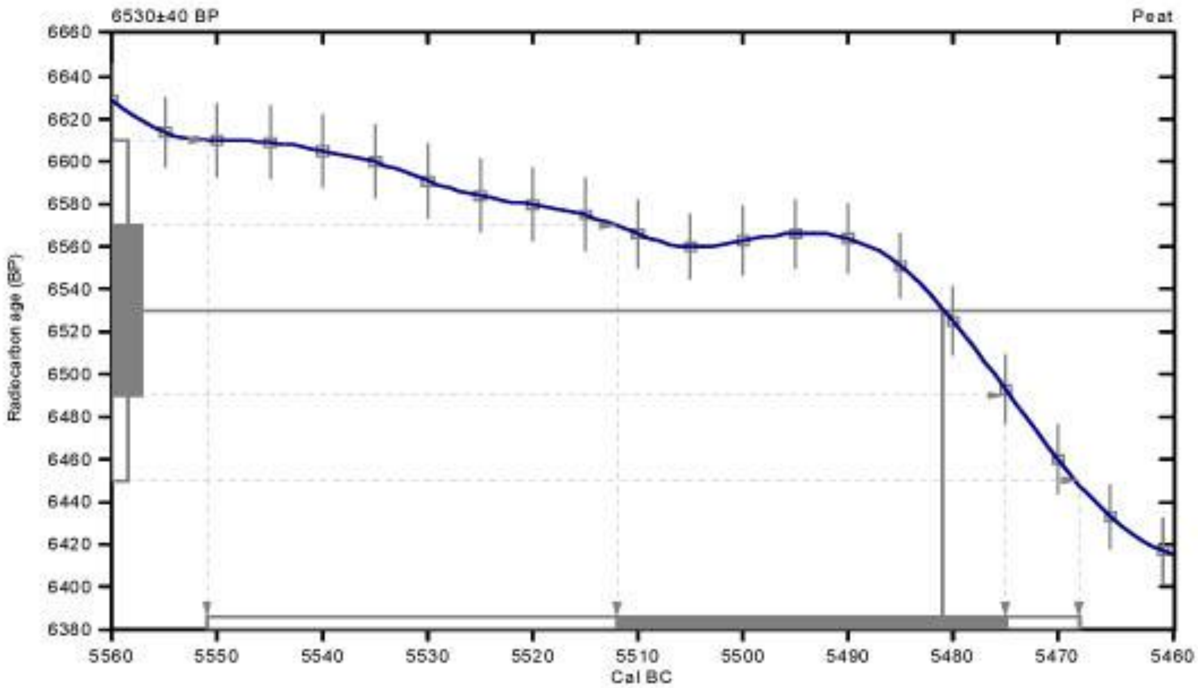
Conventional radiocarbon age: **6530±40 BP**

2 Sigma calibrated result: **Cal BC 5550 to 5470 (Cal BP 7500 to 7420)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 5480 (Cal BP 7430)

1 Sigma calibrated result: Cal BC 5510 to 5480 (Cal BP 7460 to 7420)
(68% probability)



References:

Database used
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-17.5:lab. mult=1)

Laboratory number: **Beta-320527**

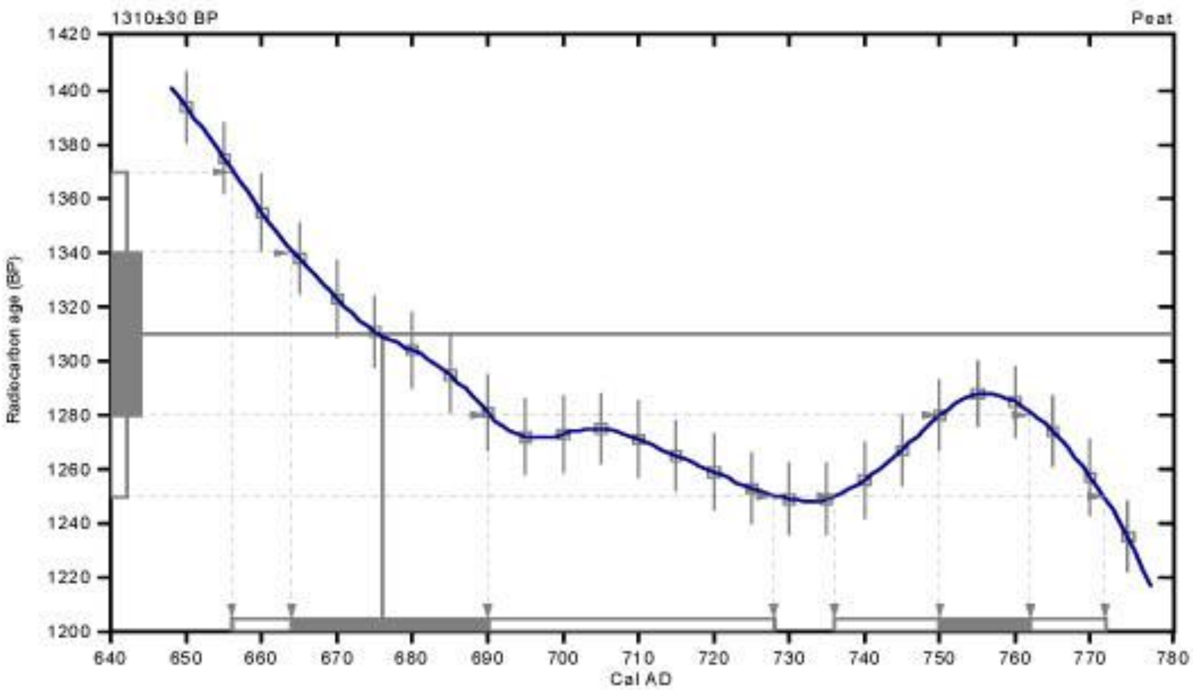
Conventional radiocarbon age: **1310±30 BP**

2 Sigma calibrated results: **Cal AD 660 to 730 (Cal BP 1290 to 1220) and**
(95% probability) **Cal AD 740 to 770 (Cal BP 1210 to 1180)**

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 680 (Cal BP 1270)

1 Sigma calibrated results: Cal AD 660 to 690 (Cal BP 1290 to 1260) and
(68% probability) Cal AD 750 to 760 (Cal BP 1200 to 1190)



References:

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Mathematics used for calibration scenario
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-20.5:lab. mult=1)

Laboratory number: **Beta-320528**

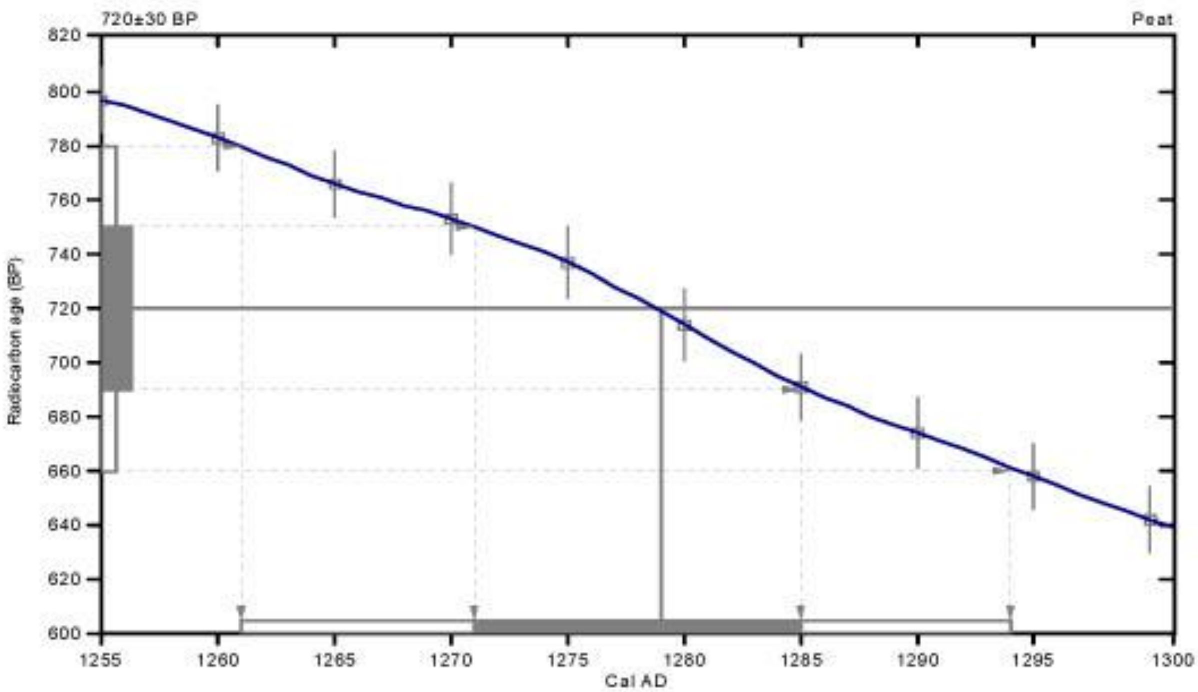
Conventional radiocarbon age: **720±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1260 to 1290 (Cal BP 690 to 660)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1280 (Cal BP 670)

1 Sigma calibrated result: (68% probability) Cal AD 1270 to 1280 (Cal BP 680 to 660)



References:

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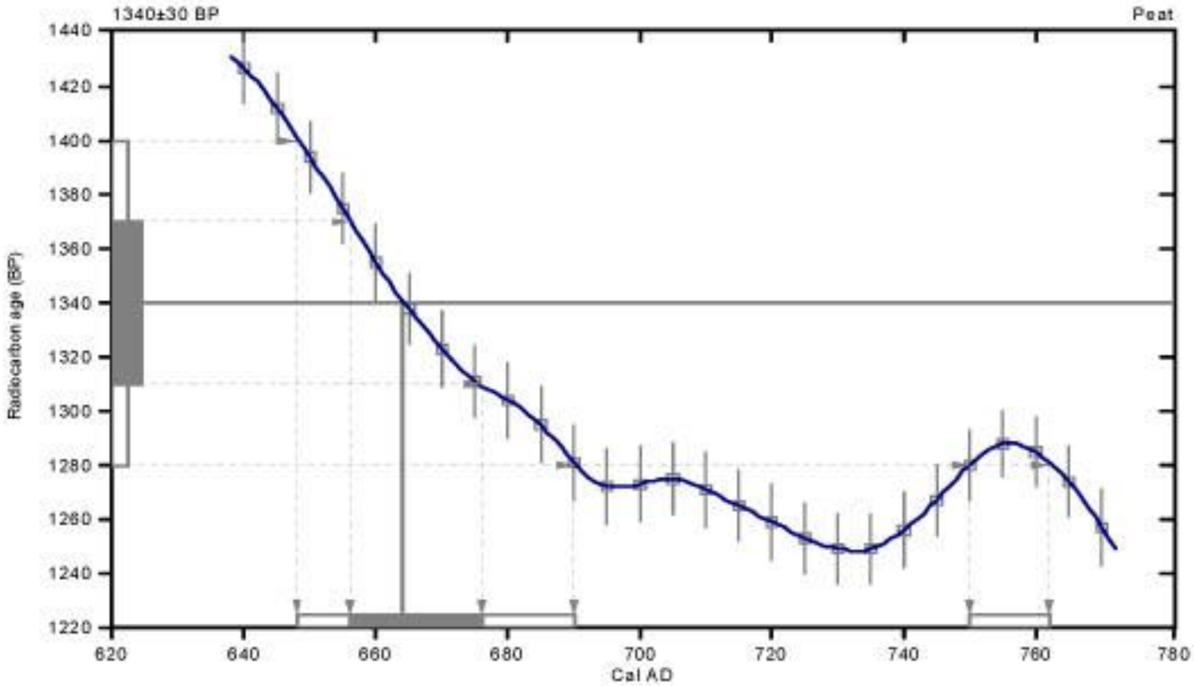
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.4:lab. mult=1)

Laboratory number:	**Beta-320529**
Conventional radiocarbon age:	**1340±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 650 to 690 (Cal BP 1300 to 1260) and Cal AD 750 to 760 (Cal BP 1200 to 1190)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 660 (Cal BP 1290)
1 Sigma calibrated result: (68% probability)	Cal AD 660 to 680 (Cal BP 1290 to 1270)



References:
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-29.7:lab. mult=1)

Laboratory number: **Beta-320530**

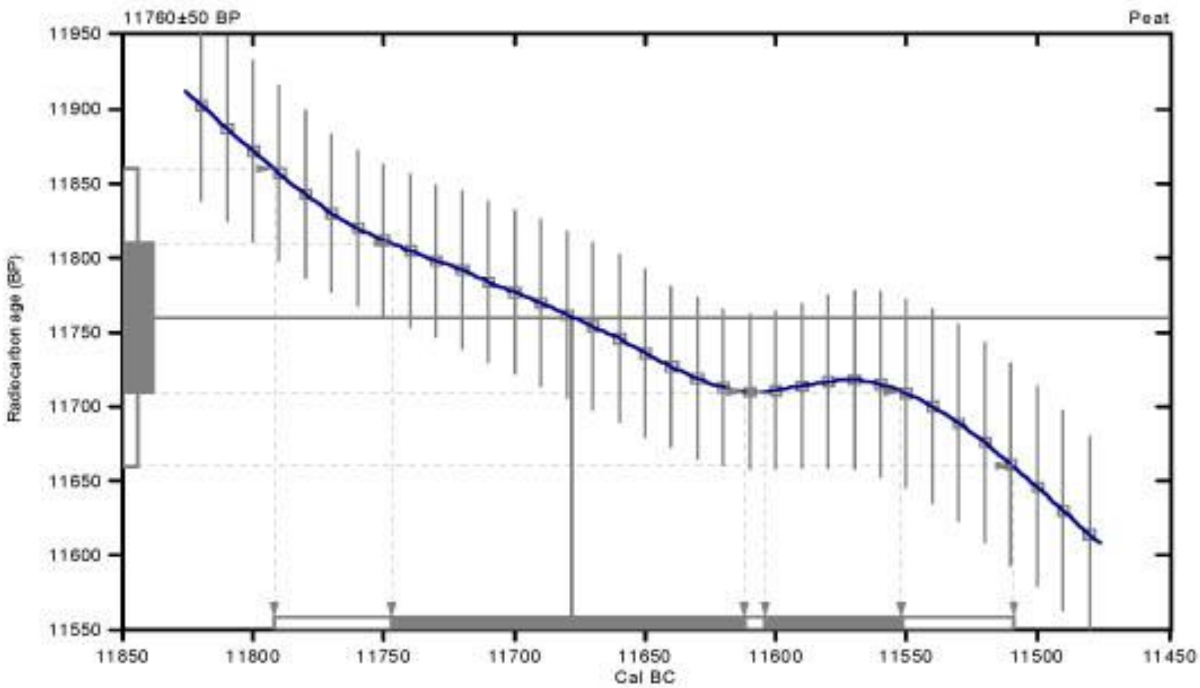
Conventional radiocarbon age: **11760±50 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 11790 to 11510 (Cal BP 13740 to 13460)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 11680 (Cal BP 13630)

1 Sigma calibrated results: (68% probability) Cal BC 11750 to 11610 (Cal BP 13700 to 13560) and Cal BC 11600 to 11550 (Cal BP 13550 to 13500)



References:

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Mathematics used for calibration scenario

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Appendix D: Radiocarbon Testing Results for Sediment Samples

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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

April 27, 2012

Dr. Joseph Schuldenrein
Geoarcheology Research Associates
92 Main Street
Suite 207
Yonkers, NY 10701
USA

RE: Radiocarbon Dating Results For Samples RCH-4-ARC-13 Sample 1 - organic sediment, RCH-4-ARC-13 Sample 4 - organic sediment, RCH-4-ARC-14 Sample 3 - organic sediment

Dear Joe:

Enclosed are the radiocarbon dating results for three samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the American Express card provided. A receipt is enclosed. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Joseph Schuldenrein — Report Date: 4/27/2012

Geoarcheology Research Associates — Material Received: 4/24/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 320840	3850 +/- 50 BP	-21.3 o/oo	3910 +/- 50 BP

SAMPLE : RCH-4-ARC-13 Sample 1 - organic sediment
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 2560 to 2530 (Cal BP 4510 to 4480) AND Cal BC 2490 to 2280 (Cal BP 4440 to 4230)
Cal BC 2250 to 2230 (Cal BP 4200 to 4180) AND Cal BC 2220 to 2210 (Cal BP 4170 to 4160)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 320841	13720 +/- 60 BP	-26.3 o/oo	13700 +/- 60 BP

SAMPLE : RCH-4-ARC-13 Sample 4 - organic sediment
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 14940 to 14830 (Cal BP 16890 to 16780)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 320842	3160 +/- 30 BP	-26.0 o/oo	3140 +/- 30 BP

SAMPLE : RCH-4-ARC-14 Sample 3 - organic sediment
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 1490 to 1480 (Cal BP 3440 to 3430) AND Cal BC 1450 to 1380 (Cal BP 3400 to 3340)
Cal BC 1330 to 1320 (Cal BP 3280 to 3280)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

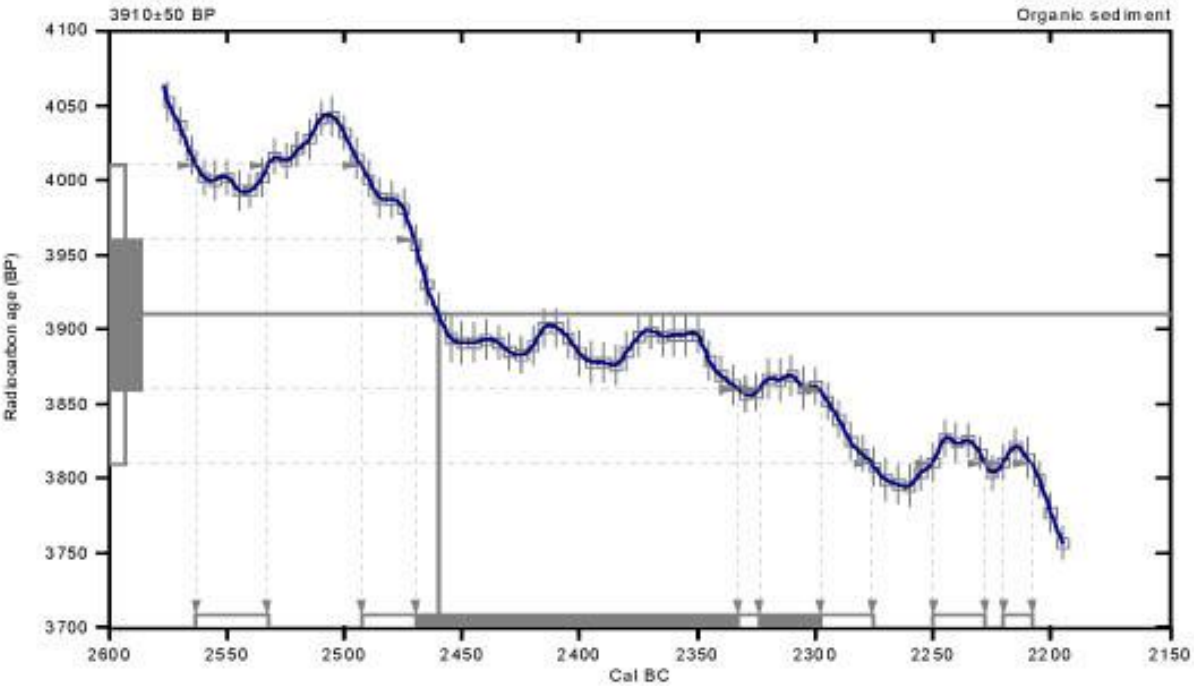
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.3:lab. mult=1)

Laboratory number:	**Beta-320840**
Conventional radiocarbon age:	**3910±50 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 2560 to 2530 (Cal BP 4510 to 4480) and Cal BC 2490 to 2280 (Cal BP 4440 to 4230) and Cal BC 2250 to 2230 (Cal BP 4200 to 4180) and Cal BC 2220 to 2210 (Cal BP 4170 to 4160)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 2460 (Cal BP 4410)
1 Sigma calibrated results: (68% probability)	Cal BC 2470 to 2330 (Cal BP 4420 to 4280) and Cal BC 2320 to 2300 (Cal BP 4270 to 4250)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.3:lab. mult=1)

Laboratory number: **Beta-320841**

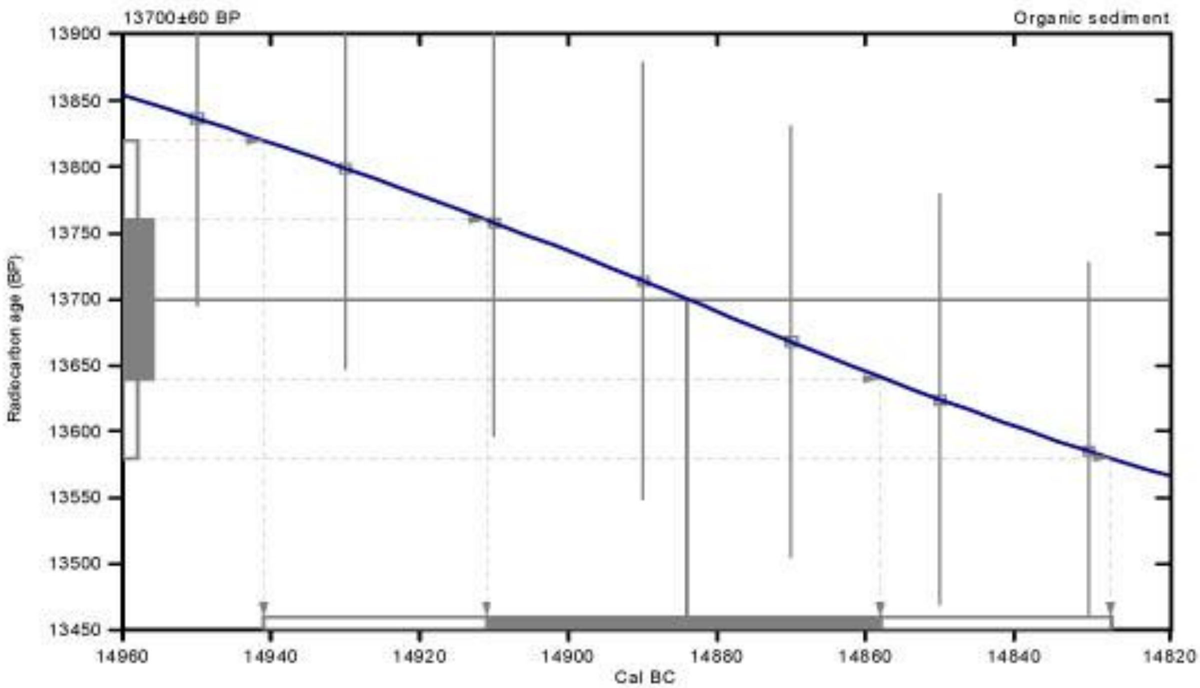
Conventional radiocarbon age: **13700±60 BP**

2 Sigma calibrated result: **Cal BC 14940 to 14830 (Cal BP 16890 to 16780)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 14880 (Cal BP 16830)

1 Sigma calibrated result: Cal BC 14910 to 14860 (Cal BP 16860 to 16810)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26:lab. mult=1)

Laboratory number: **Beta-320842**

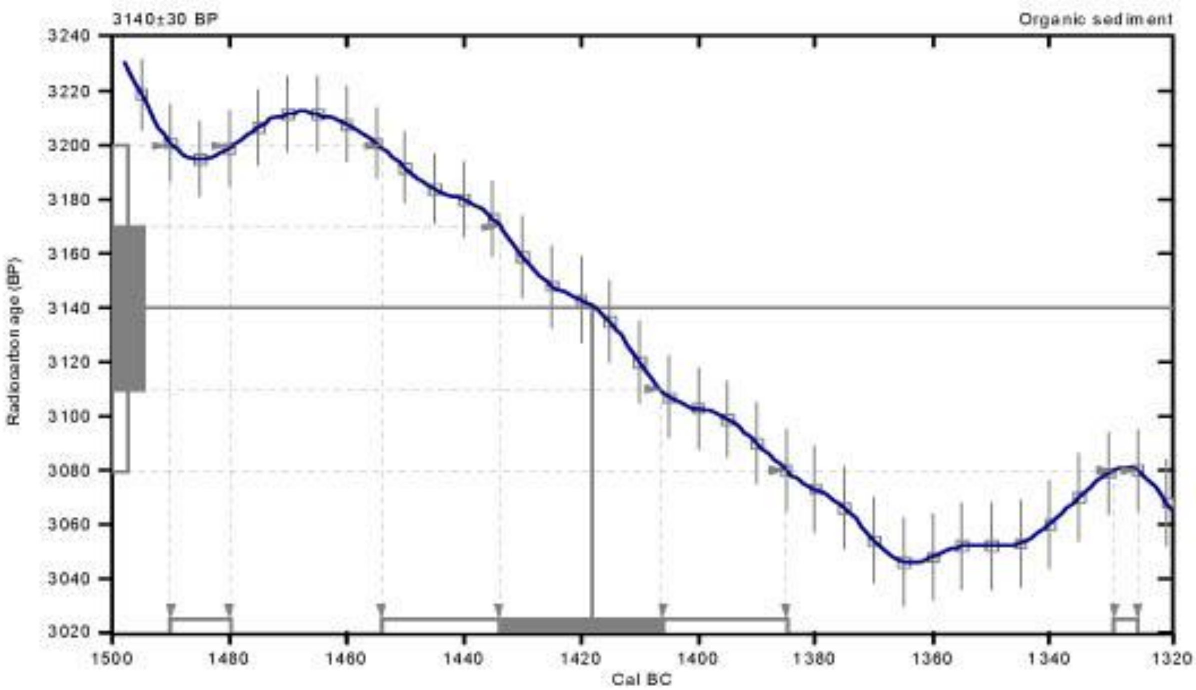
Conventional radiocarbon age: **3140±30 BP**

2 Sigma calibrated results: **Cal BC 1490 to 1480 (Cal BP 3440 to 3430) and**
(95% probability) **Cal BC 1450 to 1380 (Cal BP 3400 to 3340) and**
Cal BC 1330 to 1320 (Cal BP 3280 to 3280)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 1420 (Cal BP 3370)

1 Sigma calibrated result: Cal BC 1430 to 1410 (Cal BP 3380 to 3360)
(68% probability)



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