REPORT

Phase 1 Final Design Report
Hudson River PCBs Superfund Site

Attachment C – Geotechnical Investigation Summary Report

General Electric Company
Albany, New York

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engineers, scientists, economists

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1. Introduction

This *Geotechnical Investigation Summary Report* (Geotechnical Summary Report) has been prepared by Blasland, Bouck & Lee, Inc. (BBL) on behalf of the General Electric Company (GE) in support of Phase 1 Final Design activities. This Geotechnical Summary Report describes and presents results from the geotechnical evaluation of the Energy Park/Longe/New York State Canal Corporation (Energy Park) site, which was performed in the fall of 2005 to support the Phase 1 Final Design of the land-based sediment processing/transfer facilities (processing facilities) where sediments dredged from the river will be dewatered. This report also presents the results of additional geotechnical data collection activities conducted just south of Lock 7 to explore potential mooring locations, geotechnical borings in the Champlain Canal, and work completed to support design of an access road to the Energy Park site.

1.1 Objectives and Description of Work

Specific objectives of the geotechnical investigation conducted at the Energy Park site and in the Hudson River and Champlain Canal were to:

- Collect general geotechnical information on the geology/substrata on the upland portion of the Energy Park site;
- Collect general geotechnical information on the sediments/substrata in the Champlain Canal land cut north of Lock 7;
- Collect general geotechnical information on the sediments/substrata in the Hudson River south of Lock 7 for potential mooring locations; and
- Collect geotechnical information necessary to support alignment and construction of an access road to the Energy Park site from NYS Route 196.

For the geotechnical evaluation, borings were advanced on the upland portion of the Energy Park site, in the Champlain Canal, and along the proposed alignment of the access road to collect general geotechnical information on the geology, sediments, and substrata in these areas; and rock cores were collected from certain borings advanced adjacent to and within the Champlain Canal. Split-spoon samples were collected during the advancement of certain borings and subjected to a variety of physical tests to assess geotechnical parameters.

In addition, during the development of the Phase 1 Final Design, the feasibility of constructing a potential mooring site for barges and installing a snubbing post (turning point) for barges just south of Lock 7 was evaluated. A series of borings was advanced in the river to gather the necessary geotechnical information to support the potential location and design of the mooring facilities. This field work was conducted in accordance with protocols described in the *Supplemental Engineering Data Collection Work Plan Addendum No. 2 – Phase 1* (Phase 1 SEDC Work Plan Addendum No. 2), and the borings were advanced concurrent with the Addendum No. 2 field activities.

The remainder of this Geotechnical Summary Report discusses these activities and describes the results. Exhibit A of this report contains the test boring location plan, the test boring logs are included as Exhibit B, and Exhibit C provides the laboratory testing results.

2. Geotechnical Investigation Results

2.1 Site Description

The Energy Park site is relatively flat topographically except for a low area in the vicinity of Bond Creek. According to the Soil Survey of Washington County, soil across most of the site is classified as Wallington silt loam with a sandy substratum. This soil formed on nearly level stream terraces in deposits of silt and very fine sand. Along the Champlain Canal, the soil is mapped as random dredge spoil. The dredge spoil is mapped throughout the New York State Barge Canal parcel.

2.2 Test Borings

Between September 2005 and March 2006, geotechnical borings were advanced at various locations across the project site to support ongoing development of the Phase 1 Final Design. Borings were located in areas where structures were anticipated, based on the sediment processing facility layout developed in the Phase 1 IDR, and along the location of a proposed access road. All land-based borings were advanced using a 4¼-inch inside diameter hollow-stem auger, and the water-based borings were advanced using a barge-mounted drilling rig and NW- or HW-size casing with wash boring technology. BBL provided oversight of all boring operations. After completion, each land-based boring was abandoned using a bentonite/cement grout, and the water-based borings were abandoned by allowing the formation to collapse the borehole. Exhibit A contains the test boring location plan developed as part of this work effort (showing the "as drilled" boring locations), and the test boring logs are included as Exhibit B.

2.2.1 Processing Facility and Mooring Facility/Snubbing Post Characterization

In September 2005, Atlantic Testing Laboratories, Ltd. drilled 30 land-based and eight water-based test borings (identified as the 090, 100, and 200 series boring logs included in Exhibit B) as part of the overall processing facility investigation. Soil samples associated with the 30 land-based borings were collected in intervals using split-spoon sampling techniques. The total depth and sampling requirements were determined on a boring-by-boring basis. BBL field personnel recorded a description of each interval on field drilling logs using the United Soil Classification System (USCS), including lithographic description, moisture content, color, percent recovery, grain size distribution, and any visual or olfactory observations. The sampling effort is further described in Section 2.6.

In addition, rock cores were collected at five boring locations adjacent to the Champlain Canal (e.g., GT-107 through GT-111) and in four boring locations within the Champlain Canal (GT-095, GT-096, GT-098, and GT-102). All borings are located in the general vicinity of the proposed wharf area associated with the processing facility. A section of NX-sized rock core was obtained with a double-tube core barrel, and BBL field personnel recorded the percent recovery and rock quality designations from each core section.

In November 2005, four additional test borings (identified as the 300 series boring logs included in Exhibit B) were drilled in the main stem of the Hudson River along the eastern shoreline south of Lock 7 to support the feasibility evaluation of a potential mooring facility/snubbing post (turning point) for barges. These test boring logs (GT-301 through GT-304) are included in Exhibit B.

2.2.2 Processing Facility Access Road

On December 26, 2005 work began on a series of land-based borings planned to support the design and construction of an access road to the Energy Park site. Initially, 24 borings (identified as the 400 series boring logs included in Exhibit B) were planned, but an additional three borings (the 500 series included in Exhibit B) were added to accommodate a realignment of the access road. Completion of the 400 series was delayed when activities associated with an existing farm operation along NYS Route 196 temporarily impeded access to some of the planned boring locations. The farm activities did not impact the advancement of the 500 series borings. As a result, the 500 series was drilled on February 1, 2006 and the 400 series was completed on February 2, 2006.

Soil samples were collected in intervals during the advancement of the 400 series using split-spoon sampling techniques. The total depth and sampling requirements were determined on a boring-by-boring basis. BBL field personnel recorded a description of each interval on field drilling logs using the USCS, including lithographic description, moisture content, color, percent recovery, grain size distribution, and any visual or olfactory observations. The sampling effort is further described in Section 2.6.

2.2.3 Locating the Bedrock Surface

A series of three deep land-based borings (the 600 series) was advanced between February 3 and 9, 2006. These borings were completed in an attempt to locate the bedrock surface at the periphery of the large building/tank construction areas such that the depth to the bedrock surface could be interpolated in between the boring locations for potential deep foundation design needs. Due to the depth of the rock surface in the main processing facility area and the limited drilled depth capability of the onsite drilling equipment, the depth to rock was only determined in one of the three borings. As such, more powerful drilling equipment was mobilized to the site, and four additional 600 series borings were advanced between February 21 and March 6, 2006 to determine the depth to the rock surface. All the 600 series boring logs are included in Exhibit B.

2.3 Estimated Subsurface Conditions at and Near Energy Park Site

2.3.1 Energy Park Site

Based on the test boring data provided to BBL (laboratory data provided in Exhibit C), the generalized subsurface strata underlying the area of the Energy Park site to the depths investigated are described in Table 1 (below). The generalized subsurface strata underlying the proposed location of the mooring facility/snubbing post and the processing facility access road to the depths investigated are described in Table 2 (Section 2.3.2) and Table 3 (Section 2.3.3), respectively.

Table 1 – Descriptions of Strata Identified at the Energy Park Site

Stratum	Depth Range and Boring Location	Stratum Description
Stratum A: (Fill)	From the ground surface to a depth of 4 feet in Boring GT-200.	Brown/dark brown, fine sand and gravel, with silt, with brick and coal, Fill; firm density (N = 5 to 6)
Stratum A1: (Fill)	From the ground surface to a depth of 4 feet in Borings GT-111, GT-112, GT-113, and GT-114.	Brown/dark brown, silt with fine sand to fine to medium silty sand, Dredge Spoil Fill; very loose to firm consistency (N = 3 to 16)
Stratum B: (Alluvial)	From the ground surface and below Stratum A to depths of 10 to 31 feet.	Brown/dark brown, fine to medium Poorly Graded Sand, with silt (SP-SM) to gray, fine clayey Sand (SC)/silty Sand (SM); very loose to firm density (N = 2 to 18)

Stratum	Depth Range and Boring Location	Stratum Description
Stratum B1: (Alluvial)	Below Stratum B to a depth of 17 feet in Boring GT-202.	Brown/dark brown, Peat, with sand and silt (PT); very loose density (N = WOH to 2)
Stratum C: (Alluvial)	Below and interbedded with Stratum B to depths of 35 to 174 feet.	Gray, Fat Clay to Fat Clay with lenses of fine to medium sand (CH); very soft to soft density (N = WOR to 20*)
Stratum D: (Residual)	Below Stratum C to the maximum depth of penetration (Boring GT-603b, 174 feet).*	Gray-brown and black, moderately to highly fractured, moderately weathered, Siltstone and Shale; very compact density (REC = 60% to 100%; RQD = 15% to 81%)

Notes:

* Harder drilling conditions, including the presence of gravel, cobbles and boulders, were encountered during the advancement of Borings GT-301 through GT-304, which were performed in the river south of Lock 7 as noted in Table 2.

** Bedrock was encountered at shallower depths in borings along northern portion of site (i.e., about 20 feet in Borings GT-107, 108, and 109), while rock was encountered at greater depths along the southern portion (i.e., about 119 feet in Boring GT-114 , 112 feet in Boring GT-601, 132 feet in Boring GT-604, 172 feet in Boring GT-602a and 174 feet in Boring GT-603b). Rock was not encountered at depth of 104 feet at Boring GT-603a, as artesian conditions encountered at that depth required immediate closure of the borehole.

WOH: Weight of Hammer
WOR: Weight of Rod
REC: Range of Recovery
RQD: Rock Quality Designation

The N values listed in Table 1 indicate the low and high Standard Penetration Test (SPT) resistances encountered in a particular layer, as observed from the number of blows required to drive a 2-inch outside diameter, 1-3/8-inch inside diameter sampling spoon 1 foot using a 140-pound hammer falling 30 inches. This test is conducted after seating the sampler 6 inches in the bottom of the hole according to the procedure described in ASTM D1586.

The percentages after the rock stratum description indicate the variation in core recovery, which is the length of rock core recovered expressed as a percent of the total length cored. Rock Quality Designation (RQD) is also provided for borings drilled with NX core drilling equipment. RQD is defined as the total length of NX size rock core fragments recovered, which are greater than 4 inches in length, discounting drilling breaks, expressed as a percentage of the total length cored. The RQD values obtained generally indicate the rock to be of poor to fair quality.

Depths to rock along the canal area varied significantly from the northern end of the site (e.g., depths less than 15 feet) to the southern end of the site (e.g., depth to rock approximately 120 feet). In addition, in the center portion of the site, a boring extended to depths of 170 feet and rock was not encountered. This information indicates significant variability in depth to rock across the Energy Park site.

2.3.2 Mooring Facility/Snubbing Post

Subsurface investigative activities were conducted in the area just south of Lock 7. The primary goal for this investigation was to determine the depth to bearing strata (i.e., bedrock) for the proposed moorings and snubbing post (turning point). In general, similar conditions to those encountered during the geotechnical drilling program performed under the Year 2 SEDC work was encountered, with some localized distinct features. The generalized subsurface strata underlying this area to the depths investigated are described in Table 2 (below).

Table 2 – Descriptions of Strata Identified at the Mooring Facility/Snubbing Post Locations

Stratum	Depth Range and Boring Location	Stratum Description
Stratum B: (Alluvial)	From the mudline to depths of 6 to 30 feet*.	Brown/dark brown, fine to medium Poorly Graded Sand, with silt (SP-SM) to gray, fine clayey Sand (SC)/silty Sand (SM); very loose to hard density (N = 2 to 100+)[#]
Stratum C: (Alluvial)	From the mudline and below Stratum B to depths of 12 to 40 feet.	Gray, Fat Clay to Fat Clay with lenses of fine to medium sand (CH); very soft to hard density (N = WOR to 78**)
Stratum D: (Residual)	Below Stratum C to the maximum depth of penetration (Boring GT-304, 40.9 feet).***	Gray-brown and black, moderately to highly fractured, moderately weathered, Siltstone and Shale; very compact density

Notes:

* Harder drilling conditions, including the presence of gravel, cobbles and boulders, were encountered during the advancement of Borings GT-301 through GT-304.
** Higher blow count values were recorded in samples containing lenses of gravel (primarily Boring GT-303).
*** Split spoon refusal was encountered at shallower depths in Borings GT-302, 303, and 304. As such, the roller bit was required to extend the casing lower through Stratum B and C materials to reach the bedrock surface.
\# The N values listed in Table 2 indicate the low and high SPT resistances encountered in a particular layer, as observed from the number of blows required to drive a 2-inch outside diameter, 1-3/8-inch inside diameter sampling spoon 1 foot using a 140-pound hammer falling 30 inches.
WOR: Weight of Rod

2.3.3 Processing Facility Access Road

Based on the test boring data provided to BBL (laboratory data provided in Exhibit C), the generalized subsurface strata underlying the area of the proposed processing facility access road to the depths investigated are described in Table 3 (below).

Table 3 – Descriptions of Strata Identified along the Processing Facility Access Road

Stratum	Depth Range and Boring Location	Stratum Description
Stratum A: (Fill)	From the ground surface to a depth of 4 feet in Borings GT-401, GT-422, and GT-503.	Brown/dark brown, fine sand and silt, Fill; very loose density (N = WOH to 10)[#]
Stratum B: (Alluvial)	From the ground surface and below Stratum A to depths of 10 to 16 feet.	Brown/dark brown, fine to medium Poorly Graded Sand, with silt (SP-SM) to gray, fine clayey Sand (SC)/silty Sand (SM); very loose to firm density (N = 2 to 22)
Stratum B1: (Alluvial)	Below Stratum B to a depth of 8 feet in Boring GT-402.	Brown/dark brown, Peat, with sand and silt (PT); very loose density (N = WOH to 3)
Stratum C: (Alluvial)	From the ground surface and below Stratum B to depths of 26 to 85 feet.	Gray, Fat Clay to Fat Clay with lenses of fine to medium sand (CH); very soft to soft density (N = WOR to 17*)
Stratum D: (Residual)	Below Stratum C to the maximum depth of penetration in Boring GT-403, 85 feet.**	Gray-brown and black, moderately to highly fractured, moderately weathered, Siltstone and Shale; very compact density (N = 100+)

Notes:

* Higher blow count values were recorded in samples containing lenses of sand.
** Bedrock was encountered at a shallower depth in Boring GT-404 (i.e., about 66 feet), while rock was encountered at a greater depth in Boring GT-403 (i.e., about 85 feet). These borings were drilled on opposite shores of the feeder canal in the general vicinity of the proposed bridge at the northern end of the new access road.
\# The N values listed in Table 2 indicate the low and high SPT resistances encountered in a particular layer, as observed from the number of blows required to drive a 2-inch outside diameter, 1-3/8-inch inside diameter sampling spoon 1 foot using a 140-pound hammer falling 30 inches.
WOH: Weight of Hammer
WOR: Weight of Rod

2.4 Geology of the Energy Park Site

The Energy Park site lies within the Hudson-Mohawk Lowlands Region, which consists of shale, siltstone, and sandstone rock primarily of Late Ordovician Age from the erosion of the Taconic Highlands to the east.

Topsoil and cultivated soils were encountered to depths of 12 to 18 inches at the 100 and 200 series test boring locations. The soils of Strata A and A1 generally consist of existing fill which were most likely placed during previous grading and canal operations. The onsite soils of Strata B, B1, and C are alluvial materials associated with deposition in the river basin. Stratum D is designated as siltstone and shale bedrock. There was no transition zone from the overburden to the bedrock (i.e., weathered residual soil or disintegrated rock zone).

2.5 Groundwater at the Energy Park Site

Groundwater observations made during the time of the test boring installation at the Energy Park site indicated relatively shallow groundwater depths near the existing canal (i.e., 12 feet) and slightly deeper near the existing rail main line (i.e., 20 feet).

In test boring, GT-603a, artesian conditions were encountered in an interbedded sand and gravel layer (Stratum B). Significant flow was encountered upon penetrating the layer, which occurred at a depth of 104 feet. The casing was temporarily capped to slow flow and allow hydraulic pressures to equilibrate. Following the temporary capping, the borehole was sealed with bentonite and grouted to the ground surface. In test boring GT-604, artesian conditions were encountered in the highly fractured bedrock (Stratum D) and the porous sand and gravel layer (Stratum B) overlying the bedrock at a depth of 132 feet. Significant flow was encountered following the completion of the rock coring. The casing was temporarily capped to slow flow and allow hydraulic pressures to equilibrate. Following the temporary capping, the borehole was sealed with bentonite and grouted to the ground surface.

Fluctuations in the water table elevations should be expected with variations in precipitation, canal elevations, surface water runoff, and evaporation throughout the year.

2.6 Soil Sample Collection and Laboratory Testing

Split-spoon samples were collected as part of the SPTs per ASTM D1586 during advancement of the geotechnical soil borings targeted for sampling. Continuous split-spoon sampling was conducted during the first (i.e., top) 10 feet of drilling, then at 5-foot intervals for the remainder of the boring. Each split-spoon was characterized according to the USCS by BBL field personnel.

As part of the efforts to characterize the Energy Park site, the mooring facility/snubbing post area, and the processing facility access road, Geotechnics of Pittsburgh, Pennsylvania – a geotechnical laboratory – tested jar samples, bulk samples (collected from the auger cuttings), and undisturbed Shelby tube samples in the soils laboratory. The samples tested were collected from borings located in various areas of the site and surrounding locations to characterize physical parameters such as grain size and plasticity as well as strength parameters such as shear strength and compressibility for soils. The following physical tests were completed on selected soil samples in accordance with applicable ASTM standards:

- Shear strength measured in pounds per square foot (psf) (from UU and CU Triaxial Tests, ASTM D2850);
- Grain-size distribution/sieve analysis (from Sieve Analysis, ASTM D422);
- Grain-size distribution for finer fraction (from Hydrometer Analysis, ASTM D1140);
- Specific gravity (ASTM D854);
- Consolidation test (ASTM D2345);
- Unconfined Compression Test on Rock Cores (ASTM D2938);
- Classification by USCS method (ASTM D2487);
- California Bearing Ratio Test (ASTM D1883);
- Standard Proctor Compaction test (ASTM D698);
- Atterberg limits measured in % (ASTM D4318); and
- Water content measured in % (ASTM D2216).

The laboratory testing results summary table and the detailed laboratory data sheets are included in Exhibit C.

2.6.1 Soil Laboratory Testing – Energy Park Site

The geotechnical laboratory tested eight jar samples, six bulk samples (collected from the auger cuttings), and eight undisturbed Shelby tube samples from borings performed at the Energy Park site. Tests were performed in accordance with applicable ASTM standards. The following is a summary of the results from this testing by stratum.

Stratum B – Clayey Sand (SC)/Silty Sand (SM) and Poorly Graded Sand with Silt (SP-SM) to Sandy Lean Clay (CL)

The samples tested from this stratum contained between 51.8 and 3.6% material by weight finer than the No. 200 sieve. Samples consisted of low plasticity fines, ranging from non-plastic to a sample with a Liquid Limit of 24 and a Plasticity Index of 9. Natural moisture contents between 95.8 and 4.2% were recorded – the higher moisture contents were recorded for the deeper samples.

Three compaction tests were performed in accordance with ASTM D698, Standard Proctor, on the sandier bulk samples from Borings GT-108, GT-113, and GT-214. The soils exhibited maximum dry densities of 125.9, 121.8, and 104.7 pounds per cubic foot (pcf), at optimum moisture contents of 9.8%, 10.1% and 14.6% respectively, which is considered typical for these types of materials. The natural moisture contents recorded were about 11% above optimum moisture content. Some aeration of these soils may be required to attain adequate compaction.

For pavement analysis, three California Bearing Ratio (CBR) tests were conducted on the bulk samples compacted to 95% of maximum dry density at optimum moisture content. After soaking the test sample for 4 days under a 75-pounds-per-square-foot (psf) surcharge, less than 1% swell was recorded. Moderate, but typical values for these coarse-grained materials were recorded. Soaked CBR values of 8, 9, and 11 were recorded. These are considered typical values for these types of materials.

Stratum C – Fat Clay

Eight undisturbed tube samples were obtained from various boring locations and depths (Borings GT-100, GT-106, GT-112 (2), GT-113, GT-200, GT-204, and GT-207) within this stratum to determine the uniformity of the material's compressibility. The consolidation tests performed on this material indicates that the stratum exhibits a very slight preconsolidation. The maximum past pressure was found to be slightly higher than the existing overburden pressure. As expected, the apparent consolidation of the clay materials has had greater influence on the behavior of the clays in the lower portion of the clay layer; however, this entire stratum should still be considered highly compressible. Compression Indices ranged from 0.37 to 0.98, and Recompression Indices ranged from 0.011 to 0.05.

In addition, four Consolidated Undrained (CU) Triaxial Compression Tests were performed on three separate undisturbed tube samples from this stratum (GT-100, GT-112, GT-113, and GT-204). From the test results, a range of internal angles of friction, φ, from 25.5° to 23.0° and a range of cohesion values from 1.64 to 2.67 pounds per square inch (psi), were recorded respectively.

2.6.2 Soil Laboratory Testing – Mooring Facility/Snubbing Post

Because the primary focus for these borings related to understanding the bedrock characteristics, the geotechnical laboratory tested rock core samples from one boring in the soils laboratory in accordance with applicable ASTM standards. The following is a summary of the results from this testing.

Stratum D – Siltstone and Shale, Moderately to Highly Fractured, Moderately Weathered

An Unconfined Compression Test was performed in accordance with ASTM D2938 on three separate rock core samples from this stratum (core run samples from 31.8 to 33.8 feet) from Boring GT-303. Compressive strength test result values ranged between 4,580 and 3,710 psi.

2.6.3 Soil Laboratory Testing – Processing Facility Access Road

To better understand the characteristics of soil subgrade under repetitive vehicle loading, two bulk samples (collected from the auger cuttings from Borings GT-411 in Stratum C and GT-425 in Stratum B) were tested in the soils laboratory. Tests were performed in accordance with applicable ASTM standards. The following is a summary of the results from this testing.

Stratum B – Poorly Graded Sand with Silt (SP-SM)

The sample tested from this stratum (from Boring GT-425) contained 9.8% material by weight finer than the No. 200 sieve. The sample consisted of non-plastic fines. A natural moisture content of 15.1% was recorded.

A compaction test was performed in accordance with ASTM D698, Standard Proctor on the bulk sample. The soil exhibited maximum dry density of 113.9 pcf, at an optimum moisture content of 12.4%, which is considered typical for this type of material. The natural moisture content recorded was about 3% above optimum moisture content. Some aeration of these soils may be required to attain adequate compaction.

For pavement analysis, a CBR test was conducted on the bulk sample compacted to 95% of maximum dry density at optimum moisture content. After soaking the test sample for 4 days under a 75 psf surcharge, less than 1% swell was recorded. A moderate to high value for this coarse-grained material was recorded, along with a soaked CBR value of 18.

Stratum C – Fat Clay (CH)

The sample tested from this stratum (from Boring GT-411) contained 98.6 material by weight finer than the No. 200 sieve. This highly plastic material had a Liquid Limit of 72 and Plasticity Index of 45. A natural moisture content of 36.6% was recorded.

A compaction test was performed in accordance with ASTM D698, Standard Proctor on the bulk sample. The soil exhibited maximum dry density of 93.3 pcf, at an optimum moisture content of 24.5%, which is considered typical for this type of material. The natural moisture content recorded was about 12% above optimum moisture content. Significant aeration of these soils will likely be required to attain adequate compaction.

For pavement analysis, a CBR test was conducted on the bulk sample compacted to 95% of maximum dry density at optimum moisture content. After soaking the test sample for 4 days under a 75 psf surcharge, less than 3.8% swell was recorded. A very low value for this highly plastic material was recorded, which is typical, along with a soaked CBR value of less than 1.