GEOTECHNICAL ASSESSMENT REPORT

METRO-NORTH COMMUTER RAILROAD COMPANY
CONTRACT NO. 108739
STATION IMPROVEMENTS AT PURDY'S STATION
PURDY'S, WESTCHESTER COUNTY, NEW YORK

MATRIXNEWORLD
Engineering Progress

Prepared for:

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Matrix No. 18-802

March 2019

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1.0 INTRODUCTION

Matrix New World Engineering, Land Surveying and Landscape Architecture, P.C. (Matrix) has completed a geotechnical assessment to support the proposed improvement of the Metro-North Railroad (MNR) Purdy's Station located in Purdy's, Westchester County, New York (Site). Matrix provided geotechnical services as a consultant to AECOM. The project location is shown on the attached Site Location Map (Figure 1).

The purpose of the geotechnical engineering study was to evaluate the suitability of on-site soils for the support of the future construction at the site. Geotechnical borings were advanced in the project area for determination of the subsurface conditions. A total of 2 geotechnical borings (P-1 and P-2) were completed to depths of 22 and 32 feet below the ground surface (bgs), respectively (see Figure 2).

Matrix's geotechnical recommendations are based on an engineering evaluation of the subsurface conditions as indicated by the field exploration data and geotechnical laboratory test results on representative soil samples. These recommendations will address the geotechnical components of the anticipated construction to ensure that the proposed loads can be safely transferred to the underlying soil.

2.0 SITE LOCATION & PROJECT DESCRIPTION

The project site is located Purdy's Station in the hamlet of Purdy's, Westchester County, New York. The Purdy's station is a commuter rail stop on the MNR Harlem line, located immediately south of Mid Way and west of Interstate Highway 684. The soil investigation was performed in a grassy, wooded area located immediately north of the station parking lot and adjacent to an existing staircase connecting the station to Mid Way.

This project involves the demolition of the existing staircase connecting Mid Way to Purdy's Station, followed by replacement with a new elevator (structural steel tower enclosed with glass panels and stainless-steel glass-paneled cab). Also included in the project is a new ADA-compliant pathway to run parallel to the MNR tracks (west side) and connect to the existing station overpass.

To assist in the future design and construction within the project area, geotechnical borings were advanced in the area of proposed construction to obtain information regarding the soil's structural properties. The 2 borings were located to provide the most useful information about the subsurface conditions. Refer to Figure 2 of this report for a map of the as-drilled boring locations.

3.0 GEOLOGIC SETTING

According to the Geologic Map of New York, Lower Hudson Sheet (dated 1970), the site location is founded on Inwood Marble, which consists of dolomite marble, schist, granulite and quartzite overlain by calcite marble.

From the Surficial Geologic Map of New York, Lower Hudson Sheet, compiled by and edited by Donald H. Cadwell in 1989, the natural surface material (beyond fill) is suggested to be Till. This group is typically composed of relatively impermeable soils of variable texture (e.g. Clay, Silt-Clay, boulder Clay).

The documented site conditions presented above are not very consistent with the findings from the subsurface investigation, in which all soils encountered were predominantly sandy in nature, with varying amounts of Silt and Gravel. Groundwater was encountered in the borings at approximately 11 to 12 feet bgs. Bedrock was not encountered during this subsurface program.

4.0 SUBSURFACE FIELD PROGRAM

The subsurface investigation was completed by generally accepted practices in the Geotechnical Engineering field and consisted of the advancement of 2 Standard Penetration Test (SPT) borings using mud rotary drilling techniques.

A Matrix Geotechnical Engineer provided full-time drilling oversight, soil logging, and sample collection. Matrix prepared the field boring logs, which included sample depths, SPT-N blow counts, soil recovery, and soil descriptions based on the Burmister Soil Classification System followed by the Unified Soil Classification System (USCS) letter symbol. Soil boring logs are provided in Appendix A. Classification tables and charts used to determine the soil attributes are included in Appendix B.

Upon the completion of the field program, representative samples were subjected to geotechnical laboratory analyses. Laboratory results aided in soil classification and assessing the relevant engineering properties of the stratigraphic layers which were used in developing the revised geotechnical design recommendations outlined herein. Geotechnical laboratory reports are included in Appendix C.

4.1 SPT Borings

Matrix retained Craig Geotechnical Drilling Co., Inc. (Craig), located in Mays Landing, NJ, to complete the subsurface field program under observation of a Matrix Geotechnical Engineer qualified in Geotechnical Engineering in New York. On February 27, 2019, Craig completed a geophysical survey and advanced 2 geotechnical borings with a CME 545 track-mounted drill rig using mud-rotary drilling techniques.

Split spoon (SS) samples were collected in accordance with *ASTM D-1586*, *Standard Method for Penetration Test and Split-Barrel Sampling of Soils*. A standard 2-inch outer diameter split spoon, two feet in length, was used to collect the soil samples. An automatic 140-pound hammer having a 30-inch drop was used to drive the split spoon sampler. As a part of boring observation, the SPT blow counts were recorded for the 0- to 6-inch interval, the 6- to 12-inch interval, the 12- to 18-inch interval and the 18- to 24-inch interval. The SPT N-values for design purposes are reported as the sum of the SPT N values observed for the above referenced 6- to 12-inch interval and the 12- to 18-inch interval that the split spoon sampler was driven.

The Matrix Geotechnical Engineer observed the split spoon samples and collected representative samples in sealed containers for further examination. All borings were continuously sampled to 12 feet bgs and at every subsequent 5-foot interval thereafter. The 2 borings were advanced to a depth of 22 and 32 feet bgs. The borings were backfilled with soil cuttings and bentonite hole plug (if necessary) upon completion of the borehole.

4.2 Laboratory Testing

In addition to the field investigation, a laboratory testing program was conducted to determine additional pertinent engineering characteristics of representative samples of on-site soils. The laboratory testing program was performed in general accordance with applicable ASTM standard test methods and included physical/textural testing of representative samples of various strata.

Upon review of the boring logs, Matrix selected representative samples for laboratory testing. Laboratory testing of selected samples was completed by TerraSense, LLC, located in Totowa, New York. The following table presents a summary of the testing program:

Table 4.3-1: Laboratory Testing Program

Test	Testing Procedure	Quantity Performed	Sample Locations and Depth Intervals
Water Content	ASTM D2216	6	P-1: 4-6’, 8-10’, 15-17’ P-2: 6-8’, 10-12’, 25-27’
Sieve Analysis	ASTM D422	4	P-1: 4-6’, 15-17’ P-2: 6-8’, 25-27’
Combined Sieve and Hydrometer	ASTM D422	1	P-2: 10-12’
Percent Fines	ASTM D1140	1	P-1: 8-10’

The results of the laboratory testing program were utilized to assist in developing geotechnical design parameters and recommendations, and are provided in Appendix C.

5.0 SUBSURFACE CONDITIONS

The subsurface conditions beneath the site can be characterized by the following stratigraphy, proceeding from the surface materials downward, unless noted otherwise below. Classification tables and charts used to determine the soil attributes are included in Appendix B.

Stratum 1: Upper Sand (SP, SM)

Stratum 1 consisted of a gray, black and/or brown medium-to-fine Sand with varying amounts of Gravel and Silt. This layer began at the ground surface in each boring and extended to 10 feet below the ground surface (bgs).

The SPT N-values within this layer typically ranged from 7 to 21 blows per foot (bpf), which is indicative of loose to medium-dense Sand. One outlying N-value of 62 bpf was observed in boring P-2 at 2 feet bgs, signifying very dense soil material. The N-values within this layer typically decreased with depth, as the Silty Sand located at the bottom of the layer was looser in consistency. The SPT N-values for Stratum 1 are summarized in the table below.

Table 5.0-1: Loose SPT N-Values for Stratum 1

Soil Boring Location	USCS Group Symbol	Depth Below Ground Surface	SPT N-Values
P-1	SP, SM	6-10’	9
P-2	SM	6-10’	7-10

Table 5.0-2: Medium-Dense SPT N-Values for Stratum 1

Soil Boring Location	USCS Group Symbol	Depth Below Ground Surface	SPT N-Values
P-1	SP	4-6’	21
P-2	SP	0-6’	18-20*

*SPT N-value of 62 was noted in boring P-2 at a depth of 2’ bgs

Stratum 2: Silty Clay (CL)

Underlying Stratum 1 in both borings, a layer of brown Silty Clay was encountered with significant amounts of fine Sand. This layer began at a depth of 10 feet bgs and extended to approximately 13.5 feet bgs in both borings.

The SPT N-values within this layer ranged from 4 to 9 bpf, indicating soft to stiff Clay material. The SPT N-values for Stratum 2 are summarized in the table below.

Table 5.0-3: SPT N-Values for Stratum 2

Soil Boring Location	USCS Group Symbol	Depth Below Ground Surface	SPT N-Values
P-1	CL	10-13.5’	9
P-2	CL	10-13.5’	4

Stratum 3: Lower Sand (SP-SM, SM)

Underlying Stratum 2 in each boring is a denser layer of Sand with varying amounts of Gravel and Silt. This layer began at approximately 13.5 feet bgs in both borings. Both borings (P-1 and P2) were terminated within this layer at 22 and 32 feet bgs, respectively.

The SPT N-values within this layer ranged from 11 to 33 bpf, signifying medium-dense to dense soil material. The SPT N-values for Stratum 3 are summarized in the table below.

Table 5.0-3: SPT N-Values for Stratum 2

Soil Boring Location	USCS Group Symbol	Depth Below Ground Surface	SPT N-Values
P-1	SP-SM	13.5-22’	20-33
P-2	SP-SM, SM	13.5-32’	11-17

Groundwater

Groundwater was encountered at 11 to 12 feet bgs in the soil borings during drilling. It should be noted that the groundwater levels will vary with temperature, precipitation, and other climatic factors.

6.0 GEOTECHNICAL DESIGN PARAMETERS

6.1 General Geotechnical Parameters

The geotechnical design parameters in this report are derived from the field investigation and are based on accepted geotechnical standards and practices. The following table summarizes the recommended geotechnical design parameters for the various soil strata encountered at the site. The values are based on review and interpretation of the subsurface investigation and laboratory test data results.

At the time of the geotechnical investigation, loading conditions and the final proposed grading plans were not available. Therefore, certain assumptions were made for the recommendations provided in this report.

An allowable bearing capacity of 3,000 psf, as indicated in the following table, is recommended for foundations of permanent structures bearing on dense granular soils at the Site. This value may also be used if another soil layer is encountered at the anticipated bearing stratum and replaced with Controlled Fill down to this layer.

Table 1806.2 of the 2015 International Building Code provides allowable coefficients of friction to be used in the evaluation of resistance to sliding. For the native dense granular soil and Controlled Fill, the recommended coefficient of friction against sliding is 0.25.

Table 6.0-1: Geotechnical Design Parameters

Stratum	Unit Weight	Friction Angle (Φ')	Cohesive Strength, c_u	Earth Pressure Coefficient		Allowable Foundation Pressure*	Lateral Bearing
				Active	Passive		
	(pcf)	(deg)	(psf)	(Ka)	(Kp)	(psf)	(psf/ft bgs)
Controlled Fill	γ = 125 γ' = 63	32°	0	0.31	3.26	3,000	200
Existing Fill Material	γ = 105 γ' = 43	28°	0	0.36	2.77	2,000+	100
Native Dense Granular Soil (GP, SM, SP) [10 < SPT N]	γ = 125 γ' = 63	32°	0	0.31	3.26	3,000	200
Native Loose Granular Soil (GP, SM, SP) [SPT N ≤ 10]	γ = 120 γ' = 58	30°	0	0.33	3.00	2,000	150
Native Clay Material (CL) Stiff [Class 4b, 8 < SPT N ≤ 30]	γ = 110 γ' = 48	-	1,500	-	-	2,000*	100
Native Clay Material (CL) Medium Soft [Class 4c, 4 ≤ SPT N ≤ 8]	γ = 100 γ' = 38	-	1,000	-	-	1,000*	75
Native Clay Material (CL) Very Soft - Soft [Class 6, SPT N < 4]	γ = 90 γ' = 28	-	500	-	-	N/A	N/A

Notations: γ = moist unit weight, γ' = buoyant unit weight, and c_u = average undrained shear strength.

\+ Allowable foundation pressure is contingent upon either replacement of at least two feet of existing fill below the bottom of footing by a Controlled Fill (placed and compacted as described in Section 7.5), or upon confirmation that the field density of the existing fill material down to four feet below the bottom of footing meets 95% of the maximum dry density of the existing fill material observed in Modified Proctor Tests.

* These values are based on the 2015 New York State Building Code. To increase the allowable foundation pressure above the values recommended in the table given above, further testing of soil will be required.

● Coefficient of earth pressure at rest may be computed using Jaky's equation, Ko = 1 – Sin ϕ'.

6.2 Seismic Design Parameters

Based on a review of the subsurface conditions relevant to section 1613 of the New York State Building Code 2015 (Code), the subject site may be classified as Site Class D. Seismic design parameters are presented in the table below.

For a Risk Category equal to I/II/III and One Second Design Acceleration (S_{D1}) equal to 0.110 g, the site may be assigned to Seismic Design Category (SDC) B.

Table 6.2-1: Seismic Design Parameters

Parameter	Values
0.2 sec. Bedrock Acceleration, S_s	0.236 *g*
1.0 sec. Bedrock Acceleration, S_1	0.069 *g*
Peak Ground Acceleration, PGA	0.133 *g*
0.2 sec. Site Coefficient, F_a	1.600
1.0 sec. Site Coefficient, F_v	2.400
PGA Site Coefficient, F_{PGA}	1.534
0.2 sec. Design Acceleration, S_{DS}	0.251 *g*
1.0 sec. Design Acceleration, S_{D1}	0.110 *g*
Site Specific MCE Peak Ground Acceleration, PGA_M	0.204 *g*
Seismic Design Category, SDC	B

* Value(s) obtained from the Section Code 1613 Earthquake Loads; and corresponding Chapters 20 through 22 of the ASCE 7-10. The "*g*" is acceleration due to gravity, and $g = 32.2$ ft/s^2 or 9.81 m/s^2.

7.0 GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

The following sections present the results of our geotechnical engineering evaluation and recommendations for support of the planned construction.

7.1 Site Preparation and Earthwork

Prior to demolition and stripping operations, all utilities should be identified and protected. Existing pavements, topsoil, trees, roots, vegetative matter and deleterious materials should be removed at least five feet beyond the limits of the proposed structure areas.

All remaining underground utilities and utility backfill should be evaluated to determine if these elements are suitable for support of the planned loads. The Contractor must keep those utilities to be reused in workable condition and protected from damage during earthwork activities. Utilities not planned for re-use should be removed from planned structural areas, capped off at the property lines, and either removed or abandoned in place. All soils disturbed by utility abandonment operations should be removed or re-compacted in-place.

Prior to placing any fill materials to raise grades to designed and subgrade elevations as necessary, the existing exposed subgrade soils should be compacted to a firm and unyielding surface with several passes in two perpendicular directions of a minimum 10-ton vibratory, smooth drum roller. To help identify any soft or loose pockets which may require removal and replacement or further investigation after compaction of the subgrade, the surface should be proof-rolled in the presence of the owner's geotechnical engineer. Typical equipment used for the proof-rolling effort consists of a fully loaded tandem axle truck; and if site constraints limit the use of this equipment, equivalent alternatives may be considered subject to engineer approval. Proof-rolling should be conducted after a suitable period of dry weather to avoid degrading an otherwise acceptable subgrade. Any fill or backfill should be placed and compacted in accordance with the recommendations provided herein. If construction activities are performed during winter months, all frozen soils encountered at or below proposed subgrade elevations should be removed and replaced with Controlled Fill in accordance with the recommendations herein.

Every effort should be made to minimize disturbance of the on-site soils by construction traffic and surface runoff. The on-site soils will deteriorate when subjected to repeated construction traffic and will likely require removal and replacement. Any type of disturbance to moisture-sensitive soils can potentially affect settlement, bearing capacity and the shrinkage/swelling of clays. The services of a geotechnical engineer should be retained to inspect soil conditions during construction and verify the suitability of prepared foundations for support of the design loads.

Development of the site during periods of favorable weather and stringent quality control of soil moisture will be critical to construction schedules. Construction haul roads should be constructed throughout the site prior to the start of construction to maintain site access and construction traffic. During construction, the exposed surface soils should be regraded and sealed at the end of each day with a smooth static drum roller to prevent ponding. If subgrade soils are overly wetted, over excavation should be anticipated.

7.2 General Foundation Recommendations

Based on the results of the subsurface investigation, Matrix anticipates that the existing subsurface soils will be capable of supporting the proposed elevator and ramp structures using shallow foundations (i.e., spread footings). The finished foundations should be installed at least 4 feet bgs to protect the structures' foundations from possible frost heave during cold weather conditions. This assumed frost depth should be confirmed with the local jurisdictional building department prior to construction activities.

Assuming the new shallow footings will be located approximately 4 feet bgs, a bearing capacity of 3,000 psf is recommended for the medium-dense granular material at that depth. Actual bearing conditions of the materials within the foundation areas should be confirmed in the field during excavation, by inspection, under the direction of a Professional Engineer registered in the State of New York.

Should any unsuitable materials be encountered beneath the proposed foundation bearing depths, over-excavation and replacement of the unsuitable materials will be required to provide a suitable footing subgrade. Approximately six inches of existing soil below the foundation bottom is recommended to be replaced with ¾-inch clean crushed stone to serve as a "cushioning layer" for uniform transition of structural loads to the underlying subsurface. All foundation bottoms should be completely cleaned of loose material or debris and maintained in a dry condition immediately prior to the placement of the subgrade base course.

Any over-excavation to be restored with Controlled Fill will need to extend at least one foot laterally beyond footing edges for each vertical foot of over-excavation. Lateral over-excavation can be reduced if the grade is restored with lean concrete or approved flowable fill. The bottom of over-excavations should be compacted with walk-behind compactors, vibrating plates or plate tampers ("jumping jacks") to compact locally disturbed materials.

7.3 Construction Recommendations

The proposed redevelopment of the project site is anticipated to include slab-on-grade and concrete footing construction. The bottom of the subgrade should be excavated clean so a hard bottom is provided for the support of the structures or utility pipes. The subgrade of the slab or paved areas is anticipated to be constructed within the top four feet of existing grade. All fill used to establish the subgrade level, as necessary, should be Controlled Fill, placed and compacted under engineering controls as per Section 7.5 of this report. To protect concrete slabs exposed to frost heave, controlled crack joints and shrinkage joints should be provided at regular intervals. An 8-inch-thick layer of ¾-inch crushed clean stone shall be placed as base course between the subgrade and the bottom of the concrete footing slab.

The properly prepared Controlled Fill/backfill materials in paved areas are expected to yield a minimum subgrade modulus (k) of 75 psi/in. If any soft or loose soils are encountered, the unsuitable material should be removed, replaced and compacted with new Controlled Fill as per Section 7.5 of this report. Should the thickness of unsuitable soil to be removed be greater than 3 feet in paved areas, deep foundations are recommended as a viable option. If such a situation is encountered, Matrix shall assess and reevaluate a viable deep foundation system. At this moment, Matrix rules out any such situation will be encountered.

If a utility trench excavation becomes soft due to the inflow of surface water or groundwater, a minimum of six inches of crushed stone shall be placed on the bearing soil to provide a firm base for support of the pipe.

7.4 Excavations/Dewatering/Drainage

Excavation near existing foundations shall not remove the existing lateral or vertical support without protecting the existing foundation against settlement or lateral translation by providing underpinning or shoring. Underpinning and shoring should be provided as per section 1804 of the 2014 New York City Building Code. The contractor is solely responsible for construction site safety, including excavation safety. Excavations should be performed in accordance with the requirements of *29 CFR Part 1926, OSHA Safety and Health Regulations for Construction, Excavations*. It is anticipated that excavations will generally be open cut. The fill and underlying soils, above and below the water table, are considered Type C soils. The maximum allowable slopes stipulated by OSHA for Type C soils are 1.5 H:1 V. Flatter slopes may be required based on actual conditions encountered, which should be evaluated by a competent person (as defined by OSHA) to ensure that safe excavation methods and/or shoring and bracing requirements are implemented. Sheeting and bracing, if required, should be designed by a Professional Engineer licensed in New York with earth and water pressures, as well as equipment and other surcharge loads, considered.

Groundwater was encountered at depths of 11 to 12 feet bgs during the subsurface exploration program. Since this project is expected to involve shallow footings, dewatering should not be a concern for this project during construction. However, construction dewatering may be required if deeper structures are to be built at the site. Presence of groundwater at foundation depths may severely impede the constructability of structures due to possible inflow of groundwater into the open excavation. As stated before, groundwater levels will vary with temperature, precipitation and other climatic factors. The appropriate measures to be taken for groundwater control during construction should be determined in the field at the time of excavation and are the responsibility of the contractor.

7.5 Controlled Fill

Matrix recommends that portions of the on-site natural soil may be reused for backfilling as Controlled Fill if it meets the requirements provided within this section, is subjected to removal of all unsuitable material such as topsoil, boulders, concrete, brick, organic matter, etc. and is approved by the owner's Professional Engineer licensed in New York and qualified in geotechnical engineering. If the excavated fill material and on-site natural soils cannot be reused, imported structural fill should be used as Controlled Fill. The imported Controlled Fill should be a granular, structurally sound, free-draining fill, free of organic material and any other deleterious material. Controlled Fill should be a natural Sand or Sand and Gravel mixture with no particles larger than three inches and the material passing the No. 200 sieve shall be non-plastic. The chosen Fill soil should meet the gradation of Table 7.5-1 below.

Table 7.5-1: Grain Size Distribution for Controlled Fill

Sieve Size Designation	Percentage Passing by Weight
Passing 3 inch	100
Passing 2 inch	90 – 100
Passing ¼ inch	30 – 70
Passing #10	15 – 60
Passing #40	5 – 40
Passing #200	0 – 10

Controlled Fill shall be placed in lifts not exceeding twelve (12) inches thick, in loose state. Should the Controlled Fill be compacted with a plate compactor or jumping jack compactor, the Fill must be placed in lifts not exceeding eight (8) inches thick, in loose state. Each lift of backfill should be compacted to at least 95 percent of the maximum dry density within three percent of the optimum moisture content, as determined in accordance with the procedures of ASTM D1557, *Laboratory Compaction Characteristics of Soil Using*

Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-M/M^3)). Controlled Fill placed within ten feet of walls, foundations, utility lines and auxiliary structures should be compacted with plate compactors; the lift thickness should be adjusted if necessary to obtain the required degree of compaction. In-place density tests should be performed at a frequency of not less than one per 2,500 sf of backfill placed, and not less than one test per two feet of material placed. In addition, if compaction is being conducted near an existing foundation, the Controlled Fill shall be placed in lifts and compacted such that it does not damage the existing foundation.

Appropriate documentation, with supporting laboratory test results for proposed fill materials, should be submitted for approval prior to its use. Grain size distribution, maximum dry density, optimum water content determinations, and plasticity of the soil should be performed on representative samples of the proposed Controlled Fill.

Preparation of the subgrade and the placement of fill should be performed under the oversight of a qualified geotechnical engineer, or a technician under their direction. No fill material should be placed in areas where free water is standing, on frozen subgrade areas, or on surfaces which have not been approved by qualified geotechnical personnel.

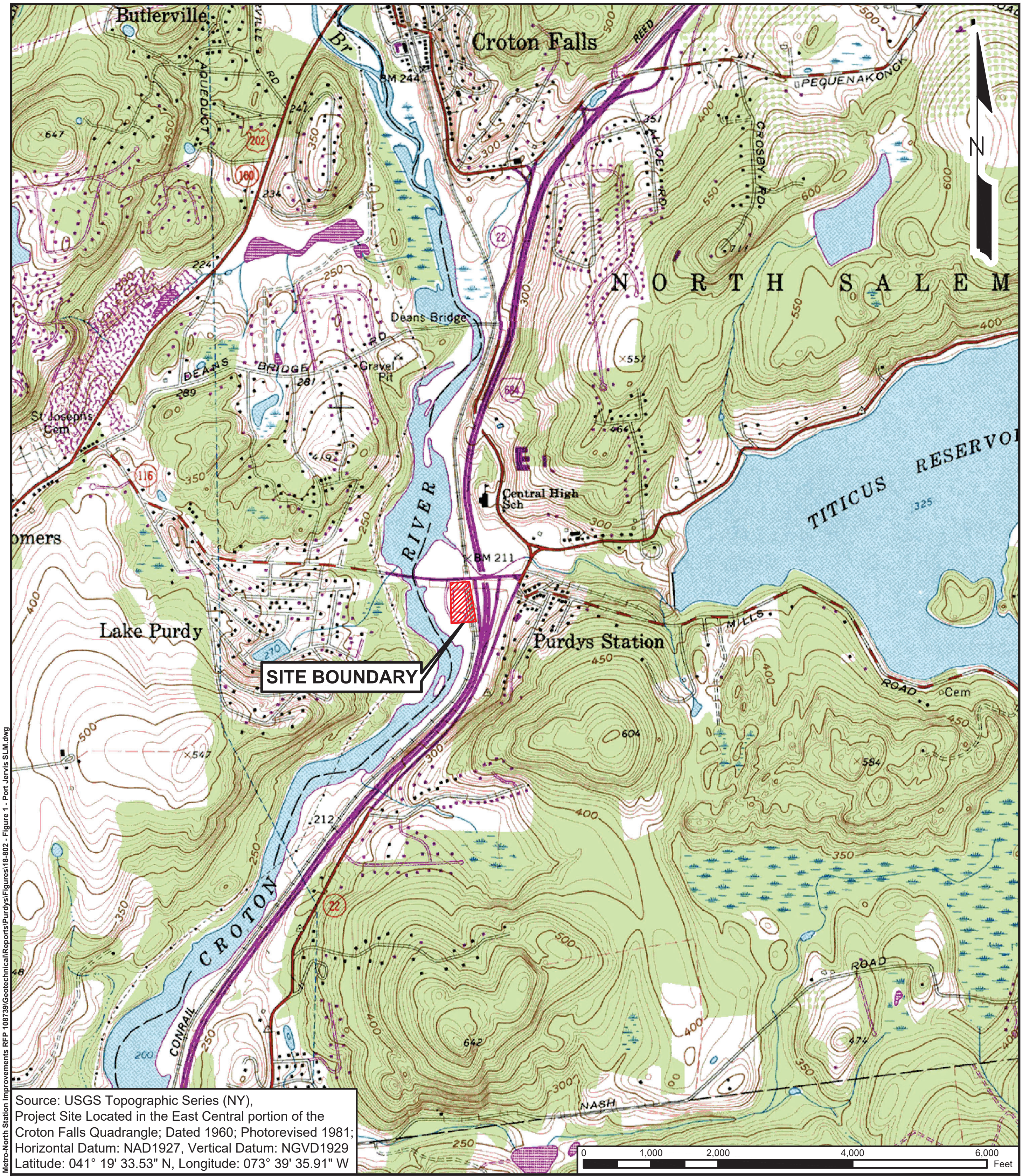
7.6 Supplemental Investigation Services

A qualified geotechnical engineer should perform inspection, testing, and consultation during construction as described in previous sections of this report. Monitoring and testing should be performed to verify that suitable materials are used for Controlled Fill, and that they are properly placed and compacted over suitable subgrade soils. The excavated materials and the on-site natural soil to be reused as Controlled Fill shall be approved for reuse by the owner’s geotechnical engineer prior to reuse.

8.0 CLOSURE

This report has been prepared to assist AECOM and the Metro-North Railroad with the proposed construction at Purdy's Station in Westchester County, New York. The conclusions and recommendations provided within this report were prepared based on our understanding of the project and through the application of generally accepted soils and foundations engineering practices. No warranties, expressed or implied, are made. Matrix should be notified of any changes to the planned construction or if subsurface conditions differing from those described herein are encountered, so the impact on the geotechnical recommendations can be evaluated.

FIGURES



Source: USGS Topographic Series (NY),
Project Site Located in the East Central portion of the Croton Falls Quadrangle; Dated 1960; Photorevised 1981;
Horizontal Datum: NAD1927, Vertical Datum: NGVD1929
Latitude: 041° 19' 33.53" N, Longitude: 073° 39' 35.91" W

SITE LOCATION MAP

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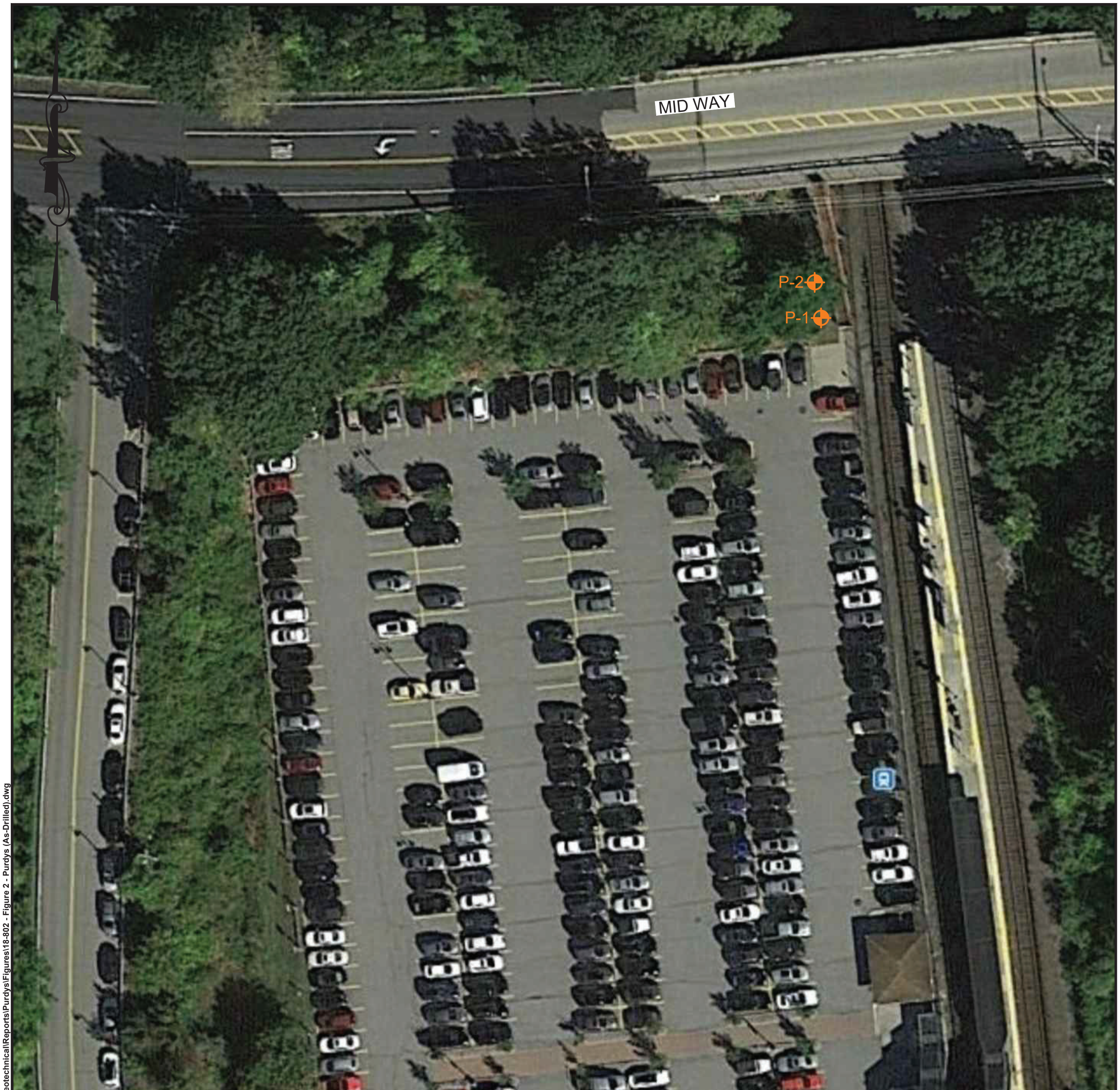
SCALE:	PROJECT NO.:	DATE:	FIGURE NO.:
1" = 2,000'	18-802	MARCH 2019	1



NOTES:

1. BORING LOCATIONS WERE IDENTIFIED IN THE FIELD BY MATRIX PERSONNEL BY TAPING AND LINE OF SIGHT MEASUREMENTS.

2. THE BORINGS WERE PERFORMED BY CRAIG GEOTECHNICAL DRILLING CO., INC. ON FEBRUARY 27, 2019 UNDER THE DIRECTION OF A MATRIX REPRESENTATIVE.

LEGEND

P-# BORING LOCATION

0 20 40 60 120

SCALE: 1" = 60'

AS-DRILLED BORING LOCATION PLAN

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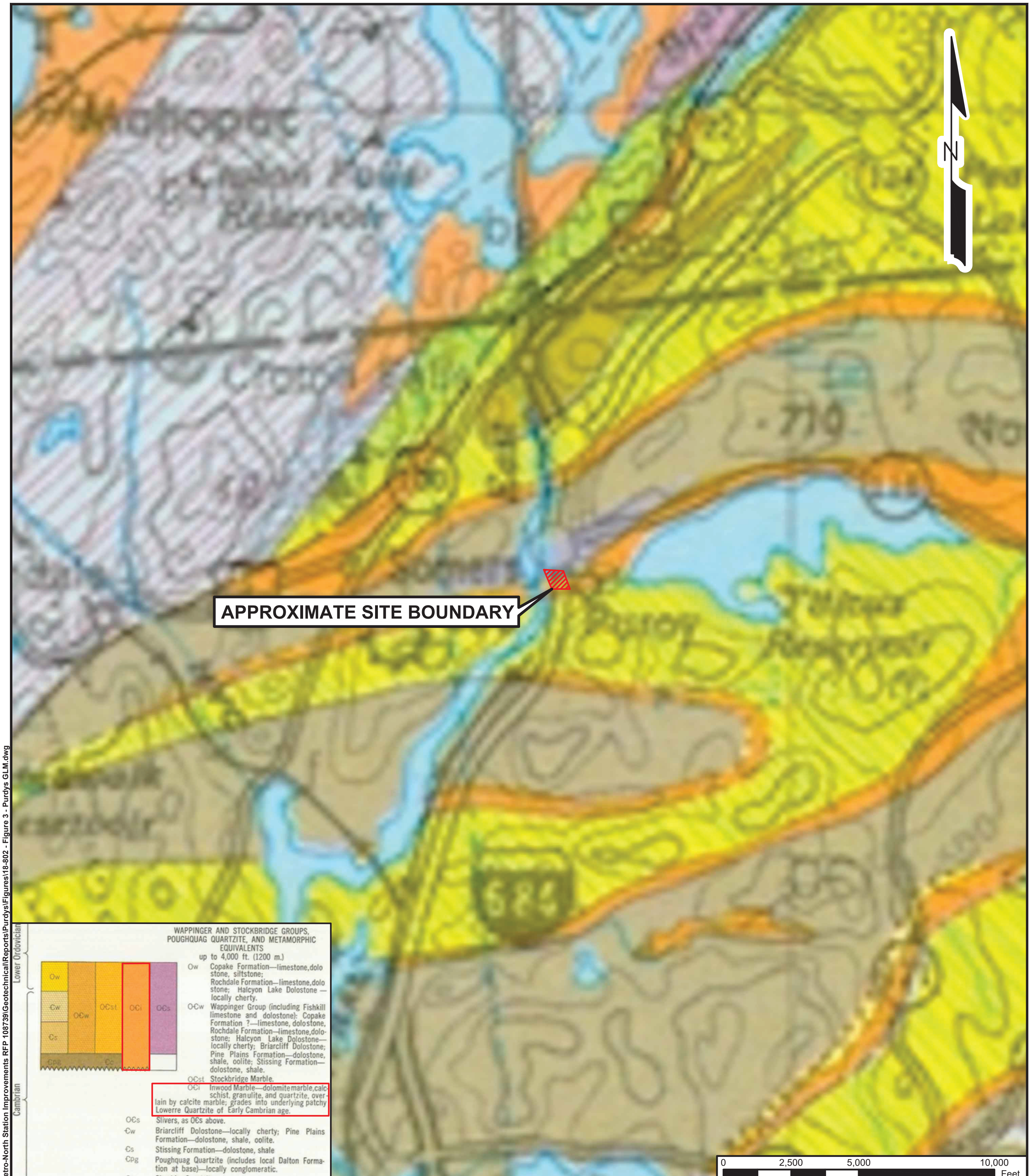
SCALE:	PROJECT NO.:	DATE:	FIGURE NO.:
1" = 60'	18-802	MARCH 2019	2



GEOLOGIC LOCATION MAP

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SCALE:	PROJECT NO.:	DATE:	FIGURE NO.:
1" = 5,000'	18-802	MARCH 2019	3

APPENDIX A

SOIL BORING LOGS

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BORING LOG

BORING NO.: **P-1**

SHEET **1** OF **1**

PROJECT NO.: **18-802** PROJECT: **MTA MNR: Metro - North Station Improvements** DATE: **2/27/19**
PROJECT LOCATION: **Metro North Railroad** BORING LOCATION: **Purdy's Station (North of Parking Lot)**
DRILLING EQUIPMENT: **CME 55** ANGLE: **-90.0** DIR.: **------** ELEV.: DATUM:
DRILLING CONTRACTOR: **Craig Geotechnical Drilling Co. Inc.** DRILLER: **M. Gorski** INSPECTOR: **D. Alia**

CASING and HAMMER				SAMPLER and HAMMER				GROUNDWATER LEVELS			
Type	I.D.	Weight	Drop	Type	I.D.	Weight	Drop	Date	Time	Depth	Casing Depth
Flush	**4"**			**SS**	**1 3/8"**			**2/27/19**	**9:50 am**	**12.0**	
Auto		**140 lbs**	**30"**	**AUTO**		**140 lbs**	**30"**				

Depth Feet (Elev.)	CASING Blows/ Foot	SAMPLE No.	Type	Depth Feet	Blows/6" (REC. %) [RQD %]	Graphic Symbol	Description Of Material	Laboratory Tests
		S-1	HA	0-2			S-1: Brown mf SAND, little mf Gravel, trace Silt, dry (SP)	
		S-2	HA	2-4			S-2: Same as Above, dry (SP)	
5		S-3	SS	4-6	14-13-8-3 (54%)		S-3: Light Brown-White mf* SAND, some Silt, trace fine Gravel, dry (SM) WC: 8.4%, Gravel: 8.7%, Sand: 65.3%, Fines: 26.0%	Sieve
		S-4	SS	6-8	3-5-4-5 (42%)		S-4: Brown fine SAND, some Silt, dry (SM)	
		S-5	SS	8-10	4-4-5-3 (29%)		S-5: Brown fine SAND and Silt, trace fine Gravel, moist (SM) WC: 18.7%, Fines: 41.5%	Pass No 200
10		S-6	SS	10-12	4-3-6-7 (46%)		S-6: Brown Silty CLAY and fine Sand, wet (CL)	
15		S-7	SS	15-17	15-17-16-15 (58%)		S-7: Brown cmf SAND, some cf* Gravel, little Silt, wet (SP-SM) WC: 10.4%, Gravel: 33.1%, Sand: 54.9%, Fines: 12.0%	Sieve
20		S-8	SS	20-22	6-8-12-10 (63%)		S-8: Brown cmf SAND, trace Silt, trace fine Gravel, wet (SP-SM)	
							4" Casing to 20 feet bgs Bottom of Borehole @ 22 ft.	

MATRIXNEWORLD
Engineering Progress

BORING LOG

BORING NO.: **P-2**

PROJECT NO.: **18-802** PROJECT: **MTA MNR: Metro - North Station Improvements** DATE: **2/27/19**
PROJECT LOCATION: **Metro North Railroad** BORING LOCATION: **Purdy's Station (North of Parking Lot)**
DRILLING EQUIPMENT: **CME 55** ANGLE: **-90.0** DIR.: **------** ELEV.: DATUM:
DRILLING CONTRACTOR: **Craig Geotechnical Drilling Co. Inc.** DRILLER: **M. Gorski** INSPECTOR: **D. Alia**

CASING and HAMMER				SAMPLER and HAMMER				GROUNDWATER LEVELS			
Type	I.D.	Weight	Drop	Type	I.D.	Weight	Drop	Date	Time	Depth	Casing Depth
Flush	**4"**			**SS**	**1 3/8"**			**2/27/19**	**11:26 am**	**11.0**	
Auto		**140 lbs**	**30"**	**AUTO**		**140 lbs**	**30"**				

Depth Feet (Elev.)	CASING Blows/ Foot	SAMPLE No.	Type	Depth Feet	Blows/6" (REC. %) [RQD %]	Graphic Symbol	Description Of Material	Laboratory Tests
		S-1	SS	0-2	7-6-12-18 (54%)		S-1: Brown mf SAND, trace fine Gravel, trace Silt, dry (SP)	
		S-2	SS	2-4	20-27-35-34 (33%)		S-2: Brown-Gray cmf SAND, little fine Gravel, trace Silt, dry (SP)	
5		S-3	SS	4-6	20-12-8-6 (17%)		S-3: Black-Gray cmf SAND, little fine Gravel, trace Silt, dry (SP)	
		S-4	SS	6-8	6-3-4-3 (46%)		S-4: Dark Brown mf* SAND, some cf Gravel, little Silt, dry (SM) WC: 9.8%, Gravel: 25.2%, Sand: 58.3%, Fines: 16.5%	Sieve
		S-5	SS	8-10	4-5-5-5 (42%)		S-5: Brown fine SAND, little Silt, moist (SM)	
10		S-6	SS	10-12	4-2-2-2 (38%)		S-6: Brown Silty CLAY and fine Sand, wet (CL) WC: 29.5%, Gravel: 0.0%, Sand: 46.6%, Fines: 53.4%, <2 μm: 12%	Sieve; Hydrometer
15		S-7	SS	15-17	10-7-5-7 (33%)		S-7: Brown mf SAND, trace Silt, wet (SP-SM)	
20		S-8	SS	20-22	4-7-7-7 (0%)		S-8: No Recovery	
25								

NEWORLD NO GROUT 18-802 - BORING LOGS.GPJ MATRIX EGS.GDT 3/25/19

MATRIXNEWORLD
Engineering Progress

BORING LOG

BORING NO.: **P-2**

SHEET **2** OF **2**

PROJECT NO.: **18-802** PROJECT: **MTA MNR: Metro - North Station Improvements** DATE: **2/27/19**

Depth Feet (Elev.)	CASING Blows/ Foot	SAMPLE No.	Type	Depth Feet	Blows/6" (REC. %) [RQD %]	Graphic Symbol	Description Of Material	Laboratory Tests
		S-9	SS	25-27	9-8-9-9 (25%)		S-9: Brown mf* SAND, little Silt, little cf* Gravel, wet (SM) WC: 18.5%, Gravel: 12.4%, Sand: 74.2%, Fines: 13.4%	Sieve
30								
		S-10	SS	30-32	5-6-5-7 (42%)		S-10: Brown mf SAND, little Silt, wet (SM)	
							4" Casing to 20 feet bgs Bottom of Borehole @ 32 ft.	

NEWORLD NO GROUT 18-802 - BORING LOGS.GPJ MATRIX EGS.GDT 3/25/19

APPENDIX B

SOIL CLASSIFICATION TABLES

LOG NOTATION

Sample Classifications

SS = Split Spoon

NR = No Recovery

NX = Rock Core

SH = Shelby Tube

REC = Soil Recovery

RQD = Rock Quality Designation

Sand Classifications

c = Coarse

m = Medium

f = Fine

* = Predominant Grain Size

Soil Properties

WC = Water Content

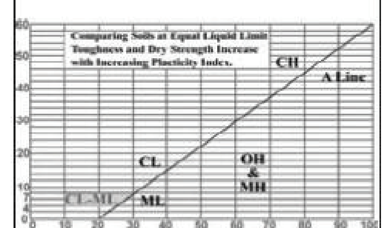
PL = Plastic Limit

LL = Liquid Limit

PI = Plasticity Index

OC = Organic Content

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (EXCLUDING PARTICLES LARGER THAN 3 IN. AND BASING FRACTIONS ON ESTIMATED WEIGHTS)			INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA			
1	2		3	4	5			6	7			
Coarse-grained Soils More than half of material is larger than No. 200 sieve size. The No. 200 sieve size is about the smallest visible to the naked eye.	Gravels More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the $^1/_4$-in. size may be used as equivalent to the No. 4 sieve size.)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixture, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture condition, and drainage characteristics.	Use grain-size curve in identifying the fractions as given under field identification.	Determine percentage of gravel and sand from grain-size curve. Depending on percentage of fine (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5% GW, GP, SW, SP. More than 12% GM, GC, SM, SC. 5% to 12% Borderline cases requiring use of dual symbols.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly graded gravels or gravel-sand mixture, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.						Not meeting all gradation requirements for GW	
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel and silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).			Give typical name; indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.			Atterberg limits below "A" line or P1 less than 4	Above "A" line with P1 between 4 and 7 are borderline cases requiring use of dual symbols.
			GC	Clayey gravels, gravel and clay mixtures.	Plastic fines (for identification procedures see CL below).						Atterberg limits above "A" line with P1 greater than 7	
	Sands More than half of coarse fraction is smaller than No .4 sieve size.	Clean Sand (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.						$Cu = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly graded sands or gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			Example: Silty sand, gravelly; about 20% hard, angular gravel particles $^1/_2$-in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).			Not meeting all gradation requirements for SW	
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).						Atterberg limits above "A" line or P1 less than 4	Limits plotting in hatched zone with P1 between 4 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).						Atterberg limits above "A" line with Pl greater than 7	
					Identification Procedure on Fraction Smaller than No. 40 Sieve Size.							
					Dry Strength (Crushing Characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)					
Fine-grained Soils More than half of material is smaller than No. 200 sieve size.	Silts and Clays Liquid limit is less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions		Plasticity Index	LIQUID LIMIT PLASTICITY CHART For laboratory classification of fine-grained soils	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium					
	Silts and Clays Liquid limit is greater than 50		OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight	Give typical name; indicate degree and character of plasticity; amount and maximum size of coarse grains; color in wet condition; odor, if any; local or geologic name and other pertinent descriptive information; and symbol in parentheses.				
			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium					
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High					
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML)				
Highly Organic Soils			Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture							



1. Boundary classifications: Soils possessing characteristics of two groups are designed by combinations of group symbols. For example GM-GC, well-graded gravel-sand mixture with clay binder.
2. All sieve sizes on this chart are U.S. standard.
3. Adopted by Corps of Engineers and Bureau of Reclamation, January 1952.

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BURMISTER SOIL IDENTIFICATION METHOD

BURMISTER SOIL IDENTIFICATION METHOD

1. SOIL MATERIAL — Composition, Gradation, and Plasticity Characteristics

a) Soil Components and Soil Fractions

Sieve	3"	1"	3/8"	No. 10 2 mm	No. 30	No. 60	No. 200 0.076 mm	0.02 mm
Granular Component Fractions	GRAVEL			SAND			SILT	
	coarse	medium	fine	coarse	medium	fine	coarse	fine
Clay Soil Components							CLAY-SOIL Defined and Named on a Plasticity Basis	

b) Identifying Terms for Granular Soils
Composition and Proportion Terms for Components

Component		Proportion Terms	Defining Range of Percentages
Principal Components- GRAVEL, SAND, SILT (all Uppercase)			50% or more
Minor Components-	Gravel	and	35 to 50%
	Sand	some	20 to 35%
	Silt	little	10 to 20%
		trace	1 to 10%

Gradation Terms for Granular Soils		ORGANIC SOILS
coarse to fine	all fractions more than 10%	Plasticity Basis, as
coarse to medium	fine less than 10%	
medium to fine	coarse less than 10%	Organic SILT, H. PI
medium	coarse and fine less than 10%	
fine	coarse and medium less than 10%	Organic SILT, L. PI
PLUS or MINUS signs used to indicate upper or lower limits.		

c) Identifying Terms for CLAY SOILS. Plasticity Basis for Combined Silt and Clay Components, Expressing the Relative Dominance of Clay

Overall Plasticity	Plasticity Index	Principal Component	Minor Component
Non-Plastic	0	SILT	Silt
Slight	1 to 5	Clayey SILT	Clayey Silt
Low	5 to 10	SILT & CLAY	Silt & Clay
Medium	10 to 20	CLAY & SILT	Clay & Silt
High	20 to 40	Silty CLAY	
Very High	more than 40	CLAY	

Example: Soil 60% coarse to fine Sand, 25% medium to fine Gravel, 15% Clayey Silt and color-brown.
Identification: Br. coarse to fine SAND, some medium to fine Gravel, little Clayey Silt.

References:
1) D. M. Burmister, "Principles and Techniques of Soil Identification" 29th Highway Research Board Proceedings, 1949.
2) "Identification and Classification of Soils – An appraisal and Statement of Principles", ASTM Special Technical Publication No. 113, 1951.

Field Classification of Soil Using the USCS

Apparent Density of Coarse-Grained Soils

SPT N-Value (corrected)	Apparent Density
0 - 4	Very loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
> 50	Very Dense

Consistency of Fine-Grained Soils

SPT N-Value (uncorrected)	Consistency	Compressive Strength (ksf)	Results of Manual Manipulation
< 2	Very Soft	< 0.5	Specimen (height = twice the diameter) sags under its own weight; extrudes between fingers when squeezed
3 - 4	Soft	> 0.5 - 1.0	Speciment can be pinched in to between the thumb and forefinger; remolded by light finger pressure
5 - 8	Medium stiff	> 1.0 - 2.0	Can be imprinted easily with fingers; remolded by strong finger pressure
9 - 15	Stiff	> 2.0 - 4.0	Can be imprinted with considerable pressure from fingers or indented by thumbnail
16 - 30	Very stiff	> 4.0 - 8.0	Can be barely imprinted by pressure from the fingers or indented by thumbnail
> 30	Hard	> 8.0	Cannot be imprinted by fingers or difficult to indent by thumbnail

APPENDIX C

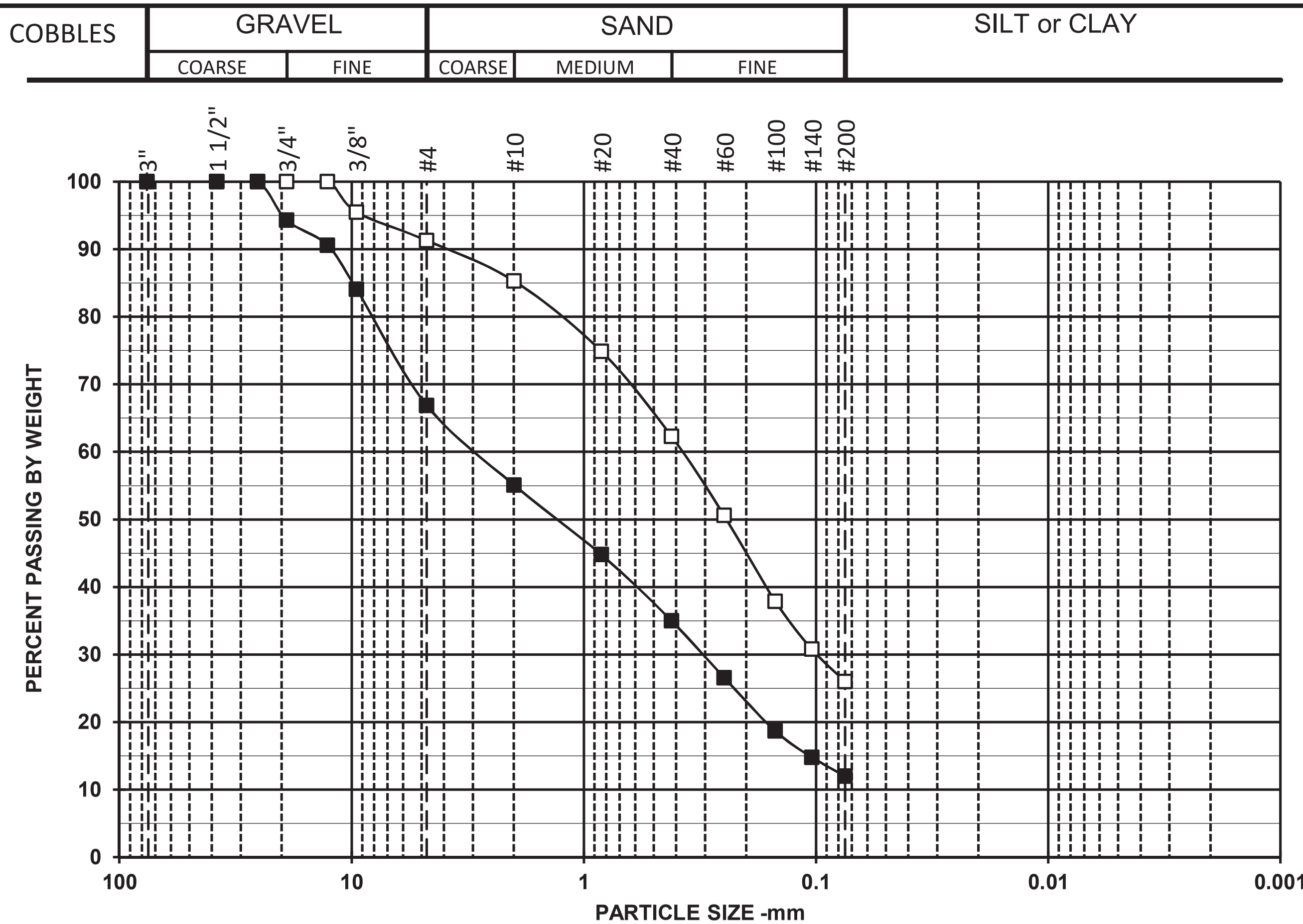
GEOTECHNICAL LABORATORY TESTING RESULTS

Matrix New World #18-802P
MTA MNR Metro North Station Improvements (Purdy's Station)
LABORATORY TESTING DATA SUMMARY

BORING NO.	SAMPLE NO.	DEPTH (ft)	IDENTIFICATION TESTS				REMARKS
			WATER CONTENT (%)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 μm (%)	
P-1	S-3	4-6	8.4	SM	26.0		
P-1	S-5	8-10	18.7	SM	41.5		
P-1	S-7	15-17	10.4	SP-SM	12.0		
P-2	S-4	6-8	9.8	SM	16.5		
P-2	S-6	10-12	29.5	CL	53.4	12	
P-2	S-9	25-27	18.5	SM	13.4		

Note: (1) USCS symbol based on visual observation and Sieve reported.

PARTICLE SIZE DISTRIBUTION



Symbol	□	■	○
Boring	P-1	P-1	
Sample	S-3	S-7	
Depth	4-6	15-17	
% +3"	0.0	0.0	
% Gravel	8.7	33.1	
% SAND	65.3	54.9	
%C SAND	6.0	11.8	
%M SAND	23.0	20.1	
%F SAND	36.3	23.0	
% FINES	26.0	12.0	
D_{100} (mm)	12.700	25.400	
D_{60} (mm)	0.378	2.863	
D_{30} (mm)	0.099	0.307	
D_{10} (mm)			
Cc			
Cu			

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	
4"	100.0	100.0	
3"	100.0	100.0	
1 1/2"	100.0	100.0	
1"	100.0	100.0	
3/4"	100.0	94.3	
1/2"	100.0	90.6	
3/8"	95.5	84.1	
#4	91.3	66.9	
#10	85.3	55.1	
#20	74.9	44.8	
#40	62.3	35.0	
#60	50.6	26.6	
#100	37.9	18.7	
#140	30.8	14.8	
#200	26.0	12.0	
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	8.4				SM		Brown, Silty sand	03/11/19
■	10.4				SP-SM		Brown, Poorly graded sand with silt and gravel	03/11/19
○								

Matrix New World #18-802P

TerraSense, LLC #7783-19009

MTA MNR Metro
North Station Improvements (Purdy's Station)

TerraSense Analysis File: GrainSizeV4R4(11/17)

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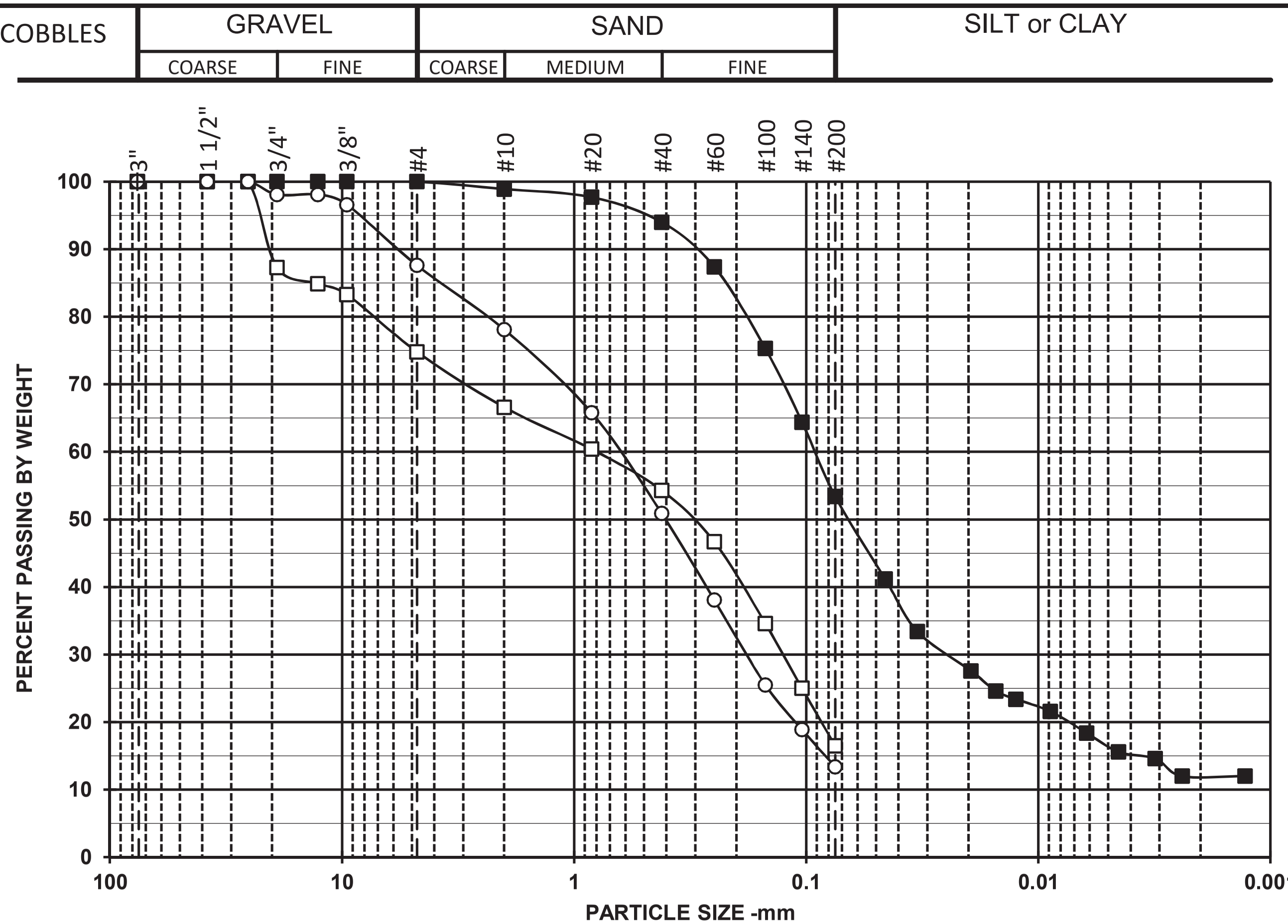

Symbol	□	■	○
Boring	P-2	P-2	P-2
Sample	S-4	S-6	S-9
Depth	6-8	10-12	25-27
% +3"	0.0	0.0	0.0
% Gravel	25.2	0.0	12.4
% SAND	58.3	46.6	74.2
%C SAND	8.2	1.1	9.5
%M SAND	12.3	4.9	27.2
%F SAND	37.8	40.6	37.5
% FINES	16.5	53.4	13.4
D_{100} (mm)	25.400	4.750	25.400
D_{60} (mm)	0.803	0.091	0.641
D_{30} (mm)	0.126	0.024	0.180
D_{10} (mm)			
Cc			
Cu			

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	100.0
4"	100.0	100.0	100.0
3"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0
1"	100.0	100.0	100.0
3/4"	87.3	100.0	98.1
1/2"	84.9	100.0	98.1
3/8"	83.3	100.0	96.6
#4	74.8	100.0	87.6
#10	66.6	98.9	78.1
#20	60.4	97.7	65.8
#40	54.3	94.0	50.9
#60	46.7	87.4	38.1
#100	34.6	75.3	25.5
#140	25.0	64.4	18.9
#200	16.5	53.4	13.4
5μ m		16	
2μ m		12	
1μ m		12	

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	9.8				SM		Gray, Silty sand with gravel	03/11/19
■	29.5				CL		Brown, Sandy lean clay	03/14/19
○	18.5				SM		Gray, Silty sand	03/11/19

Matrix New World #18-802P

TerraSense, LLC #7783-19009

MTA MNR Metro
North Station Improvements (Purdy's Station)

PARTICLE SIZE DISTRIBUTION

TerraSense Analysis File: GrainSizeV4R4(11/17)

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