



Vaughan Fire Station 7-12

9541 Weston Road, Woodbridge, Ontario

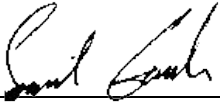
City of Vaughan
Final Geotechnical report
SEL Project No.20210932

June 8, 2022
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City of Vaughan

SEL Project No.20210932

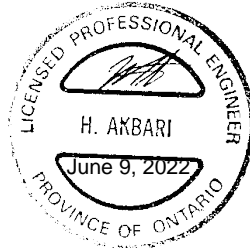
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Summary

Englobe Corp. has completed a geotechnical investigation for the proposed development of Vaughn Fire Station 7-12 in the City of Vaughan, Ontario. The investigation primarily consisted of borehole drilling, installation of monitoring, laboratory testing. Various engineering analyses were carried out for the site of the proposed facilities using methods considered suitable for more detailed conceptual design and feasibility assessment purposes. A description of the physical properties, cohesion and friction angles, soil constraints (rest, active and passive conditions), unit weights, and modulus of subgrade reaction for the various subsoil types are presented in the report. Recommendation for flexible and rigid pavement, sidewalk construction and floor slab are also discussed in the report. Both shallow and deep foundation were considered to support the proposed building. The bearing capacity under serviceability limit state and ultimate limit state using both type of foundations is presented in the report.

A total of fifteen (15) boreholes were advanced to depths ranging from approximately 4.4 m to 8.2 m below grade. The borehole investigations were carried out to determine the soil stratigraphy and assess the site groundwater conditions. A flexible pavement structure was observed at eleven (11) borehole locations. A surficial topsoil layer of an average depth of 0.2 m in thickness was encountered at four (4) borehole locations. The soil stratigraphy as revealed in the boreholes comprised primarily of a native sandy silt and silty sand. The sandy silt fill was encountered below the pavement structure and was generally in a loose to dense state with SPT 'N' values ranging from 7 to 40 per 300 mm penetration recorded. The silty sand was encountered under the sandy silt and was in a loose to very dense state with SPT 'N' values ranging from 7 to 73. A total of five (5) 50 mm monitoring wells were installed to determine the groundwater levels within the project limits. Groundwater was present in two (2) of the boreholes where monitoring wells were installed. The stabilized groundwater level ranges from 2.69 to 7.57 mbgs at the time of the investigation. It is likely that this water is perched within the soils at these levels.

In Englobe laboratory, the moisture content testing was carried out on all recovered granular and subsoil samples. Representative subsoil samples were collected in the field to assess the subsoil classifications and frost susceptibility characteristics. A total of six (6) sets of Atterberg Limits tests were completed on representative samples of the subsoil within the area. The results from the Atterberg test indicates that the subsoil is predominantly a clayey silt with a low degree of plasticity. The grain size distribution analysis on the ten (10) representative subsoil samples indicates that the subsoil is considered to have predominantly high susceptibility to frost heaving.

A conventional shallow foundation system utilizing strip/square footings founded on an engineered fill pad, and below all fill material and organic soils, is generally deemed to be suitable to support the structural loadings of the proposed type of buildings for this development. The frost penetration at the project site is approximately 1.2 m. All footings subject to frost action should be provided with a minimum of 1.2 m of soil cover. If the minimum required soil cover over foundation footings cannot feasibly be achieved, foundation insulation such as a 50-mm thick layer of extruded polystyrene rigid thermal insulation can be installed between the foundation element and the underlying subgrade soil.

Based on the borehole information, the subject site founded on the native soils can be classified as "Class D" for seismic site response.

The subsoil encountered at site contains more than one type of soil (Type 2 and Type 3). Excavations should be able to be carried out to the depths required for the installation of the various utilities using conventional excavation equipment. Seepage of ground or surface water can be control using conventional construction dewatering techniques; open pumping from properly constructed sumps

and/or ditches. Provision for trench plugging can also be considered to address the potential influx of water. Considering the observed groundwater levels at the time of this investigation and the current anticipated maximum depth of excavation, a Permit to Take Water (PTTW) is not anticipated to be required for this project.

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If tests have been carried out, the results of these tests are valid only for the sample described in this report.

Englobe Corp.’s subcontractors who have carried out on-site or laboratory work are duly assessed according to the purchase procedure of our quality system. For further information, please contact your project manager.”

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1 Introduction

Englobe Corp. (Englobe) was retained by City of Vaughan to conduct a geotechnical investigation for the proposed development of Vaughn Fire Station 7-12 in the City of Vaughan, Ontario. The investigation was carried out at the request of Adriana Tantalo, B.Arch. Sci, PMP, Project Manager at the City of Vaughn in the Design and Construction, Facility Management.

It is understood that the City of Vaughan is developing a Fire Station on a parcel of land located at 9541 Weston Road, Woodbridge, Ontario. The site is located in the southeastern quadrant of the intersection of Weston Road and Ashberry Boulevard in Woodbridge, Ontario and is currently occupied with a paved parking lot and grassed area that is part of Vellore Hall Park. The current development plans include a two-storey building.

The purpose of this investigation was to explore the subsurface soil and groundwater conditions at the subject site and prepare a geotechnical report with geotechnical design parameters and recommendations pertaining to foundations, basement, shallow underground utility installation and trench backfill, and pavement structure.

In accordance with O.Reg. 406/19 separate reports are submitted for Assessment of Past Uses, Sampling and Analysis Plan, Soil Characterization and Soil Destination. The Assessment of Past Uses Report provides an overview on previous activities that were carried out at the project site and to identify potential environmental and contaminants concerns. The Sampling and Analysis Report includes the minimum frequency of sampling to comply with O.Reg. 406/19 to determine the concentration of contaminants in the excavated soil. The Soil Characterization Report describes in details the characterization of the soil including the quality and quantity of excess soil to be generated at the project site. The Soil Destination Report provides recommendations of where the materials are to be reused or disposed. It also details the volumes of soil to be received at the location and verify that the quality of the soil being sent at the site meets the standards applicable at that location.

Hydraulic conductivity and infiltration rates were not done because of the weather condition. These tests will be conducted as soon as there favorable weather conditions, and the results will be incorporated in the Final Report.



2 Project methodology

2.1 Field program

The fieldwork for this investigation was completed from January 13, 14 and 21, 2022 and involved the drilling of fifteen (15) boreholes (Boreholes BH01 through BH16, except BH14) to depths ranging from approximately 4.4 m to 8.2 m below grade. The borehole locations are shown in Appendix A. The field investigation was carried out in general conformance with the professional standards set out in the Canadian Foundation Engineering Manual (CFEM 2006, 4th Edition), applicable Ontario Regulations and ASTM International. The following is a summary of field investigation tasks:

- Public and private utility companies were contacted prior to the start of drilling activities in order to demarcate underground utilities on the site.
- The boreholes were advanced using a D-50 track-mounted drill rig equipped using a continuous flight solid stem augers equipment supplied and operated by Drilltech Drilling Ltd. under the supervision of an Englobe's drilling supervisor. The boreholes were logged by Englobe's geotechnical supervisor.
- All borehole locations and ground surface elevations were surveyed by Englobe. The boreholes were referenced to Universal Transverse Mercator North American Datum of 1983 (UTM NAD83) coordinates.

Table 1: Borehole Survey Details

Borehole ID	Northing	Easting	Elevation	Depth
BH01	4854296.61	615967.53	225.59	4.40
BH02	4854300.33	615988.76	225.01	4.40
BH03	4854305.11	616028.72	224.94	4.40
BH04	4854288.74	615980.07	225.40	8.20
BH05	4854296.05	616010.29	225.07	8.20
BH06	4854299.18	616019.58	224.95	8.20
BH07	4854281.30	615973.69	225.29	4.40
BH08	4854284.19	615997.34	225.16	8.20
BH09	4854275.65	615983.37	225.16	8.20
BH10	4854285.52	616013.24	225.06	8.20
BH11	4854275.36	616002.16	224.97	8.20
BH12	4854275.87	616022.48	225.02	8.20
BH13	4854286.17	616050.54	225.78	4.40
BH15	4854317.90	616043.57	224.85	4.40
BH16	4854334.48	616039.55	224.93	4.40

- Soil samples were recovered from the boreholes at regular depth intervals using a 50 mm outside diameter split spoon sampler in accordance with ASTM D1586 Standard Penetration Test (SPT). The recorded SPT N-values are provided on the borehole logs (Appendix B).
- Groundwater levels were measured in the open boreholes upon completion of drilling and the observations are noted on the borehole logs (Appendix B).
- Five (5) monitoring wells were installed in Borehole BH01, BH08, BH09, BH12, and BH15 to allow measurement of groundwater levels and analyse for infiltration rate. The monitoring wells were constructed using stick-up and threaded 50 mm diameter PVC pipe with 3.0 m long 10-slot well screens, delivered to the site pre-cleaned in individually sealed plastic bags. The screen and riser pipes were not allowed to come into contact with the ground or any drilling equipment prior to installation.
- Groundwater level measured in the monitoring wells on different dates are provided on the borehole log and summarized in Table 5.
- The boreholes were backfilled with soil cuttings and bentonite in accordance with Ontario Regulation 903 as amended, under the Ontario Water Resources Act.
- In-situ infiltration testing were completed at borehole BH15 on April 11, 2022 and in BH01 on May 25, 2022. Infiltration rates were determined using the One-Head Analysis as described in the Soil Moisture Equipment Corp. 2800K1 Operating Instructions (Dec. 2012).

2.2 Laboratory testing

The recovered subsoil samples were visually examined in the field and then preserved and transported to Englobe Toronto laboratory for examination and testing. In the laboratory, each soil sample was examined as to its visual and textural characteristics. Moisture content testing was completed on all recovered subsoil samples with the results plotted on the borehole logs. In addition, Englobe selected representative subsoil samples and completed grain size and hydrometer analyses to assess the subsoil permeability and frost susceptibility characteristics. A summary of the type and number of tests carried out during this stage, is provided in Table 2. The complete laboratory test results are presented in Appendix C.

Table 2: Summary of laboratory testing conducted for soil classifications

Geotechnical Laboratory Test	Applicable Standard	No. of tests
Natural Moisture Content	ASTM D2216	114
Particle Size Distribution (Sieve and Hydrometer)	ASTM D6913 / ASTM D7928	10
Atterberg Limits	ASTM D4318 10e1	6



3 Description of subsurface Condition

Details of the subsurface conditions encountered during the field investigation are presented on the borehole logs (provided in Appendix B) and summarized, in the following sections. Summaries of the subsurface stratigraphy, and depths of different soil layers encountered in the boreholes, are presented in Table 3.

It should be noted that the boundaries between strata have been inferred from observations made during drilling. The strata boundaries generally represent a transition from one soil type to another and should not be inferred to represent an exact plane of geological change. Conditions may vary between and beyond the borehole locations.

Table 3: Summary of Generalized Stratigraphy Encountered in the Boreholes with Elevations (m)

	Topsoil (or Fill)	Asphalt Concrete	Sand & Gravel	Native Sandy Silt	Native Sandy Silty Clay	Native Silt	Native Silty Sand	Clayey Silt	Clayey Sandy Silt
BH01	-	225.6 - 225.5	225.5 - 225.3	225.3 - 223.4	-	223.4 - 221.2 (EOB)	-	-	-
BH02	-	225.0 - 224.9	224.9 - 224.8	-	-	224.4 - 220.6 (EOB)	224.8 - 224.4	-	-
BH03	-	224.9 - 224.8	224.8 - 224.7	224.7 - 222.0	-	-	222.0 - 220.5 (EOB)	-	-
BH04	225.4 - 225.2	-	225.2 - 225.1	225.1 - 223.2	-	-	223.2 - 217.2 (EOB)	-	-
BH05	-	225.1 - 225.0	225.0 - 224.8	224.8 - 222.8	-	-	222.8 - 218.4	218.4 - 216.8 (EOB)	-
BH06	-	225.0 - 224.9	224.9 - 224.7	224.7 - 222.1	-	-	222.1 - 218.3	218.3 - 216.7 (EOB)	-
BH07	-	225.3 - 225.2	225.2 - 225.0	225.0 - 223.1	-	-	223.1 - 220.9 (EOB)	-	-
BH08	-	225.2 - 225.1	225.1 - 224.8	224.8 - 223.8	-	223.8 - 218.5	-	-	218.5 - 216.9 (EOB)
BH09	-	225.2 - 225.1	225.1 - 224.8	224.8 - 222.9	-	-	222.9 - 216.9 (EOB)	-	-
BH10	-	225.1 - 224.9	224.9 - 224.7	224.7 - 223.7	-	-	223.7 - 218.4	218.4 - 216.8 (EOB)	-
BH11	-	225.0 - 224.9	224.9 - 224.7	-	-	224.7 - 216.7 (EOB)	-	-	-
BH12	-	225.0 - 224.9	224.9 - 224.8	222.8 - 222.1	-	-	222.1 - 218.3	224.8 - 222.8	218.3 - 216.8 (EOB)
BH13	225.8 - 225.6	-	225.6 - 225.4	-	-	-	-	-	225.4 - 221.4 (EOB)
BH15	224.8 - 224.6	-	-	-	224.6 - 220.4 (EOB)	-	-	-	-
BH16	224.9 - 224.7	-	-	-	-	-	-	224.7 - 220.5 (EOB)	-

3.1 Pavement structure and subsurface conditions

3.1.1 Pavement structure

A flexible pavement structure was encountered at eleven (11) of the borehole locations. within the project limits. The asphalt thickness ranges from 80 to 110. The granular base/ subbase material at the borehole locations consisted of sand and gravel that ranges from 120 mm to 300 mm. The in-situ moisture content of this material ranged from 8 to 26 percent (moist to wet).

The average pavement structure thicknesses including thickness ranges are summarized in Table 4.

Table 4: Summary of existing pavement structure

No. of Observations	Asphaltic Concrete (mm) Range (Average)	Granular Base/Subbase (mm) Range (Average)
Eleven (11) boreholes	80 to 110 (105)	120 to 300 180

3.1.2 Topsoil

A surficial topsoil layer of an average depth of 0.2 m in thickness was encountered in BH04, BH13, BH15 and BH16. Beneath the topsoil, native deposits of sandy silty clay and silty clay till was encountered in BH15 and BH16, respectively. Granular material was found below the topsoil layer in BH04 and BH13.

3.1.3 Native sandy silt

The subsoil at the borehole locations within the project limits predominantly consisted of sandy silt. This material was encountered below the pavement structure. The sandy silt was generally in a loose to dense state with SPT 'N' values ranging from 4 to 49 per 300 mm penetration recorded. The natural moisture content of this material ranged from 11 to 20 percent (moist to wet).

3.1.4 Native silt

Silt deposit was encountered below the native sandy silt fill in BH01, BH02, BH08 and under the pavement structure in BH11. This material extended to the depth of exploration in these boreholes except BH08. The native silt was generally in a compact to very dense state with SPT 'N' values ranging from 10 to 71 per 300 mm penetration recorded. The natural moisture content of this material ranged from 9 to 22 percent (moist to wet).

3.1.5 Native silty sand

The subsoil below the sandy silt predominantly consisted of silty sand and generally extended to the depth of exploration. The sandy silt deposit was generally in a loose to very dense state with SPT 'N' values ranging from 7 to 73 per 300 mm penetration recorded. The natural moisture content of this material ranged from 6 to 23 percent (moist to wet).

3.1.6 Clayey silt/Silty Clay

Clayey silt was encountered below the silty sand in BH05, BH06, BH10, and BH12 and extended to the depth of exploration. In BH 12 and 16, Clayey silt was encountered below the pavement structure and topsoil respectively. It extended to the depth of exploration in BH12. The clayey silt was generally in a firm to hard state with SPT 'N' values ranging from 6 to 32 per 300 mm penetration recorded. The natural moisture content of this material ranged from 9 to 20 percent (moist to wet).

3.1.7 Clayey sandy silt

Clayey sandy silt was encountered below the cohesionless deposit in borehole BH8, 12 and 13 respectively. This material extended to the depth of exploration in these three boreholes. The clayey sandy silt till was generally in a loose to compact state with SPT 'N' values ranging from 4 to 21 per 300 mm penetration recorded. The natural moisture content of this material ranged from 6.7 to 17.6 percent (moist).

3.2 Ground water measurement

Five (5) 50mm monitoring wells were installed in BH01, BH08, BH09, BH12 and BH15 to record the stabilized ground water level. The monitoring wells were each constructed by installing a 1.5 m length with 50 mm diameter slotted, schedule 40 PVC well screen and riser pipes of various length into the open auger holes. The annular space around the screen was filled with clean filter sand (up to approximately 0.3 m above the top of the screened section) with bentonite seals then placed above the sand pack to prevent the infiltration of surface water. The top of all the wells riser pipes were vented to allow the groundwater levels to stabilize, and flush mount/ stick-up protective casings set in concrete were installed at each of the monitoring well location.

Groundwater was present in two (2) of the boreholes where monitoring wells were installed after completion. To measure the stabilized groundwater level at the site, water readings were taken after completion of drilling. Two stabilized water level readings were taken at the well locations as shown in the Table 5. Groundwater levels finding are summarized in Table 5. Details of the groundwater conditions encountered at the monitoring well and other borehole locations are provided on the borehole logs in Appendix B.

Table 5: Water level measurements

Borehole No.	Ground Surface Elevation (m)	Groundwater depth					
		Date	Elevation (m)	Date	Elevation (m)	Date	Elevation (m)
BH01	225.6	January 14, 2022	Dry	February 14, 2022	Dry	February 24, 2022	4.0/221.6
BH08	225.2	January 13, 2022	7.6/217.6		7.6/217.6		Dry
BH09	225.2	January 13, 2022	Dry		Dry		7.7/217.5
BH12	225.0	January 21, 2022	Dry		Dry		7.6/217.4
BH15	224.8	January 21, 2022	2.7/222.1		2.7/222.1		1.3/223.5

It is important to note that the groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the report. These elevations and conditions

may vary locally due to seasonal fluctuations, groundwater regimes encountered at the site or as a consequence of construction activities on the site or adjacent sites.

It should be noted that the groundwater level could rise over time and fluctuate seasonally (potentially up to 1 m) in response to climatic conditions. Some seepage of groundwater from permeable layers within the soil profile should also be anticipated during construction. Seepage of ground or surface water can be control using conventional construction dewatering techniques; open pumping from properly constructed sumps and/or ditches. Provision for trench plugging can also be considered in order to address the potential influx of water.

Dewatering effort required will depend on several factors, including excavation depth, season and weather conditions and the length of time the excavation is left open. Considering the observed groundwater levels at the time of this investigation and the current anticipated maximum depth of excavation, the volumes of water anticipated to be involved in dewatering during construction are not expected to exceed 50,000 L/day. A Permit to Take Water (PTTW) is not anticipated to be required for this project.

3.3 Laboratory testing results

A comprehensive laboratory testing program was completed to aid in the confirmation of soil descriptions and the characterization of the recovered soil samples. In Englobe laboratory, moisture content testing was carried out on all the recovered granular base/subbase and subsoil samples. Gradation analyses were performed on ten (10) selected soil samples. Atterberg Limits test was performed on six (6) selected fine-grained soil samples. The in-place liquid limit, plastic limit, and plasticity index of this sample are summarized in Table 5.

3.3.1 Sieve and hydrometer

A total of ten (10) gradations (sieve and hydrometer) were completed on representative samples of the subsoil. Based on the grain size distribution analysis on the ten (10) selected samples of the subsoil; the subsoil is considered to have predominantly high susceptibility to frost heaving. A summary of the gradations results is shown in Table 6 with the detail laboratory results provided in Appendix C. In addition, the results are presented on the borehole logs in Appendix B.

Table 6: Summary of Laboratory Particle Size Distribution Results

Borehole/ Sample	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	ASTM Unified Soil Classifications	Susceptibility to frost heave
BH01/SS5	3.7	0	0	90.7	9.3	Silt, trace clay	High
BH02/SS3	2.1	0	0.9	91.2	7.9	Silt, trace clay	High
BH08/SS7	5.2	0	13.8	78.3	7.9	Silt, some sand, trace clay	High
BH09/SS8	6.7	1.4	19.2	46.0	33.4	Clay and silt, some sand	Moderate
BH10/SS4	2.8	0	5.5	88.0	6.5	Silt, trace clay, trace sand	High
BH11/SS2	1.9	0	0	87.7	12.3	Silt, some clay	High
BH12/SS7	5.7	0	68.9	23.8	7.3	Silty sand, some clay	Low

Borehole/ Sample	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	ASTM Unified Soil Classifications	Susceptibility to frost heave
BH13/SS1	0.6	0.3	25.2	43.7	30.8	Sandy clayey silt	Moderate
BH15/SS5	3.7	2.7	18.2	37.0	42.1	Clay and silt, some sand	Low
BH16/SS3	2.1	0	10.4	65.6	24.0	Clayey silt, some sand	High

3.3.2 Atterberg limits

A total of six (6) sets of Atterberg Limits tests were completed on representative samples of the subsoil within the area. The in-place liquid limit, plastic limit, and plasticity index of this sample are summarized in Table 7. Based on the results, the subsoil test is predominantly a clayey silt with a low degree of plasticity.

Table 7: Summary of Laboratory Particle Size Distribution of subsoil

Borehole/ Sample	Depth (m)	Plastic Limit (%)	Liquid Limit (%)	Plastic Index (%)	Plasticity
BH05/SS8	6.7	11.2	18.3	7.1	CL+ML
BH06/SS8	6.7	12.5	20.3	7.8	CL+ML
BH08/SS8	6.7	12.4	20.8	8.4	CL+ML
BH10/SS8	6.7	13.4	20.1	6.7	CL+ML
BH12/SS8	6.7	12.0	18.8	6.8	CL+ML
BH15/SS5	3.7	11.9	23.1	11.2	CL

3.3.3 Soil infiltration test result

The in-situ infiltration testing near Borehole BH15 and BH1 at 1.0 m depth were completed on April 11, 2022 and May 25, 2022 respectively, on the underlying silty clay. The soil description is based on visual inspection of the soils encountered at the time of excavation and will be confirmed by laboratory tests.

Infiltration rates for BH15 were determined using the One-Head Analysis as described in the Soil Moisture Equipment Corp. 2800K1 Operating Instructions (Dec. 2012). This method is expressed by the following equation:

$$K_{fs} = \frac{C_1 Q_1}{2\pi(H_1)^2 + \pi a^2 C_1 + 2\pi \left(\frac{H_1}{\alpha^*} \right)}$$

Where:

Kfs =Field saturated hydraulic conductivity (entrapped air present) (cm/sec)

C1 = Shape factor

Q1 = Discharge from combined reservoir (cm³/min)

H1 = Well height (cm)

a = Well radius (cm)

α^* = Soil texture (cm⁻¹)

Field saturated hydraulic conductivities have been indirectly measured using the Guelph Permeameter. One (1) test was completed at the site allowing for pre-soaking of the initially unsaturated soils encountered. This hydraulic conductivity is measured when ponded water is allowed to infiltrate into an initially unsaturated soil.

Infiltration rates for BH1 was estimated using a datalogger that records the instant water level change. In this method water was poured into the well and left to percolate into the soil while having the datalogger lowered at the bottom of the well, recording the water level rise and fall. The following expression was used to calculate the hydraulic conductivity (Hvorslev's Method, Applied Hydrogeology 4th Edition. C.W. Fetter, Prentice-Hall Inc., 2001).

$$K = \frac{r^2}{2LT_0} \ln \left[\frac{L}{R} \right]$$

Where:

K = hydraulic conductivity (m/s)

L = length of the screen, 3.05 m

R = radius of the borehole:

- Hollow Stem Auger, 0.1048 m

r = radius of the well casing, 0.0254 m

T₀ = basic time lag in seconds

The estimated infiltration rate is based on recommendations found in the "Low Impact Development Stormwater Management Planning and Design Guide, Appendix C", published by the Toronto and Region (TRCA) and the Credit Valley (CVC) Conservation Authority, and the assumed relationship between hydraulic conductivity and infiltration rate. It should be noted that hydraulic conductivity and infiltration rate are two different concepts and that conversion from one parameter to another must account for the hydraulic gradient and consequently cannot be done through unit conversion. A factor of safety of 2.5 was applied to the approximate infiltration rate to account for soil variability, gradual accumulation of fine soil sediments during the lifespan of the facility, and compaction during construction. The field measured hydraulic conductivities and estimated factored infiltration rates assuming a favourable hydraulic gradient of 1 is presented in Table 8 below. The infiltration computations are presented in Appendix D.

Table 8: Summary of infiltration rate calculations

Borehole No.	Test depth (m)	Soil type	Field saturated K-value (cm/sec)	Factored infiltration rate (mm/hr)
BH15	1.0	Silty Clay	4.74E-05	15.2
BH1	1.0	Silt	6.70E-05	16.6

4

4 Discussion and Recommendations

4.1 Suggested Geotechnical Parameters

The following recommendations are intended for the City of Vaughan, with any reliance on this report by other parties at their sole risk. If significant differences or changes in subsurface soil and groundwater conditions are found at the time of construction, Englobe should be contacted immediately in order to review and revise the following recommendations, as required.

Englobe recommends the general geotechnical engineering design parameters summarized in Table 9 for the subsoils encountered across the site. These values are based on observations recorded during the drilling program and the results of the geotechnical index testing, and Englobe's local experience.

Table 9: Suggested parameters for geotechnical analysis

Soil type	Unit Weight, γ (kN/m ³)	Effective Friction Angle, ϕ' (°)	Cohesion, c_u (kPa)	K_0	K_a	K_p
Loose to compact sandy silt/silt	18	30	-	0.50	0.33	3.00
Compact to very dense silty sand	19	32	-	0.47	0.31	3.25
Soft to hard silty clay to clayey silt	20	26	5	0.56	0.39	2.56

Note:

(1) K_0 : Coefficient of at-rest lateral earth pressure

(2) K_a : Coefficient of active earth pressure

(3) K_p : Coefficient of passive earth pressure

(4) Each of the three earth pressure coefficients above have been calculated for an assumed level backfill surface. Earth pressure coefficients should be re-calculated if slope of backfill is to exceed 10° from the horizontal.

4.2 Foundation

4.2.1 Shallow foundation

Preliminary foundation design parameters are provided in this report for static, vertically and concentrically loaded foundations in compression, unless specifically noted otherwise. All foundation design recommendations presented in this report should be considered preliminary in nature for feasibility and volume considerations and subject to refinements and change during subsequent supplementary analysis during more detailed design stages of the project. In addition, all recommendations assume that an adequate level of construction monitoring during foundation excavation and installation will be provided. An adequate level of construction monitoring is considered to include:

- For shallow foundations, examination of all excavation surfaces before engineered fill placement to ensure the suitability of the subgrade; and
- For earthwork, full-time monitoring and compaction testing or engineered fill below footings.

Based on OPSD 3090.000 “Foundation Frost Depths for Southern Ontario”, the frost penetration at the project site is approximately 1.2 m. A conventional shallow foundation system utilizing strip/square footings founded on an engineered fill pad, and below all fill material and organic soils, is generally deemed to be suitable to support the structural loadings of the proposed type of buildings for this development.

The topsoil must be removed from all new foundation areas. Footings must be founded on the native silty sand/sandy silt or on engineering fill. In area where the silty clay or clayey silt is encountered, it recommended that the existing inorganic native soil is removed at the footing locations and a granular pad (extending 0.5 m width on either side of the footing) shall be placed with minimum thickness of 1.0 m below the foundation depths. The static groundwater table shall be lowered at least 1.0 below the base of the proposed footings. A maximum total length of 10 m was considered for estimation of the strip footing geotechnical resistances.

Strip and spread footings can be designed using limit state static bearing pressures listed in Table 10. These values assumed that the width of the foundation is not smaller than 1 m. For these estimated bearing pressure to be realized, minimum soil covers of 1.2 m are required above the footing. A minimum distance of one footing width is also required between adjacent footings. The geotechnical resistance of the proposed granular pad can be estimated for the ultimate limit state (ULS) and serviceability limit state (SLS) for a maximum settlement of 25 mm. The geotechnical resistance at ULS was calculated by applying load resistance factor of 0.5 according to the 2006 Canadian Foundation Engineering Manual (4th Edition).

Table 10: Geotechnical resistance and reactions of strip and square footing

Possible Bearing Strata	Depth of footing, D, m	Recommended geotechnical bearing resistance, kPa	
		Factored ULS	SLS for maximum 25 mm settlement
Native Sandy silt to silt (Loose)	1.5	165	110
Native Sandy Clayey Silt to Silty Clay (CL) (Stiff to Very Stiff)	2.0	300	200

Possible Bearing Strata	Depth of footing, D, m	Recommended geotechnical bearing resistance, kPa	
		Factored ULS	SLS for maximum 25 mm settlement
Native Sandy silt to silty sand (Compact)	2.5	375	250

Note: Subject to satisfactory site-specific settlement checks and necessary adjustments for each individual footing during detailed design stage

It should be noted that where unsuitable (e.g., peat/organic soil and others) or unstable (e.g., disturbed during excavating) soils are encountered during construction; the foundation soils must be removed and replaced with engineered fill to the foundation grade. The unsuitable material should be excavated, under the direction of a geotechnical engineer, to competent subgrade and then backfilled either with Granular 'B' Type I material compacted to 100% standard Proctor maximum dry density (SPMDD) or with a lean concrete mix. The footprint of such removal of weak soils and replacement with engineered fill, should be considered on a case-by-case basis depending on depths required for removal so that bearing pressures can be distributed accordingly.

As previously stated, the granular pad below footings, or for engineered fill to raise site grade below footings, should comprise of Granular 'B' Type I material meeting Ontario Provincial Standard Specifications (OPSS). The engineered fill should be placed and compacted in an unfrozen condition and the subgrade should always be protected from frost penetration. The material should be compacted to 100% standard Proctor maximum dry density (SPMDD). Engineered fill below footings shall be placed immediately upon excavation and subgrade approval, using equipment compatible with lift thicknesses suitable based on-site conditions, and generally in level consistently placed lifts not exceeding 300 mm in thickness.

Bearing areas will require very careful preparation. Following excavation, all bearing surfaces should be cleaned of all organic, loose, disturbed, or slough material prior to concreting or placing compacted engineered fill. Bearing surfaces should be protected at all times from rain, freezing temperatures and the ingress of groundwater before, during, and after construction. All foundation excavations and bearing surfaces should be inspected by a qualified geotechnical engineer to confirm the suitability of bearing surfaces and to confirm that the resistances provided in this report are consistent with what is observed during construction inspection.

Backfill against foundation walls should consist of granular backfill such as Granular B Type I compacted to at least 95% of the SPMDD. Backfill for foundation walls should be placed a minimum of 50 mm above finished exterior grade and sloped 2 percent away from the building envelope to prevent long term surface drainage into the footings.

4.2.2 Excavation Considerations

All excavations must be carried out in accordance with the Ontario Occupational Health and Safety Act (OHSA). The consistency of the subsoils encountered ranges from loose to very dense. In accordance with OHSA criteria 226 the subsoil encountered at site would typically be considered:

- Type 2 - Moist, dense to very dense silty sand/sandy silt/silt
- Type 3 - Moist, stiff to firm clayey silt
- Type 3 - Moist, loose to compact silty sand/sandy silt/silt

All wet and/or disturbed material, or other obviously objectionable material such as organics, should be sub-excavated to the depths required for placement of the watermain bedding. If an excavation contains more than one type of soil, the soil shall be classified as the type with the highest number as per section 227.3 of O.Reg.213/91. Every excavation that a worker may be required to enter shall be

kept reasonably free of water. Care should be taken to direct surface runoff away from open excavations. Based on the field evaluation of the subsurface conditions excavations for all footings must be cut back at side slopes of 1H:1V. Excavation side slopes may require further flattening in zones of persistent seepage. If it is not possible to cut back the excavation side slopes due to space restrictions, it is recommended the excavations be undertaken within the confines of an engineered support system designed and installed in accordance with OHSA.

Surface surcharges (such as stockpiles or excavated soils) should not be placed closer to the edge of the excavation than a distance equal to twice the depth of the excavation, unless the excavation support system has been designed to accommodate such surcharge.

Attention should be paid to structures or buried service lines close to the excavation. A general guideline is that the extent of the proposed excavation should not intersect a line originating from the foundation base of an adjacent structure projected 30 degrees downward from the horizontal. If this cannot be avoided, underpinning or special shoring techniques may be required to avoid producing potentially damaging earth movements.

A pre-construction condition survey of nearby buildings, infrastructure (such as roadways, underground services) and any other settlement sensitive structures should be undertaken prior to the start of construction activities.

4.3 Subgrade preparation, engineering fill construction and compaction

Prior to preparation of a new subgrade, the footprint area should be stripped of any existing topsoil, existing asphalt pavements, organic material, deleterious material and removing any disturbed material. Any soft, loose, or otherwise unsuitable material revealed by proof rolling or inspection of the native sub-grade stratum should be sub-excavated, removed and replaced with approved fill soil material and compacted as per the recommendations below. Approved fill materials comprise debris-free, inorganic granular material or imported granular material meeting Granular "A" or Granular "B" Type II specifications in accordance with Ontario Provincial Standard Specification (OPSS) 1010. The prepared subgrade should then be proof-rolled and inspected by a qualified geotechnical professional prior to the placement of bulk fill to raise the site grades.

Engineered fill supporting foundations or slabs-on-grade should extend beyond the face of the footing/slab by a distance equal to not less than the depth of fill. Engineered fill for foundations and hardscapes should be placed in maximum 250 mm thick loose lifts and compacted to minimum 100% SPMDD. Foundation backfill material should be placed in the same manner and compacted to minimum 98% SPMDD. It should be noted that the lift thickness for engineered fill depends on type/size of compactor, if heavier size compactor can not be accommodated the lift thickness should be reduced to 150 mm.

Final site grading should be provided to direct water to areas remote from all proposed structures and hardscapes. Minimum landscape gradients of 2% are recommended to reduce the risk of runoff ponding in localized areas.

Engineered fill and subgrade preparation should take place in favourable weather conditions. If work is carried out during freezing temperatures, all material affected by frost must be removed prior to placement of frost-free engineered fill material.

4.4 Groundwater Control

Given the observed short-term groundwater level, at the time of the field investigation, the static and elevated groundwater levels is expected to be close or below the depths of excavation for footings.

Minor seepage should generally be anticipated during any excavations in the relatively permeable silt to sand (granular) materials near surface. It should be possible to control and remove any such groundwater seepage using conventional filtered sump pump techniques. Nevertheless, it should be noted that the required dewatering effort will depend on several factors, including excavation depth, season and weather conditions and the length of time the excavations are to be left open.

4.5 Frost Protection and Foundation Insulation Requirements

Based on OPSD 3090.000 “Foundation Frost Depths for Southern Ontario”, the frost penetration at the project site is approximately 1.2 m. All footings subject to frost action should be provided with a minimum of 1.2 m of soil cover. If the minimum required soil cover over foundation footings cannot feasibly be achieved, foundation insulation is an acceptable alternative. Where soil cover is deemed to be inadequate, Englobe generally recommends that a 50-mm thick layer of extruded polystyrene rigid thermal insulation be installed between the foundation element and the underlying subgrade soil. The insulation sheets are recommended to be placed with at least 600 mm of soil cover and to extend laterally in all directions at least 1800 mm beyond the foundation. The insulation recommendation from the manufacture shall be incorporated in the foundation insulation design.

4.6 Seismic site classification

Based on the borehole information and according to Table 4.1.8.4.A of Ontario Building Code (OBC 2012), the subject site founded on the native soils can be classified as “Class D” for seismic site response.

The OBC 2012 requires a Seismic Site Class for calculations of earthquake design forces based on a two percent probability of exceedance in 50 years. In accordance with OBC 2012, the Seismic Site Class can be classified based on the average properties of the subsoil strata to a depth of 30 m below the ground surface. The information obtained in the geotechnical field investigation was gathered from the upper 4.4 m to 8.2 m of strata.

Englobe can provide a site-specific measurement such as shear wave velocities to a depth of 30 m below ground surface, to further refine the seismic site class classification if warranted. Englobe utilizes a geophysical technique (Multi-channel Analyses of Surface Waves, or MASW) for direct measurement of shear wave velocity profiles with depth.

4.7 Pavement Structures

4.7.1 Flexible pavement

The existing asphalt, granular materials, foundations and slabs, any existing surficial vegetation, and organic soil should be removed from below the pavement areas and if required, grades should be raised with approved granular fill. The subgrade should be thoroughly proof rolled with a smooth drum vibratory roller. The subgrade fill should be placed in 150 mm thick lifts and compacted to 100% SPMDD.

The flexible pavement component thicknesses in Table 12 are recommended based on the anticipated light-duty and heavy-duty pavement usage, the frost-susceptibility, and strength of the subgrade soils.

Table 11 Flexible Pavement Component Thicknesses

Pavement Component	Light Duty Thickness mm	Heavy Duty Thickness mm
Hot-Mix Asphalt Surface course (SP 12.5/HL3)	40	40
Hot-Mix Asphalt Binder course (SP 19.0/HL8)	50	80
Granular A Base Course	150	150
Granular B Type II Subbase Course	300	300

Samples of both the Granular A and Granular B aggregates should be checked for conformance to OPSS.MUNI 1010 prior to utilization on site and during construction. The Granular B Type II subbase and Granular A base courses should be placed in maximum 150 mm thick lifts and must be compacted to 100% SPMDD, as verified by insitu density testing.

The hot-mix asphalt paving materials should conform to the requirements of OPSS.MUNI 1150. The asphalt should be placed and compacted in accordance with OPSS 310. Performance graded asphalt cement (PGAC) 64-28 should be utilized in the hot mix asphalt in accordance with the recommendations of OPSS.MUNI 1101.

The subgrade and granular courses will lose their strength to support traffic loads if allowed to become wet due to surface water or groundwater infiltration; therefore, drainage of the pavement and the granular courses is essential. In order to provide proper drainage for the pavement structure, it is recommended that subdrains be installed to intercept and remove excess subsurface moisture. Where required the subdrains should be placed parallel to the parking lot edges and positively sloped to frost free outlets (OPSS.MUNI 405 and OPSD 216.021). The finished pavement surface and underlying subgrade should be free of depressions and should be sloped to provide effective drainage. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas.

The need for continuous paving supervision by a qualified pavement technician, and quality control testing during pavement construction cannot be over emphasized. All materials and construction services required for the work should be in accordance with the applicable sections of the Ontario Provincial Standard Specifications.

4.7.2 Concrete pavement

We understand that City will construct some areas with rigid pavement for vehicle. Englobe recommend the following rigid pavement thicknesses listed in Table 12.

Table 12 Rigid Pavement Component Thicknesses

Pavement Component	Concrete Paving Thickness mm
Concrete	250
OGDL (Open Graded Drainage Layer)	100
Granular "A" Base	200

The proposed concrete pavement is recommended to be constructed as follows:

- Mill/excavate the existing asphalt full depth (ranging between 80 and 110 mm) and dispose off-site. The existing asphalt concrete millings may be re-used as reclaimed asphalt pavement (RAP) in recycled hot-mix asphalt mixtures. Where require strip the existing top soil/ any unsuitable underline material to full depth;
- Excavate the existing granular fill material and subgrade to a depth of 550 mm below ground surface to accommodate the new pavement structure and dispose the excavated material off-site;
- Install new subdrains for improved drainage in accordance with OPSD 207.041;
- Proof-roll the exposed sub-grade material to identify "weak zones/soft area" under the supervision of a qualified geotechnical engineer. In weak areas excavate granular to competent subgrade and replace with new Granular B, Type I and compact to 100% of the materials' Standard Proctor Maximum Dry Density (SPMDD). The minimum depth of soft spot repairs is typically 450 mm;
- Place a minimum of 200 mm Granular A (OPSS 1010) sub-base course on the prepared subgrade in conformance with TS1010, compact to 100% of the material's Standard Proctor Maximum Dry Density (SPMDD) and provide the required crossfall. It should be noted that excessive rolling using heavy rollers and/or dynamic compaction can lead to subgrade softening;
- Place curbs and gutters;
- Place 100 mm OGDL (Open Graded Drainage Layer), curb to curb
- Place 250 mm of Jointed Plain Concrete Pavement d cement concrete. The concrete should satisfy the requirements of CAN/CSA A 23 -1.00 Class C2 concrete with a minimum compressive strength of 32 MPa and a minimum flexural strength of 4.8 MPa. Control joints in the new Portland cement concrete shall be spaced at 4.5 m. The dowels shall be 35 mm diameter glass-fibre reinforced polymer (GFRP), 450 mm long spaced at 300 mm. Proper joint spacing and construction techniques are critical when constructing a durable concrete pavement. Joints should be constructed in accordance with OPSD 551 and 552. For concrete base specification, Dowel Detail, Joint details, concrete joint layout and joint spacing, please refer to OPSS 350, OPSD 552.051, 552.010, 551.031 and 551.010, respectively.

4.8 Sidewalk Construction

The concrete sidewalk should be constructed using the following procedure.

- Remove the existing topsoil/ any unsuitable underline material to a depth of 275 mm below the proposed finished sidewalk surface. The width of the excavation should be sufficient to accommodate a minimum finished sidewalk width of 2 m as per OPSD 310.010, Concrete Sidewalk;
- Regrade and compact the exposed subgrade to achieve 2 to 4 percent crossfall toward the curb and gutter;
- Place 150 mm of new OPSS 1010 Granular A material. The granular material should be compacted to 100 percent Standard Proctor Maximum Dry Density, noting that excessive rolling using heavy rollers and/or dynamic compaction can lead to subgrade softening, and graded to maintain 2 to 4 percent crossfall toward the existing curb and gutter;
- Place 125 mm of portland cement concrete (PCC) in accordance with OPSD 310.010 and conforming to OPSS 1350 specifications, except for driveways where the thickness shall be 150 mm.

4.9 Floor Slab and Permanent Drainage

The existing fill is not considered suitable to support slab-on-grade construction without further site-specific field evaluations and appropriate and necessary ground improvements. For the design of the floor slabs on native soils or engineered fill, a modulus of subgrade reaction of $k = 25 \text{ MPa/m}$ can be used.

A moisture barrier consisting of at least 200 mm of 19 mm clear crushed stone should be installed under the floor slabs.

For structures with a basement or partial basement area, a perimeter drainage system and underfloor drainage will be required around the exterior basement walls. Perimeter drainage is not considered to be necessary for areas without basement if the floor slab is more than 300 mm higher than the exterior grade.

4.10 Underground Utilities

It is understood that underground utility will be installed as a part of the site development. Design drawings or invert levels of the proposed utilities are not available to us at the time of writing this report.

4.10.1 Pipe Bedding

The contacted fill and any encountered very loose/loose native mineral soils may not be suitable to support the proposed pipes without undergoing possible detrimental post-construction settlement. Any organic material (topsoil, peat), fill and/or any encountered loose native mineral soils must be removed from below the pipe invert. Sub excavated fill or loose native soils should be replaced with OPSS.MUNI 1010 Granular A to ensure adequate support for the pipe. The fill should be placed in 150 mm thick lifts and compacted to a minimum 95% SPMDD. The compact to very dense native mineral soils or well compacted granular fill are generally considered suitable for support of buried pipes.

The pipe bedding for the services should be conventional Class B pipe bedding comprising a minimum 150 mm thick layer of OPSS.MUNI 1010 Granular A aggregate below the pipe invert. The bedding course may be thickened if portions of the subgrade become wet during excavation. OPSS.MUNI 1010 Granular A type aggregate should be provided around the pipe to at least 300 mm above the top, and the bedding should be compacted to 95% SPMDD. Service lines installed outside of heated areas should be provided with a minimum 1.2 m of soil cover or equivalent insulation for frost protection.

4.10.2 Backfilling of Trenches

The trenches above the specified pipe cover material should be backfilled with inorganic soils that are not excessively wet, placed in 150 mm thick lifts, and compacted to at least 95% SPMDD. Where the service trenches enter the building, the trench backfill must be compacted as structural fill to a minimum of 100% SPMDD. Any trench backfill below a pavement structure should be compacted to 100% SPMDD within 1 m from the top of subgrade level.

Organic material (topsoil) and fill containing debris (asphalt, concrete, plastic, etc.) are not considered suitable for reuse as trench backfill and if encountered, shall be separated. Inorganic fill may be suitable for reuse on-site following approval by a geotechnical engineer/technician and should be stockpiled separately. Based on the results of insitu moisture content tests carried out on the fill and native overburden deposits, the existing inorganic fill and native soil deposits from above the groundwater table will be geotechnically suitable for reuse as trench backfill. Any overly wet material may require air drying or may need to be excluded from the backfill material.

To minimize potential problems, backfilling operations should follow closely after excavation so that only a minimal length of trench is exposed. Care should be taken to direct surface runoff away from the excavations. Should construction extend into the winter season then backfilling operations should be planned to ensure that backfill material is kept to a minimum and ensured that frozen material is not used as backfill.

Particular attention must be made to backfilling service connections where the trenches are narrow. If work is carried out during very dry weather, then water could be added to the backfill to improve compaction.

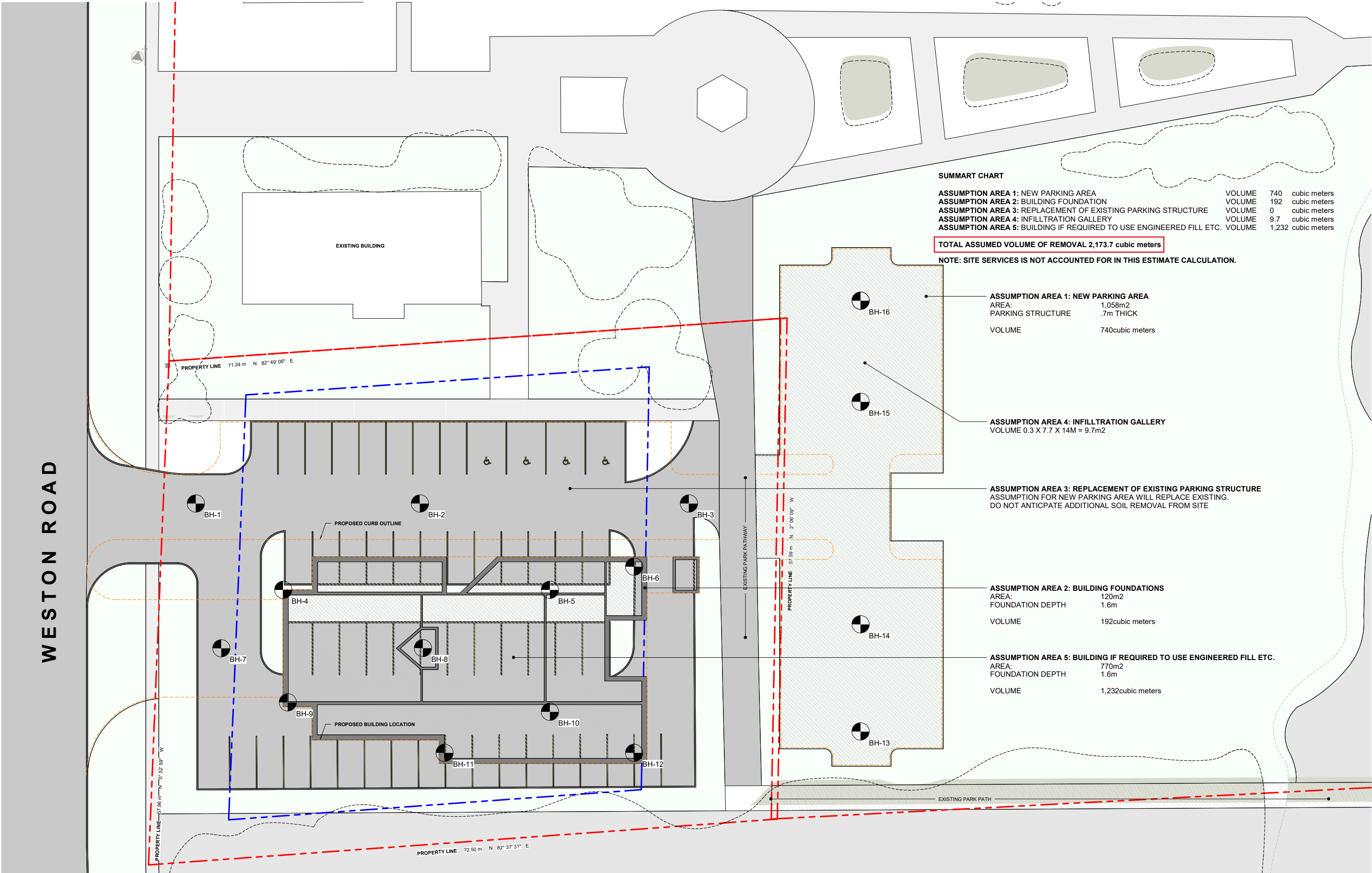
Frequent inspection and compaction testing by experienced geotechnical personnel should be carried out to examine and approve backfill material, and to verify that the specified degree of compaction has been achieved.

Appendix A

Borehole Plan



eNGLOBE



Appendix B

Borehole Logs



eNGLOBE

LOG OF BOREHOLE No. BH01

Englobe

Project No. 02112512.000

DRAWING No. BH1

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,296.606 E 615,967.529

Date Drilled: 2022-1-14

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content

Atterberg Limits

Undrained Triaxial at

% Strain at Failure

Shear Strength by

Penetrometer Test



GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH m	Standard Penetration Test N Value		Natural Moisture Content % Atterberg Limits (% Dry Weight)	SAMPLING METHOD	Soil Type	Natural Unit Weight kN/m ³	Percent of Fines, %
					40	80	120	160			
		ASPHALT CONCRETE (110 mm)	225.6	0	50	100	150	200	20	40	60
		SAND AND GRAVEL (Granular Base/Subbase, 180 mm)	225.5	0.1	50				7.5		
		SANDY SILT: trace to some clay, brown, moist, loose to compact	225.3								
				1	5				17.5		
					14				17.6		
				2							
		SILT: trace clay, brown, moist, compact to very dense Gr: 0%, Sa: 0%, Si: 90.7%, Cl: 9.3%	223.4		22				14.9		
				3					20.7		
					62				20.8		
				4							
		Terminated at 4.4 m	221.2								
		Borehole advanced using continuous flight solid stem augering equipment on January 14, 2022 by DrillTech Drilling LTD.									

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none
Feb 14, 2022	Dry	
Feb 24, 2022	4.0	

Checked By: A. Rahman

Logged By: P. Jin

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

LOG OF BOREHOLE No. BH02

Englobe

Project No. 02112512.000

DRAWING No. BH2

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,300.325 E 615,988.755

Date Drilled: 2022-1-14

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by
Vane Test



Natural Moisture Content



Atterberg Limits



Undrained Triaxial at

% Strain at Failure

Shear Strength by
Penetrometer Test



GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH m	Standard Penetration Test N Value		SAMPLING	Soil Zone	Natural Unit Weight kN/m ³	Percent of Fines, %
					40	80				
					50	100				
		ASPHALT CONCRETE (110 mm)	225.0	0						
		SAND AND GRAVEL (Granular Base/Subbase, 140 mm)	224.9	0.1						
			224.8	0.2						
			224.6	0.4						
		SILTY SAND: brown, moist, compact	224.4	0.6						
		SILT: trace clay, trace sand, brown, moist, compact to dense								
		Gr: 0%, Sa: 0.9%, Si: 91.2%, Cl: 7.9%								
				1	14					
				2	24					
				3	59					
				4	57					
		Terminated at 4.4 m	220.6	4.4						
		Borehole advanced using continuous flight solid stem augering equipment on January 14, 2022 by DrillTech Drilling LTD.								

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

Checked By: A. Rahman

Logged By: P. Jin

LOG OF BOREHOLE No. BH03

Englobe

Project No. 02112512.000

DRAWING No. BH3

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,305.111 E 616,028.716

Date Drilled: 2022-1-14

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



Undrained Triaxial at



% Strain at Failure



Shear Strength by



Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH m	Standard Penetration Test N Value		Natural Moisture Content % Atterberg Limits (% Dry Weight)	SAMPLING METHOD	Soil Type	Natural Unit Weight kN/m ³	Percent of Fines, %
					40	80					
		ASPHALT CONCRETE (90 mm)	224.9	0	50	100	20		SS1		
		SAND AND GRAVEL (Granular Base/Subbase, 120 mm)	224.8				10.9				
		SANDY SILT: trace clay, brown, moist, compact to dense	224.7								
				1	13		11.9		SS2		
				2	32		11.8		SS3		
					49		11.3		SS4		
			2.9								
		SILTY SAND: brown, moist, dense to very dense	222.0	3	48		19.4		SS5		
				4	55		15.4		SS6		
			4.4								
		Terminated at 4.4 m	220.5								
		Borehole advanced using continuous flight solid stem augering equipment on January 14, 2022 by DrillTech Drilling LTD.									

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

Checked By: A. Rahman

Logged By: P. Jin

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none

LOG OF BOREHOLE No. BH04

Englobe

Project No. 02112512.000

DRAWING No. BH4

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,288.738 E 615,980.069

Date Drilled: 2022-1-13

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by
Vane Test



Natural Moisture Content



Atterberg Limits

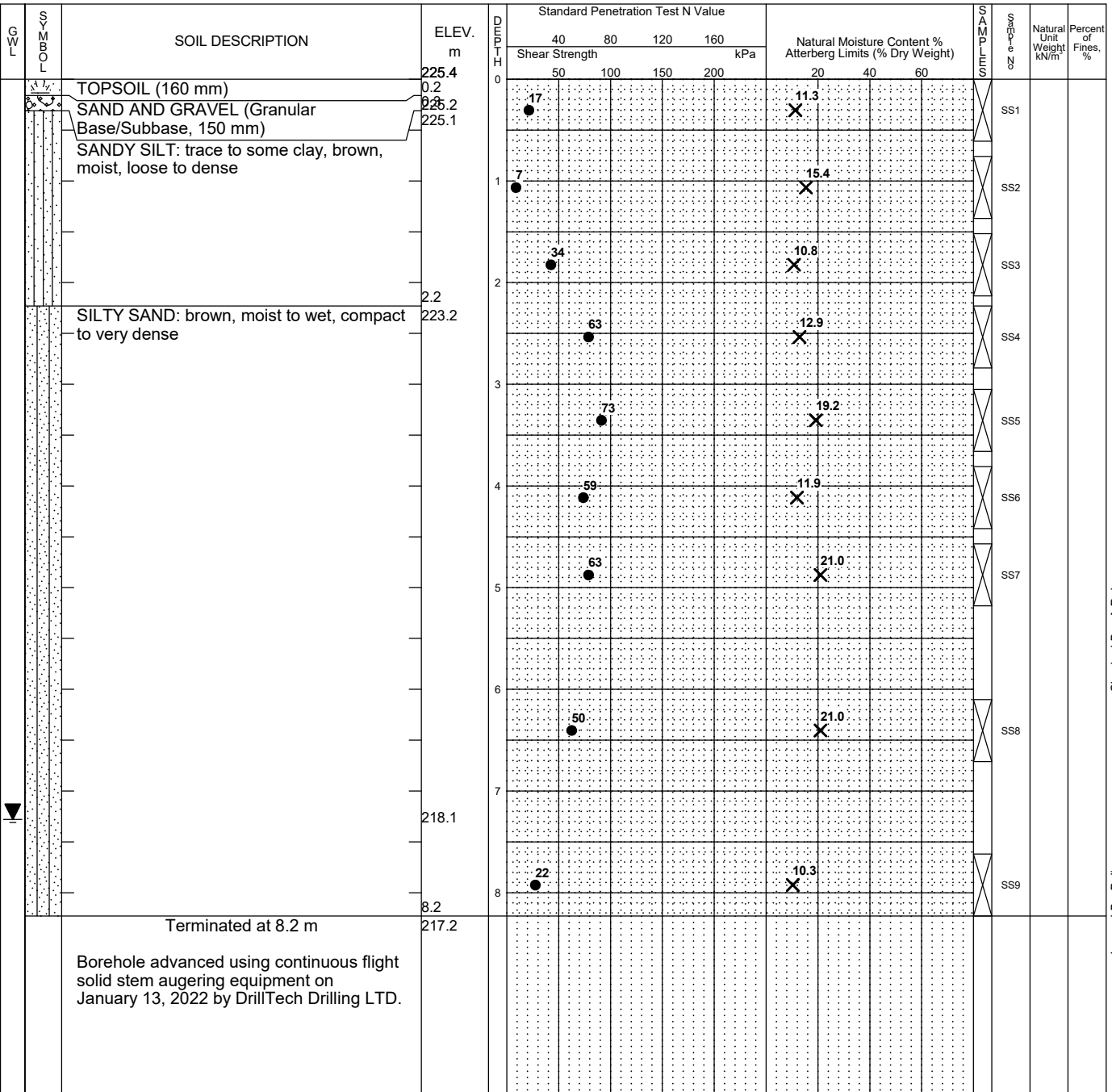


Undrained Triaxial at

% Strain at Failure

Shear Strength by

Penetrometer Test



LOG OF BOREHOLE No. BH05

Englobe

Project No. 02112512.000

DRAWING No. BH5

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,296.052 E 616,010.286

Date Drilled: 2022-1-13

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



Undrained Triaxial at

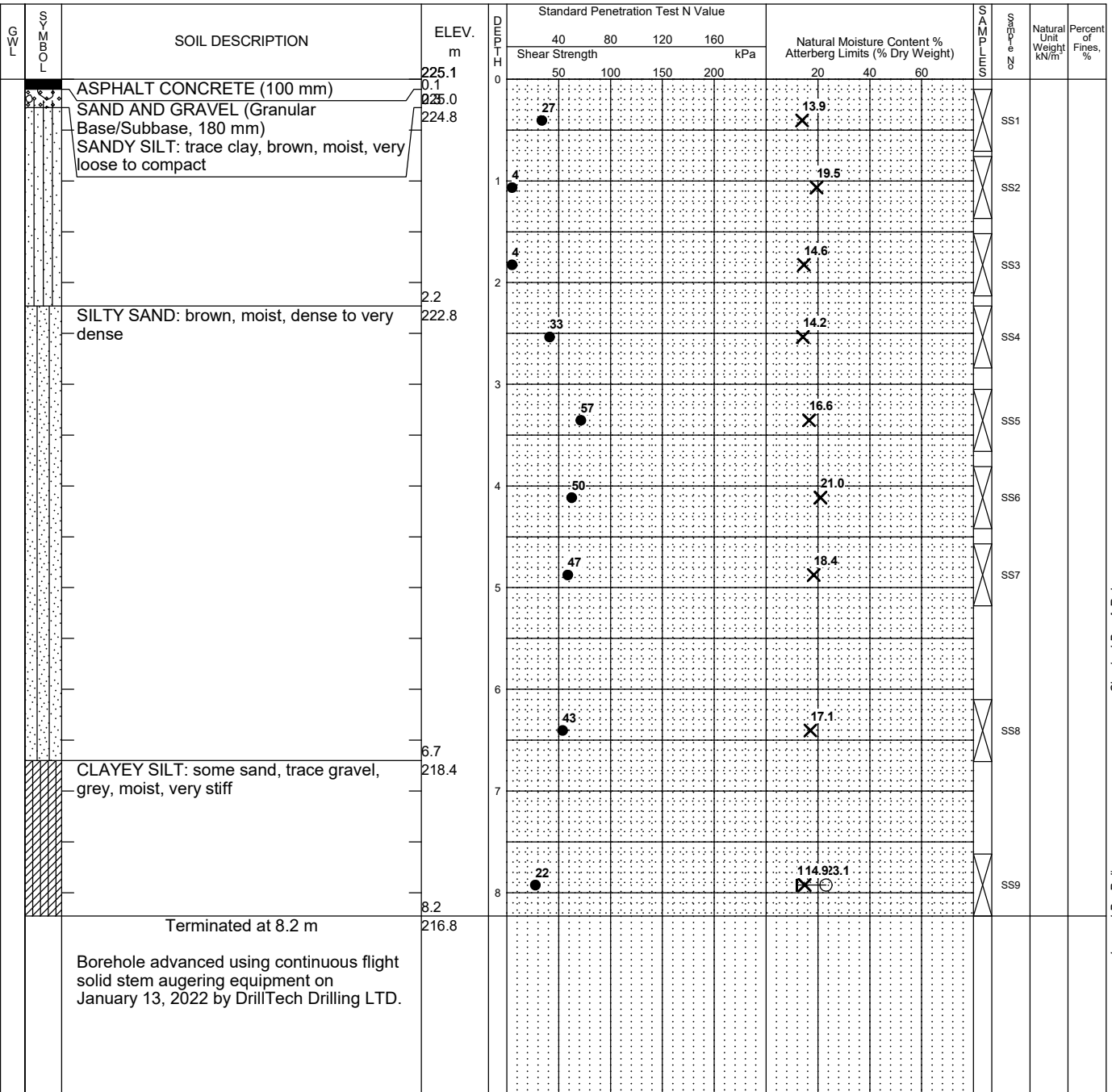


% Strain at Failure

Shear Strength by



Penetrometer Test



CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

Checked By: A. Rahman

Logged By: P. Jin

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none

LOG OF BOREHOLE No. BH06

Englobe

Project No. 02112512.000

DRAWING No. BH6

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,299.182 E 616,019.578

Date Drilled: 2022-1-13

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



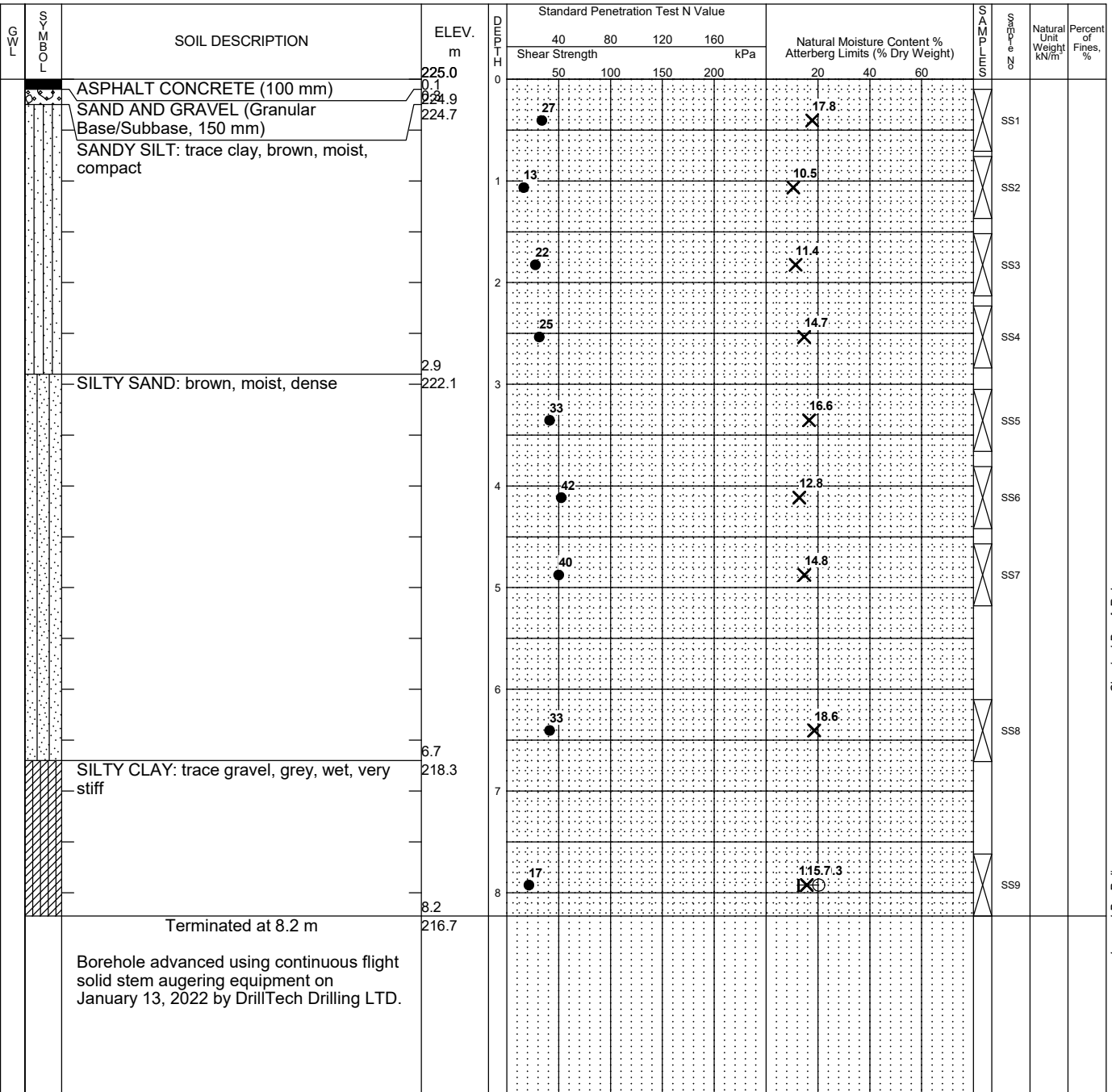
Undrained Triaxial at

% Strain at Failure



Shear Strength by

Penetrometer Test



CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

Checked By: A. Rahman

Logged By: P. Jin

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none

Englobe

Datum: Geodetic

Vane Test

Penetrometer Test

[illegible]

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none

Checked By: A.Rahman

Logged By: P. Jin

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

LOG OF BOREHOLE No. BH08

Englobe

Project No. 02112512.000

DRAWING No. BH8

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,284.188 E 615,997.335

Date Drilled: 2022-1-13

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



Undrained Triaxial at

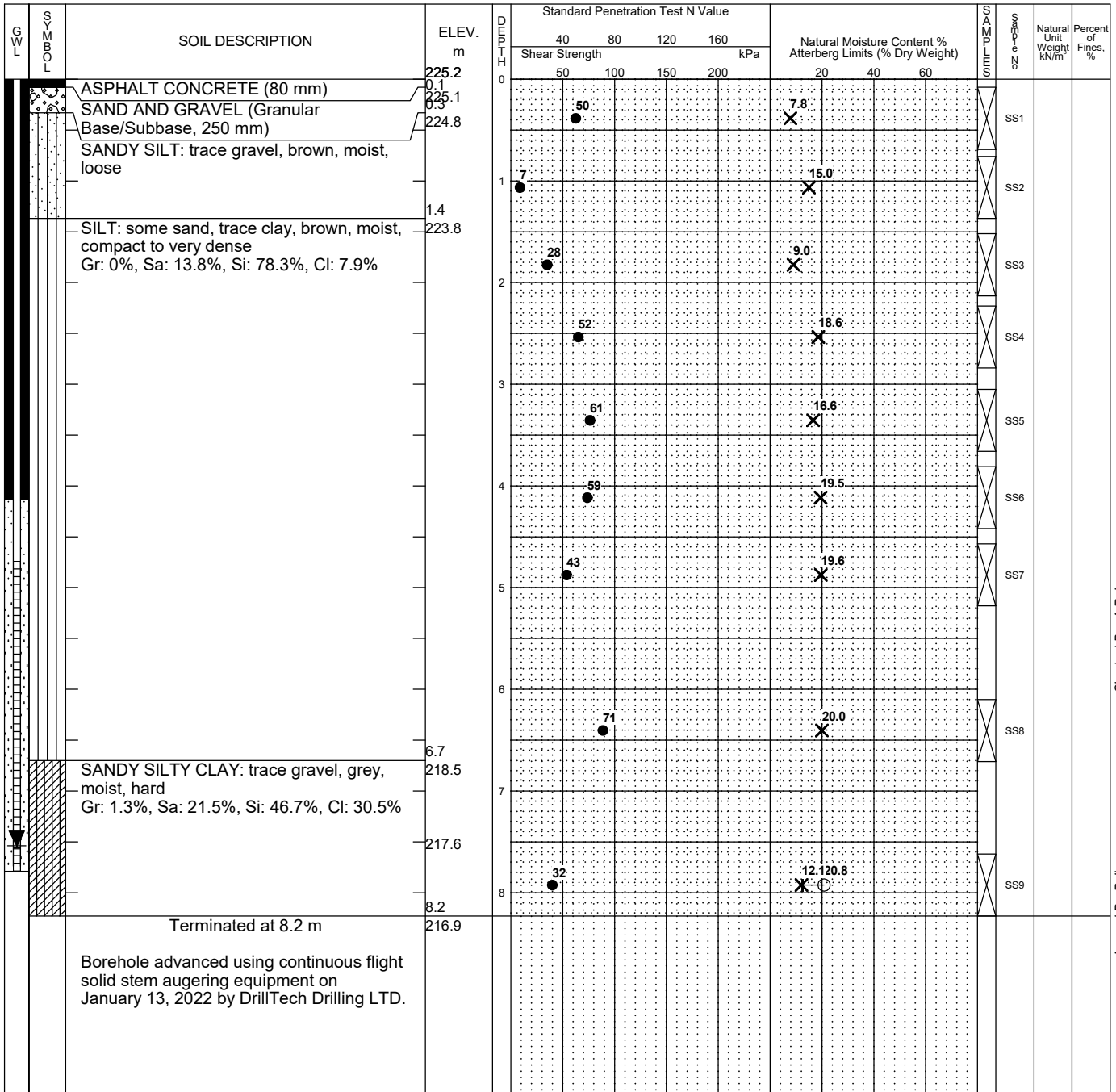


% Strain at Failure

Shear Strength by



Penetrometer Test



Time	Water Level (m)	Depth to Cave (m)
Upon Completion	7.6	none
Feb 14, 2022	7.6	
Feb 24, 2022	Dry	

Checked By: A. Rahman

Logged By: P. Jin

Englobe

DRAWING No. BH9

Sheet No. 1 of 1

N 4,854,275.648 E 615,983.373

Split Spoon Sample

Auger Sample

SPT (N) Value

Dynamic Cone Test

Shelby Tube

Shear Strength by

Vane Test

☒☐

+S

Natural Moisture Content

Atterberg Limits

Undrained Triaxial at

% Strain at Failure

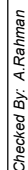
Shear Strength by

Penetrometer Test

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10



Logged By: P. Jin

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none
Feb 14, 2022	Dry	
Feb 24, 2022	7.7	

LOG OF BOREHOLE No. BH10

Englobe

Project No. 02112512.000

DRAWING No. BH10

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,285.523 E 616,013.237

Date Drilled: 2022-1-14

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



Undrained Triaxial at

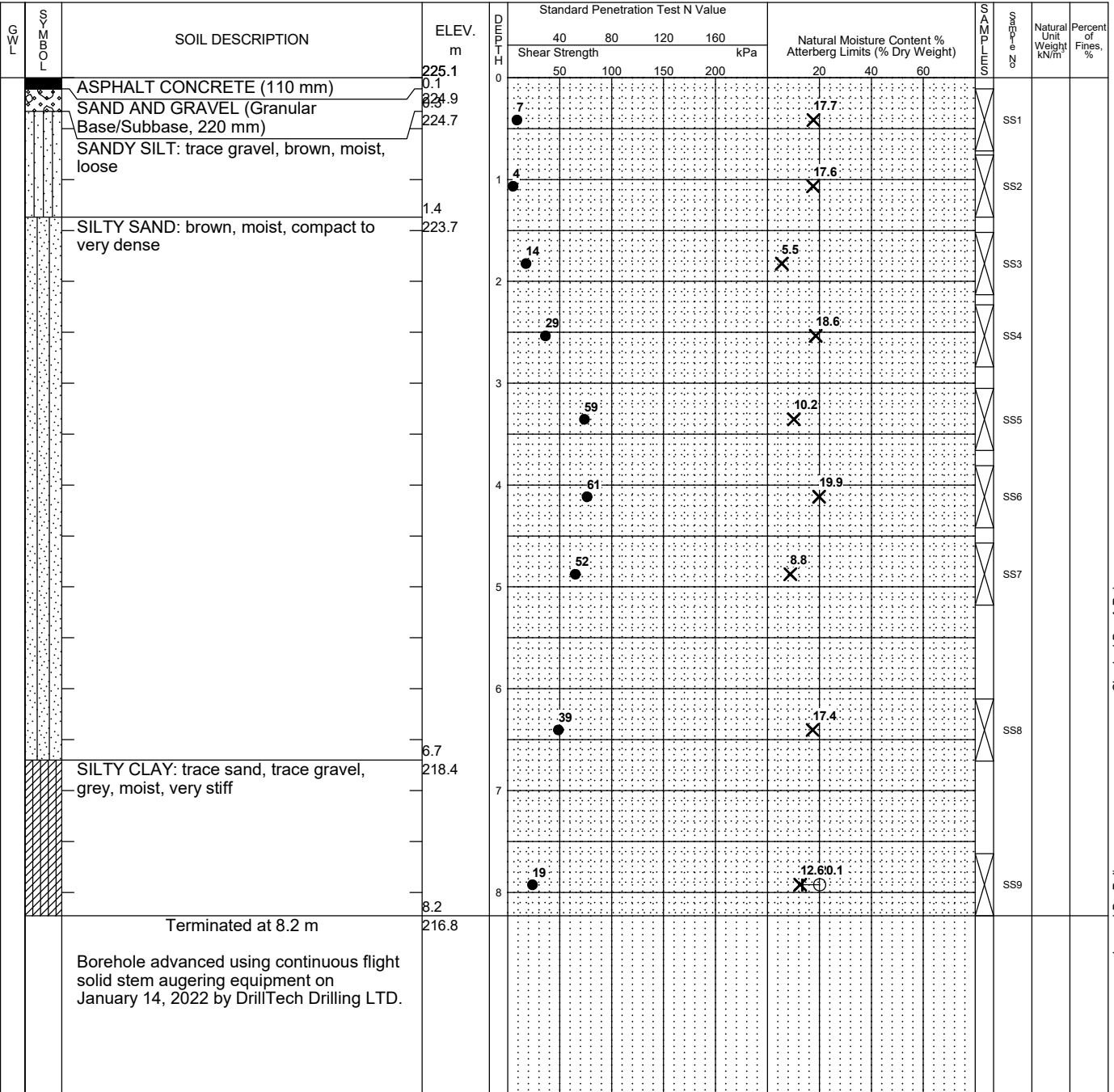
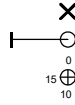


% Strain at Failure

Shear Strength by



Penetrometer Test



Checked By: A. Rahman

Logged By: P. Jin

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

LOG OF BOREHOLE No. BH11

Englobe

Project No. 02112512.000

DRAWING No. BH11

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,275.359 E 616,002.160

Date Drilled: 2022-1-21

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



Undrained Triaxial at



% Strain at Failure

Shear Strength by



Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH m	Standard Penetration Test N Value		Natural Moisture Content % Atterberg Limits (% Dry Weight)	SAMPLING METHOD	Soil Type	Natural Unit Weight kN/m ³	Percent of Fines, %
					40	80					
					50	100					
		ASPHALT CONCRETE (110 mm)	225.0	0							
		SAND AND GRAVEL (Granular Base/Subbase, 120 mm)	224.9								
		SILT: with clay, brown, moist, loose to very dense	224.7								
		Gr: 0%, Sa: 0%, Si: 87.7%, Cl: 12.3%									
				1	10		17.9		SS1		
				2	10		13.0		SS2		
				3	16		20.3		SS3		
				4	47		13.2		SS4		
				5	65		17.5		SS5		
				6	50		15.8		SS6		
				7	58		17.2		SS7		
				8	29		16.1		SS8		
				9	28		22.4		SS9		
		Terminated at 8.2 m	216.7								
		Borehole advanced using continuous flight solid stem augering equipment on January 21, 2022 by DrillTech Drilling LTD.									

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

Checked By: A. Rahman

Logged By: P. Jin

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	7.5	none

LOG OF BOREHOLE No. BH12

Englobe

Project No. 02112512.000

DRAWING No. BH12

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,275.874 E 616,022.481

Date Drilled: 2022-1-21

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by
Vane Test



Natural Moisture Content



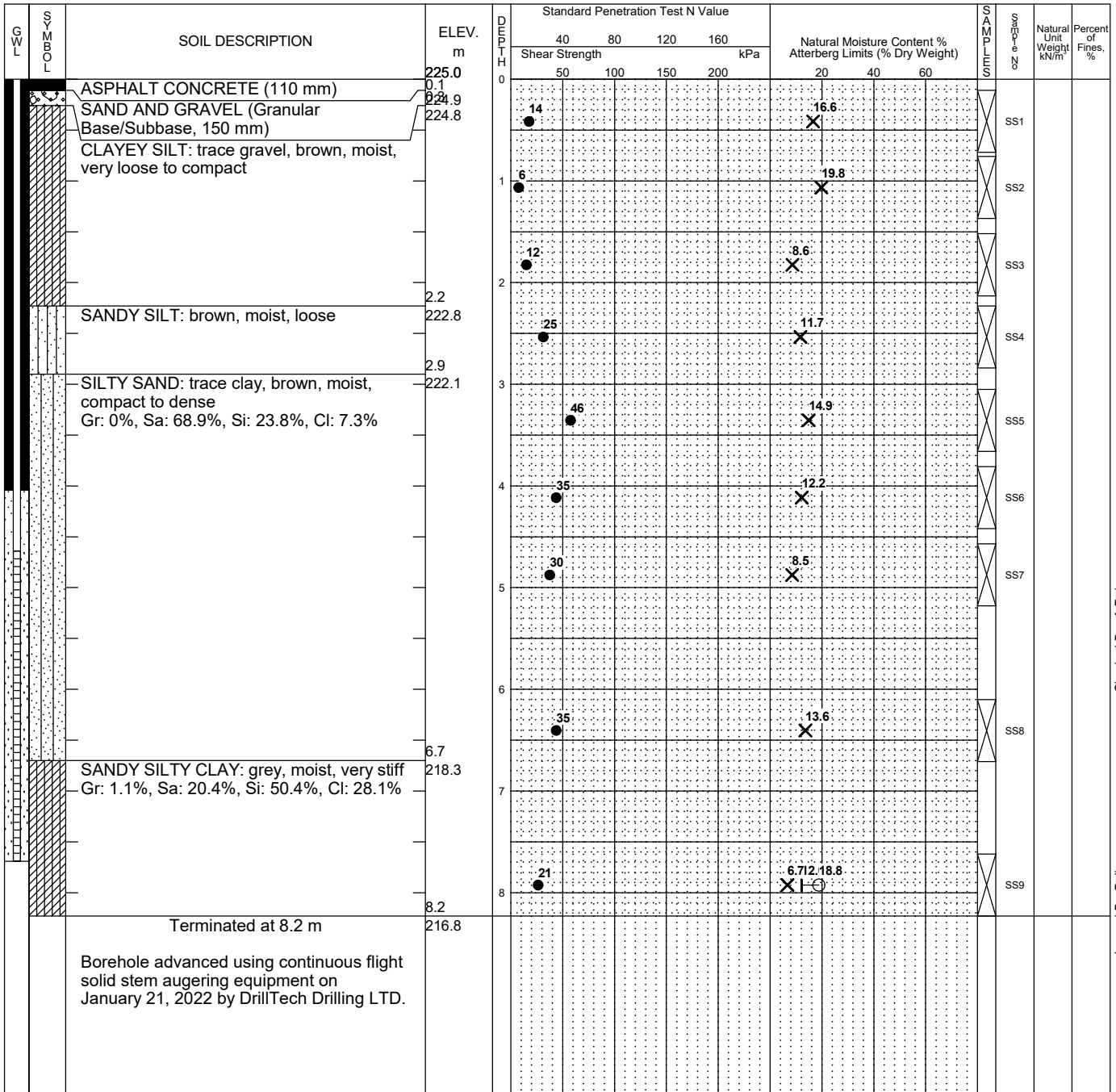
Atterberg Limits



Undrained Triaxial at

% Strain at Failure

Shear Strength by
Penetrometer Test



Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none
Feb 14, 2022	Dry	
Feb 24, 2022	7.6	

Checked By: A. Rahman

Logged By: P. Jin

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

LOG OF BOREHOLE No. BH13

Englobe

Project No. 02112512.000

DRAWING No. BH13

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,286.170 E 616,050.535

Date Drilled: 2022-1-21

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



Undrained Triaxial at



% Strain at Failure

Shear Strength by



Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH m	Standard Penetration Test N Value		Natural Moisture Content % Atterberg Limits (% Dry Weight)	SAMPLING METHOD	Natural Unit Weight kN/m ³	Percent of Fines, %
					40	80				
		TOPSOIL (200 mm)	225.8	0						
		SAND AND GRAVEL (Granular Base/Subbase, 150 mm)	225.6	0.2	15		25.9		SS1	
		SANDY SILTY CLAY: brown, moist, firm to hard Gr: 0.3%, Sa: 25.2%, Si: 43.7%, Cl: 30.8%	225.4	0.4						
				1	7		20.0		SS2	
				2	12		12.0		SS3	
				3	21		11.8		SS4	
				4	30		12.3		SS5	
				4.4	40		13.4		SS6	
		Terminated at 4.4 m	221.4							
		Borehole advanced using continuous flight solid stem augering equipment on January 21, 2022 by DrillTech Drilling LTD.								

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

Checked By: A. Rahman

Logged By: P. Jin

LOG OF BOREHOLE No. BH15

Englobe

Project No. 02112512.000

DRAWING No. BH15

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,317.902 E 616,043.569

Date Drilled: 2022-1-21

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



Undrained Triaxial at

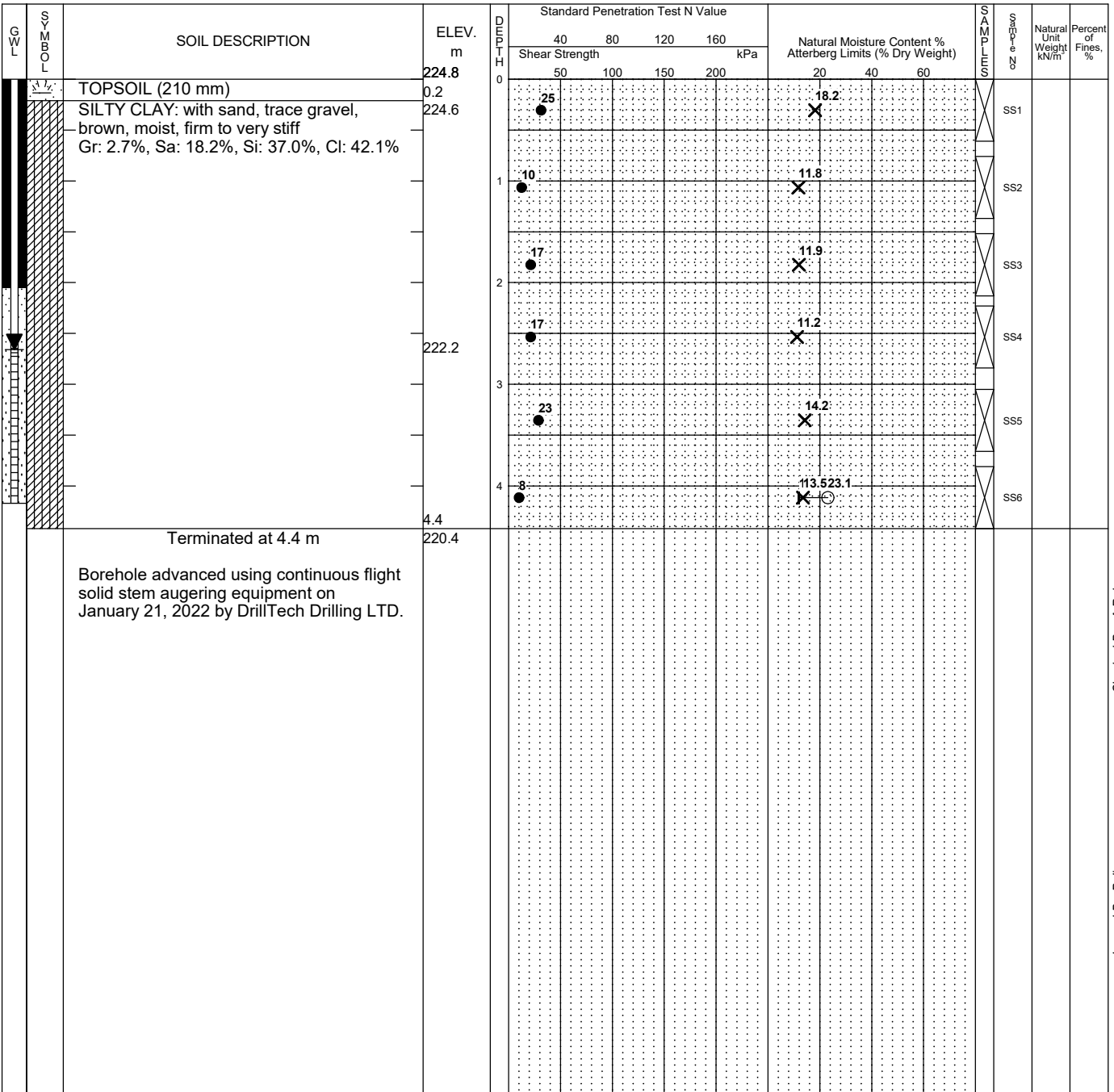


% Strain at Failure

Shear Strength by



Penetrometer Test



Checked By: A. Rahman

Logged By: P. Jin

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	2.7	none
Feb 14, 2022	2.7	
Feb 24, 2022	1.3	

LOG OF BOREHOLE No. BH16

Englobe

Project No. 02112512.000

DRAWING No. BH16

Project: City of Vaughan Fire Station - 9541 Weston Road, Woodbridge, Ontario

Sheet No. 1 of 1

Location: Refer to Borehole Location Plan

N 4,854,334.484 E 616,039.548

Date Drilled: 2022-1-13

Drill Type: Solid Stem Augers

Datum: Geodetic

Split Spoon Sample



Auger Sample



SPT (N) Value



Dynamic Cone Test



Shelby Tube



Shear Strength by



Vane Test

Natural Moisture Content



Atterberg Limits



Undrained Triaxial at



% Strain at Failure



Shear Strength by



Penetrometer Test



GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH m	Standard Penetration Test N Value				Natural Moisture Content %				SAMPLING	Soil Type	Natural Unit Weight kN/m	Percent of Fines, %
					Shear Strength				Atterberg Limits (% Dry Weight)							
					40	80	120	160	20	40	60					
		TOPSOIL (200 mm)	224.9	0												
		SILTY CLAY: with sand, brown, moist, compact Gr: 0%, Sa: 10.4%, Si: 65.6%, Cl: 24%	224.7	0.2	15					14.6				SS1		
				1	15					12.2				SS2		
				2	13					12.4				SS3		
				3	23					13.5				SS4		
				4	22					20.4				SS5		
				4	16					20.2				SS6		
		Terminated at 4.4 m	220.5													
		Borehole advanced using continuous flight solid stem augering equipment on January 13, 2022 by DrillTech Drilling LTD.														

CLASSIFICATION LOG 02112512.GPJ LOG A GWGL02.GDT 22-4-6

Checked By: A. Rahman

Logged By: P. Jin

Time	Water Level (m)	Depth to Cave (m)
Upon Completion	Dry	none

Appendix C

Laboratory Results



eNGLOBE

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH1_SS5
SAMPLING DEPTH, m: 3.50
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Silt trace Clay
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %
% GRAVEL (> 4.75 mm): 0.0
% SAND (75 µm to 4.75 mm): 0.0
% Silt (5 µm to 75 µm): 90.7
% Clay (<5 µm): 9.3
SUSCEPTIBILITY TO FROST HEAVING: High

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	82.2
37.5	100.0	0.026	67.4
26.5	100.0	0.017	42.4
19.0	100.0	0.010	21.5
13.2	100.0	0.007	13.7
9.5	100.0	0.005	9.3
4.75	100.0	0.003	5.3
2.36	100.0	0.001	2.7
1.18	100.0	ATTERBERG LIMITS, %	
0.60	100.0		
0.30	100.0		
0.15	100.0	Plastic Limit	
0.075	100.0	Liquid Limit	
		Plastic Index	

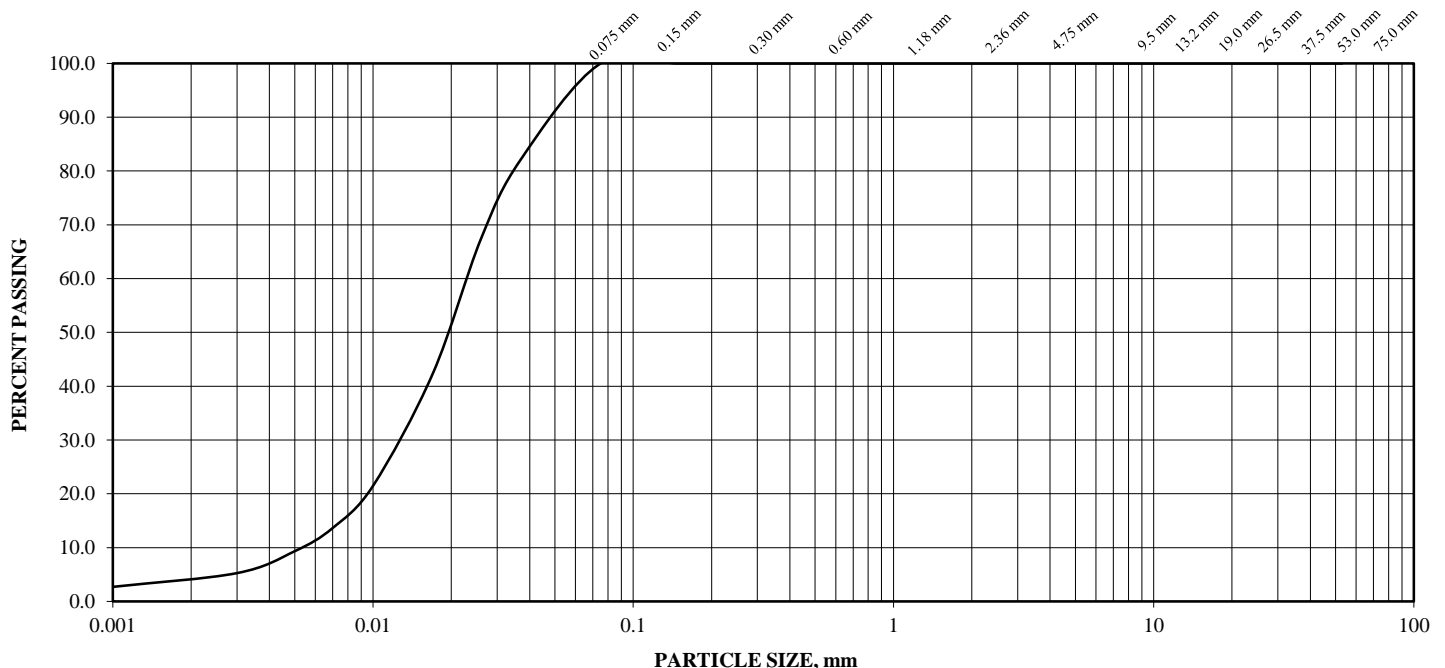
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH2_SS3
SAMPLING DEPTH, m: 2.00
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Silt, trace clay, trace
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %
% GRAVEL (> 4.75 mm): 0.0
% SAND (75 µm to 4.75 mm): 0.9
% Silt (5 µm to 75 µm): 91.2
% Clay (<5 µm): 7.9
SUSCEPTIBILITY TO FROST HEAVING: High

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	75.2
37.5	100.0	0.026	60.1
26.5	100.0	0.017	39.1
19.0	100.0	0.010	20.6
13.2	100.0	0.007	11.8
9.5	100.0	0.005	7.9
4.75	100.0	0.003	4.4
2.36	100.0	0.001	1.8
1.18	100.0	ATTERBERG LIMITS, %	
0.60	100.0		
0.30	100.0		
0.15	100.0	Plastic Limit	
0.075	99.1	Liquid Limit	
		Plastic Index	

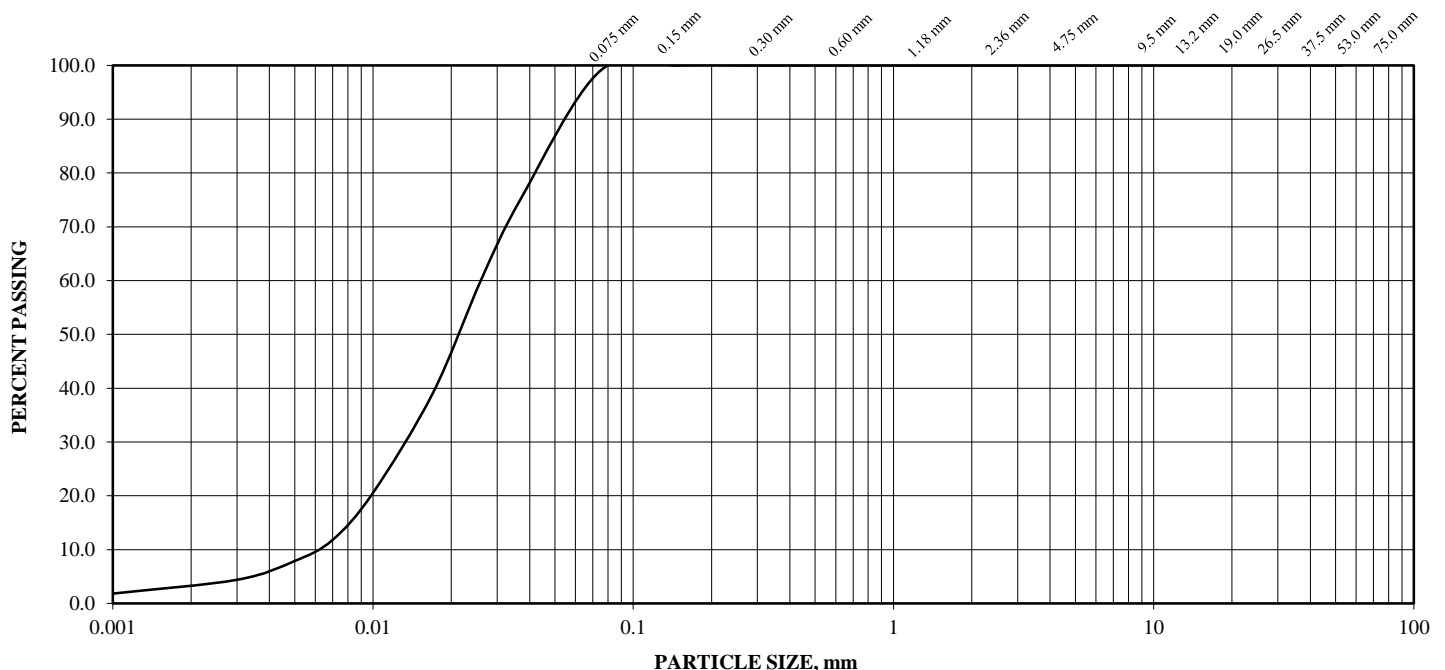
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
------	------	----------------	-----------	-------------	-------------	-------------	--------

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH8_SS7
SAMPLING DEPTH, m: 5.00
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Silt, some sand, trace clay
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %
% GRAVEL (> 4.75 mm): 0.0
% SAND (75 µm to 4.75 mm): 13.8
% Silt (5 µm to 75 µm): 78.3
% Clay (<5 µm): 7.9
SUSCEPTIBILITY TO FROST HEAVING: High

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	58.5
37.5	100.0	0.026	44.7
26.5	100.0	0.017	31.0
19.0	100.0	0.010	18.7
13.2	100.0	0.007	11.9
9.5	100.0	0.005	7.9
4.75	100.0	0.003	4.5
2.36	100.0	0.001	2.7
1.18	100.0	ATTERBERG LIMITS, %	
0.60	100.0		
0.30	100.0		
0.15	99.4		
0.075	86.2	Plastic Limit	
		Liquid Limit	
		Plastic Index	

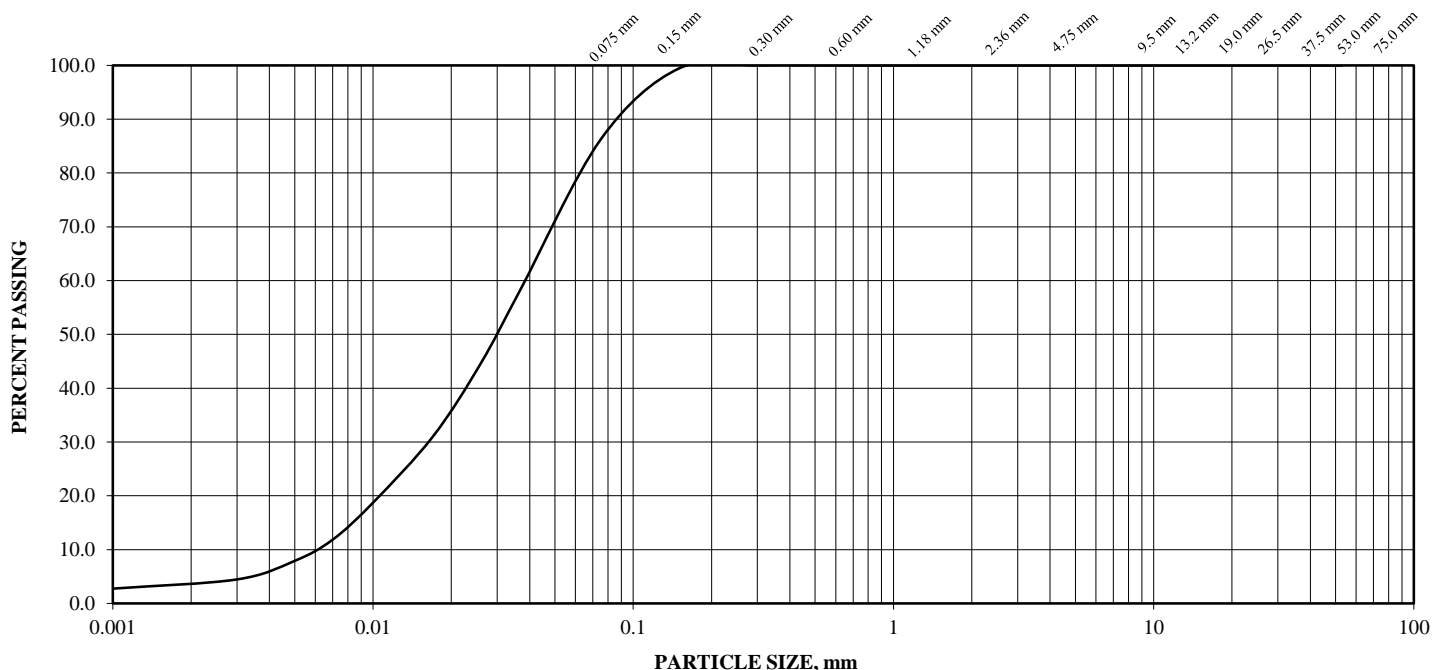
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
------	------	----------------	-----------	-------------	-------------	-------------	--------

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
---------------------	-----------	-------------	-------------	-------------	---------------



GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH8_SS8
SAMPLING DEPTH, m: 6.50
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Clayey Sandy Silt, trace gravel
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm): 1.3
% SAND (75 µm to 4.75 mm): 21.5
% Silt (5 µm to 75 µm): 46.7
% Clay (<5 µm): 30.5
SUSCEPTIBILITY TO FROST HEAVING: Moderate

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	65.9
37.5	100.0	0.026	59.8
26.5	100.0	0.017	52.5
19.0	100.0	0.010	43.1
13.2	100.0	0.007	36.5
9.5	100.0	0.005	30.5
4.75	98.7	0.003	22.3
2.36	97.2	0.001	13.0
1.18	95.5	ATTERBERG LIMITS, %	
0.60	93.2		
0.30	89.7		
0.15	84.1	Plastic Limit	12.4
0.075	77.2	Liquid Limit	20.8
		Plastic Index	8.4

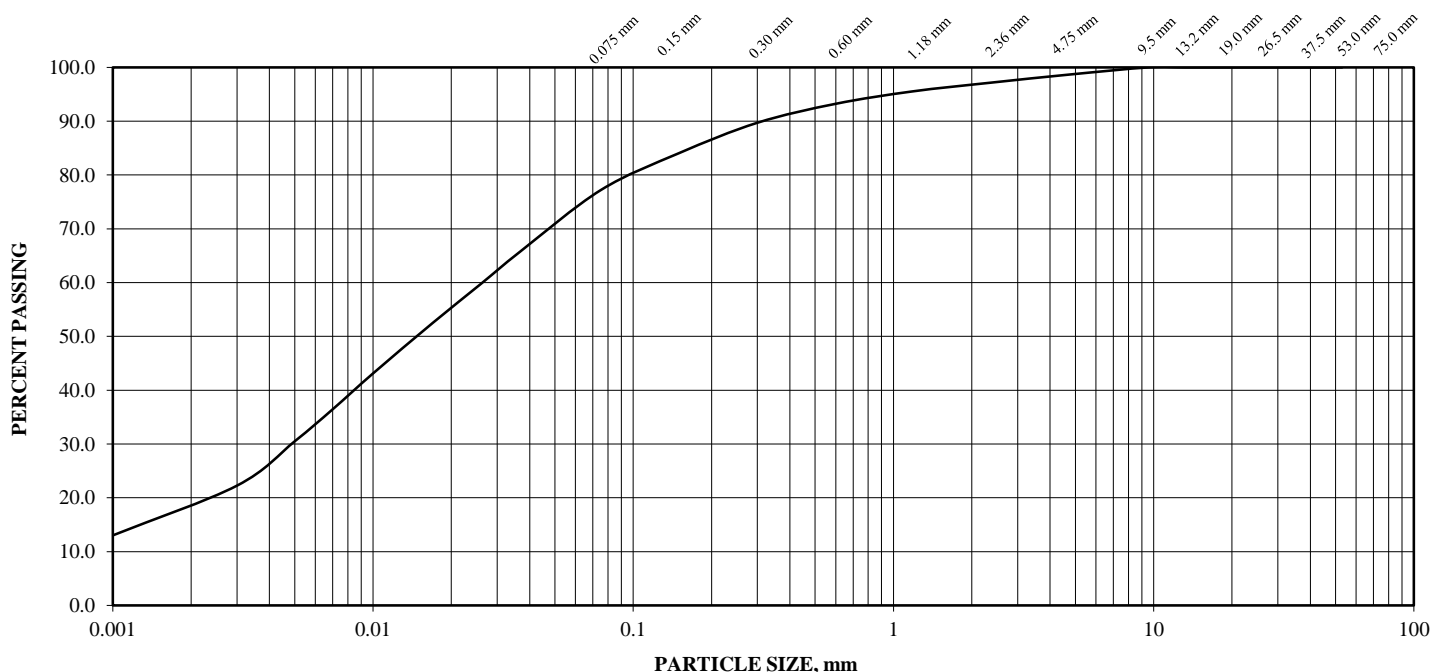
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
------	------	----------------	-----------	-------------	-------------	-------------	--------

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
---------------------	-----------	-------------	-------------	-------------	---------------



GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH9_SS8
SAMPLING DEPTH, m: 6.50
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Clayey Silt, some sand, trace gravel
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	68.7
37.5	100.0	0.026	62.4
26.5	100.0	0.017	54.8
19.0	100.0	0.010	45.0
13.2	100.0	0.007	38.4
9.5	100.0	0.005	33.4
4.75	98.6	0.003	27.3
2.36	97.5	0.001	15.4
1.18	96.7	ATTERBERG LIMITS, %	
0.60	95.6		
0.30	93.4		
0.15	87.3		
0.075	79.4	Plastic Limit	
		Liquid Limit	
		Plastic Index	

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm): 1.4
% SAND (75 µm to 4.75 mm): 19.2
% Silt (5 µm to 75 µm): 46.0
% Clay (<5 µm): 33.4
SUSCEPTIBILITY TO FROST HEAVING: Moderate

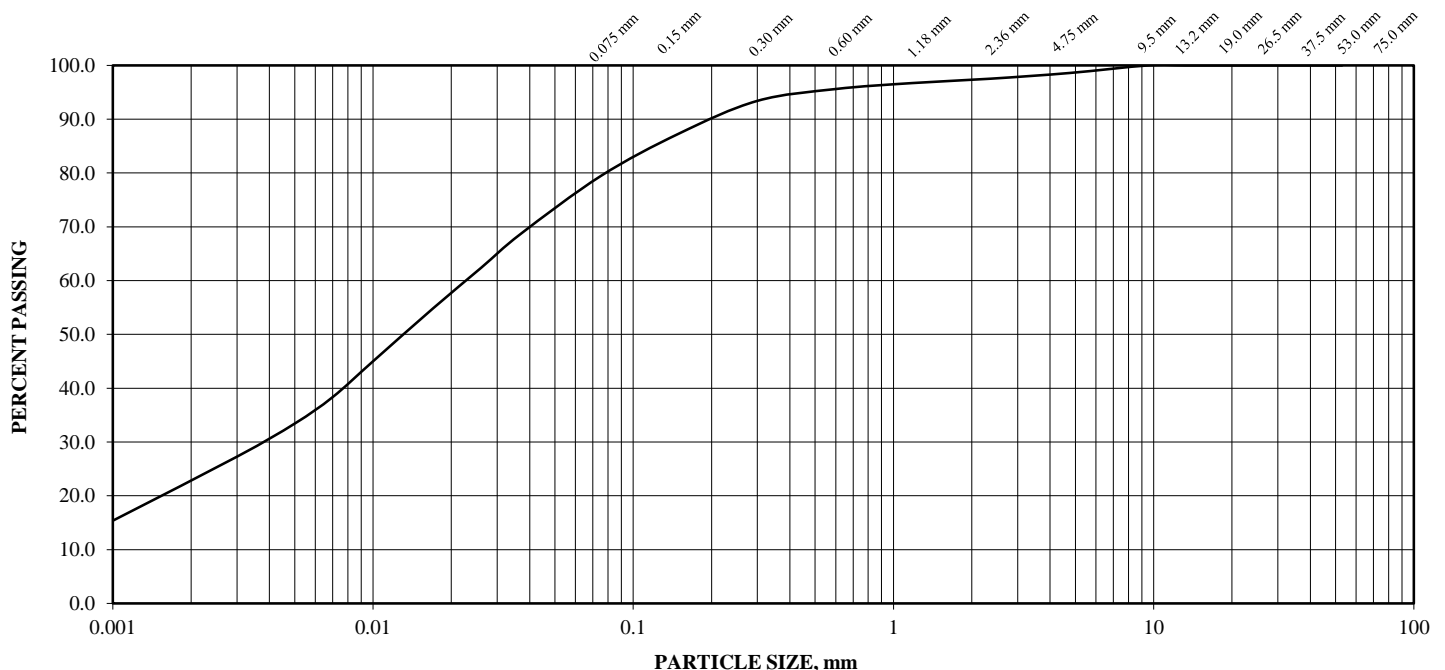
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH10_SS4
SAMPLING DEPTH, m: 2.50
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Silt, trace clay, trace sand
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %
% GRAVEL (> 4.75 mm): 0.0
% SAND (75 µm to 4.75 mm): 5.5
% Silt (5 µm to 75 µm): 88.0
% Clay (<5 µm): 6.5
SUSCEPTIBILITY TO FROST HEAVING: High

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	54.6
37.5	100.0	0.026	37.3
26.5	100.0	0.017	23.3
19.0	100.0	0.010	13.9
13.2	100.0	0.007	9.1
9.5	100.0	0.005	6.5
4.75	100.0	0.003	4.7
2.36	100.0	0.001	2.9
1.18	100.0	ATTERBERG LIMITS, %	
0.60	100.0		
0.30	100.0		
0.15	100.0	Plastic Limit	
0.075	94.5	Liquid Limit	
		Plastic Index	

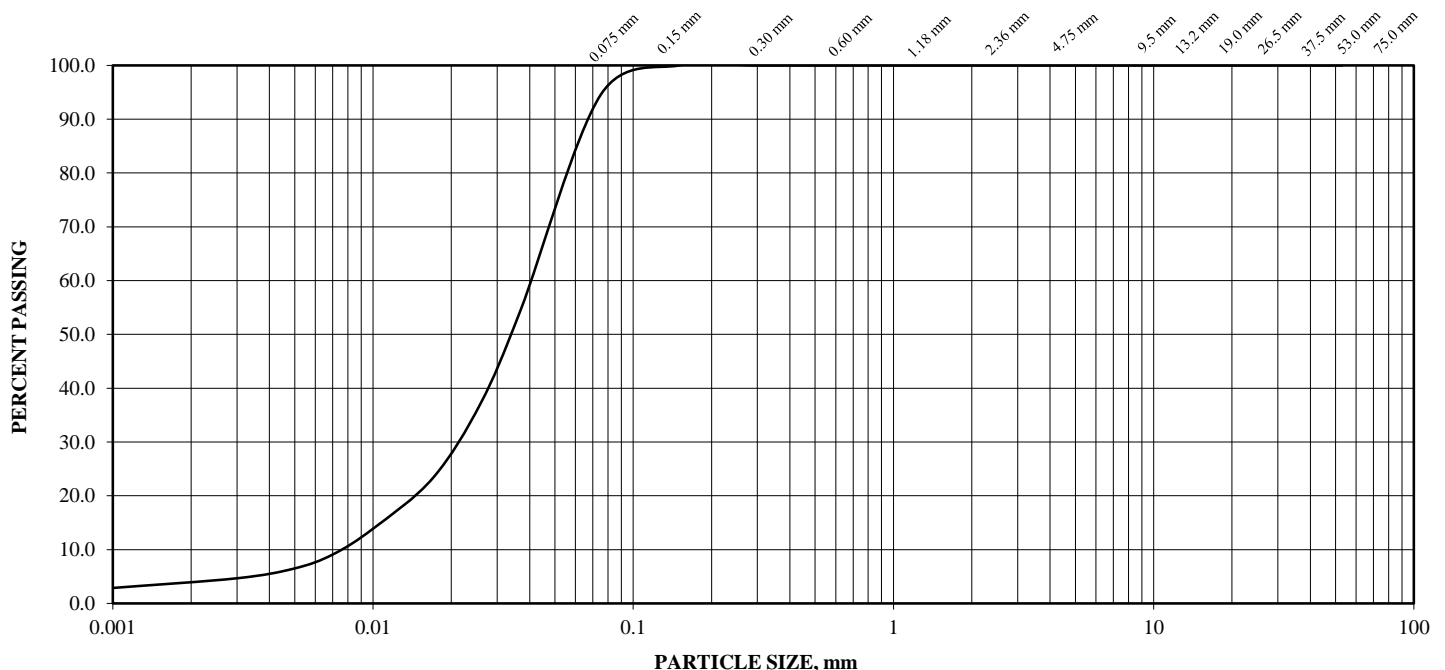
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH11_SS2
SAMPLING DEPTH, m: 1.00
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Silt, some clay
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %
% GRAVEL (> 4.75 mm): 0.0
% SAND (75 µm to 4.75 mm): 0.0
% Silt (5 µm to 75 µm): 87.7
% Clay (<5 µm): 12.3
SUSCEPTIBILITY TO FROST HEAVING: High

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	97.7
37.5	100.0	0.026	81.5
26.5	100.0	0.017	60.0
19.0	100.0	0.010	29.7
13.2	100.0	0.007	19.0
9.5	100.0	0.005	12.3
4.75	100.0	0.003	6.3
2.36	100.0	0.001	4.6
1.18	100.0	ATTERBERG LIMITS, %	
0.60	100.0		
0.30	100.0		
0.15	100.0	Plastic Limit	
0.075	100.0	Liquid Limit	
		Plastic Index	

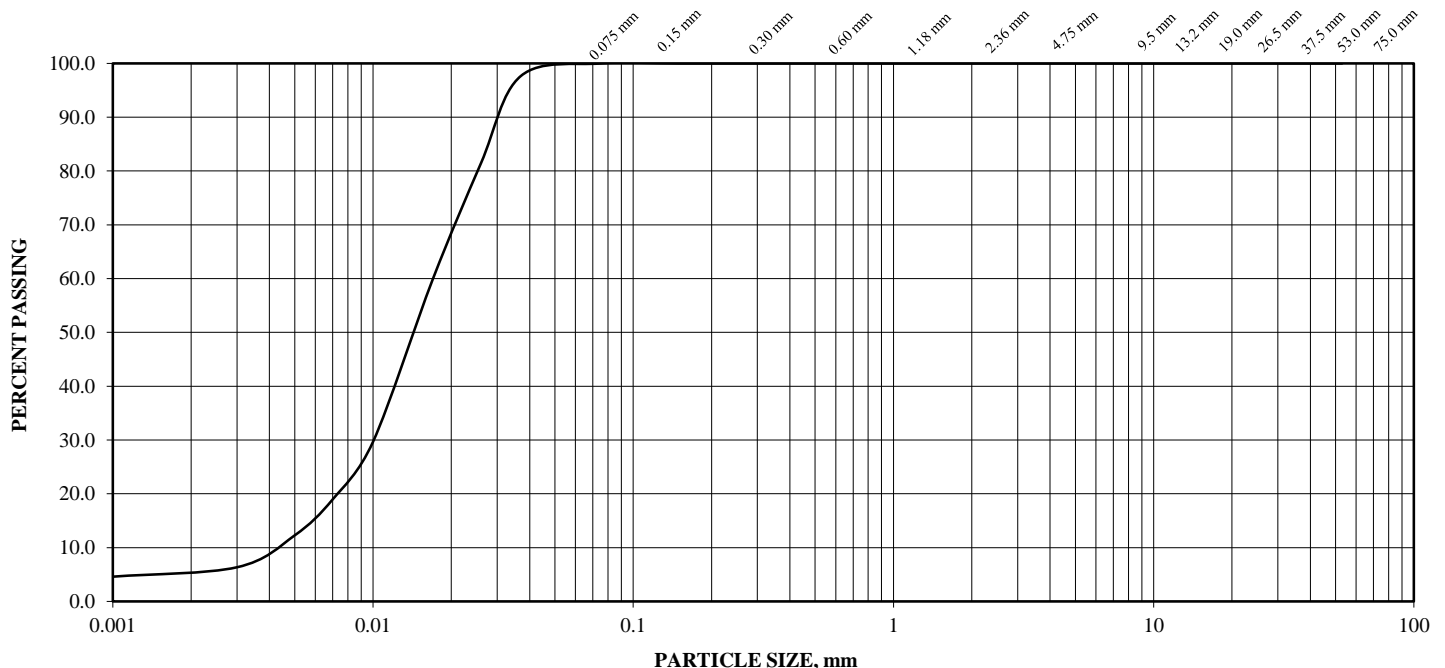
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH12_SS7
SAMPLING DEPTH, m: 5.00
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Silty Sand, trace Clay
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %
% GRAVEL (> 4.75 mm): 0.0
% SAND (75 µm to 4.75 mm): 68.9
% Silt (5 µm to 75 µm): 23.8
% Clay (<5 µm): 7.3
SUSCEPTIBILITY TO FROST HEAVING: Low

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	20.1
37.5	100.0	0.026	17.0
26.5	100.0	0.017	14.1
19.0	100.0	0.010	10.9
13.2	100.0	0.007	8.9
9.5	100.0	0.005	7.3
4.75	100.0	0.003	5.5
2.36	99.2	0.001	3.7
1.18	98.5	ATTERBERG LIMITS, %	
0.60	97.0		
0.30	88.1		
0.15	56.1	Plastic Limit	
0.075	31.1	Liquid Limit	
		Plastic Index	

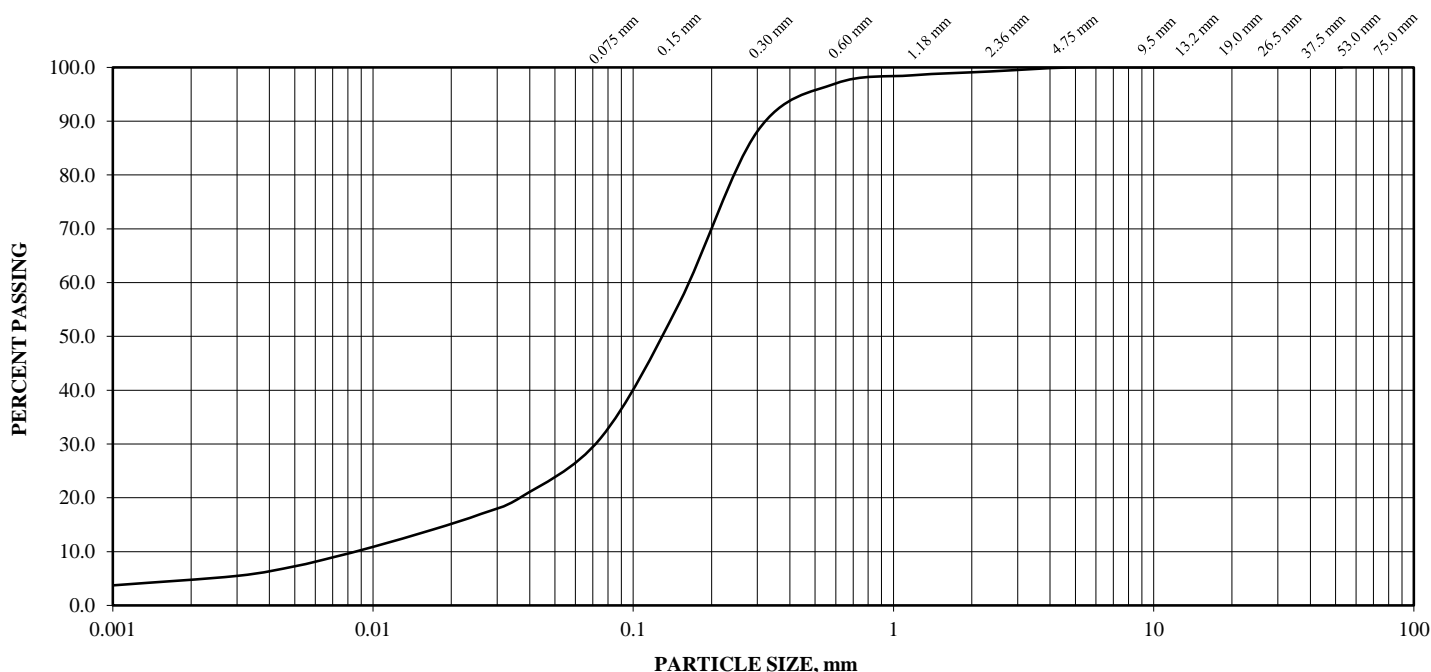
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH12_SS8
SAMPLING DEPTH, m: 6.50
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Clayey Silt, some sand, trace gravel
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm): 1.1
% SAND (75 µm to 4.75 mm): 20.4
% Silt (5 µm to 75 µm): 50.4
% Clay (< 5 µm): 28.1
SUSCEPTIBILITY TO FROST HEAVING: Moderate

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	61.5
37.5	100.0	0.026	54.5
26.5	100.0	0.017	47.4
19.0	100.0	0.010	39.0
13.2	100.0	0.007	32.8
9.5	100.0	0.005	28.1
4.75	98.9	0.003	22.1
2.36	97.9	0.001	12.9
1.18	97.2	ATTERBERG LIMITS, %	
0.60	96.5		
0.30	94.2		
0.15	88.5	Plastic Limit	12.0
0.075	78.5	Liquid Limit	18.8
		Plastic Index	6.8

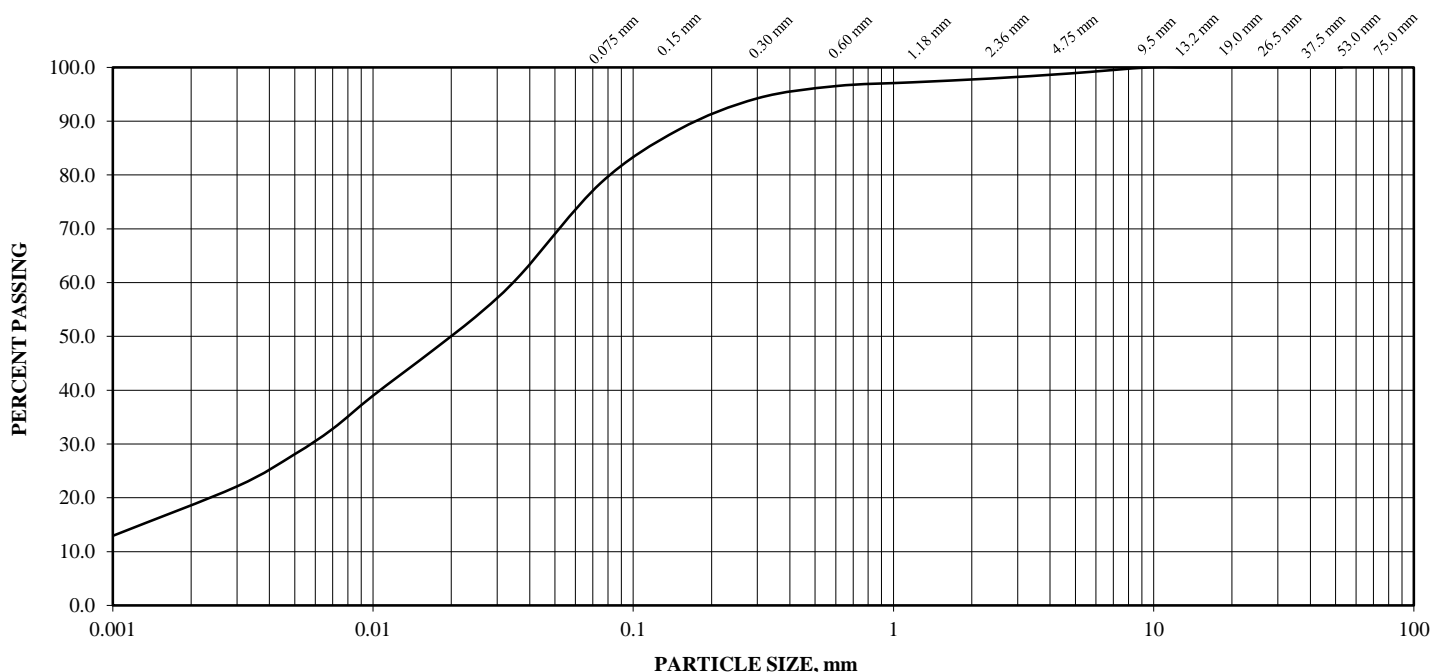
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH13_SS1
SAMPLING DEPTH, m: 0.50
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Clayey Sandy Silt, trace gravel
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm): 0.3
% SAND (75 µm to 4.75 mm): 25.2
% Silt (5 µm to 75 µm): 43.7
% Clay (< 5 µm): 30.8
SUSCEPTIBILITY TO FROST HEAVING: Moderate

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	60.2
37.5	100.0	0.026	54.0
26.5	100.0	0.017	47.5
19.0	100.0	0.010	39.7
13.2	100.0	0.007	34.3
9.5	100.0	0.005	30.8
4.75	99.7	0.003	27.1
2.36	99.2	0.001	21.1
1.18	98.7	ATTERBERG LIMITS, %	
0.60	97.7		
0.30	93.8		
0.15	84.9	Plastic Limit	
0.075	74.5	Liquid Limit	
		Plastic Index	

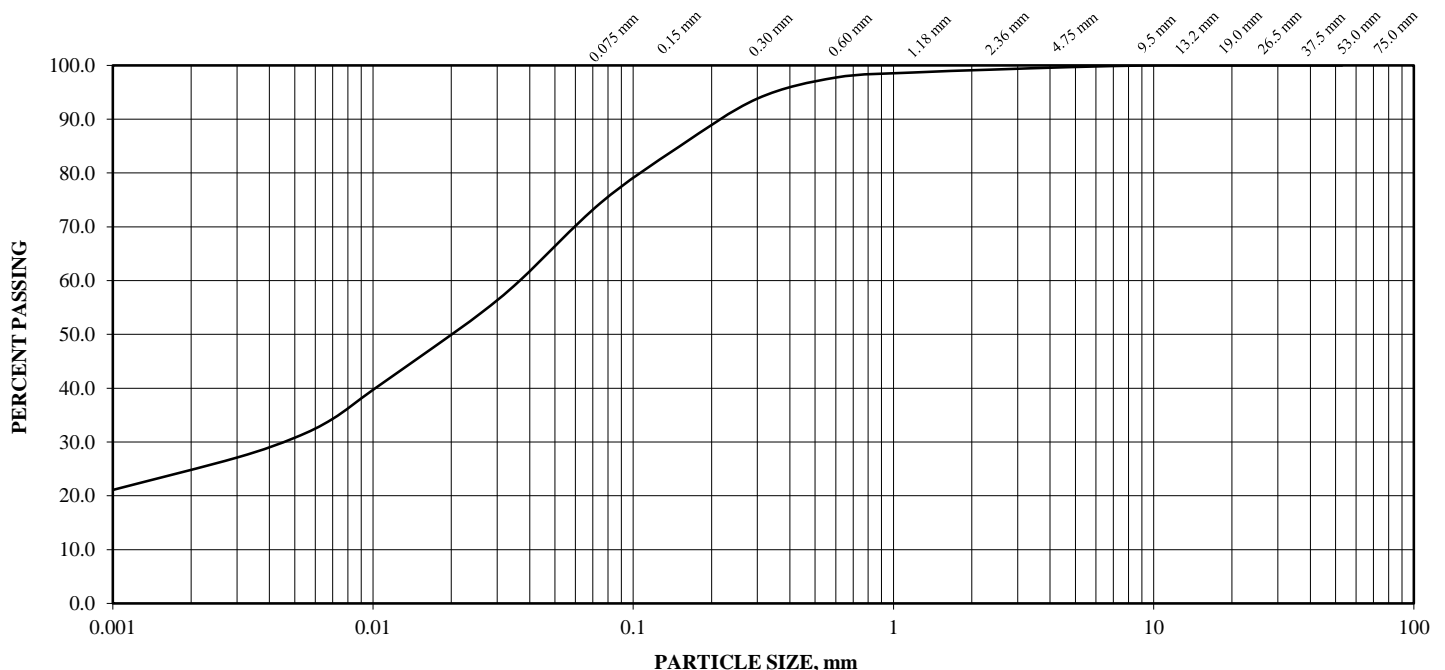
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH15_SS5
SAMPLING DEPTH, m: 3.50
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Silty Clay, some sand, trace gravel
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %
% GRAVEL (> 4.75 mm): 2.7
% SAND (75 µm to 4.75 mm): 18.2
% Silt (5 µm to 75 µm): 37.0
% Clay (< 5 µm): 42.1
SUSCEPTIBILITY TO FROST HEAVING: Low

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	72.2
37.5	100.0	0.026	68.1
26.5	100.0	0.017	62.5
19.0	100.0	0.010	54.6
13.2	100.0	0.007	48.2
9.5	100.0	0.005	42.1
4.75	97.3	0.003	33.8
2.36	96.6	0.001	23.2
1.18	95.4	ATTERBERG LIMITS, %	
0.60	93.9		
0.30	90.5		
0.15	84.9	Plastic Limit	11.9
0.075	79.0	Liquid Limit	23.1
		Plastic Index	11.2

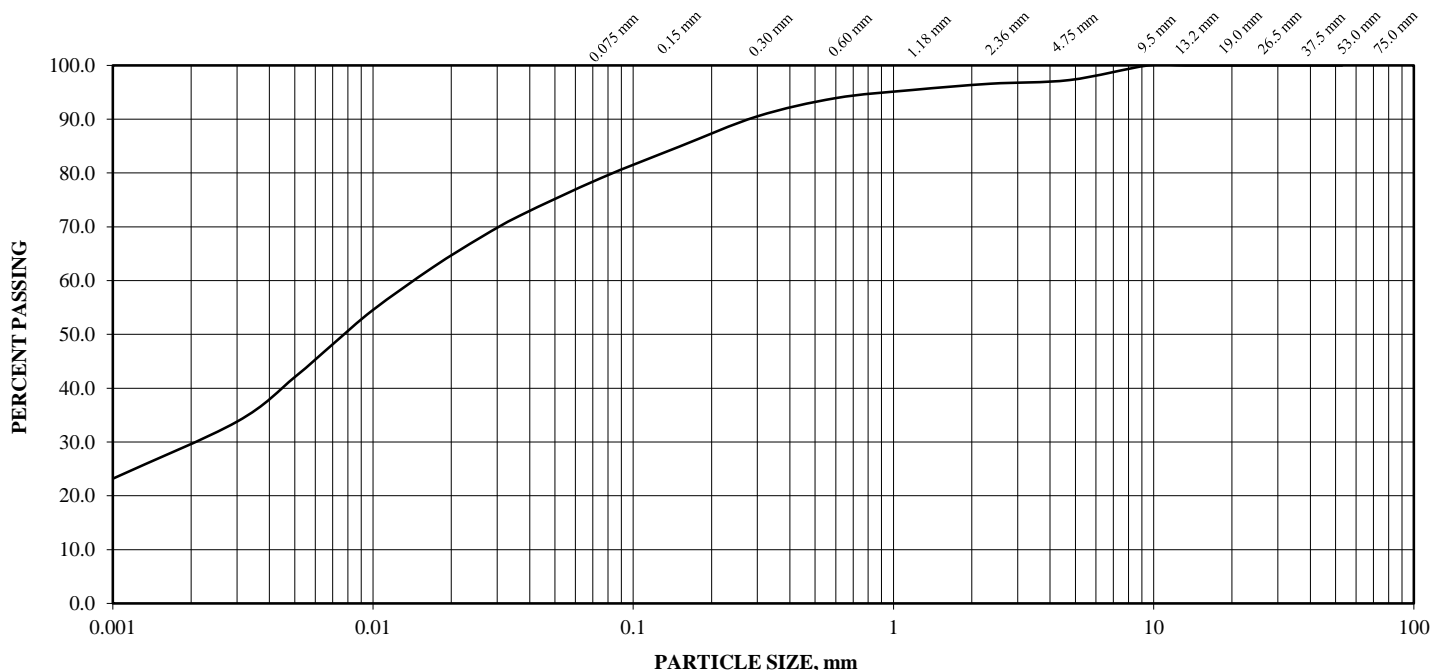
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT MTO LS-602, 702, AND 703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan CONTRACT NUMBER: -

ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation / City of Vaughan Fire Station 7-12

SAMPLING LOCATION: BH16_SS3
SAMPLING DEPTH, m: 2.00
SAMPLING METHOD: Split Spoon
SAMPLED BY: P.J. Englobe Corp
SAMPLE DESCRIPTION: Clayey Silt, some sand
SAMPLING DATE: 2022-01-21
SAMPLE RECEIVED DATE: 2022-01-21

GRAIN SIZE PROPORTIONS, %
% GRAVEL (> 4.75 mm): 0.0
% SAND (75 µm to 4.75 mm): 10.4
% Silt (5 µm to 75 µm): 65.6
% Clay (<5 µm): 24.0
SUSCEPTIBILITY TO FROST HEAVING: High

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	72.7
37.5	100.0	0.026	65.0
26.5	100.0	0.017	54.9
19.0	100.0	0.010	41.2
13.2	100.0	0.007	31.1
9.5	100.0	0.005	24.0
4.75	100.0	0.003	16.8
2.36	99.6	0.001	9.3
1.18	99.2	ATTERBERG LIMITS, %	
0.60	98.6		
0.30	97.3		
0.15	95.4	Plastic Limit	
0.075	89.6	Liquid Limit	
		Plastic Index	

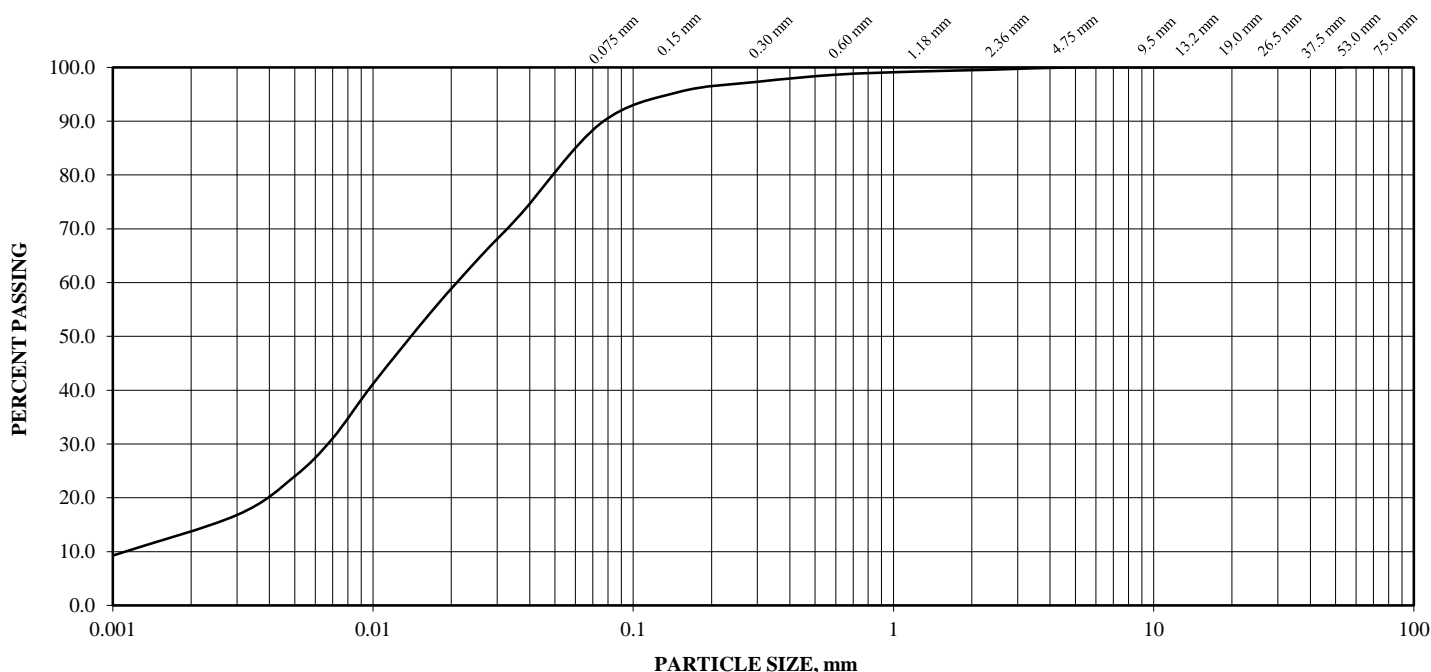
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	GRAVEL
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UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL
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ATTERBERG LIMITS MTO LS-703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan DATE: 21/01/2022

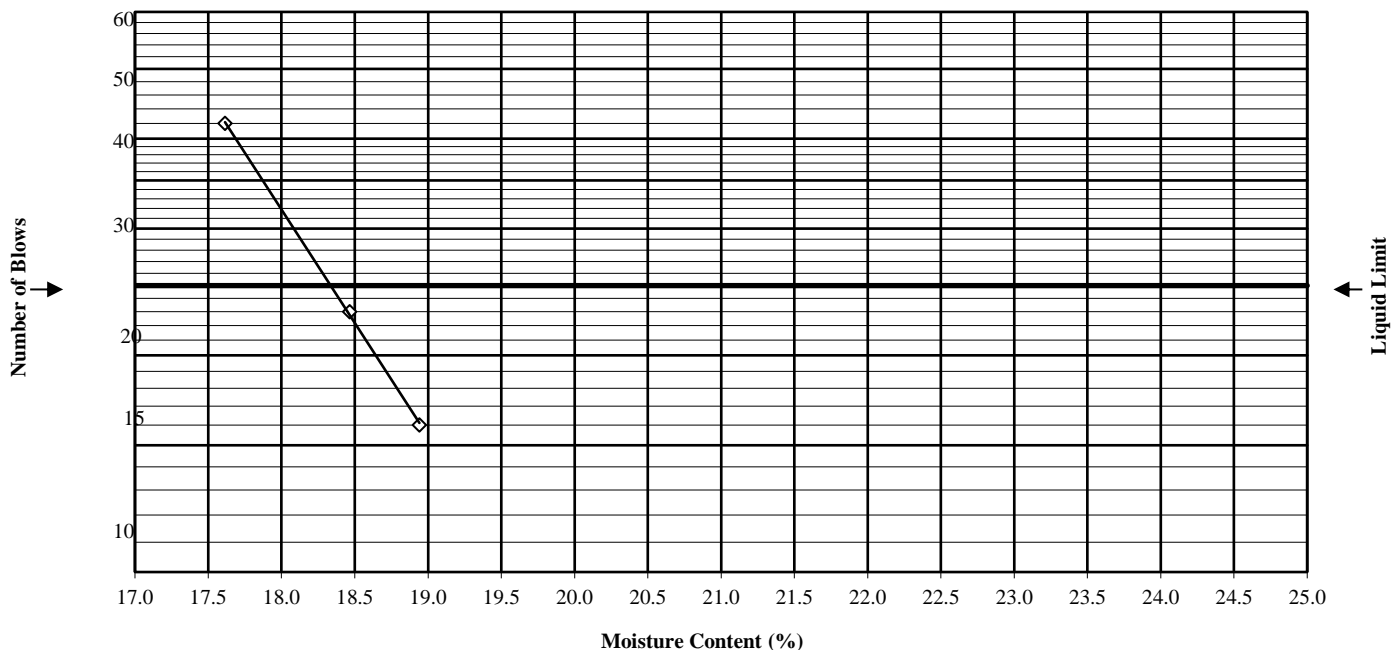
ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation, City of Vaughan Fire Station 7-12

SAMPLE DESCRIPTION: - SAMPLE LOCATION: BH5_SS8

IMTE used: SA71-TO & SA77-TO, SA11-TO

Part A		Liquid Limit						
Sample No.					Retest			
No. of Blows		42	23	16				
Dish No.								
Dish + Wet Soil		31.27	31.39	34.44				
Dish + Dry Soil		29.04	29.20	31.65				
Moisture		2.23	2.19	2.79				
Dish		16.38	17.34	16.92				
Dry Soil		12.66	11.86	14.73				
% Moisture		17.6	18.5	18.9				
Part B		Plastic Limit						
Dish No.								
Dish + Wet Soil		20.76	20.98					
Dish + Dry Soil		20.39	20.6					
Moisture		0.37	0.38					
Dish		17.05	17.25					
Dry Soil		3.34	3.35					
% Moisture		11.1	11.3					
Plastic Limit, %		11.2						
Liquid Limit, %		18.3						
Plastic Index		7.1						

Atterburg - Limits of Soils Data Card



TECHNICIAN: SA CHECKED BY: LB DATE: 21/01/2022

ATTERBERG LIMITS MTO LS-703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan DATE: 21/01/2022

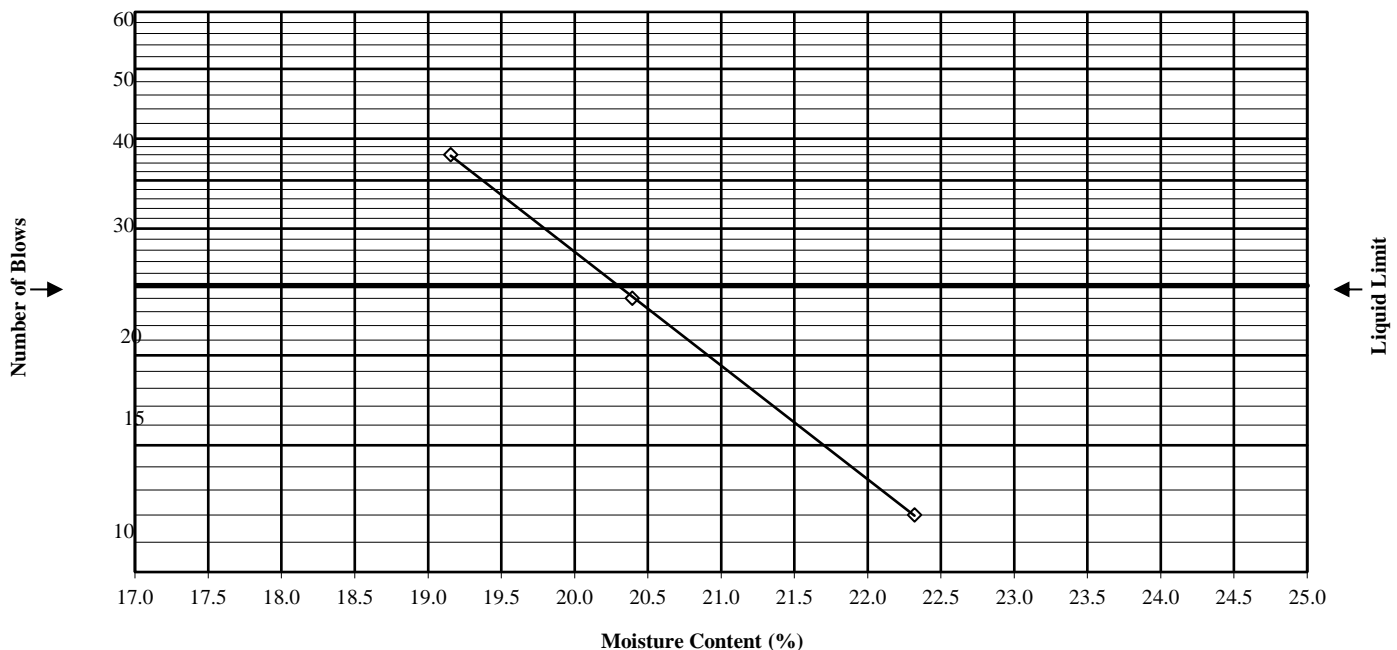
ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation, City of Vaughan Fire Station 7-12

SAMPLE DESCRIPTION: - SAMPLE LOCATION: BH6_SS8

IMTE used: SA71-TO & SA77-TO, SA11-TO

Part A		Liquid Limit						
Sample No.					Retest			
No. of Blows		38	24	12				
Dish No.								
Dish + Wet Soil		29.04	30.12	32.39				
Dish + Dry Soil		27.09	27.85	29.60				
Moisture		1.95	2.27	2.79				
Dish		16.91	16.72	17.10				
Dry Soil		10.18	11.13	12.5				
% Moisture		19.2	20.4	22.3				
Part B		Plastic Limit						
Dish No.								
Dish + Wet Soil		21.02	20.18					
Dish + Dry Soil		20.58	19.81					
Moisture		0.44	0.37					
Dish		17.13	16.78					
Dry Soil		3.45	3.03					
% Moisture		12.8	12.2					
Plastic Limit, %		12.5						
Liquid Limit, %		20.3						
Plastic Index		7.8						

Atterburg - Limits of Soils Data Card



TECHNICIAN: SA CHECKED BY: LB DATE: 21/01/2022

ATTERBERG LIMITS MTO LS-703/704

PROJECT: 02112512.000 CLIENT/JOB NAME: City of Vaughan DATE: 21/01/2022

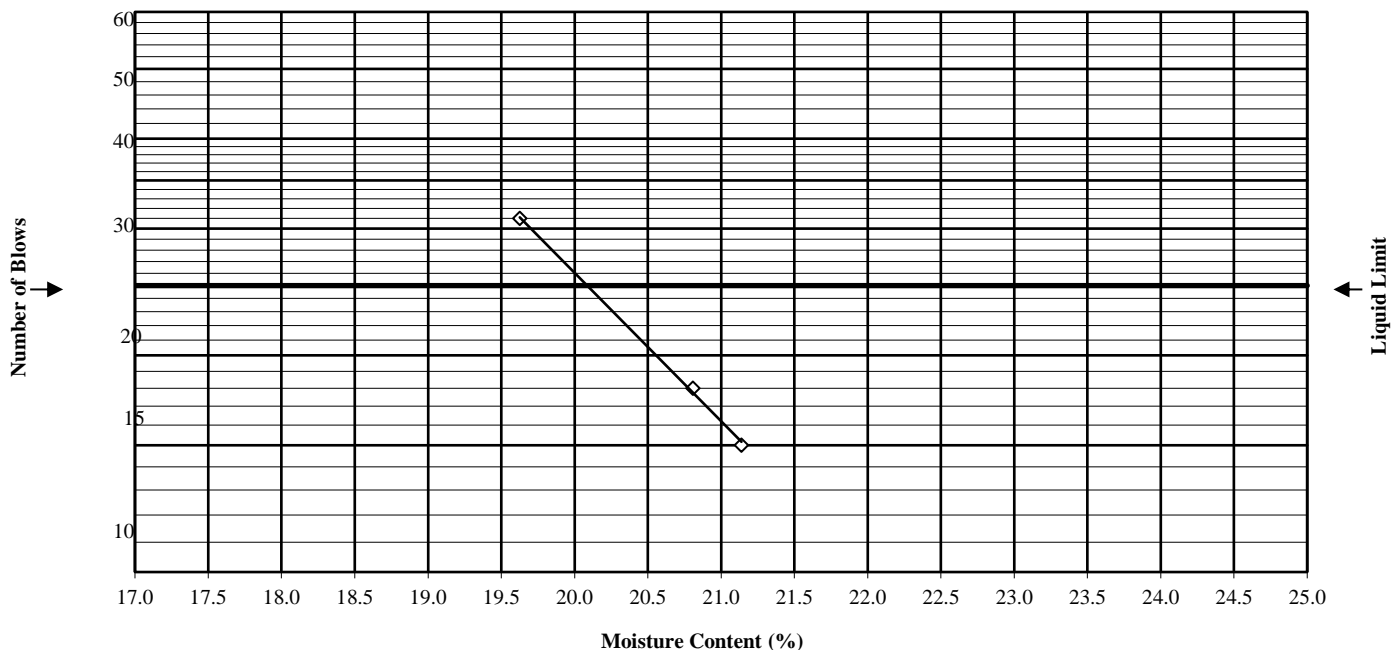
ROS ID: 101009 PROJECT/LOCATION: Geo. Tech. Investigation, City of Vaughan Fire Station 7-12

SAMPLE DESCRIPTION: - SAMPLE LOCATION: BH10_SS8

IMTE used: SA71-TO & SA77-TO, SA11-TO

Part A		Liquid Limit						
Sample No.					Retest			
No. of Blows		18	31	15				
Dish No.								
Dish + Wet Soil		29.06	27.32	29.52				
Dish + Dry Soil		26.95	25.64	27.33				
Moisture		2.11	1.68	2.19				
Dish		16.81	17.08	16.97				
Dry Soil		10.14	8.56	10.36				
% Moisture		20.8	19.6	21.1				
Part B		Plastic Limit						
Dish No.								
Dish + Wet Soil		20.74	20.6					
Dish + Dry Soil		20.28	20.17					
Moisture		0.46	0.43					
Dish		16.86	16.95					
Dry Soil		3.42	3.22					
% Moisture		13.5	13.4					
Plastic Limit, %		13.4						
Liquid Limit, %		20.1						
Plastic Index		6.7						

Atterburg - Limits of Soils Data Card



TECHNICIAN: SA CHECKED BY: LB DATE: 21/01/2022

Appendix D

Infiltration Test Results

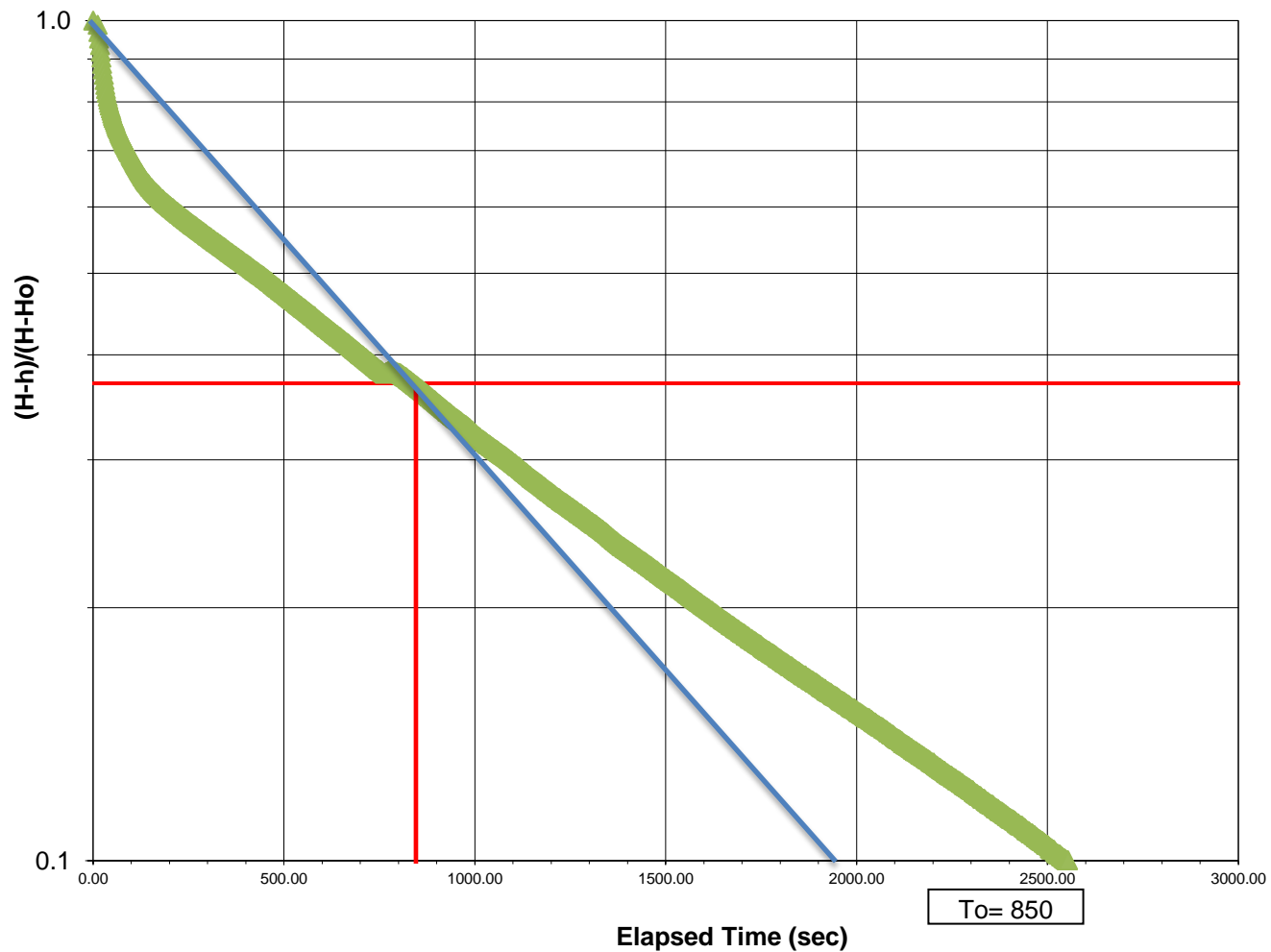


eNGLOBE

Infiltration Test: BH1 - 9541 Weston Rd
(Based on data from Datalogger - Falling Head Method)

Project No.:	2112512.000		
Date:	26-May-22	H =	Initial Water Head prior to test
Conducted by:	Alfred Iskander	Ho =	Water Head at time = 0
Processed by:	Alfred Iskander	h =	Water Head/Level at time t
Well Number:	BH1		
Screen Depth (mbgs):	2.5m - 4.0m		
Well Elevation:	225.600	L =	150 cm
Well Diameter:	2.0" ID	R =	10.48 cm
Static Water Level (mbgs):	3.99	r =	2.54 cm
Initial Datalogger Reading (H)	3.98	To =	850 sec
		$K = r^2 \ln(L/R) / (2LT_o) = $ <div style="border: 1px solid black; padding: 2px;">6.7E-07</div> m/s	

Slug Test Result (Hvorslev Method)
Based on Datalogger Readings



HYDRAULIC CONDUCTIVITY ESTIMATES AND INFILTRATION RATES

Vaughan Fire Station 7-12

Location	Test ID	Test Used	Depth (m)	Soil Description	K (cm/s)	LN(I)	Infiltration Rate (mm/hour)	Design Infiltration Rate (Safety factor of 2.5)
BH 15	Test 1	Guelph Permeameter	1	Silty Clay some sand	4.7E-05	3.6	37.9	15.2
BH1	Test 1	Datalogger	1	Silt	6.7E-05	3.7	41.6	16.6

For Guelph Permeameter:

$y=6E-11(X^{3.7363})$

$LN(K)=LN6-11LN10+3.7363LN(I)$

$K = \text{cm/s}$

$I = \text{mm/hour}$

$LN(I)=(LN(K)+11LN(10)-LN(6))/3.7363$

Note regarding safety factors as referenced from *Toronto and Region Conservation Authority (2012) Stormwater Management Criteria, Appendix C: Water Balance and Recharge*:

1. The measured infiltration rate (in mm/hour) at the proposed bottom elevation of the infiltration gallery must be divided by a safety factor selected from Table C 3 to calculate the design infiltration rate. To select a safety correction factor from Table C 3, calculate the ratio of the mean (geometric) measured infiltration rate at the proposed bottom elevation of the infiltration gallery to the rate in the least permeable
2. Where the soil horizon is continuous within 1.5 m below the proposed bottom elevation of the gallery, the mean infiltration rate measured at the bottom of the gallery should be divided by a safety correction factor of 2.5 to calculate the design infiltration rate.

