



FINAL REPORT

FOUNDATION INVESTIGATION AND DESIGN REPORT New Material Storage Facility at Haileybury Patrol Yard, Timiskaming Shores

**Agreement No. 5015-E-0007
Assignment No. 10
Geocres No. 31M-126**

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1 FOUNDATION INVESTIGATION REPORT

1.1 Introduction

This report presents the results of a geotechnical investigation carried out by EXP Services Inc. (EXP) for the proposed new material (including winter sand/salt) storage facility at the Haileybury Patrol Yard, located in Timiskaming Shores, Northeastern Ontario. The work was undertaken under Agreement # 5015-E-0007, Assignment No. 10. The terms of reference (TOR) were as presented in the Ministry of Transportation (MTO) email received on March 12, 2019.

The purpose of this investigation is to establish existing subsurface conditions at the proposed location of the patrol yard structure within construction limits defined by MTO. The site-specific geotechnical investigation consisted of field investigation including visual inspection, drilling, soil sampling, and laboratory testing. Factual results of the investigation and laboratory testing are included in this report. The report has been prepared specifically and solely for the project described in the report.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The Haileybury Patrol Yard is located on West Road, approximately 1 km east of the Hwy 11 and West Road junction in the Town of Haileybury, Timiskaming Shores, Northeastern Ontario (see Key Map on Drawing 1, Appendix B). The site is bound by West Road to the south, a residential home and farm land to the west, and by farm land to the north and east.

A paved roadway and parking area lead from the site entrance on West Road to an approximately 40x65 m garages/office, which is located approximately 60 m northwest of entrance gate. The proposed new storage facility will be located approximately 40 m north from the garages/office and approximately 110m northwest from the site entrance.

The topography of the site is considered flat lying with borehole elevations ranging from 259.8 to 260.1 m. The ground surface of the proposed material storage facility is paved on the east and west and has gravel near the northwest end of the facility. The area beyond the east boundary of the proposed facility consists of bush with mature trees. Photographs of the site and core samples of the Sand and Gravel Till encountered in borehole BH19-H-1 are included in Appendix A.

1.2.2 Geological Setting

According the Ministry of Northern Development and Mines, Map 2555 (Quaternary Geology of Ontario, East-Central Sheet, 1991), the site is located at the boundary between a glaciolacustrine plain and bedrock knob landforms. The glaciolacustrine deposits consisting of silt and clay with minor sand is a basin and quiet water deposits and according to Map 2543 (Bedrock Geology of Ontario, East-Central

Sheet, 1991), the bedrock geology of the site is of conglomerate, wacke, arkose, quartz arenite, argillite of the Cobalt Group (Huronian Supergroup).

1.3 Investigation Procedures

1.3.1 General

The field investigation was performed between April 8 and 12, 2019. The field program consisted of drilling four (4) sampled boreholes (BH19-H-1 to BH19-H-4). The boreholes were strategically located at the patrol yard to provide the subsurface information for the design of the proposed material storage facility. The borehole locations are shown on Drawing 1 in Appendix B.

The borehole locations (referenced to the MTM NAD83 coordinate system) and their ground surface elevations were surveyed by EXP personnel, with reference to the benchmark (BM) established on a 18mm diameter anchor bolt set horizontally in concrete foundation located at the east side of the existing sand dome facility. The elevation of the BM was considered 260.293 m based on the drawing provided with TOR. The BM location is shown on Drawing 1, in Appendix B.

The boreholes were advanced using a truck mounted CME-55 drill rig, equipped with a hollow stem augers and diamond bit NW casing. All borehole drilling and sampling operations were performed by a specialist drilling contractor, Landcore Drilling Services. The locations, elevations and depths of boreholes are shown below in Table 1.1.

Table 1.1. Locations, elevations and depths of boreholes completed by EXP Services Inc.

BH #	Location	MTM NAD83 Northing	MTM NAD83 Easting	Ground Elevation (m)	Borehole Depth (m)
BH19-H-1	Proposed new materials storage facility footprint	5257092.15	288600.63	260.1	15.3
BH19-H-2	Proposed new materials storage facility footprint	5257130.08	288605.36	259.8	5.3
BH19-H-3	Proposed new materials storage facility footprint	5257081.13	288653.44	259.9	5.9
BH19-H-4A/B	Proposed new materials storage facility footprint	5257125.15	288653.29	259.8	15.0

During the drilling of the boreholes, soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (CFEM pg. 40) and used to provide an assessment of in-situ consistency of cohesive soils or relative density of non-cohesive soils. Field vane testing was conducted in cohesive soil to measure the in-situ undrained shear strength of this soil. Field vane test was conducted with the standard MTO vane

(6" tampered vane, 2.5" diameter) in accordance with ASTM D2573-08. When a hard stratum was reached sampling of hard material was performed by diamond core drilling, using a 1.5 m long NQ double tube wireline core barrel. The water supply from the site, Haileybury Patrol Yard was used for soil sampling (wash boring) and rock coring.

Upon completion of the drilling operations, groundwater level measurements were carried out in the open holes. The groundwater levels encountered in the boreholes are shown on the borehole logs and presented below in Table 1.9. The boreholes were decommissioned by bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the Ontario Water Resources Act).

The fieldwork was supervised by a member of EXP's engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO and/or ASTM standards for soils classification, and retrieved soil samples for subsequent laboratory testing and identification.

All the recovered soil samples were placed in labelled moisture-proof bags and returned to EXP's Sudbury and Brampton laboratory for additional visual, textual and olfactory examination, and sampling for laboratory testing.

1.3.2 Available Documents

The available report of the previous investigation for Haileybury Patrol Yard (formerly known as Tri-Town Patrol Yard) in the MTO GEOCREs library is:

Geocres No. 31M-001: "Proposed Site of D.H.O Patrol Garage at Secondary Hwy No. 558 and Tri-town By-pass", July 19, 1961

Geocres No. 31M-096: "Foundation Investigation and Design Report, Proposed Sand/Salt Storage Facility, Haileybury Patrol Yard" prepared by Genivar Inc., January 15, 2013

The details of four boreholes completed by Genivar Inc. (Genivar) for Haileybury Patrol Yard are outlined in Table 1.2 and the borehole locations are shown on Drawings in Appendix B. The ground elevations mentioned in Table 1.2 are in reference to BM noted in Section 1.3.1 and Drawing 1 in Appendix B. The borehole logs are included in Appendix H.

Table 1.2. Summary of boreholes completed by Genivar Inc.

BH #	MTM NAD83 Northing	MTM NAD83 Easting	Ground Elevation (m)	Borehole Depth (m)
BH12-1	5256348.1	596922.5	259.9	11.1
BH12-2	5256331.4	596921.8	259.9	10.4
BH12-3	5256352.0	596899.7	260.0	11.1

BH #	MTM NAD83 Northing	MTM NAD83 Easting	Ground Elevation (m)	Borehole Depth (m)
BH12-4	5256333.1	596898.3	259.9	10.4

1.3.3 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content, particle size distribution and Atterberg Limits tests for approximately 25% of the collected soil samples. In addition, one consolidation test and a unit weight test were performed on representative cohesive sample. Soil chemical (Corrosivity and Contamination) package tests were performed on two soil samples. All the laboratory tests were carried out in accordance with MTO and/or ASTM standards as appropriate.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses are presented graphically in Appendix D.

1.4 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the borehole log sheets in Appendix C. Laboratory test results are provided in Appendix D. The “Explanation of Terms Used in Report” preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and stratigraphic section along the proposed material storage facility are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole logs and stratigraphic section are inferred from non-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Further, subsurface conditions may vary between and beyond the borehole locations.

In general, the stratigraphic sequence at the proposed structure site consists of top sand and gravel fill, underlain by native silty clay, varved silty clay and silt to clayey silt deposits followed by sand and gravel till with cobbles and boulder, followed by bedrock. A summary of the soil and groundwater conditions encountered in the boreholes is provided below.

1.4.1 Asphalt

Asphalt was encountered at the surface of EXP’s borehole BH19-H-3 and all Genivar’s borehole BH12-1 to BH12-4, and ranged in thickness from approximately 0.1 m to 0.2 m. Asphalt thicknesses may further vary beyond the borehole locations.

1.4.2 Fill: Gravelly Sand

A gravelly sand fill layer was encountered at the surface of EXP's boreholes BH19-H-1, BH19-H-2 and BH19-H-4 and, below the layer of asphalt for EXP's borehole BH19-H-3, Genivar's borehole BH12-1 to BH12-4. The approximate elevations of the surface and base of the fill and the thickness of fill as encountered in boreholes are summarized in Table 1.3 below:

Table 1.3. Summary of sand and gravel fill layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-H-1 (EXP)	260.1	258.6	0.0	1.5
BH19-H-2 (EXP)	259.8	258.3	0.0	1.5
BH19-H-3 (EXP)	259.7	258.4	0.2	1.3
BH19-H-4A/B (EXP)	259.8	258.3	0.0	1.5
BH12-1 (Genivar)	259.8	258.5	0.1	1.3
BH12-2 (Genivar)	259.8	258.5	0.1	1.3
BH12-3 (Genivar)	260.0	257.9	0.1	2.0
BH12-4 (Genivar)	259.8	258.6	0.1	1.3

This layer consists of gravelly sand with some silt, some to occasional cobbles, some organics. The material is brown in color, and moist to damp. The SPT "N" values within this layer ranged from 10 to 64 blows per 300 mm penetration, corresponding to compact to very dense compactness condition.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture Content: (EXP and Genivar)

- 3% to 40.7%

Grain Size Distribution: (EXP and Genivar)

- 14% to 20% gravel;
- 61% to 71% sand; and
- 9% to 16% fines

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The result of grain size distribution tests performed by EXP is also provided on Figure 1, in Appendix D. The results of tests performed by Genivar are shown on the borehole logs attached in Appendix H.

1.4.3 Silty Clay (Varved)

A layer of native varved silty clay was encountered below the sand and gravel fill in EXP's borehole BH19-H-2, and below the native silty clay in EXP's boreholes BH19-H-1 and BH19-H-4A. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.4 below:

Table 1.4. Summary of silty clay layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-H-1 (EXP)	257.8	255.5	2.3	2.3
BH19-H-2 (EXP)	258.3	257.5	1.5	0.8
BH19-H-4A/B (EXP)	257.5	256.9	2.3	0.6

The composition of this layer is silty clay, and trace sand. The material is brown to grey in color with orange molting, and frozen to wet. The SPT "N" values within this layer ranged from 5 to 22 blows per 300 mm penetration, suggesting firm to very stiff material in consistency. Laboratory testing performed on selected sample consisted of moisture content, grain size distribution and Atterberg Limit tests. The test results are as follow:

Moisture Content: (EXP)

- 21.3% to 40.3%

Grain Size Distribution: (EXP)

- 0% gravel;
- 2% sand;
- 53% silt; and
- 45% clay

Atterberg limits: (EXP)

- Liquid Limit: 38%
- Plastic Limit: 21%
- Plasticity Index: 17%

The results of the moisture content, grain size distribution and Atterberg Limit tests are provided on the record of borehole sheets in Appendix C. The results of grain size distribution and Atterberg Limit tests performed by EXP are also provided on Figures 2 and 6, respectively, in Appendix D.

1.4.4 Silty Clay/ Clayey Silt

A layer of native silty clay was encountered in all EXP's and Genivar's boreholes. A layer of silty clay was encountered below sand and gravel fill in EXP's boreholes BH19-H-1, BH-19-2 and BH19-H-4A/B; silty clay to clayey silt was encountered below sand and gravel fill in Genivar's boreholes BH12-1 to BH12-4. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.5 below:

Table 1.5. Summary of silty clay/ clayey silt

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-H-1 (EXP)	258.6	257.8	1.5	0.8
BH19-H-2 (EXP)	257.5	256	2.3	1.5
BH19-H-3 (EXP)	258.4	255.9	1.5	2.5
BH19-H-4A/B (EXP)	258.3	257.5	1.5	0.8
	256.8	255.2	3.0	1.6
BH12-1 (Genivar)	258.5	255.5	1.4	3.0
BH12-2 (Genivar)	258.5	254.1	1.4	4.4
BH12-3 (Genivar)	257.9	254.3	2.1	3.6
BH12-4 (Genivar)	258.6	254.2	1.4	4.4

The composition of this layer is silt and clay, trace sand and trace gravel. The material is brown to grey in color with orange/brown molting and frozen to wet. The SPT "N" values within this layer ranged from 1 to 13 blows per 300 mm penetration, suggesting very soft to stiff material in consistency. In addition, in-situ shear vane tests were performed in EXP's boreholes BH19-H-1 to BH-19-H-3, no shear was experienced up to 100 lbs. In-situ shear vane test performed by Genivar ranged from 80 kPa to 100 kPa,

confirming stiff consistency. The corresponding sensitivity ranged from 3.2 to 4.7, medium to sensitive clay soil.

Laboratory testing performed on selected sample consisted of moisture content, grain size distribution and Atterberg Limit tests. The test results are as follow:

Moisture Content: (EXP and Genivar)

- 8.1% to 46%

Grain Size Distribution: (EXP and Genivar)

- 0% to 3% gravel;
- 1% to 7% sand;
- 35% to 59% silt; and
- 34% to 62% clay

Atterberg limits: (EXP and Genivar)

- Liquid Limit: 26% to 50%
- Plastic Limit: 19% to 23%
- Plasticity Index: 7% to 30%

One-dimensional consolidation test was performed on Shelby Tube sample of clayey silt from BH19-H-2 TW5 (Depth: ~3.0 m). The result of the test is summarized below:

- Moisture Content = 31.4%
- Initial Void Ratio (e_0) = 0.991
- Pre-consolidation Pressure (p'_c) = 480 kPa
- Compression Index (C_c) = 0.39
- Recompression Index (C_r) = 0.033

The results of the moisture content grain size distribution and Atterberg Limit tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test and Atterberg Limit tests performed by EXP are also provided on Figures 5 and 8, respectively, in Appendix D. The results of tests performed by Genivar are shown on the borehole logs attached in Appendix H.

1.4.5 Silt/ Silt to Clayey Silt

A layer of silt to clayey silt was encountered below varved silty clay in EXP's borehole 19BH-H-1; below silty clay deposit in EXP's boreholes BH19-H-2 to BH19-H-4, and a layer of silt with some clay was encountered below the clayey silt to silty clay layer in Genivar's boreholes BH12-1 and BH12-3. Borehole BH19-H-2 is terminated within this layer. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.6 below:

Table 1.6. Summary of silt/ silt to clayey silt layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-H-1 (EXP)	255.5	254.3	4.6	1.2
BH19-H-2 (EXP)	256.0	254.5	3.8	1.5
BH19-H-3 (EXP)	255.9	254.6	4.0	1.3
BH19-H-4A/B (EXP)	255.2	254.6	4.6	0.6
BH12-1 (Genivar)	255.5	254.2	4.4	1.3
BH12-3 (Genivar)	254.3	251.5	5.7	2.8

The composition of this layer is silt/ molted silt, clayey silt and some clay, trace sand. The material is brown grey to grey, and wet. The SPT "N" values within this layer ranged from 17 blows per 300 mm penetration to 100 blows per 76 mm, suggesting very stiff to hard material in consistency. In-situ shear vane test ranged from 27 kPa to greater than 100 kPa, firm to very stiff consistency. The corresponding sensitivity was about 2.0 and 3.6, medium sensitivity silt/ silt to clayey silt layer.

Laboratory testing performed on selected sample consisted of moisture content, grain size distribution and Atterberg Limit tests. The test results are as follow:

Moisture Content: (EXP and Genivar)

- 8% to 22%

Grain Size Distribution: (EXP and Genivar)

- 0% to 3% gravel;
- 3% to 7% sand;
- 72% to 79% silt; and

- 18% to 22% clay

Atterberg limits: (EXP and Genivar)

- Liquid Limit: 22% to 24%
- Plastic Limit: 18% to 20%
- Plasticity Index: 2% to 5%

The results of the EXP's moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The result of the grain size distribution test and Atterberg Limit tests performed by EXP are also provided on Figures 3 and 7, respectively, in Appendix D. The results of tests performed by Genivar are shown on the borehole logs attached in Appendix H.

1.4.6 Silty Sand Till

A layer of native silty sand till was encountered in all Genivar's boreholes, below silt deposit in boreholes BH12-1 and BH12-3; below silty clay to clayey silt deposit in boreholes BH12-2 and BH12-4. Boreholes BH12-2, BH12-3 and BH12-4 are terminated within this layer. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.7 below:

Table 1.7. Summary of silty sand till layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH12-1 (Genivar)	254.2	250.9	5.7	3.3
BH12-2 (Genivar)	254.1	251.6	5.7	2.5
BH12-3 (Genivar)	254.3	251.5	5.7	2.8
BH12-4 (Genivar)	254.2	250.2	5.7	4.0

The composition of this till layer is silty sand, with some gravel and trace clay. The material is grey in color, and wet. The SPT "N" values within this layer were between 15 and 100 blows per 300 mm penetration, suggesting compact to very dense in consistency. Auger refusal was frequently encountered in this layer in Genivar's boreholes BH12-2 and BH12-4 during drilling.

Laboratory testing performed on selected sample consisted of moisture content and grain size distribution tests. The test results are as follow:

Moisture Content: (Genivar)

- 6% to 25%

Grain Size Distribution: (Genivar)

- 18% gravel;
- 41% sand;
- 33% silt; and
- 8% clay

The results of tests performed by Genivar are shown on the borehole logs attached in Appendix H.

1.4.7 Sand and Gravel Till with Cobbles and Boulder/ Gravelly Sand Till

A layer of sand and gravel till with cobbles and boulder was encountered below the silt to clayey silt in EXP's boreholes BH19-H-1, BH19-H-3 and BH19-H-4A/B; below silty sand till in Genivar's borehole BH12-1. EXP's boreholes BH19-H-1, BH19-H-3 and Genivar's borehole BH12-1 are terminated in this layer. Auger and spoon refusal were encountered in this layer in all EXP's boreholes during drilling and the till deposit was cored to advance boreholes. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.8 below:

Table 1.8. Summary of sand and gravel till with cobbles and boulder/ gravelly sand till

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-H-1	254.3	244.8	5.8	9.5
BH19-H-3	254.6	254.0	5.3	0.6
BH19-H-4A/B	254.6	246.3	5.2	8.3
BH12-1 (Genivar)	250.9	248.7	9.0	2.2

The composition of this till layer is gravel and sand, with cobbles and boulder, trace to some silt, trace clay. The material is grey in color, and wet. The SPT "N" values within this layer were 50 blows per 300 mm to 50 blows per 102 mm penetration, suggesting very dense in consistency.

Laboratory testing performed on selected sample consisted of moisture content and grain size distribution test. The test results are as follow:

Moisture Content: (EXP and Genivar)

- 1% to 21.1%

Grain Size Distribution: (EXP and Genivar)

- 33% to 43% gravel;
- 43% to 46% sand;
- 18% silt; and
- 6% clay
- 11% fines

The results of the EXP's moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The result of the grain size distribution tests performed by EXP is also provided on Figure 4, in Appendix D. The results of tests performed by Genivar are shown on the borehole logs attached in Appendix H.

1.4.8 Bedrock

The bedrock was encountered below the till deposit in BH 19-H-4B at a depth about 13.6 m below the ground surface with elevation about 246.3 m. The bedrock was confirmed using coring a depth of 1.5 m.

Based on the bedrock core recovered, the bedrock is identified as metamorphosed conglomerate. In general, the bedrock sample is described as grey groundmass with medium to fine grained with well-developed foliation. The Rock Quality Designation (RQD) measured on the core samples is about 91.7%, indicating a rock mass of very good quality. Based on the International Society for Rock Mechanics and Rock Engineering classification (ISRM 1980) the rock is described as very high strength (R5 grade) with an estimated Uniaxial Compressive Strength (UCS) of between 100 and 250 MPa. Photographs of rock cores are included in Appendix E.

1.5 Groundwater Conditions

Information regarding groundwater levels at the site was obtained by measuring water levels in the open holes of all the boreholes after completion of drilling. The groundwater levels measured in the boreholes are shown on Table 1.9 and on the borehole logs. Water levels measured in open boreholes might not be stabilized due to the relatively short period of observation.

Table 1.9 Groundwater data

Borehole	Date of Drilling	Ground surface Elevation (m)	Groundwater Elevation (m)	Groundwater Depth (m)
BH19-H-1	4/11/2019	260.1	254.9	5.2
BH19-H-2	4/9/2019	259.8	Dry in open hole	
BH19-H-3	4/8/2019	259.9	256.8	3.1
BH19-H-4A/B	4/11/2019	259.8	Not measured ¹	
BH12-1 (Genivar)	5/31/2012	259.9	256.9	3.0
BH12-2 (Genivar)	6/1/2012	259.9	257.8	2.1
BH12-3 (Genivar)	6/1/2012	260.0	258.0	2.0 ²
BH12-4 (Genivar)	6/4/2012	259.9	257.7	2.2

Notes:

¹Since wash boring technique was used to advanced borehole, accurate groundwater levels at these holes could not be measured in the open holes at the time of drilling operations.

²The groundwater level measured in piezometer on next day of completion of drilling.

During current investigation, four hours after borehole drilling, the unstabilized groundwater level was measured within the silty clay to clayey silt deposit approximately 3 m below ground surface (Elev. 256.9 m). However, the groundwater elevation measured in one piezometer installed during previous investigation was at about 2.0 m below ground surface (Elev. 258.0 m). Seasonal variations in the water tables should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods.

1.6 Chemical Analyses

One (1) soil sample was selected for chemical analyses, and were sent via courier, in a secure cooler under chain of custody, to AGAT Laboratories., a CALA-certified and accredited laboratory in Mississauga, Ontario.

The sample SS3 from borehole BH19-H-3 was analyzed for corrosivity chemical analysis. The analytical results are summarized in Table 1.10 below and are presented in Appendix D.

Table 1.10. Corrosivity chemical analysis

Sample Identification	pH (unitless)	Soluble Chloride (ppm)	Soluble Sulphate (ppm)	Resistivity (ohm-cm)	Conductivity (mS/cm)	Redox Potential (mV)
BH19-H-3-SS3 Silty Clay	8.16	3750	89	156	6.4	181

1.7 Environmental Analyses

In addition to corrosivity testing, two (2) samples of fill materials from BH 19-H-2 (AG2) and BH 19-H-1 (AG1) were analyzed for metals and general inorganics parameters and BTEX/ Petroleum Hydrocarbons (PHCs) – (F1-F4), respectively. The analytical results (Certificate of Analysis) are compiled in Appendix D.

2 DISCUSSIONS AND ENGINEERING RECOMMENATIONS

2.1 General

This section of the report provides geotechnical design recommendations for the proposed Patrol Yard sand/salt storage structure at the Haileybury Patrol Yard, located in the Town of Haileybury, Timiskaming Shores, Northeastern Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the previous and current investigations at the site and presented in **Part I-Foundation Investigation Report**. The interpretation and recommendations provided are intended solely to permit designers to assess foundation alternatives and design the proposed structure. Comments on construction are only provided to highlight issues that could affect the design. Contractors bidding on the works should make their own assessments of the factual data and how it might affect construction means and methods, scheduling and the like.

Based on information included in the TOR and correspondence with MTO it is understood that the new sand/salt storage building will be constructed at the MTO Haileybury Patrol Yard at the location defined by MTO. Based on the provided sketch for the proposed sand/salt storage building, it is understood that the footprint of the building will be about 52 m x 35 m in plan dimensions. At the time of writing this report the design of the building was not defined. However, based on the provided similar design, it is assumed that a building will have a maximum height of about 11.0 m to the bottom of the trusses (underside of roof truss) and it will be encompassed with a 2.5 m high, cast-in-place concrete foundation walls around the perimeter. The building can then be erected with either steel or timber framing, at a height to accommodate indoor loading and delivery of road sand/salt. The existing ground surface at the structure location varies between Elev. 259.8 m and 260.1 m. It is assumed that finished top of floor will be at the current ground level of about Elev. 259.8 m to tie-in to the adjacent exterior paved areas.

This report addresses the geotechnical design of the foundation for the proposed structure by providing geotechnical design parameters at the Ultimate Limit State (ULS) and Serviceability Limit States (SLS) as well as other geotechnical parameters that may be required in accordance with the latest edition of the *Canadian Highway Bridge Design Code (CHBDC)* (CAN/CSA-S6-14), the *Guideline for Professional Engineers Providing Geotechnical Engineering Service* (1992), the *Canadian Foundation Engineering Manual (CFEM)* (2006), the *provisions in the TOR* and good practice. It also provides discussion about the structure foundation type, stability and settlement analyses, frost protection, construction considerations and dewatering during construction, as requested in the TOR from the MTO email dated March 18, 2019.

As further requested in the TOR, the settlement and stability analyses were completed for a scenario in which the new structure would be loaded to its full allowable capacity. This scenario consists of sand/salt stacked to the maximum allowable height of the concrete walls with a stockpile area covering the entire footprint of the building. The angle of repose for sand/salt was assumed to be 33°.

2.2 Geotechnical Design Considerations for Foundations

The subsurface conditions at the site generally consist of a layer of granular fill (sand and gravel) underlain by mostly firm to very stiff silty clay/ varved silty clay/ silty clay to clayey silt, followed by silt to clayey silt, followed by a layer of very dense silty sand till/ sand and gravel till followed by a bedrock. The total overburden thickness ranged from 13.6 m (BH 19-H-4B) to 15.3 m (BH 19-H-1) at the tested locations. The overburden soils are underlain by metamorphic rock of excellent quality. During current investigation, four hours after borehole drilling, the unstabilized groundwater level was measured within the silty clay to clayey silt deposit approximately 3 m below ground surface (Elev. 256.9 m). The groundwater elevation measured in one piezometer installed during previous investigation was at about 2.0 m below ground surface (Elev. 258.0 m), suggesting a high groundwater level, that is within excavation depth of foundation.

2.2.1 Structure Foundation Alternatives

Based on the results of this investigation as well as the previous investigation, several foundation alternatives for the structure are evaluated in this report. Advantages, disadvantages relative cost and risk/consequences of shallow foundations such as strip/spread footings and deep foundations such as driven steel H-piles and drilled caissons are presented in Table 2.1.

2.2.2 Evaluation of Foundation Alternatives

Considering the findings during the geotechnical investigations, as well as the high cost of pile foundations and the structure's operating life it is unlikely that deep foundations can be considered practical for this patrol yard structure. It appears that shallow foundations are more practicable. Therefore, as noted in Table 2.1, the shallow foundation using strip footings on the native firm to stiff silty clay to clayey silt layer is ranked as the preferred foundation design option if the geotechnical resistance is adequate. However, if the higher geotechnical resistance is required the shallow foundation using strip footings on 1.7 m thick engineered fill over native stiff to very stiff silty clay (varved)/ silty clay to silt to clayey silt layer will be recommended option, as discussed in the following sections.

Given the subsurface conditions at the site the impact on settlement at the foundations of the structure will be influenced by the operating/stockpiling practices. It is our understanding that the structure will accommodate stockpiles of sand/salt at strategic locations within the structure. Based on the information mentioned in Section 2.1, the maximum loading condition is likely to be salt stockpiled to at least the level of the concrete wall over the full footprint. Mounding in the center at the angle of repose material of 33% beyond the height of the concrete wall is also a possibility.

These types of structures generally have service lives of about 20 years. Typically, in settings of poor soil conditions, the approach would be to mitigate potential distress for a shallow foundation supported on it rather than employ expensive deep foundations for building support. Mitigation to create stable foundation soils can include preloading of the footprint area before construction, structure support on engineered fill and/or stockpiling constrains in order to enhance serviceability.

Table 2.1 Evaluation of foundation alternatives

Options		Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Shallow Foundation	Strip/Spread Footings on Native silty clay to clayey silt layer	1*	<ul style="list-style-type: none"> • Straightforward construction 	<ul style="list-style-type: none"> • Fairly low geotechnical resistance available • Foundation on engineered fill might be necessary • Preloading the footprint of structure area might be required • Require dewatering for the construction of footing 	<ul style="list-style-type: none"> • Significantly lower relative cost compared to piles and other shallow foundation option 	<ul style="list-style-type: none"> • Risk of differential settlements due to loading patterns in the past and during operations • Risk of high groundwater and subgrade disturbance • Possible constraints on a storage volume
	Strip/Spread Footings on Engineered Fill	2	<ul style="list-style-type: none"> • Straightforward construction • Higher geotechnical resistance than footing on native soil layer • Compaction control 	<ul style="list-style-type: none"> • Require greater effort for dewatering to allow the construction of footing in dry and prevention of subgrade disturbance 	<ul style="list-style-type: none"> • Significantly lower relative cost compared to deep foundation but higher cost comparing to shallow foundation on native soil 	<ul style="list-style-type: none"> • Risk of differential settlements due to loading patterns in the past and during operations • Risk of high groundwater and subgrade disturbance • Possible constraints on a storage volume

Deep Foundation	Driven Steel H-Piles	3	<ul style="list-style-type: none"> Higher geotechnical resistance Negligible settlement No subgrade disturbance 	<ul style="list-style-type: none"> Not typical for this type of structure Could be difficult driving condition due to presence of cobbles and boulders May need predrilled due to presence of cobbles and boulders 	<ul style="list-style-type: none"> Higher relative costs compared with shallow foundations Unlikely to be economically feasible at the site since they have to extend to deeper competent material (~15 m) 	<ul style="list-style-type: none"> Not viable due to cost
	Drilled Caissons	4	<ul style="list-style-type: none"> High geotechnical resistance available Reduce number of deep elements compared to steel-H-piles Negligible settlement No subgrade disturbance 	<ul style="list-style-type: none"> Not typical for this type of structure May be difficult to install caissons through sandy and gravely glacial till with cobbles and boulders Temporary liners would be required for groundwater control and support through overburden Concrete for caissons would have to be placed by tremie methods below the water level 	<ul style="list-style-type: none"> Higher relative costs compared with other deep foundation option and shallow foundations Unlikely to be economically feasible at the site since it has to extend to deeper competent material (~15 m) 	<ul style="list-style-type: none"> Not viable due to cost Potential installation difficulties through glacial till

* If geotechnical resistance is adequate, otherwise preloading and/or founding on engineered fill and/or stockpiling constraints may be necessary.

Based on the provided typical design for the sand/salt storage structure, it is assumed that the strip/spread footings for the structure will be about 2.1 m. As mentioned, the footings could be founded on/within the native firm to stiff silty clay/clayey silt deposit, or on free draining engineered fill, such as Granular 'A' or Granular 'B', Type I or Type II (OPSS.PROV 1010).

The feasibility of shallow foundations depends on whether the structure can be accommodated in ground conditions with the axial resistance and settlement conditions described below. If the geotechnical resistances provided below for strip/spread footings are not sufficient for the design of the structure driven steel piles or caissons can be also considered.

2.2.3 Shallow Foundation

2.2.3.1 Footing Elevation

Based on the results of the geotechnical investigation and a requirement for adequate protection against frost penetration in the project area (i.e. a minimum 2.2 m below the lowest surrounding area, see Section 2.2.5), the following founding elevations of strip/spread footings are recommended:

Table 2.2 Recommendations for footing elevation

Soil at Founding Level	Foundation Elevation (m)	Depth Below Existing Grade
Native firm to stiff silty clay (varved)/ silty clay	257.7	~2.2 m
1.7 m thick engineered fill over native stiff to very stiff silty clay (varved)/ silty clay to silt to clayey silt	257.7	~2.2 m (requires excavation up to Elev. 256.0 m)

2.2.3.2 Geotechnical Resistances

In the context of the CHBDC, a satisfactory foundation design would require, in terms of Limit States Design, the factored geotechnical resistance of its foundation to withstand and not exceed the imposed Ultimate Limit State loads - (ULS) Design Approach, and its ability to deform acceptably under the Service Limit State loads - (SLS) Design Approach. These associated loads are typically known as unfactored and factored loads, respectively. Therefore, strip/spread footings placed on the properly prepared subgrade at the design elevation given in Table 2.2, should be designed based on the factored resistances at ULS and geotechnical reactions at SLS for 25 mm of settlement given in Table 2.3 below. The footing width of 2.1 m is assumed. Settlement of the footings under the loading from the stockpile inside the structure which will occur after its construction is considered and discussed in Section 2.6.2. In determining the settlement characteristics of the proposed building (tolerable total and differential settlement), the unfactored loads are required to be provided by the Structural or Design Engineer.

Table 2.3 Geotechnical resistance at ULS and geotechnical reaction at SLS for a 2.1 m wide footing

Soil at Founding Level	Width of Footing (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS* (kPa) (for 25 mm settlement)
Native firm to stiff silty clay (varved)/ silty clay to clayey silt	2.1	225	150
1.7 m thick engineered fill over native stiff to very stiff silty clay (varved)/ silty clay to clayey silt	2.1	375	250

Note: * SLS values can be review, if higher settlement is tolerable

Since the ULS resistance and the settlement depend on the footing size and depth of embedment, the geotechnical resistances given in Table 2.3 should be reviewed if the selected footing width or founding elevations differ from those given in the table. Similarly, if an inclined load is applied instead of a vertical load, which is used in these calculations, the values given in Table 2.3 should be reviewed to consider those inclinations.

Prior to placing footings, the exposed native subgrade should be inspected according with OPSS 902 and SP 109S12. A Qualified Geotechnical Engineer should check that the design foundation elevation is achieved and all unsuitable soils including fill and organics should be removed.

2.2.3.3 Resistance to Lateral Loads

Resistance to lateral forces/sliding resistance between the subgrade and concrete should be calculated in accordance with Section 6.7.5 of the CHBDC. The unfactored values of the coefficient of friction, $\tan \delta$, between the base of cast-in-place concrete footing and the native silty clay/ clayey silt subgrade soils below the frost level are presented in Table 2.4.

Table 2.4 Recommendations for coefficient of friction

Interface	Coefficient of Friction, $\tan \delta$
Concrete and native firm to stiff silty clay/clayey silt	0.4
Concrete and engineered fill	0.55

A factor of 0.8 should be applied in calculation of the horizontal resistance in accordance with CHBDC.

In a case of the unbalanced lateral earth pressures caused by sand/salt stockpiles being piled against the perimeter walls, these walls should be designed based on the following geotechnical parameters assuming a triangular lateral earth pressure distribution:

- Unit weight of sand/salt stockpile material = 20 kN/m³
- Friction angle of sand/salt stockpile material = 33°
- Lateral earth pressure coefficient (K_o) = 0.5

2.2.3.4 Frost Protection

According to Ontario Provincial Standard Drawing (OPSD – 3090.100), the frost depth in Haileybury township is about 2.2 m. Consequently, all footings exposed to seasonal freezing conditions should be protected from frost action by at least 2.2 m of soil cover or equivalent insulation.

2.2.4 Deep Foundation

2.2.4.1 Driven Steel Piles

Even it is unlikely that deep foundations are practical for this patrol yard structure, the steel H-piles (HP 310 x 110) driven to the competent till or bedrock can be used to support the patrol yard structure. The piles will be installed through the mostly firm to very stiff silty clay/ varved silty clay/ silty clay to clayey silt and terminated either in a layer of very dense silty sand till/ sand and gravel till, or on the bedrock. For design purpose, tip elevations for the piles discussed in this report are estimated and given in Table 2.5.

Geotechnical Axial Resistances of Piles

The factored geotechnical axial resistances at ULS and geotechnical axial reactions at SLS for 25 mm of displacement for recommended driven piles are presented in Table 2.5. It is anticipated that for H-piles driven and seated on the underlying unyielding bedrock, the geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored axial resistance at ULS; as such, ULS conditions will govern for this foundation type.

Table 2.5 Factored geotechnical resistances for considered HP 310 x 110 piles

Pile Founding Stratum	Estimated Tip Elevation (m)	Approx. Design Pile Length ¹ (m)	Factored Geotechnical Axial Resistance at ULS (kN/pile)	Geotechnical Axial Resistance at SLS (kN/pile) ²
Very Dense Till (Sand and Gravel with Some Cobbles and Boulders)	~250	~7.6 m	1,600	1,400

Pile Founding Stratum	Estimated Tip Elevation (m)	Approx. Design Pile Length ¹ (m)	Factored Geotechnical Axial Resistance at ULS (kN/pile)	Geotechnical Axial Resistance at SLS (kN/pile) ²
Bedrock	~244	~13.6	2,000	NA

Notes:

- (1) below frost depth of 2.2 m; ground elevation 259.8 m
- (2) NA-not applicable for H-piles driven and seated on the underlying unyielding bedrock, the geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored axial resistance at ULS; therefore, ULS conditions will govern the design

Resistance of Piles to Lateral Loads

The resistance of a vertical pile to lateral loads may be calculated using subgrade reaction theory, Broms' Method where the coefficient of lateral subgrade reaction, K_h (MPa/m) for granular soils is based on the following equations:

For cohesionless soils:

$$K_h = n_h(z/d)$$

For cohesive soils:

$$K_h = 67C_u/d$$

where,

K_h =coefficient of horizontal subgrade reactions (MPa/m)

d =pile diameter/ width (m)

n_h =constant of horizontal subgrade reaction (MPa/m)

C_u =undrained shear strength (kPa)

z =depth below ground surface (m)

Pile Installation

Piles will be driven through the glacial till and presence of cobbles and boulders within that glacial till must be considered for the proper pile installation. In view of this, the piles should be fitted with a driving shoe section (Titus pile point due to sloping bedrock, APF Hard Bite bearing points or similar) offering some protection against buckling at the toe as the piles are driven through the glacial till or the piles should be stiffened as per OPSD 3000.100, Type I to minimize damage to the piles in anticipation of heavy driving conditions. Care must be taken to avoid overdriving and damaging the pile tip (i.e., the structural capacity of the piles should not be exceeded).

In addition, all piles should be visually monitored by experienced personnel during installation to check for plumbness, set, internal damage, etc. All damaged piles should be rejected, or if the damage is considered to be minor, the pile can be dynamically tested to determine the available pile capacity.

2.2.4.2 Drilled Caissons

Alternatively, the patrol yard structure may also be supported on caissons socketed into the bedrock. The high axial capacity of caissons would result in fewer units being required to support the structure than that required for the H-piles. Temporary liners and tremie concrete will be required to install caissons at this site.

Table 2.6 below provides the factored geotechnical axial resistances for 1.2 m diameter caissons socketed a minimum of 1.5 m into the bedrock. The given value for caissons was results mainly from the shaft resistance of the bedrock socket. The end-bearing will be neglected due to the difficulties in cleaning and inspecting the base of sockets.

Table 2.6 Geotechnical resistance for a 1.2 m diameter caisson

Relevant Borehole	Foundation Elevation (m)	Factored ULS (kN)	SLS (kN)
BH19-H-1	242.5	6,000	N/A

Note:

NA-not applicable since for caissons socketed into the bedrock, the geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored axial resistance at ULS and, therefore, ULS conditions will govern

To verify the soundness/structural integrity of the caissons, one of the following non-destructive evaluation tests may be performed:

- Cross-hole acoustic testing and backscatter gamma ray (gamma-gamma) tests through access tubes installed within the caissons during the placement of the concrete; or
- Sonic echo tests. The advantage of these tests is that they do not require preparation during construction of the caissons. The disadvantage is that these tests do not identify all imperfections in a caisson, but provides information about continuity, defects, such as cracks, necking, soil incursions, changes in cross section and approximate pile lengths, unless the pile is very long or the skin friction is too high.

Static load tests to confirm the bearing capacity of the caissons may also be completed as described in ASTM D1143-81 (Compression Test Quick Method) and ASTM D3966-90 (Lateral Test) or as per designer's specification.

2.3 Earthquake Considerations

Recommendations for the geotechnical aspects to determine the earthquake loading are presented below.

Subsoil Conditions:

The subsoil and groundwater information at this site have been examined in relation to Section 4.1.8.4 A of the Ontario Building Code (OBC, 2012). The subsoil generally consists of firm to stiff silty clay (varved)/ silty clay to clayey silt, underlain by very dense glacial till located at the depth of approximately between 5.2 m to 5.9 m below the ground surface. It is expected that the foundations will be founded in the silty clay (varved) layer. The reported N-values for the soil below 3 m of the founding level ranged from 5 to 61 blows for 300 mm of penetration, with an average value being around 25 blows per 300 mm of penetration.

Corrected N-Values N_{60} :

The Average Standard Penetration Resistance shown in Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 refers to N_{60} which is defined as “Average Standard Penetration Resistance for the top 30 m, corrected to a rod energy efficiency of 60% of the theoretical maximum”. It should be noted that the drillers in the Haileybury area do not have their rod energy efficiencies measured and therefore, computed N_{60} values are not available for this site. In our opinion, the reported N-values could be considered as an approximate equivalent to the normalized N_{60} values as noted in the OBC 2012 for establishing the site classification.

Depth of Boreholes:

Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 indicated that the average properties in the top 30 m are to be used to determine the site classification. The four (4) boreholes advanced for building construction at this site were between 5.3 m and 15.3 m deep. The total overburden thickness was between 13.6 m and 15.3 m at the tested locations. The overburden soils are typically underlain by conglomerate bedrock of excellent quality.

Site Classification:

Based on the above assumptions and interpretations, and the soil conditions, the Site Class for this site is estimated to be Class “D” as per Table 4.1.8.4.A, Site Classification for Seismic Site Response, OBC 2012.

These parameters should be reviewed by a Structural Engineer.

2.4 Liquefaction Considerations

Based on soils and groundwater condition encountered at the site, no liquefaction is expected due to the ground motion from an earthquake having 10% probability of exceedance in a 50-year period.

2.5 Perimeter Wall and Floor Construction

The perimeter wall of the proposed structures may be constructed as a cantilever retaining wall with an extended heel toward the inside of the structure and founded on native soils or engineered fill. Structural steel bars should be provided in the footings and in the walls.

The concrete and/or asphalt floor slabs supported on the existing granular fill or on engineered fill could

be designed inside the structure. Based on available information, the floor slab/ asphalt surface elevation will be around 259.8 m. Below the floor, the sub-floor drainage system should be placed and compacted as described later in this section. The asphalt pavement structure will need to be designed by a pavement engineer. The concrete floor slab has to be design by a structural engineer specialist as well. However, it is recommended that for the concrete floor slab the final lift of granular fill beneath the floor slabs should consist of a minimum thickness of 200 mm of OPSS Granular A material, uniformly compacted to 100% of SPMDD. For this condition, a modulus of subgrade reaction k_v of 50 MPa/m may be assumed for preliminary assessment purposes. For design purposes, the value provided above needs to be modified to account for size effects as per standard design methods as outlined in CFEM 2006. The concrete floor slabs should be structurally separate from the foundation walls and columns and saw-cut control joints should be provided at regular intervals along column lines to minimize shrinkage cracking and allow for normal differential settlement of the floor slabs. Considering that the floor will be covered by sand/salt stockpile during cold weather, no need for a frost protection is required.

The construction of spread footing and subgrade for the floor may be carried out in accordance with the following recommendations:

Prior to construction, all obviously unsuitable material should be fully removed from the entire underfooting and underfloor area (see Section 2.7). Following rough grading, the exposed subgrade should be proof-rolled with a roller under the full-time supervision of a qualified geotechnical personnel. Any soft spots detected during proof-rolling should be sub-excavated and replaced with Granular A or Granular B, Type I or Type II materials compacted to at least 98 % of the Standard Proctor Maximum Dry Density (SPMDD). The prepared subgrade should be covered with at least 200 mm thick layer of Granular A compacted to not less than 100% of the material's SPMDD, crowned slightly in the central area.

Around the perimeter of the building the ground surface should be sloped on a positive grade away from the structure to promote surface water run-off and reduce groundwater infiltration adjacent to the foundations. Permanent perimeter drains are not required if the interior base is set at least 200 mm above the exterior grade and the grade is sloped away from the structure. However, a permanent subfloor drainage system may be required to collect salt-bearing water. To minimize contamination into the native soils and subsequently into the groundwater, a barrier such as a compacted low-permeability clay liner or geomembrane usually should be installed below a salt storage area. In practice, the use of geomembrane shows advantage over the compacted clay liner in terms of improved performance of the barrier. The geomembrane should be installed on a minimum 75 mm thick sand layer (OPSS PROV 1004 or OPSS PROV 1002) and covered with a 300 mm thick layer of sand fill on top of the geomembrane to protect it from the overlying pavement structure. At this particular site, the presence of layer of natural stiff silty clay could be considered as a natural barrier system for contaminant transport.

2.6 Stability and Settlement Analyses

2.6.1 Stability

To assess the global stability of the material storage facilities and to check that a minimum Factor of Safety of 1.3 will be achieved for the maximum height winter sand/salt stockpiles, a series of slope stability analyses were performed. The static slope stability analyses were performed using the Morgenstern-Price method developed based on limit equilibrium. The SLOPE/W computer program developed by GeoSlope International was employed for computation.

Stability assessments were performed for the proposed new structure of 52 m x 35 m dimensions assuming that the maximum sand/salt stockpile height could be 11 m having the side slopes of 1.5H:1V as shown on in Appendix F. The stratigraphy and groundwater condition at the site were developed based on the results of the geotechnical investigation presented in Part I - Foundation Investigation Report.

Given the above, effective stress analyses for a long-term stability assessment and total stress analysis for a short-term stability assessment was performed taking into consideration the subsoil conditions encountered directly beneath and adjacent the proposed structures.

Tabulated below in Table 2.7 are the soil parameters used for the slope stability analyses. The soil parameters were generally estimated based on the results of field and laboratory investigation.

Table 2.7 Soil properties used in slope stability analyses

Material Type	Effective Stress Parameters			Total Stress Parameters		
	ϕ (degrees)	c (kPa)	γ (kN/m ³)	ϕ (degrees)	c (kPa)	γ (kN/m ³)
Engineered Fill	32	0	21	32	0	21
Gravelly Sand Fill	32	0	20	32	0	20
Firm to Stiff Silty Clay	26	0	18	0	50	18
Firm to Stiff Silty Clay (Varved)	24	0	18	0	50	18
Stiff to Very Stiff Silt to Clayey Silt	26	0	18	0	65	18
Sand and Gravel Till	35	0	22	35	0	22
Stockpile Material (Winter sand/salt)	33	0	20	33	0	20

The graphical results of these analyses can be seen in Appendix F. As shown on Figures in Appendix F, the results of stability analyses for an approximately 11 m high winter sand/salt stockpile (in the center, with the side slopes of 1.5H:1V) restrained with concrete walls on both sides in the building suggest that the factor of safety greater of 1.3 can be obtained for a deep-seated failure surface.

2.6.2 Settlement

To evaluate the maximum settlement and differential settlement values below the material (including winter sand/salt) stockpile loadings in the proposed storage building, a 3D computer program; Settle3D (Rocscience) was employed. The properties for the encountered soil layers used in the settlement model are evaluated based on the results of the SPT as per CHBDC. The parameters are listed in Table 2.8.

Table 2.8 Soil properties used in settlement analyses

Material Type	γ (kN/m ³)	E (MPa)	C _c	C _r	P _c (kPa)	e ₀
Compact to very dense gravelly sand fill	20	50	-	-	-	-
Firm to stiff silty clay	18	-	0.39	0.033	480	0.991
Stiff to Very Stiff silt to clayey silt	18	25	-	-	-	-
Very dense sand and gravel till	22	350	-	-	-	-

The geometry of the stockpiles was assumed based on its maximum allowable capacity which is a maximum height of approximately 11 m at the center and 2.5 m along the sides at the wall. The model is illustrated on Figures G1 included in Appendix G.

The results of the settlement analyses are plotted on Figure G1 (Appendix G). The estimated settlements under the stockpile at the center and at the edges of the stockpile (i.e. location of footings) are presented in Table 2.9.

Table 2.9 Results of settlement analyses

Foundation Soil Type	Estimated Settlement (mm)			
	Elastic		Consolidation	
	Edge	Centre	Edge	Centre
Firm to stiff silty clay (varved)/ silty clayey	6	19	25	43

The calculated settlements are anticipated to occur immediately after the stockpile loadings are applied or within a period of one month. However, the loadings and consequent consolidation settlement would be occurred after the footings have been constructed. Therefore, the footings for these structures should be design under the full allowable stockpile loadings. The geometries of stockpiles under the full

allowable loadings including their maximum heights are recommended above. Since, the existing storage building lie within the footprint of proposed building, the post construction settlement within the existing stockpile area must be less than estimated above. The differential settlement between the existing stockpile area and new area could be an issue. Therefore, it is recommended to preload the portion of proposed storage building within the virgin area (i.e. outside of the existing structure footprint). It is also recommended that the designer include detailed procedures in the contract drawings and note.

If the virgin footprint area is preloaded by a gravel/sand stockpile prior of construction, the post-construction settlement can be significantly reduced. The settlement analyses for different height of the stockpile preloading were performed and the results are presented in Table 2.10 and attached Figures G3 and G4, Appendix G. The results show that the total settlement of approximately 34 mm and 40 mm at the center could be achieved by placing a 4 m and 5 m high stockpile, respectively. The total settlement of 10 mm to 11 mm can be produced at the proposed location of the storage footings. Therefore, these analyses demonstrate that preloading can significantly reduce the post construction settlement. It is anticipated that these predicted total settlements will take place as the load is applied or within a time period of about 20 days.

Table 2.10 Results of settlement analyses for preloading the virgin footprint area

Height of Stockpile Preloading (m)	Estimated Settlement at Centre (mm)	Estimated Settlement at Location of Proposed Footing (mm)
4	34	10
5	40	11

As noted before, the preloading is not necessary within the footprint of the existing structure, since that area has already experienced preloading with the maximum 11 m high stockpile during its past service time. Based on these observations no issue regarding the settlement at this site is anticipated, resulting in no need for settlement monitoring. However, in a case that settlement monitoring is required the settlement pins should be installed on the perimeter concrete wall.

2.7

2.7 Site Preparation and Engineered Fill Construction

As mentioned previously, the areas within the limits of the buildings should be stripped and cleared of asphalt, surface vegetation, topsoil and debris prior to construction. Any soils containing excessive organics or loose/disturbed materials are not suitable for the subgrade of building foundations, floor slabs or engineered fill. Therefore, areas with those soils should be excavated and replaced with engineered fill comprised of Granular A or Granular B, Type I or Type II.

Engineered fill could be placed after stripping all topsoil, organic matter, fill and other compressible, weak and deleterious materials within an area extending at least 1.0 meters beyond the outside edge of

the founding level of any footings. After stripping, the entire area should be heavily proof-rolled inspected and approved by a Geotechnical Engineer. Engineered fill should be placed in accordance with OPSS 501 and SP105S22. The fill material should be placed in thin layers not exceeding approximately 300 mm when loose. Oversize particles larger than 120 mm should be discarded, and each fill layer should be uniformly compacted with heavy compactors, suitable for the type of fill used. The engineered fill below the footing and floor slab should be compacted to 100% of its SPMDD, while within outside/exterior paved areas, the fill should be compacted to 98% of its SPMDD.

Full-time geotechnical inspection and quality control (by means of frequent field density and laboratory testing) should be provided by the Geotechnical Engineer. Every lift should be evaluated by a sufficient number of tests to ensure that the level of compaction is constantly achieved, and the compaction procedure is applied.

2.8 Excavation and Groundwater Control

The groundwater level at the site was encountered between Elev. 258.0 m and Elev. 254.9 m, while the excavation to the foundation level has to be carried out to Elev. 257.7 m or 256.0 m for footing founded on native soil or footing founded on engineered fill, respectively. Therefore, it is possible that the groundwater table is about 2 m above the bottom of excavation. Considering that the soils encountered below the groundwater table and within potential excavation depths consist of native silty clay (varved)/silty clay to clayey silt, it is assessed that these soils are susceptible to disturbance from groundwater and mobilized equipment. Therefore, the groundwater level needs to be controlled to at least 0.5 m below the excavation level to avoid disturbance, and any surface or groundwater seepage should be removed from the excavation prior to placement of granular backfill in dry. In general, where the excavation base is within 0.5 m of the prevailing groundwater level at the time of construction, it is anticipated that control of seepage can be accomplished by using properly filtered sumps, and/or filtered drains placed along the base the excavation. However, given the conditions at the site, it is expected that positive dewatering systems will be required to control the groundwater seepage.

Dewatering shall be carried out in accordance with OPSS.PROV 517, SP 517F01 and SP FOUN0003. It is responsibility of the Contractor to propose a suitable dewatering system based on the time of construction, water levels and flow conditions for prior approval of the MTO. As noted in the SP FOUN0003 working drawings, discharge of water, monitoring and removal of the dewatering system should be according to OPSS 517. The method used should not undermine the adjacent existing footings and utilities. Alternatively, and in accordance with SP 5017F01, the dewatering systems may be completed by a design Engineer and design-checking Engineer with a minimum of 5 year experience.

All excavations should be carried out in accordance with the latest version of the Occupational Health and Safety Act. For the act, the existing materials are considered as Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. Temporary excavations (i.e. those that are open only for a short period) above the groundwater table may be made with side slopes not steeper than about 1H:1V, while the temporary slopes below the groundwater table must be formed at 3H:1V unless a suitable dewatering system is installed to lower the water level below the base of the excavation.

Qualified geotechnical personnel should be on-site during the foundation installation and for fill material placement, to verify the design assumptions, and to verify the design recommendations.

2.9 Corrosion Protection

As stated above, one soil sample was selected for analyses of pH, water soluble sulphate, chloride concentrations, resistivity, conductivity and oxidation-reduction potential. The testing was completed to determine the potential for degradation of the concrete in the presence of soluble sulphate and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in Section 1.6 of this report and detailed results are included in Appendix D.

The chemical data presented in Section 1.6 indicates very low resistivity of the tested soil, which indicates a severe potential for corrosion of buried metallic elements (MTO Gravity Pipe Design Guidelines, Page 25). The maximum chloride content reported is 3,750 ppm ($\mu\text{g/g}$) which indicates a severe potential for additional corrosion. The soil pH was about 8.16 which is within what is considered the normal range for soil pH of 5.0 to 9.0. The test results in Table 1.10 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

The maximum water-soluble sulphate content of the soils tested is 89 ppm ($\mu\text{g/g}$), i.e. 0.0089% which is less than 0.10%. It indicates low potential to corrode normal Portland cement concrete. Therefore, no particular precautions are required to provide protection against sulphate attack such as special cements or mixtures.

2.10 Environmental Consideration

One (1) sample of fill materials from BH 19-H-2 (AG2) was analyzed for metals and general inorganics parameters and one (1) sample of fill material from BH 19H-1 (AG1) was analyzed for BTEX/ Petroleum Hydrocarbons (PHCs) –(F1-F4) in accordance with land use criteria listed in the Ministry of the Environment standards (Ontario Regulation 153). The results were compared with soil criteria in Table 2 (Potable Groundwater Condition) and Table 3 (Non-Potable Groundwater Condition). The analytical results (Certificate of Analysis) are compiled in Appendix D and summarized below.

The soil samples met all property use standards in Table 2 and Table 3 of Ontario Regulation 153.

May 31 2019

3 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project and are provided solely for the team responsible for the design of the works described herein.

We recommend that we be retained to review our recommendations as the design nears completion to ensure that the final design is in agreement with the assumptions on which our recommendations are based and that our recommendations have been interpreted as intended. If not accorded this review, EXP will assume no responsibility for the interpretation and use of the recommendations in this report.

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigation and analysis.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation and Design Report has been prepared by Sugitha Anandakumar, M.Eng., EIT, Nimesh Tamrakar, M.Eng., P.Eng. and Silvana Micic, Ph.D., P.Eng., and reviewed by TaeChul Kim, M.E.Sc., P.Eng. and Stan E. Gonsalves, M.Eng., P.Eng., MTO Designated Foundation Contact. The field investigation was conducted by Phillips Laframboise.

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Principal Engineer
MTO Designated Foundation Contact



Encl.

4 LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of EXP may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by EXP. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and EXP's recommendations. Any reduction in the level of services recommended will result in EXP providing qualified opinions regarding the adequacy of the work. EXP can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by EXPerience personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to EXP to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to EXP by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. EXP has relied in good faith upon such representations,

information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions EXPRESSED in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to EXP.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, EXPRESSED or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to EXP by its client ("Client"), communications between EXP and the Client, other reports, proposals or documents prepared by EXP for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions EXPRESSED in the Report, reference must be made to the Report in its entirety. EXP is not responsible for use by any party of portions of the Report.

USE OF REPORT

The information and opinions EXPRESSED in the Report, or any document forming part of the Report, are for the sole benefit of the Client. No other party may use or rely upon the Report in whole or in part without the written consent of EXP. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. EXP is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

REPORT FORMAT

Where EXP has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by EXP have utilize specific software and hardware systems. EXP makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are EXP's instruments of professional service and shall not be altered without the written consent of EXP.

Appendix A – Photographs



Photo 1: Haileybury Patrol Yard - existing sand dome, borehole BH19-H-1 facing south



Photo 2: Haileybury Patrol Yard, borehole BH19-H-2 facing north



Photo 3: Haileybury Patrol Yard - existing Gambrel style shed and sand dome, borehole BH19-H-3 facing southeast

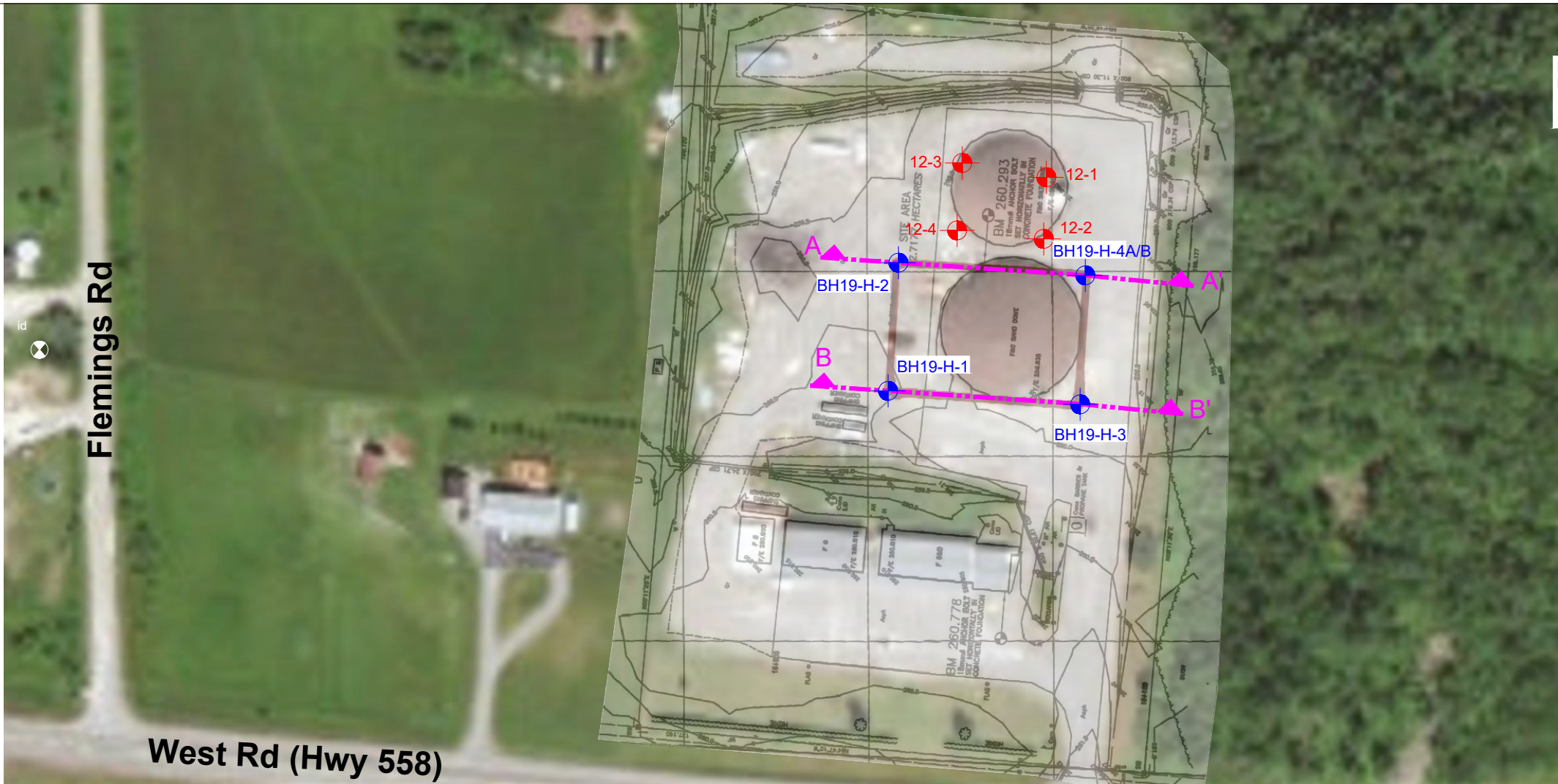


Photo 4: Haileybury Patrol Yard - existing sand/salt dome, borehole BH19-H-4A/B facing northwest




Photo 5: Sand and Gravel Till Cores with Cobbles and Boulder from BH19-H-1

Appendix B – Drawings



METRIC
DIMENSIONS ARE IN METERS AND/OR
MILLIMETERS UNLESS OTHERWISE
SHOWN. STATIONS ARE IN KILOMETERS
+METERS

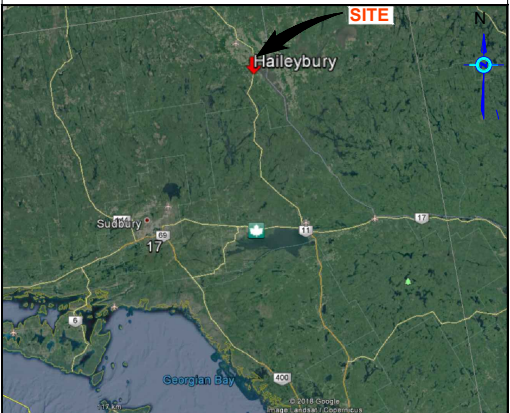
CONT. No. 5015-E-0007
GWP No. -
Assignment No. 10


SHEET
1


exp


exp Services Inc.


KEY PLAN




LEGEND


 Borehole Location


 Existing Borehole Location


 Standard Penetration Test (Blows/0.3 m)


 Groundwater level measured in open hole


SOIL STRATA SYMBOLS

 ASPHALT

 SILTY CLAY (VARVED)

 BEDROCK

 FILL

 TILL: SAND AND GRAVEL WITH SOME COBBLES AND BOULDERS

BH No.	ELEV.	MTM CO-ORDINATES (ZONE ON-10)	
		NORTHING	EASTING
BH19-H-1	260.1	5257089	288605
BH19-H-2	259.8	5257124	288607
BH19-H-3	259.9	5257085	288657
BH19-H-4A	259.8	5257119	288658
BH19-H-4B	259.8	5257119	288658

NOTES

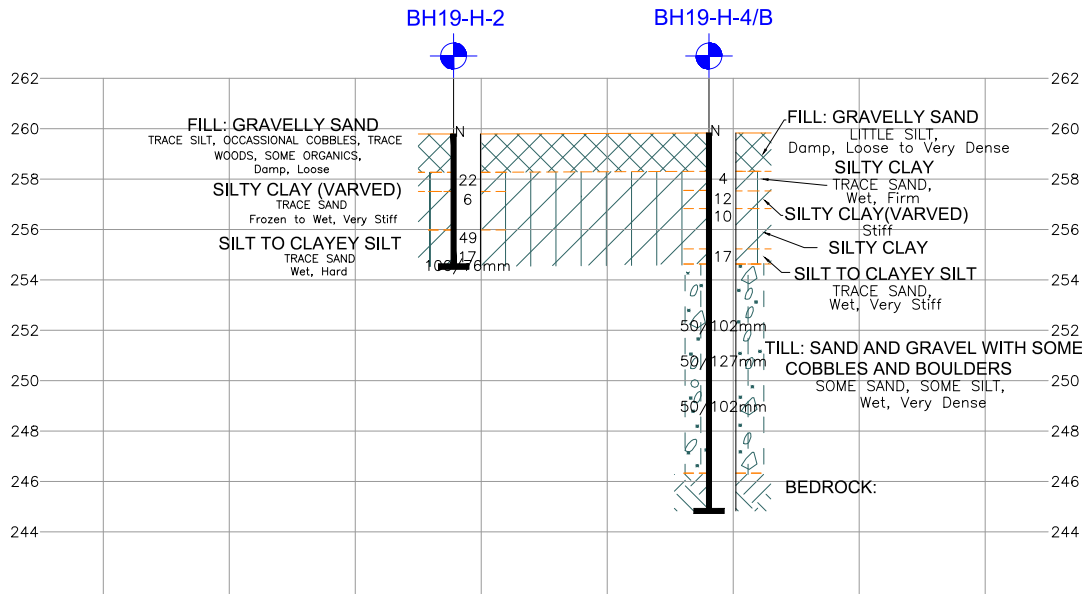
This drawing is for subsurface information only. The proposed structure details/ works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

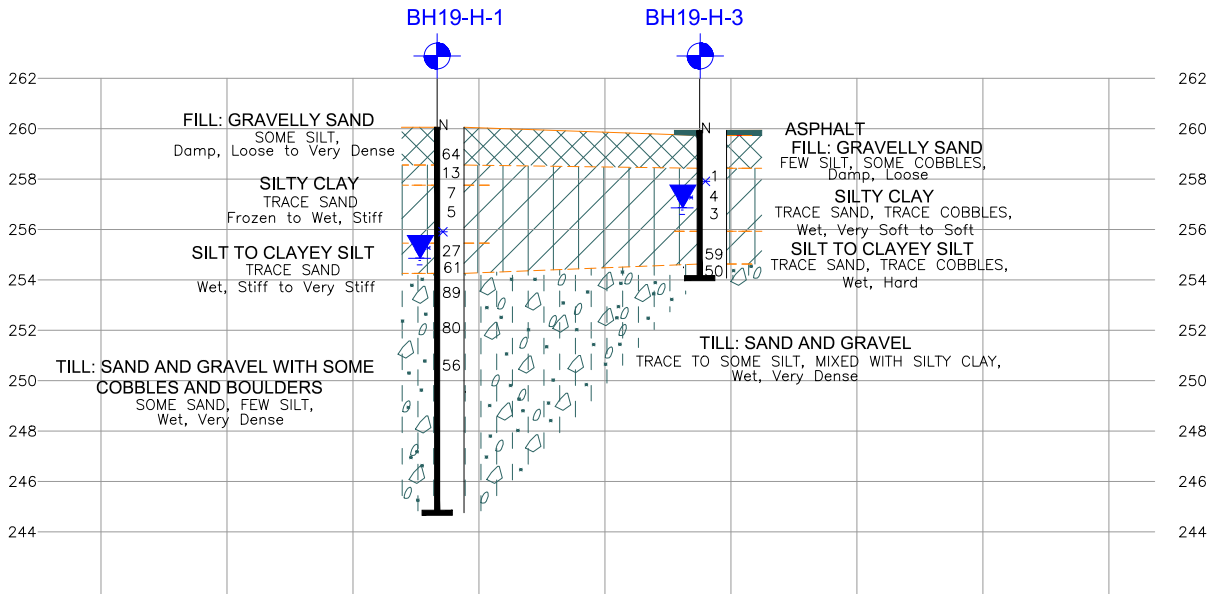
SCALE: HOR 0 5 30 m
VERT 0 6 m

	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRES NO. 31M-126	
		PROJECT NO. ADM-00233185-K0	
SUBM'D SH	CHECKED SM	DATE	May. 30, 19
DRAWN SH	CHECKED SM	APPROVED SG	DWG. 1

PLAN



SECTION A-A'



SECTION B-B'

Appendix C – Borehole Logs

Explanation of Terms Used on Borehole Records

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil: mixture of soil and humus capable of supporting good vegetative growth.

Peat: fibrous fragments of visible and invisible decayed organic matter.

Fill: where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

Till: the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

Desiccated: having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

Stratified: alternating layers of varying material or color with the layers greater than 6 mm thick.

Laminated: alternating layers of varying material or color with the layers less than 6 mm thick.

Fissured: material breaks along plane of fracture.

Varved: composed of regular alternating layers of silt and clay.

Slickensided: fracture planes appear polished or glossy, sometimes striated.

Blocky: cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Lensed: inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

Seam: a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

Homogeneous: same color and appearance throughout.

Well Graded: having wide range in grain sized and substantial amounts of all predominantly on grain size.

Uniformly Graded: predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.

ISSMFE SOIL CLASSIFICATION											
CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		
<div><div>0.002</div><div>0.006</div><div>0.02</div><div>0.06</div><div>0.2</div><div>0.6</div><div>2.0</div><div>6.0</div><div>20</div><div>60</div><div>200</div></div>											
EQUIVALENT GRAIN DIAMETER IN MILLIMETRES											
CLAY (PLASTIC) TO				FINE		MEDIUM		CRS.		FINE COARSE	
SILT (NONPLASTIC)				SAND				GRAVEL			
UNIFIED SOIL CLASSIFICATION											

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Note 16 in ASTM D2488-09a:

Table a: Percent or Proportion of Soil, Pp

	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	$5 \leq Pp \leq 10\%$
Little	$15 \leq Pp \leq 25\%$
Some	$30 \leq Pp \leq 45\%$
Mostly	$50 \leq Pp \leq 100\%$

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test 'N' value:

Table b: Apparent Density of Cohesionless Soil

	'N' Value (blows/0.3 m)
Very Loose	$N < 5$
Loose	$5 \leq N < 10$
Compact	$10 \leq N < 30$
Dense	$30 \leq N < 50$
Very Dense	$50 \leq N$

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

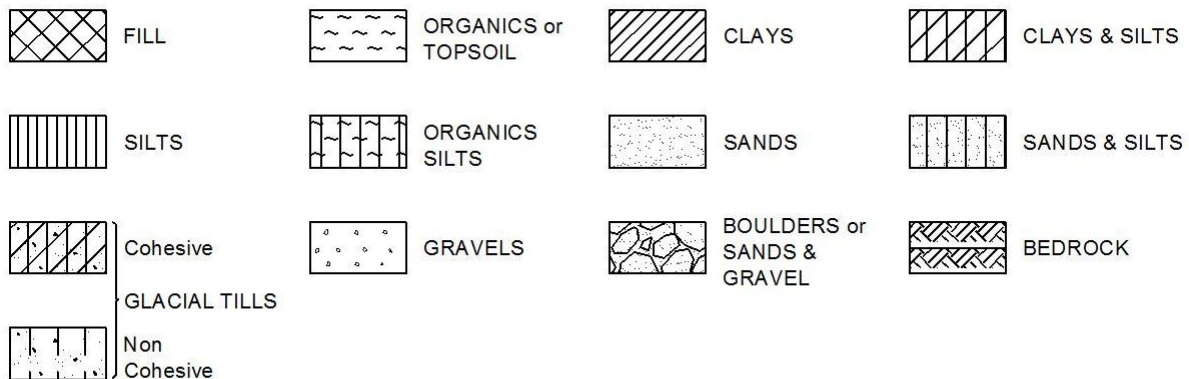
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



Open Borehole or Test Pit



Monitoring Well, Piezometer or Standpipe

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

STRESS AND STRAIN

u_w	kPa	Pore water pressure
r_u	1	Pore pressure ratio
σ	kPa	Total normal stress
σ'	kPa	Effective normal stress
τ	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
ε	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
μ	1	Coefficient of friction

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	Coefficient of volume change
c_c	1	Compression index
c_s	1	Swelling index
c_r	1	Recompression index
c_v	m ² /s	Coefficient of consolidation
H	m	Drainage path
T_v	1	Time factor
U	%	Degree of consolidation
σ'_{v0}	kPa	Effective overburden pressure
σ'_p	kPa	Preconsolidation pressure
τ_f	kPa	Shear strength
c'	kPa	Effective cohesion intercept
ϕ'	—°	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	—°	Apparent angle of internal friction
τ_R	kPa	Residual shear strength
τ_r	kPa	Remoulded shear strength
S_t	1	Sensitivity = c_u/τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m ³	Density of solid particles
γ_s	kN/m ³	Unit weight of solid particles
ρ_w	kg/m ³	Density of water
γ_w	kN/m ³	Unit weight of water
ρ	kg/m ³	Density of soil
γ	kN/m ³	Unit weight of soil
ρ_d	kg/m ³	Density of dry soil
γ_d	kN/m ³	Unit weight of dry soil
ρ_{sat}	kg/m ³	Density of saturated soil
γ_{sat}	kN/m ³	Unit weight of saturated soil
ρ'	kg/m ³	Density of submerged soil
γ'	kN/m ³	Unit weight of submerged soil
e	1, %	Void ratio
n	1, %	Porosity
w	1, %	Water content
S_r	%	Degree of saturation
W_L	%	Liquid limit
W_P	%	Plastic limit
W_s	%	Shrinkage limit
I_p	%	Plasticity index = $(W_L - W_P)$
I_L	%	Liquidity index = $(W - W_P)/I_p$
I_C	%	Consistency index = $(W_L - W)/I_p$
e_{max}	1, %	Void ratio in loosest state
e_{min}	1, %	Void ratio in densest state
I_D	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
D_n	mm	N percent - diameter
C_u	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m ³ /s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m ³	Seepage force

Brampton, Ontario

RECORD OF BOREHOLE No 19-H-1

1 OF 2

METRIC

W.P. _____ LOCATION Haileybury Patrol Yard, West Road, Haileybury ON, MTM ON10 ORIGINATED BY PL
 DIST Timiskaming HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill, NW Casing COMPILED BY NT/ SA
 DATUM Geodetic DATE 2019.04.08 - 2019.04.11 LATITUDE 47.452875 LONGITUDE 79.714836 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X P. PENETROMETER							WATER CONTENT (%)
260.1	Ground Surface						20 40 60 80 100		20 40 60					GR SA SI CL	
0.0	FILL: GRAVELLY SAND some silt, brown, damp, loose to very dense		1	AS			260							17 67 (16)	
	- becoming gravelly sand fill changing to silty clay, trace sand, frozen		2	SS	64		259								
258.6															
1.5	SILTY CLAY trace sand, brown to grey, some orange mottling, frozen to wet, stiff		3	SS	13		258								
257.8			4	SS	7		257								0 2 53 45
2.3	SILTY CLAY (VARVED) trace sand, brown to grey, some orange mottling, frozen to wet, firm to stiff		5	SS	5		256								Vane attempted no shear
			6	SS	27		255								1 7 74 18
255.5															
4.6	SILT TO CLAYEY SILT trace sand, grey, wet, stiff to very stiff		7	SS	61		254								
254.3	-Auger and Spoon refusal @ 5.8 m, start coring to advance borehole		8	NQ			253								
5.8	TILL: SAND AND GRAVEL WITH SOME COBBLES AND BOULDERS some sand, few silt, grey, wet, very dense Run 1 Length 0.28 m		9	SS	89		252								43 46 (11)
	Run 2 Length 0.79 m		10	NQ			251								
			11	SS	80		250								
	Run 3 Length 0.88 m		12	NQ			249								
			13	SS	56										
	Run 4 Length 0.77 m		14	NQ											
	-Attempted to drive spoon @ 10.67 m. Spoon bouncing.														
	Run 5 Length 1.52 m		15	NQ											

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO HAILEYBURY BH LOGS.GPJ ONTARIO MTO.GDT 5/29/19

2 OF 2

METRIC

W.P.	LOCATION			Haileybury Patrol Yard, West Road, Haileybury ON, MTM ON10		ORIGINATED BY	PL
DIST	Timiskaming	HWY	11	BOREHOLE TYPE		CME 55, Hollow stem auger drill, NW Casing	
COMPILED BY				NT/ SA			
DATUM	Geodetic			DATE	2019.04.08 - 2019.04.11	LATITUDE	47.452875
				LONGITUDE	79.714836	CHECKED BY	SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										
								● QUICK TRIAXIAL P. PENETROMETER										
							20 40 60 80 100				20 40 60							
	TILL: SAND AND GRAVEL WITH SOME COBBLES AND BOULDERS some sand, few silt, grey, wet, very dense (<i>continued</i>) Run 6 Length 1.53 m -Attempted to drive spoon @ 13.72 m. Spoon bouncing. Run 7 Length 1.57 m		16	NQ			248											
							247											
			17	NQ			246											
244.8 15.3	End of borehole at 15.3 m depth. Notes: 1. This record of borehole is to be read with the report presented above. 2. Groundwater level was measured in open hole before starting coring. 3. Groundwater level measured at 5.18 m below ground surface.						245											

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

Brampton, Ontario

RECORD OF BOREHOLE No 19-H-2

1 OF 1

METRIC

W.P. _____ LOCATION Haileybury Patrol Yard, West Road, Haileybury ON, MTM ON10 ORIGINATED BY PL
 DIST Timiskaming HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY NT/ SA
 DATUM Geodetic DATE 2019.04.09 - 2019.04.09 LATITUDE 47.453216 LONGITUDE 79.714774 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
259.8	Ground Surface													
0.0	FILL: GRAVELLY SAND trace silt, occasional cobbles, trace woods, some organics, blackish brown, damp, loose - becoming gravelly sand fill changing to silty clay, trace wood, some organics, frozen		1	AS										
			2	AS										
258.3														
1.5	SILTY CLAY (VARVED) trace sand, brown to grey, some orange mottling, frozen to wet, very stiff		3	SS	22									
257.5														
2.3	SILTY CLAY trace sand, brown to grey, wet, firm		4	SS	6									
			5	TW										
256.0														
3.8	SILT TO CLAYEY SILT trace sand, brown to grey, wet, hard		6	SS	49									
			7	SS	17									
254.5			8	SS	100/76mm									
5.3	Auger and Spoon refusal @ 5.26 m on possible till with cobbles and boulders End of borehole at 5.26 m depth. Notes: 1. This record of borehole is to be read with the report presented above. 2. No groundwater encountered in open hole upon completion of drilling. 3. Borehole open up to 5.2 m below ground surface upon completion of drilling.													

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO HAILEYBURY BH LOGS.GPJ ONTARIO MTO.GDT 5/29/19

Brampton, Ontario

RECORD OF BOREHOLE No 19-H-3

1 OF 1

METRIC

W.P. _____ LOCATION Haileybury Patrol Yard, West Road, Haileybury ON, MTM ON10 ORIGINATED BY PL
 DIST Timiskaming HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY NT/ SA
 DATUM Geodetic DATE 2019.04.08 - 2019.04.08 LATITUDE 47.452777 LONGITUDE 79.714135 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL X P. PENETROMETER										
259.9	Ground Surface							20	40	60	80	100							
259.9	<ASPHALT 178 mm asphalt																		
0.2	FILL: GRAVELLY SAND few silt, some cobbles, brown, damp, loose		1	AS			259											21 70 (9)	
	-unable to drive spoon due to cobbles, becoming gravelly sand fill changing to silty clay		2	AS															
258.4	SILTY CLAY trace sand, trace cobbles, brown to grey, orange mottling, wet, very soft to soft		3	SS	1		258												
1.5	-sample disturbed by attempted vane		4	SS	4*		257											Vane attempted no shear	
	-sample disturbed by attempted vane		5	SS	3*													Vane attempted no shear	
255.9	SILT TO CLAYEY SILT trace sand, trace cobbles, brown to grey, orange mottling, wet, hard			VANE			256											0 4 55 41	
4.0			6	SS	59		255											2 4 75 19	
254.6	TILL: SAND AND GRAVEL trace to some silt, mixed with silty clay, grey wet, very dense		7	SS	50														
5.3																			
254.0	Auger and Spoon refusal @ 5.9 m on till with cobbles and boulders End of borehole at 5.9 m depth.																		
5.9	Notes: 1. This record of borehole is to be read with the report presented above. 2. Borehole open up to 4.3 m below ground surface upon completion of drilling. 3. Groundwater level was measured at 3.05 m depth in open hole upon completion of drilling. * sample disturbed by attempted vane																		

ONTARIO MTO HAILEYBURY BH LOGS.GPJ ONTARIO MTO.GDT 5/29/19

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Brampton, Ontario

RECORD OF BOREHOLE No 19-H-4A

1 OF 1

METRIC

W.P. _____ LOCATION Haileybury Patrol Yard, West Road, Haileybury ON, MTM ON10 ORIGINATED BY PL
 DIST Timiskaming HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill, NW Casing COMPILED BY NT/ SA
 DATUM Geodetic DATE 2019.04.09 - 2019.04.11 LATITUDE 47.453173 LONGITUDE 79.714139 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
259.8 0.0	Ground Surface FILL: GRAVELLY SAND little silt, brown, damp, loose to very dense - Unable to drive spoon. Becoming gravelly sand fill changing to silty clay, trace sand, wet		1	AS		259	20	40	60	80	100	20	40	60	14 71 (15)
			2	AS											
258.3 1.5	SILTY CLAY trace sand, brown , wet, firm		3	SS	4	258									0 2 53 45
257.5 2.3	SILTY CLAY (VARVED) trace sand, brown to grey, wet, stiff - Shelby tube broken off in hole, spoon sample taken within shelly tube		4	SS	12										
256.9 2.9	-Unable to advance auger due to broken shelly tube in hole. Relocate borehole 1 m to south, see BH19-H-4B for further detail End of borehole at 2.9 m depth. Notes: 1. This record of borehole is to be read with the report presented above.					257									

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Brampton, Ontario

RECORD OF BOREHOLE No 19-H-4B

1 OF 2

METRIC

W.P. _____ LOCATION Haileybury Patrol Yard, West Road, Haileybury ON, MTM ON10 ORIGINATED BY PL
 DIST Timiskaming HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill, NW Casing COMPILED BY NT/ SA
 DATUM Geodetic DATE 2019.04.09 - 2019.04.11 LATITUDE 47.453173 LONGITUDE 79.714139 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p W W _L				
259.8 0.0	Ground Surface - Auger advanced to 3.05 m depth, see BH19-H-4A for detail							20 40 60 80 100					kN/m ³ γ	GR SA SI CL
256.8 3.0	SILTY CLAY trace sand, grey with brown mottling, wet, stiff		5	SS	10									
			6	TW										
255.2 4.6	SILT TO CLAYEY SILT trace sand, grey with brown mottling, wet, very stiff		7	SS	17									
254.6 5.2	-Auger and Spoon refusal @ 5.18 m, switch to coring to advance borehole TILL: SAND AND GRAVEL WITH SOME COBBLES AND BOULDERS some sand, some silt, grey, wet, very dense Run 1 Length 0.74 m Run 2 Length 0.12 m		8	NQ										
			9	NQ										
			10	SS	50/ 102mm									
	Run 3 Length 0.74 m		11	NQ										
			12	SS	50/ 127mm									
	Run 4 Length 1.71 m		13	NQ										
			14	SS	50/ 102mm									
	Run 5 Length 1.14 m		15	NQ										
	</													

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO HAILEYBURY BH LOGS.GPJ ONTARIO MTO.GDT 5/29/19

2 OF 2

METRIC

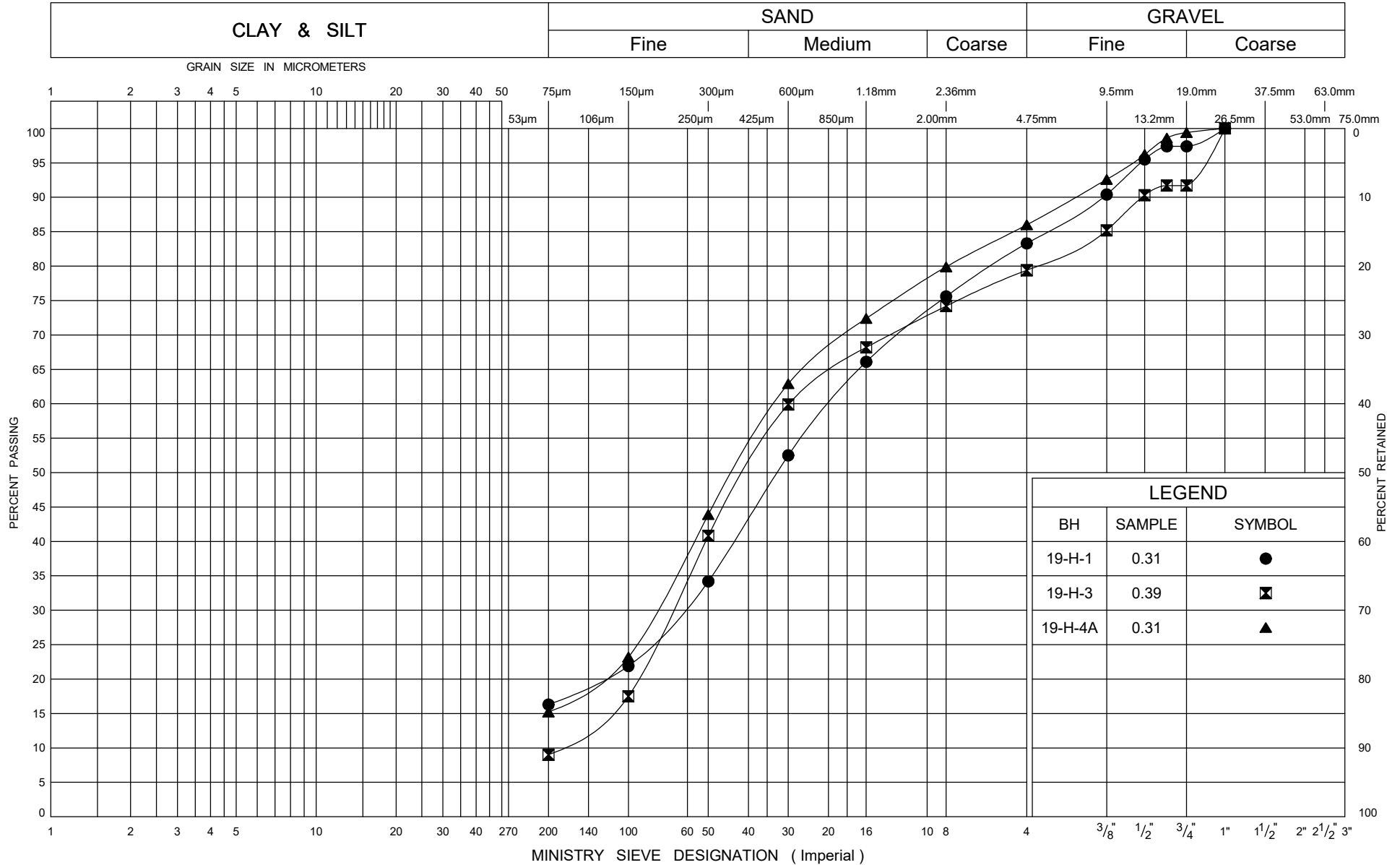
W.P.	LOCATION			Haileybury Patrol Yard, West Road, Haileybury ON, MTM ON10		ORIGINATED BY	PL				
DIST	Timiskaming	HWY	11	BOREHOLE TYPE		CME 55, Hollow stem auger drill, NW Casing	COMPILED BY	NT/ SA			
DATUM	Geodetic			DATE	2019.04.09 - 2019.04.11	LATITUDE	47.453173	LONGITUDE	79.714139	CHECKED BY	SM

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER TYPE "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X P. PENETROMETER</div> <div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W_p W W_L WATER CONTENT (%)</div>					
246.3 13.5	TILL: SAND AND GRAVEL WITH SOME COBBLES AND BOULDERS some sand, some silt, grey, wet, very dense (continued) Run 6 Length 1.46 m		16 NQ		247
244.8 15.0	BEDROCK: metamorphosed conglomerate, medium to fine grained, grey groundmass with well developed foliation, strong NQ Coring Run 7 Length (m) RQD(%) 1.5 91.7%		17 NQ		246
	End of borehole at 15.0 m depth. Notes: 1. This record of borehole is to be read with the report presented above. 2. Since water was used to advanced borehole, no groundwater level was measured in open hole.				245

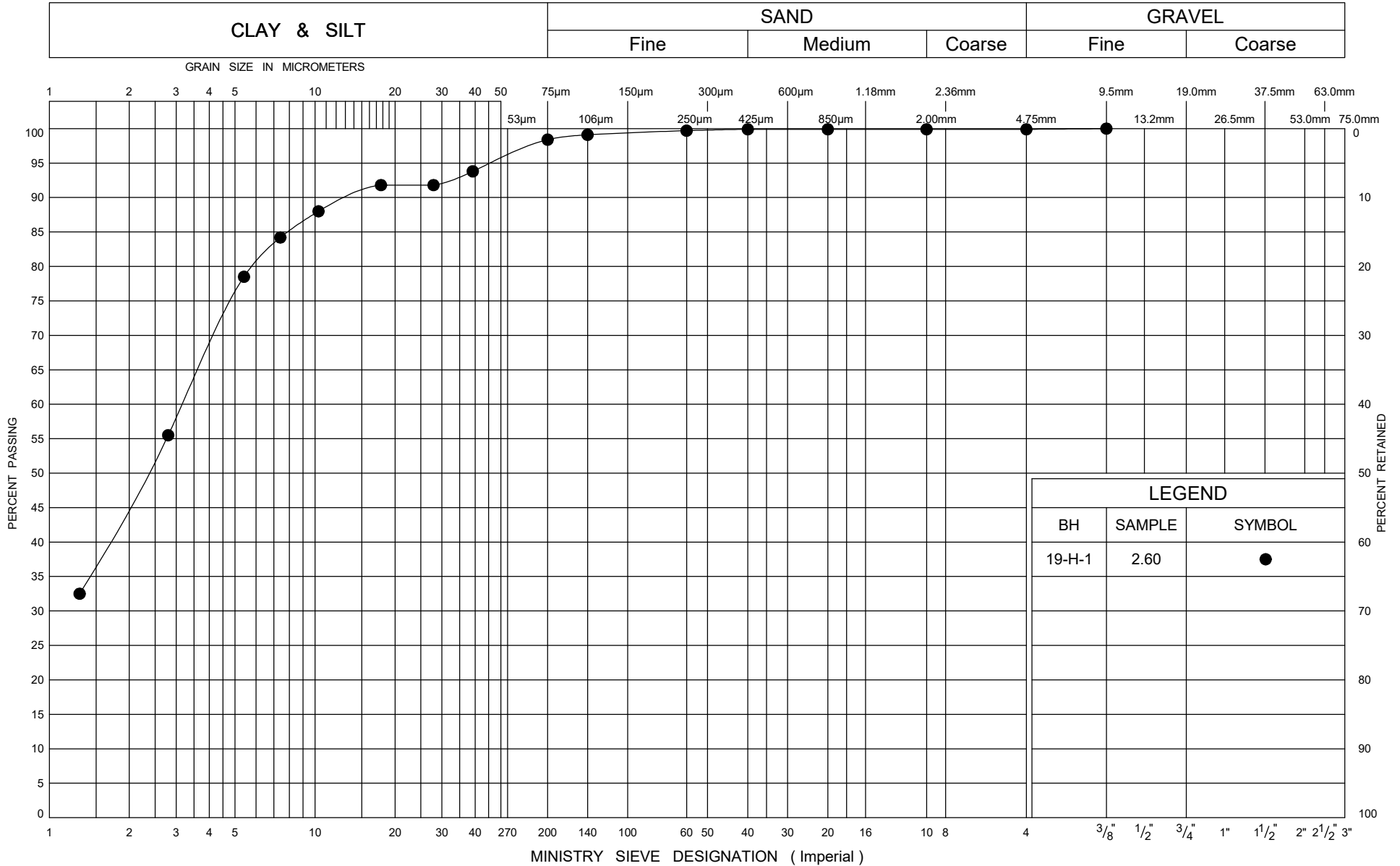
+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

Appendix D – Laboratory Data

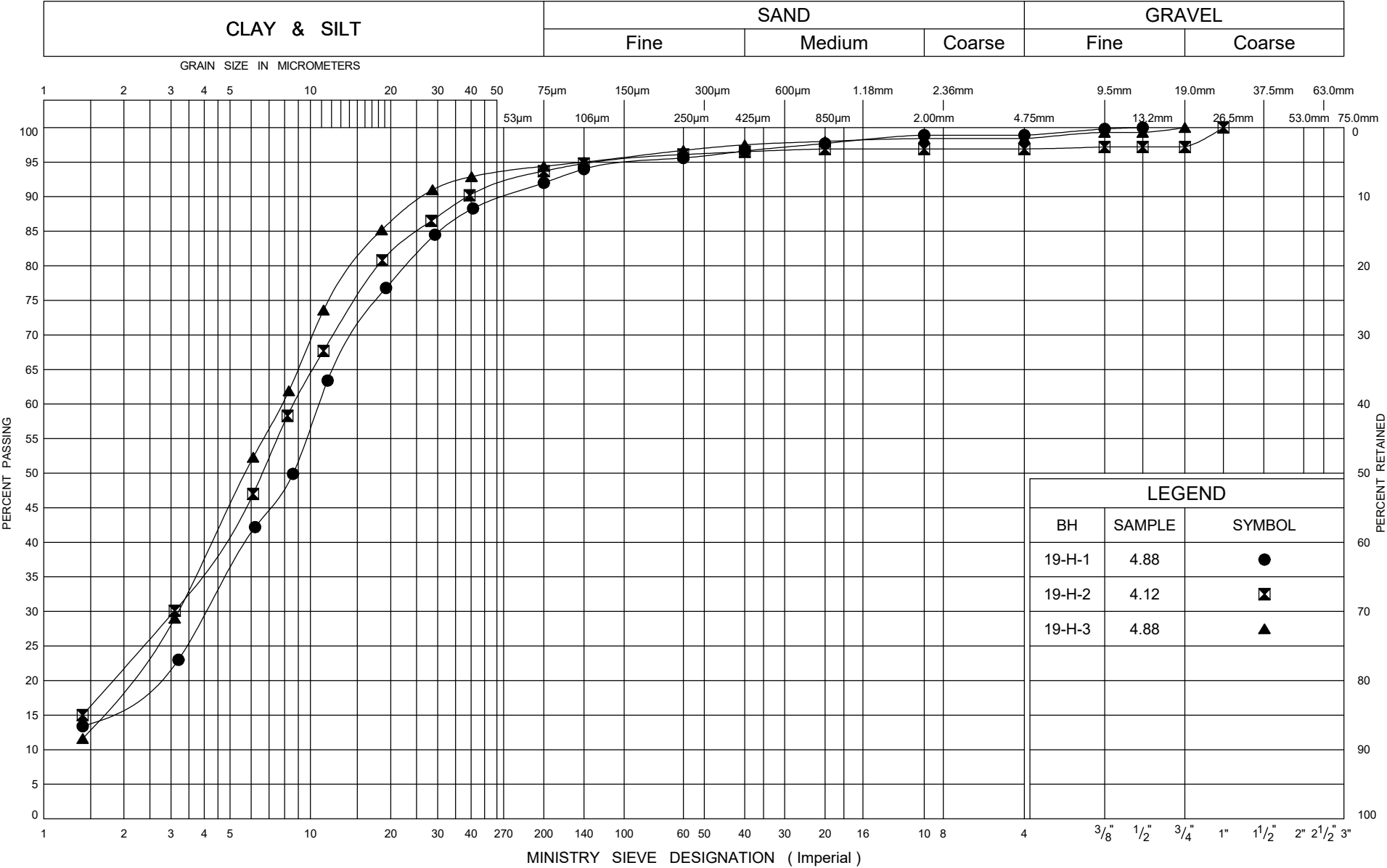
UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

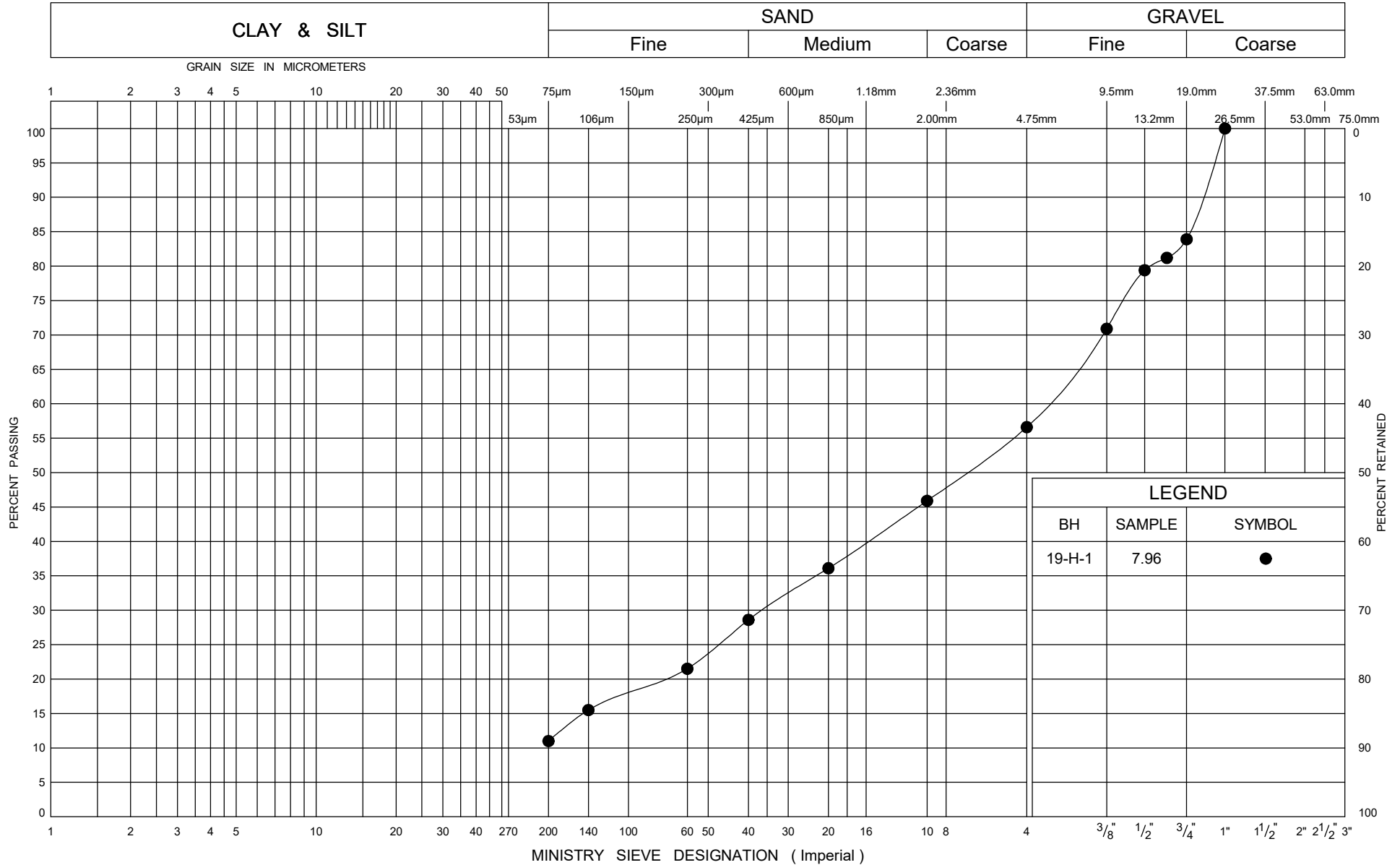
Silt to Clayey Silt

FIG No 3

W P

5015-E-0007, Assignment 10

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

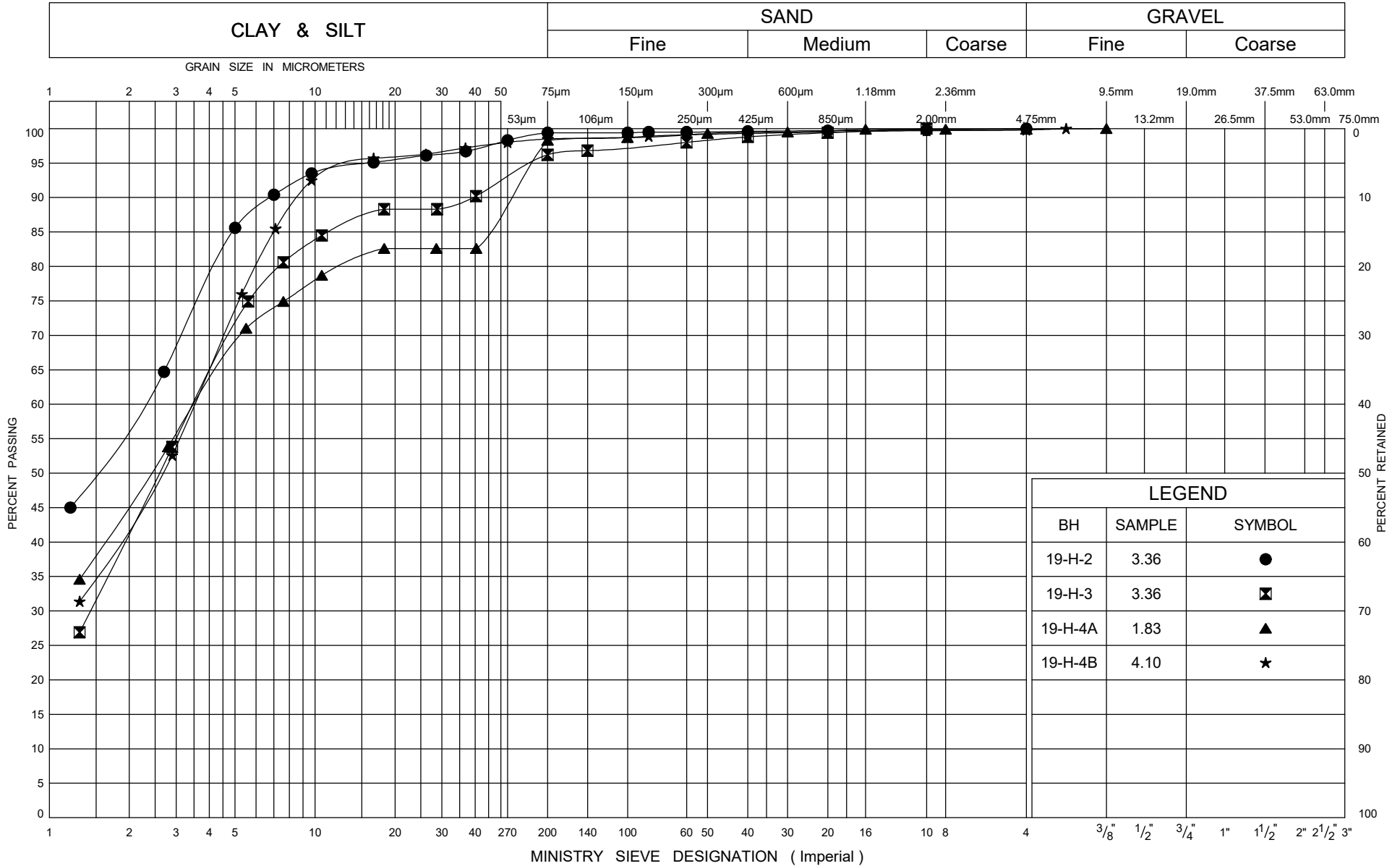
Sand and Gravel Till

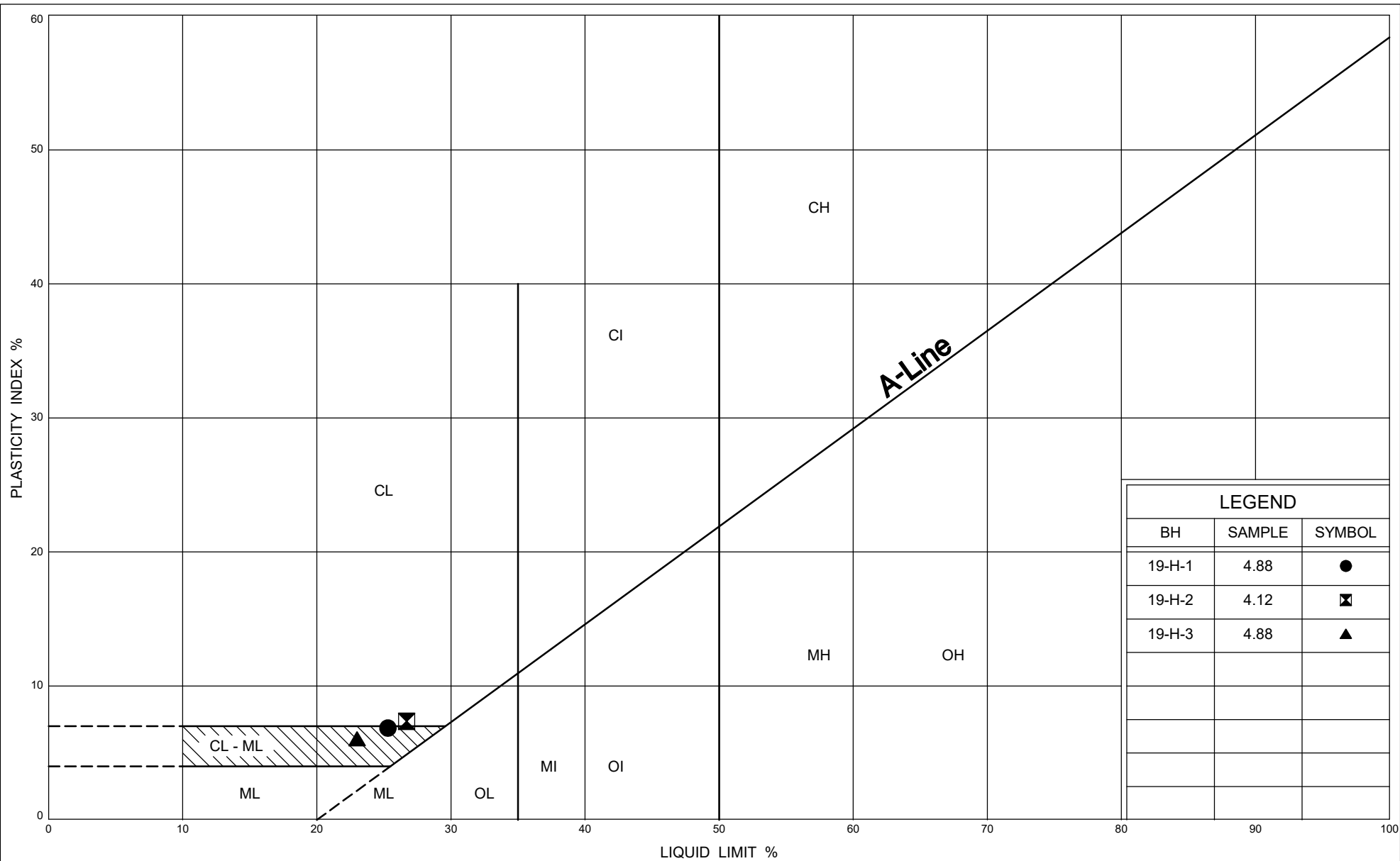
FIG No 4

W P

5015-E-0007, Assignment 10

UNIFIED SOIL CLASSIFICATION SYSTEM





LEGEND		
BH	SAMPLE	SYMBOL
19-H-1	4.88	●
19-H-2	4.12	⊠
19-H-3	4.88	▲



Ministry of
Transportation

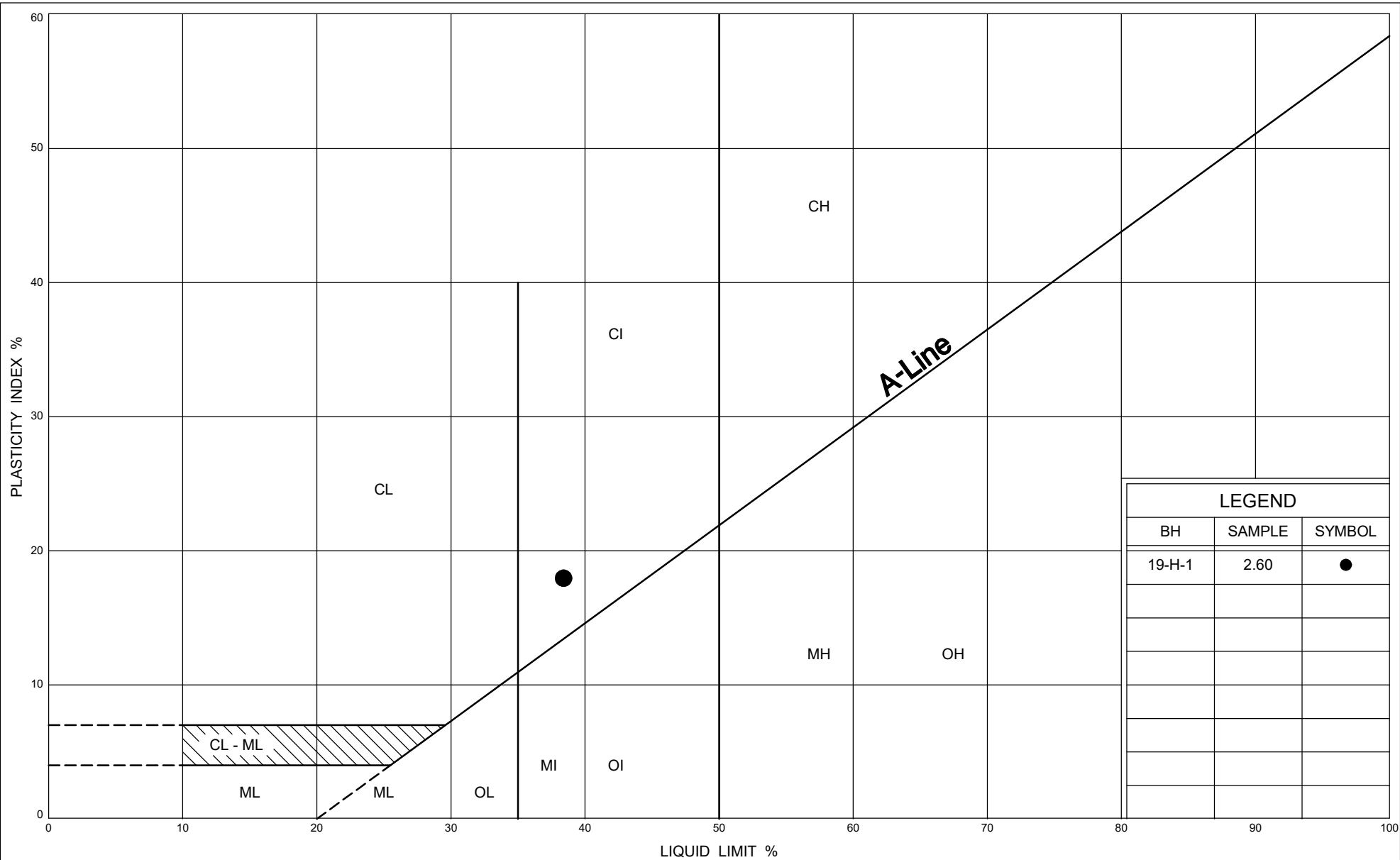
PLASTICITY CHART

Silt to Clayey Silt

FIG No 7

W P

5015-E-0007, Assignment 10



Ministry of
Transportation

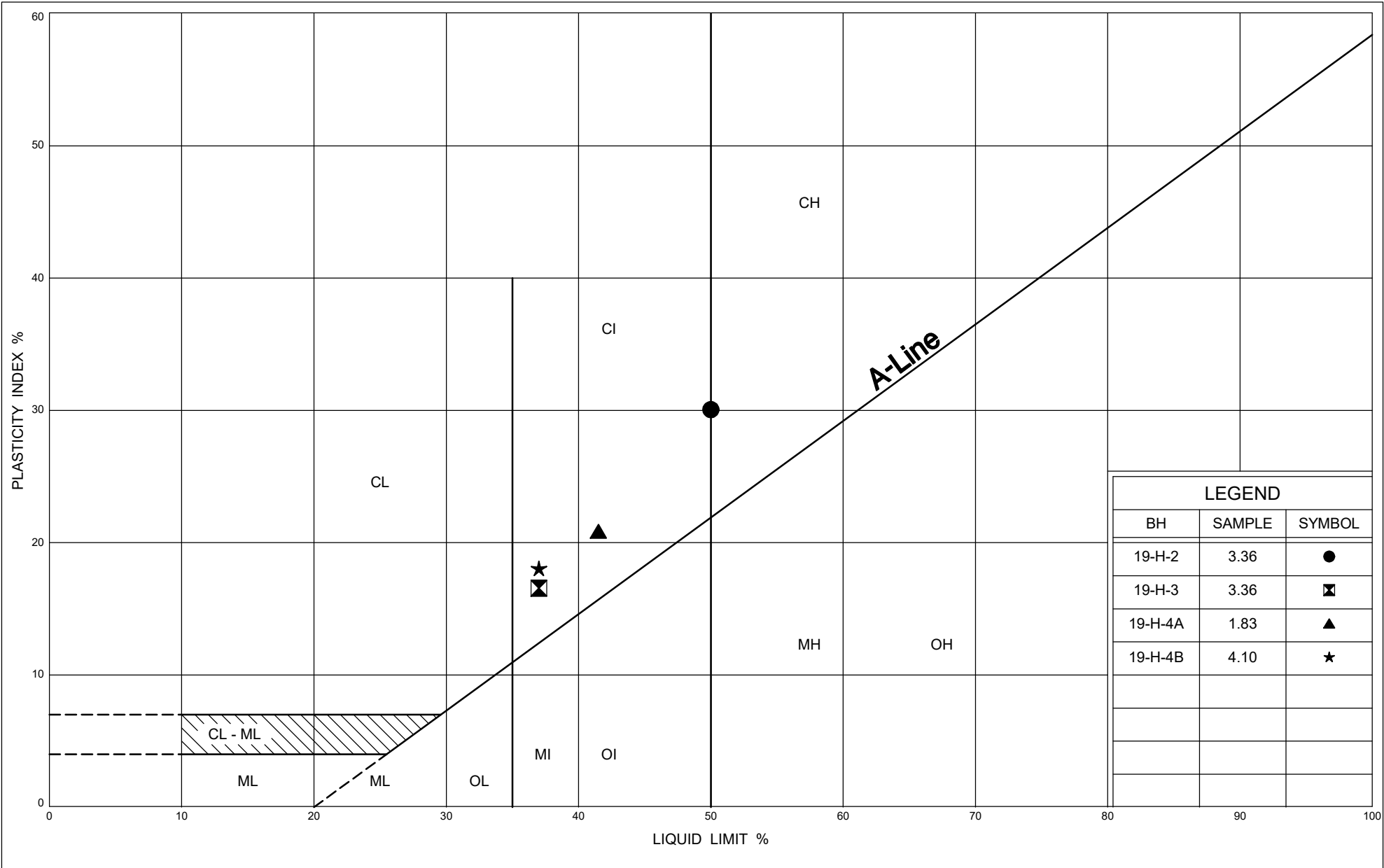
PLASTICITY CHART

Silty Clay (Varved)

FIG No 6

W P

5015-E-0007, Assignment 10



Ministry of
Transportation

PLASTICITY CHART

Silty Clay

FIG No 8

W P

5015-E-0007, Assignment 10



exp Services Inc.

1595 Clark Boulevard
Brampton, ON
L6T 4V1
Tel.: 905-793-9800
Fax: 905-793-0641

**Consolidation Test
Summary Data Sheet
(ASTM: D 2435)**

Project No.: adm-00233185-k0 adm-300Project Name: MTO-HaileyburyBorehole No. BH 19-H-2

Client Job No.: _____

Sample No. Shelby-

Sample Location: _____

Depth: 10'-12'Sample Description: Silty Clay, trace Sand; brown; Stiff; Desiccated

Water Content Determination	Before Test		After Test
	Specimen	Trimming	Specimen
Wt. of wet sample + Ring (tare) - g	220.48	215.37	216.78
Wt. of dry sample + Ring (tare) - g	189.12	161.32	189.12
Wt. of water (W_w) - g	31.36	54.05	27.66
Wt. of Ring - g	101.08	3.16	101.08
Wt. of dry soil (W_s) - g	88.04	158.16	88.04
Water Content (W) - %	35.6	34.2	31.4
Average (W) - %	34.9		31.4

Apparatus:

Machine No.	2
Cell No.	2
Ring No.	2
Diameter of Ring (in) :	2.5
Height of Ring - H_1 (in):	0.7835
Area of Ring (in^2) :	4.9087

Load Factor:

1.55
500

 lb. on Hanger
lb/ft² on Sample

Test Data

Initial Dial Reading (in) :	0.03
Final Dial Reading (in) :	0.0931
Difference (in) :	0.0631
Machine Correction 0 to 0 (in) :	0.0047
Change in Ht., specimen, ΔH (in) :	0.0584
Final Ht. of specimen, $H_2 = H_1 - \Delta H$:	0.7251

Spec. Gr. of Solids (G) :	(estimated)	2.78
Spec. Gr. of Solids (G) :	(determined)	
Initial Height of Specimen, H_1 (in):		0.7835

Calculations	Before Test	After Test
Height of Specimen, H_1, H_2 (in):	0.7835	0.7251
Ht of Solids, H_s (in):	0.3935	0.3935
Ht. of Voids, H_v (in):	0.3900	0.3316
Ht. of Water, H_w (in):	0.3897	0.3437
Saturation, S_r (%):	99.9	100.0
Void ratio (e):	0.991	0.842

Comments:

Reported By: Willie RodychDate Reported: May 8, 2019



exp Services Inc.

1595 Clark Boulevard
Brampton, ON
L6T 4V1
Tel.: 905-793-9800
Fax: 905-793-0641

Consolidation Test Determination of Void Ratio (ASTM: D 2435)

Project No. adm-00233185-k0 adm-300

Project Name Lab Testing

Client Job No.:

Sample No. BH 19-H-2 Shelby- 10'-12'

Sample Location

Height of Solids (in):	0.394
Initial Height of Voids (in):	0.390
Initial Void Ratio (e_0):	0.991
Initial Dial Reading:	0.030

Load No.	Hanger Load (lbs.)	Pressure on sample (lb/ft ²)	Final Dial Reading	Decrease in Height of Voids (in)	Machine Deflection (in)	Net Decrease in Height of Voids (in)	Height of Voids (in)	Void Ratio (e)
1	1.55	500	0.0330	0.0030	0.0015	0.0015	0.3885	0.987
2	3.1	1000	0.0350	0.0050	0.0025	0.0025	0.3875	0.985
3	6.2	2000	0.0377	0.0077	0.0038	0.0039	0.3861	0.981
4	12.4	4000	0.0430	0.0130	0.0051	0.0079	0.3821	0.971
5	24.8	8000	0.0524	0.0224	0.0067	0.0157	0.3743	0.951
6	49.6	16000	0.0806	0.0506	0.0086	0.0420	0.3480	0.884
7	99.2	32000	0.1318	0.1018	0.0107	0.0911	0.2989	0.759
8	24.8	8000	0.1242	0.0942	0.0090	0.0852	0.3048	0.774
9	6.2	2000	0.1114	0.0814	0.0071	0.0743	0.3157	0.802
10	1.55	500	0.1080	0.0780	0.0058	0.0722	0.3178	0.807
11								
12								
13								
14								
15								

Tested By:

Willie Rodych

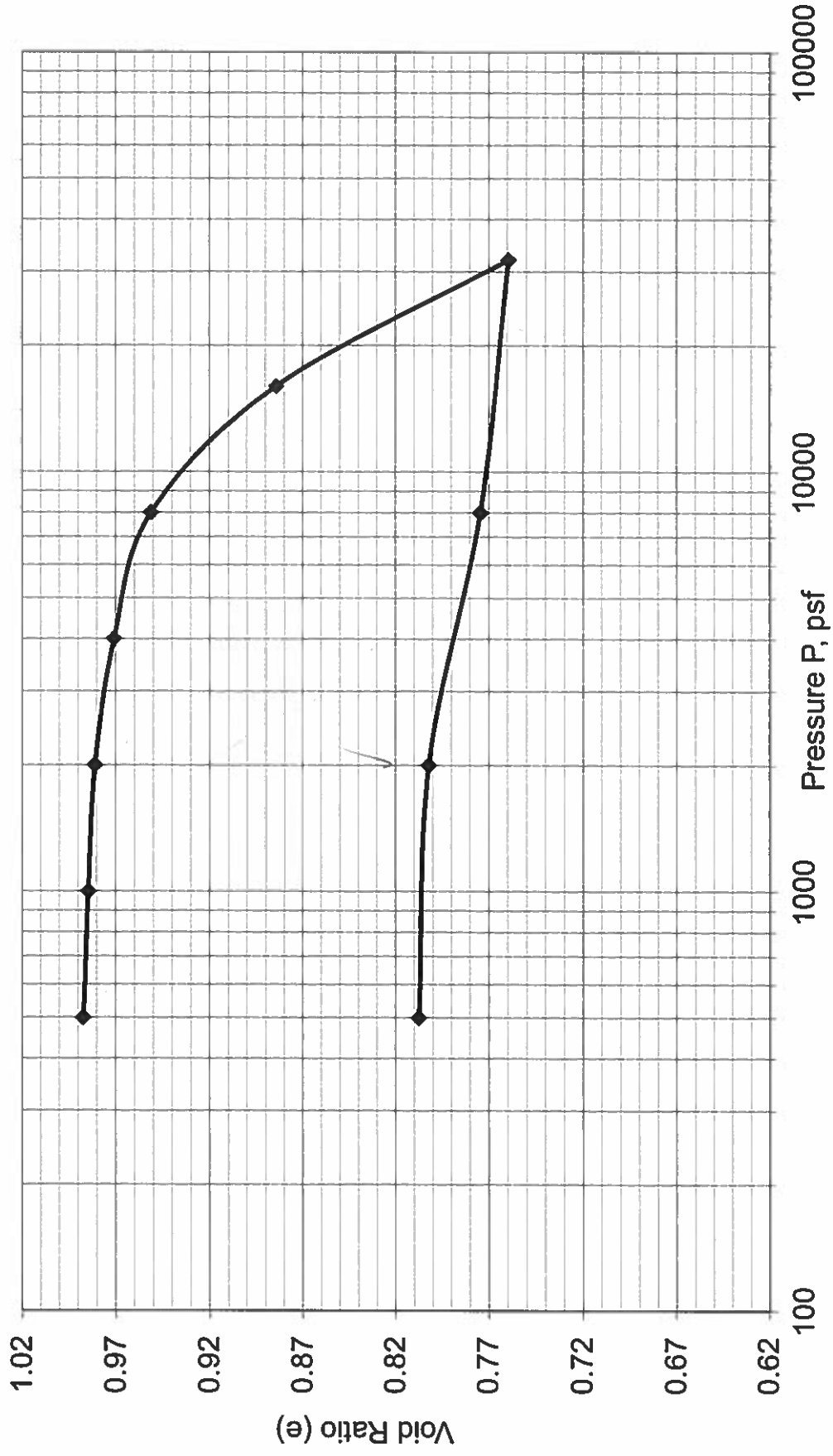
Date:

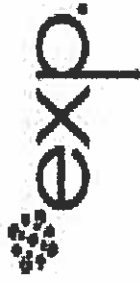
4/28/2019

Graph - e vs log P

Sample Test No.: 319575-6

Page 3 of 5





exp Services Inc.

**1595 Clark Boulevard
Brampton, ON
L6T 4V1
Tel.: 905-793-9800
Fax: 905-793-0641**

**Consolidation Test
Coefficient of Consolidation
(ASTM: D 2435)**

Project No.: adm-00233185-k0 adm-300

Project Name: Lab Testing

Client Job No.:

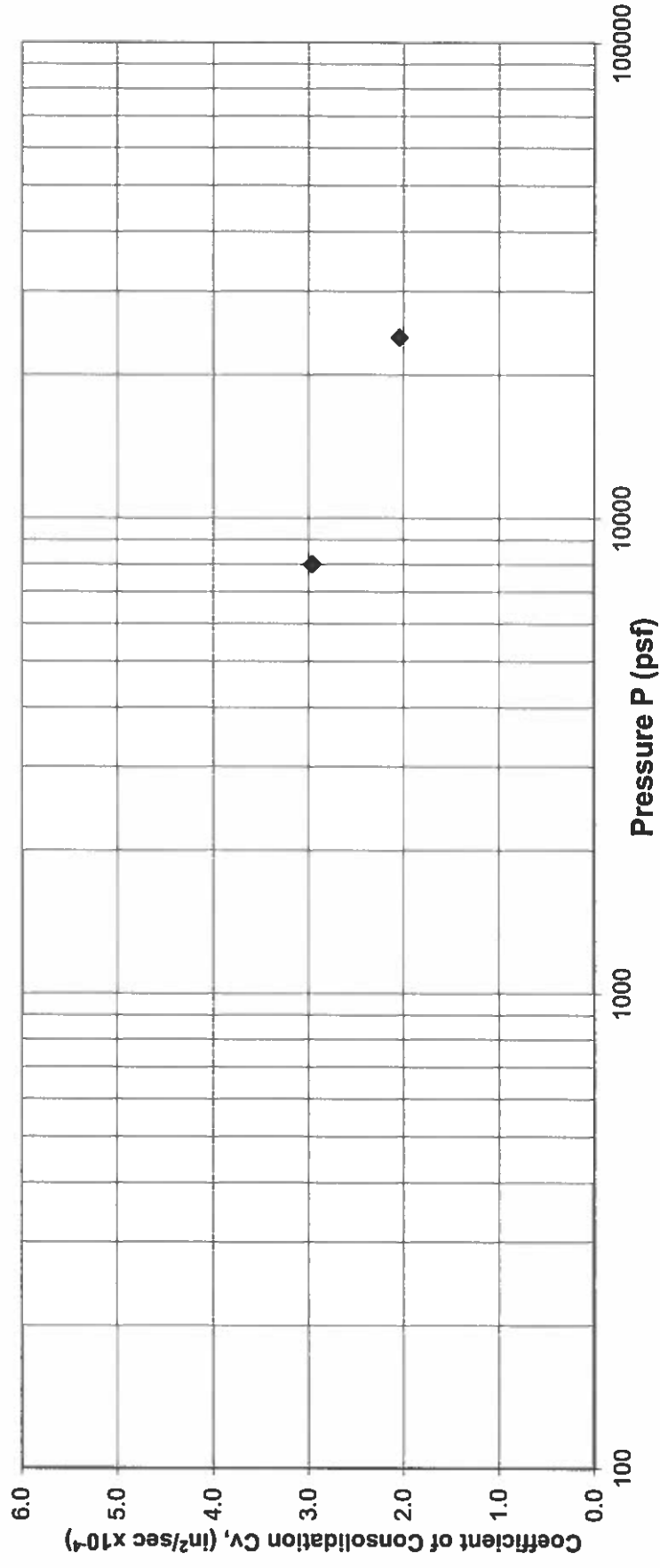
Site Location:

Sample No. BH 19-H-2 Shelby- 10'-12'

Initial Height of Sample (in):	0.7835
Initial Dial Reading:	0.0300

[illegible]

Graph - C_v vs $\log P$



**exp Services Inc.**

The new identity of Trow Associates Inc.

1595 Clark Blvd.
Brampton, Ontario, L6T 4V1

Tel.: (905) 793-9800

Fax.: (905) 793-0641

www.exp.com

***Unit Weight of Soil
(ST02)***

Project No.: adm-00233185-k0 adm-300

Date Started: 5/8/2019

Project Name: Lab Testing

Project PM: Silvana Micic

(Test No)	(Borehole No)	(Sample Method)	(Sample No)	(Depth)	(Density KN/m ³)	(Test Status)
319575-3	BH 19-H-2	Shelby		10'-12'	19.10	Distributed

**CLIENT NAME: EXP. SERVICES INC.
885 REGENT ST
SUDBURY, ON P3E5M4
(705) 674-9681**

ATTENTION TO: Jeff Newman

PROJECT: 233185-KO

AGAT WORK ORDER: 19U458711

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Apr 26, 2019

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19U458711

PROJECT: 233185-KO

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Newman

SAMPLING SITE:

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-04-18

DATE REPORTED: 2019-04-26

SAMPLE DESCRIPTION: 19-H-3-SS3

SAMPLE TYPE: Soil

DATE SAMPLED: 2019-04-08

Parameter	Unit	G / S	RDL	144668
Sulfide (S2-)	%		0.05	<0.05
Chloride (2:1)	µg/g		20	3750
Sulphate (2:1)	µg/g		20	89
pH (2:1)	pH Units		NA	8.16
Electrical Conductivity (2:1)	mS/cm		0.005	6.40
Resistivity (2:1)	ohm.cm		1	156
Redox Potential (2:1)	mV		5	181

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

144668 EC, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.

*Sulphide analyzed at AGAT 5623 McAdam

PI note: Redox Potential is not an accredited parameter.

Elevated RDL indicates the degree of sample dilution prior to the analysis in order to keep analytes within the calibration range of the instrument and to reduce matrix interference.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:





AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19U458711

PROJECT: 233185-KO

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Jeff Newman

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-04-18

DATE REPORTED: 2019-04-26

SAMPLE DESCRIPTION: 19-H-2-AG2

SAMPLE TYPE: Soil

DATE SAMPLED: 2019-04-09

Parameter	Unit	G / S	RDL	144666
Antimony	µg/g		0.8	<0.8
Arsenic	µg/g		1	3
Barium	µg/g		2	149
Beryllium	µg/g		0.5	0.6
Boron	µg/g		5	6
Boron (Hot Water Soluble)	µg/g		0.10	<0.10
Cadmium	µg/g		0.5	<0.5
Chromium	µg/g		2	95
Cobalt	µg/g		0.5	16.4
Copper	µg/g		1	37
Lead	µg/g		1	14
Molybdenum	µg/g		0.5	<0.5
Nickel	µg/g		1	53
Selenium	µg/g		0.4	<0.4
Silver	µg/g		0.2	0.2
Thallium	µg/g		0.4	<0.4
Uranium	µg/g		0.5	1.5
Vanadium	µg/g		1	66
Zinc	µg/g		5	105
Chromium VI	µg/g		0.2	<0.2
Cyanide	µg/g		0.040	0.065
Mercury	µg/g		0.10	<0.10
Electrical Conductivity	mS/cm		0.005	2.49
Sodium Adsorption Ratio	NA		NA	16.2
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.33

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

144666 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

PROJECT: 233185-KO

SAMPLING SITE:

AGAT WORK ORDER: 19U458711

ATTENTION TO: Jeff Newman

SAMPLED BY:

Soil Analysis

RPT Date: Apr 26, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - Metals & Inorganics (Soil)															
Antimony	138612		<0.8	<0.8	NA	< 0.8	123%	70%	130%	104%	80%	120%	108%	70%	130%
Arsenic	138612		5	5	0.0%	< 1	106%	70%	130%	101%	80%	120%	88%	70%	130%
Barium	138612		34	35	2.9%	< 2	96%	70%	130%	97%	80%	120%	93%	70%	130%
Beryllium	138612		0.9	1.1	NA	< 0.5	111%	70%	130%	107%	80%	120%	107%	70%	130%
Boron	138612		26	25	3.9%	< 5	85%	70%	130%	110%	80%	120%	86%	70%	130%
Boron (Hot Water Soluble)	143239		0.29	0.26	NA	< 0.10	106%	60%	140%	95%	70%	130%	84%	60%	140%
Cadmium	138612		<0.5	<0.5	NA	< 0.5	93%	70%	130%	107%	80%	120%	102%	70%	130%
Chromium	138612		29	29	0.0%	< 2	99%	70%	130%	102%	80%	120%	78%	70%	130%
Cobalt	138612		15.7	15.7	0.0%	< 0.5	98%	70%	130%	106%	80%	120%	91%	70%	130%
Copper	138612		24	23	4.3%	< 1	95%	70%	130%	100%	80%	120%	87%	70%	130%
Lead	138612		4	4	NA	< 1	102%	70%	130%	101%	80%	120%	99%	70%	130%
Molybdenum	138612		<0.5	<0.5	NA	< 0.5	107%	70%	130%	106%	80%	120%	91%	70%	130%
Nickel	138612		35	34	2.9%	< 1	98%	70%	130%	102%	80%	120%	86%	70%	130%
Selenium	138612		2.2	2.1	4.7%	< 0.4	98%	70%	130%	100%	80%	120%	93%	70%	130%
Silver	138612		<0.2	<0.2	NA	< 0.2	108%	70%	130%	107%	80%	120%	98%	70%	130%
Thallium	138612		<0.4	<0.4	NA	< 0.4	104%	70%	130%	101%	80%	120%	97%	70%	130%
Uranium	138612		0.8	0.8	NA	< 0.5	109%	70%	130%	101%	80%	120%	102%	70%	130%
Vanadium	138612		36	36	0.0%	< 1	102%	70%	130%	104%	80%	120%	87%	70%	130%
Zinc	138612		74	73	1.4%	< 5	101%	70%	130%	103%	80%	120%	89%	70%	130%
Chromium VI	144757		<0.2	<0.2	NA	< 0.2	107%	70%	130%	102%	80%	120%	101%	70%	130%
Cyanide	135207		<0.040	<0.040	NA	< 0.040	99%	70%	130%	104%	80%	120%	98%	70%	130%
Mercury	138612		<0.10	<0.10	NA	< 0.10	103%	70%	130%	93%	80%	120%	100%	70%	130%
Electrical Conductivity	142019		0.116	0.121	4.2%	< 0.005	103%	90%	110%	NA			NA		
Sodium Adsorption Ratio	138612		15.1	15.2	0.7%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	138612		7.89	7.91	0.3%	NA	99%	80%	120%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Corrosivity Package

Sulfide (S2-)	144668	144668	< 0.05	< 0.05	NA	< 0.05	100%	80%	120%						
Chloride (2:1)	145204		1780	1780	0.0%	< 2	97%	80%	120%	106%	80%	120%	104%	70%	130%
Sulphate (2:1)	145204		10800	11000	1.8%	< 2	109%	80%	120%	109%	80%	120%	110%	70%	130%
pH (2:1)	143193		7.80	7.83	0.4%	NA	99%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	142019		0.116	0.121	4.2%	< 0.005	103%	90%	110%	NA			NA		
Redox Potential (2:1)	143193		160	160	0.0%	< 5	101%	70%	130%	NA			NA		

Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19U458711

PROJECT: 233185-KO

ATTENTION TO: Jeff Newman

SAMPLING SITE:

SAMPLED BY:

Soil Analysis (Continued)

RPT Date: Apr 26, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL

Certified By:



Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: 233185-KO

SAMPLING SITE:

AGAT WORK ORDER: 19U458711

ATTENTION TO: Jeff Newman

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulfide (S2-)	MIN-200-12025	ASTM E1915-09	GRAVIMETRIC
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential (2:1)		McKeague 4.12 & SM 2580 B	REDOX POTENTIAL ELECTRODE
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6029	SM 3500 B; MSA Part 3, Ch. 25	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER

**CLIENT NAME: EXP. SERVICES INC.
885 REGENT ST
SUDBURY, ON P3E5M4
(705) 674-9681**

ATTENTION TO: Ian MacMillan

PROJECT: ADM-00233185-K0

AGAT WORK ORDER: 19U464857

TRACE ORGANICS REVIEWED BY: Pinkal Patel, Report Reviewer

DATE REPORTED: May 14, 2019

PAGES (INCLUDING COVER): 8

VERSION*: 2

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

VERSION 2: Partial report for sample "19-H-1-SS2" issued May 14, 2019.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - PHCs F1 - F4 (Soil)

DATE RECEIVED: 2019-05-08

DATE REPORTED: 2019-05-13

SAMPLE DESCRIPTION: 19-H-1-SS2				
SAMPLE TYPE: Soil				
DATE SAMPLED: 2019-05-08				
Parameter	Unit	G / S	RDL	182120
Benzene	µg/g		0.02	<0.02
Toluene	µg/g		0.05	<0.05
Ethylbenzene	µg/g		0.05	<0.05
Xylene Mixture	µg/g		0.05	<0.05
F1 (C6 to C10)	µg/g		5	<5
F1 (C6 to C10) minus BTEX	µg/g		5	<5
F2 (C10 to C16)	µg/g		10	<10
F3 (C16 to C34)	µg/g		50	<50
F4 (C34 to C50)	µg/g		50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA
Moisture Content	%		0.1	25.6
Surrogate	Unit	Acceptable Limits		
Terphenyl	%	60-140		

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

182120 Results are based on sample dry weight.
The C6-C10 fraction is calculated using Toluene response factor.
Xylenes is a calculated parameter. The calculated value is the sum of m&p-Xylene and o-Xylene.
C6-C10 (F1 minus BTEX) is a calculated parameter. The calculated value is F1 minus BTEX.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present.
The chromatogram has returned to baseline by the retention time of nC50.
Total C6 - C50 results are corrected for BTEX contribution.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 + nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.
Fractions 1-4 are quantified with the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.
Quality Control Data is available upon request.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Jinkal Patel

Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

Soil Analysis															
RPT Date:			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

O. Reg. 153(511) - Metals & Inorganics (Soil)

Antimony	182264		<0.8	<0.8	NA	< 0.8	91%	70%	130%	95%	80%	120%	94%	70%	130%
Arsenic	182264		3	3	NA	< 1	101%	70%	130%	94%	80%	120%	98%	70%	130%
Barium	182264		109	110	0.6%	< 2	105%	70%	130%	100%	80%	120%	116%	70%	130%
Beryllium	182264		<0.5	<0.5	NA	< 0.5	99%	70%	130%	98%	80%	120%	76%	70%	130%
Boron	182264		7	7	NA	< 5	101%	70%	130%	104%	80%	120%	76%	70%	130%
Boron (Hot Water Soluble)	2		NA	NA	NA	< 0.10	100%	60%	140%	102%	70%	130%	NA	60%	140%
Cadmium	182264		<0.5	<0.5	NA	< 0.5	99%	70%	130%	101%	80%	120%	99%	70%	130%
Chromium	182264		30	31	3.8%	< 2	103%	70%	130%	102%	80%	120%	112%	70%	130%
Cobalt	182264		10.0	10.3	2.7%	< 0.5	105%	70%	130%	105%	80%	120%	103%	70%	130%
Copper	182264		20	20	2.0%	< 1	95%	70%	130%	101%	80%	120%	97%	70%	130%
Lead	182264		9	9	0.5%	< 1	105%	70%	130%	104%	80%	120%	100%	70%	130%
Molybdenum	182264		<0.5	<0.5	NA	< 0.5	108%	70%	130%	100%	80%	120%	98%	70%	130%
Nickel	182264		25	25	1.2%	< 1	103%	70%	130%	108%	80%	120%	110%	70%	130%
Selenium	182264		0.5	0.5	NA	< 0.4	103%	70%	130%	92%	80%	120%	96%	70%	130%
Silver	182264		<0.2	<0.2	NA	< 0.2	99%	70%	130%	99%	80%	120%	95%	70%	130%
Thallium	182264		<0.4	<0.4	NA	< 0.4	101%	70%	130%	113%	80%	120%	107%	70%	130%
Uranium	182264		0.5	0.5	NA	< 0.5	112%	70%	130%	116%	80%	120%	121%	70%	130%
Vanadium	182264		41	43	5.5%	< 1	103%	70%	130%	112%	80%	120%	111%	70%	130%
Zinc	182264		52	52	1.1%	< 5	93%	70%	130%	102%	80%	120%	103%	70%	130%
Chromium VI	182119	182119	<0.2	<0.2	NA	< 0.2	108%	70%	130%	100%	80%	120%	102%	70%	130%
Cyanide	182122	182122	<0.040	<0.040	NA	< 0.040	98%	70%	130%	99%	80%	120%	104%	70%	130%
Mercury	182264		<0.10	<0.10	NA	< 0.10	127%	70%	130%	109%	80%	120%	110%	70%	130%
Electrical Conductivity	182119	182119	0.099	0.108	8.7%	< 0.005	109%	90%	110%	NA			NA		
Sodium Adsorption Ratio	182119	182119	1.30	1.38	5.5%		NA			NA			NA		
pH, 2:1 CaCl2 Extraction	182119	182119	5.59	5.61	0.4%		100%	80%	120%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Corrosivity Package -new

Chloride (2:1)	178497		10	9	NA	< 2	93%	80%	120%	89%	80%	120%	89%	70%	130%
Sulphate (2:1)	178497		10	9	NA	< 2	92%	80%	120%	93%	80%	120%	97%	70%	130%
pH (2:1)	182124	182124	6.04	6.01	0.5%		99%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	182119	182119	0.099	0.108	8.7%	< 0.005	109%	90%	110%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL

Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

PROJECT: ADM-00233185-K0

SAMPLING SITE:

AGAT WORK ORDER: 19U464857

ATTENTION TO: Ian MacMillan

SAMPLED BY:

Soil Analysis (Continued)

RPT Date:			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Certified By: _____

Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

Trace Organics Analysis

RPT Date:			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE		MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits	Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower		Upper	Lower		Upper	Lower

O. Reg. 153(511) - PHCs F1 - F4 (Soil)

Benzene	174969		< 0.02	< 0.02	NA	< 0.02	90%	60%	130%	85%	60%	130%	89%	60%	130%
Toluene	174969		< 0.05	< 0.05	NA	< 0.05	88%	60%	130%	89%	60%	130%	86%	60%	130%
Ethylbenzene	174969		< 0.05	< 0.05	NA	< 0.05	101%	60%	130%	87%	60%	130%	79%	60%	130%
Xylene Mixture	174969		< 0.05	< 0.05	NA	< 0.05	97%	60%	130%	81%	60%	130%	82%	60%	130%
F1 (C6 to C10)	174969		< 5	< 5	NA	< 5	96%	60%	130%	86%	85%	115%	80%	70%	130%
F2 (C10 to C16)	173534		< 10	< 10	NA	< 10	100%	60%	130%	95%	80%	120%	70%	70%	130%
F3 (C16 to C34)	173534		< 50	< 50	NA	< 50	104%	60%	130%	98%	80%	120%	76%	70%	130%
F4 (C34 to C50)	173534		< 50	< 50	NA	< 50	95%	60%	130%	87%	80%	120%	116%	70%	130%

Comments: When the average of the sample and duplicate results is less than 5x the RDL, the Relative Percent Difference (RPD) will be indicated as Not Applicable (NA).

Certified By:




Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: ADM-00233185-K0

SAMPLING SITE:

AGAT WORK ORDER: 19U464857

ATTENTION TO: Ian MacMillan

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulfide (S2-)	MIN-200-12025	ASTM E1915-09	GRAVIMETRIC
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6029	SM 3500 B; MSA Part 3, Ch. 25	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A; SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER

Method Summary

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Trace Organics Analysis			
Benzene	VOL-91-5009	EPA SW-846 5035 & 8260D	P&T GC/MS
Toluene	VOL-91-5009	EPA SW-846 5035 & 8260D	P&T GC/MS
Ethylbenzene	VOL-91-5009	EPA SW-846 5035 & 8260D	P&T GC/MS
Xylene Mixture	VOL-91-5009	EPA SW-846 5035 & 8260D	P&T GC/MS
F1 (C6 to C10)	VOL-91-5009	CCME Tier 1 Method	P&T GC/FID
F1 (C6 to C10) minus BTEX	VOL-91-5009	CCME Tier 1 Method	P&T GC/FID
F2 (C10 to C16)	VOL-91-5009	CCME Tier 1 Method	GC/FID
F3 (C16 to C34)	VOL-91-5009	CCME Tier 1 Method	GC/FID
F4 (C34 to C50)	VOL-91-5009	CCME Tier 1 Method	GC/FID
Gravimetric Heavy Hydrocarbons	VOL-91-5009	CCME Tier 1 Method	BALANCE
Moisture Content	VOL-91-5009	CCME Tier 1 Method	BALANCE
Terphenyl	VOL-91-5009		GC/FID



Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: exp
Contact: Ian Macmillan @ exp.com
Address: Sudbury
Phone: _____ Fax: _____
Reports to be sent to: Ian Macmillan @ exp.com
1. Email: _____
2. Email: _____

Project Information:

Project: ADM-00233185-KO
Site Location: MTO
Sampled By: PL
AGAT Quote #: SOA PO: _____
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Company: _____
Contact: _____
Address: _____
Email: _____
Bill To Same: Yes ☒ No ☐

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04

Table Indicate One

- ☐ Ind/Corn
☐ Res/Park
☐ Agriculture

Soil Texture (Check One)

- ☐ Coarse
☐ Fine

☐ Sewer Use

☐ Sanitary

☐ Storm

Region Indicate One

☐ MISA

☐ Regulation 558

☐ CCME

☐ Prov. Water Quality
Objectives (PWQO)

☐ Other

Indicate One

Is this submission for a
Record of Site Condition?

☐ Yes ☒ No

Report Guideline on
Certificate of Analysis

☐ Yes ☒ No

Sample Matrix Legend

B Biota
GW Ground Water
O Oil
P Paint
S Soil
SD Sediment
SW Surface Water

Field Filtered - Metals, Hg, CrVI

0. Reg 153

Metals and Inorganics
☐ All Metals ☐ 153 Metals (excl. Hydrides)
☐ Hydride Metals ☐ 153 Metals (incl. Hydrides)

ORPs: ☐ B-HWS ☐ Cl- ☐ CN
☐ Cr* ☐ EC ☐ FOC ☐ Hg
☐ pH ☐ SAR

Full Metals Scan

Regulation/Custom Metals

Nutrients: ☐ TP ☐ NH₃ ☐ TKN
☐ NO₃ ☐ NO₂ ☐ NO₂+NO₃

Volatiles: ☐ VOC ☒ BTEX ☐ THM

PHCs F1 - F4

ABNs

PAHs

PCBs: ☐ Total ☐ Aroclors

Organochlorine Pesticides

TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs

Sewer Use

Corrosivity

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Y / N	Metals and Inorganics	0. Reg 153	Full Metals Scan	Regulation/Custom Metals	Nutrients	Volatiles	PHCs F1 - F4	ABNs	PAHs	PCBs	Organochlorine Pesticides	TCLP	Sewer Use	Corrosivity
19-G-1-SS2	May 8/19		5	S	No rush		<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								
19-H-1-SS2			2		Rush 2 day - no M&I		<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								
19-PS-1-SS2			5		No rush		<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								
19-P-1-SS2							<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								
19-D-2-SS2							<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								
19-D-2-SS4							<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								
19-PS-2-SS3							<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								
19-G-1-SS3							<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								
19-P-2-SS3							<input checked="" type="checkbox"/>	<input type="checkbox"/>				<input checked="" type="checkbox"/>								

Samples Relinquished By (Print Name and Sign):

Samples Relinquished By (Print Name and Sign):

Samples Relinquished By (Print Name and Sign):

Date

Date

Date

Time

Time

Time

Samples Received By (Print Name and Sign):

Samples Received By (Print Name and Sign):

Samples Received By (Print Name and Sign):

Date

Date

Date

Time

Time

Time

Page 1 of 1

No: T 087566

Appendix E – Rock Core Photographs

Project No: ADM 00233185-K0
BH No: 19-H-4B Run No: 1
Sample Depth: 13.5 m to 15 m
Elevation: 246.3 m to 244.8 m
Description: Metamorphosed Conglomerate
Date: April 8 to 11, 2019



Figure E1. Rock core from BH19-H-4B

Appendix F – Results of Stability Analyses

**Haileybury Patrol Yard
Stockpile Stability
North-South Section
Undrained Static Analysis**

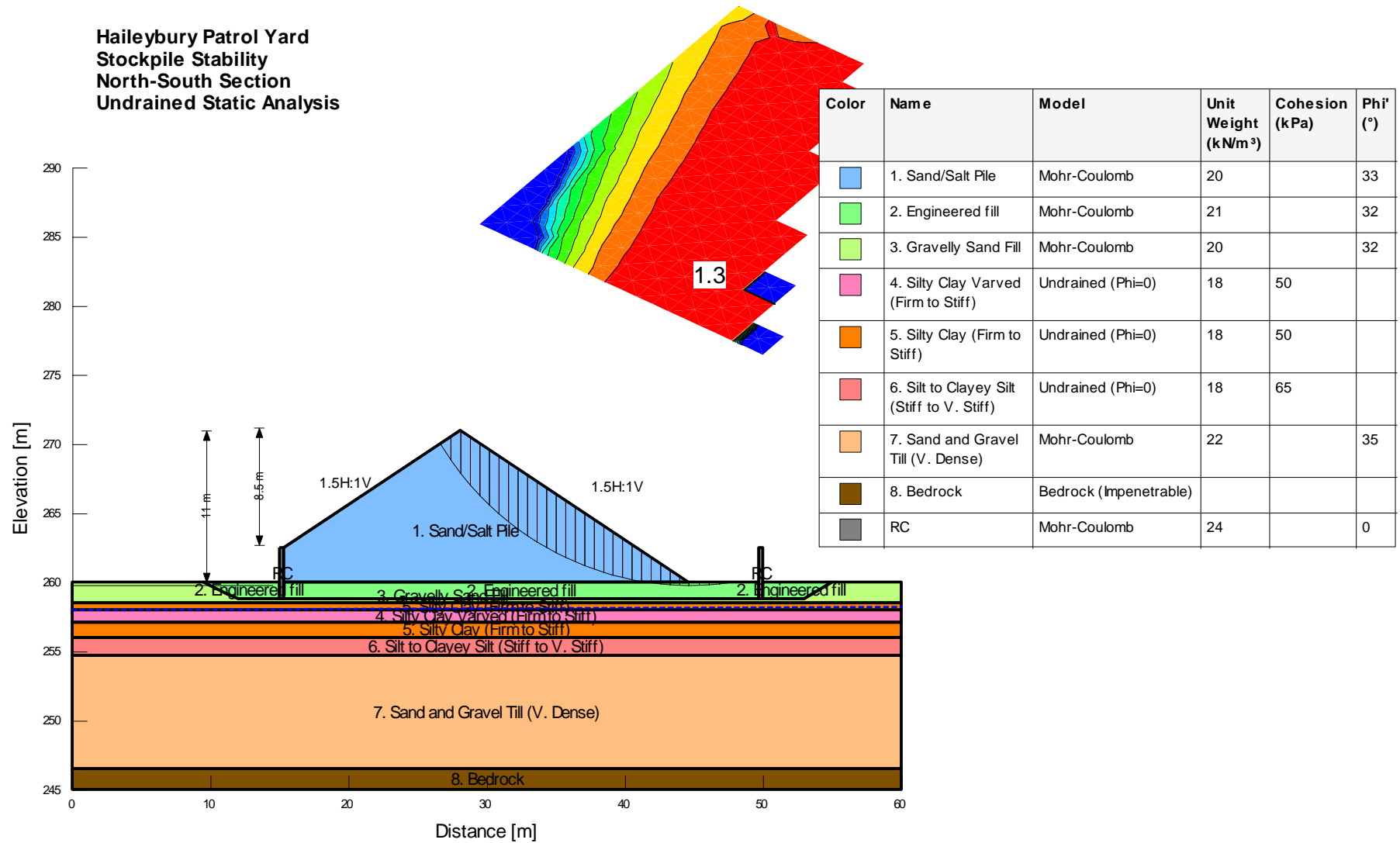


Figure F1 – Stockpile Stability for Haileybury Patrol Yard – Undrained Static Analysis

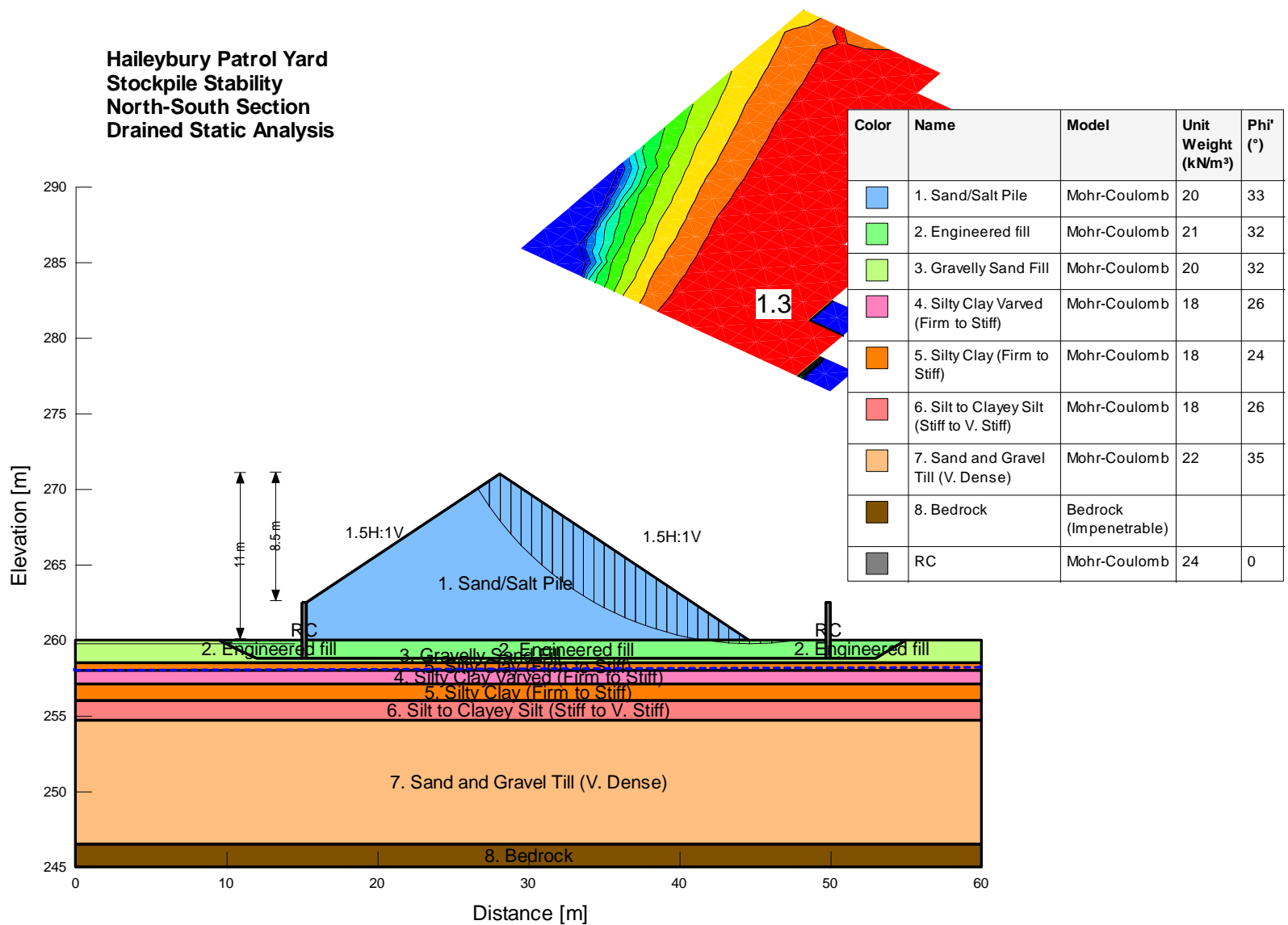
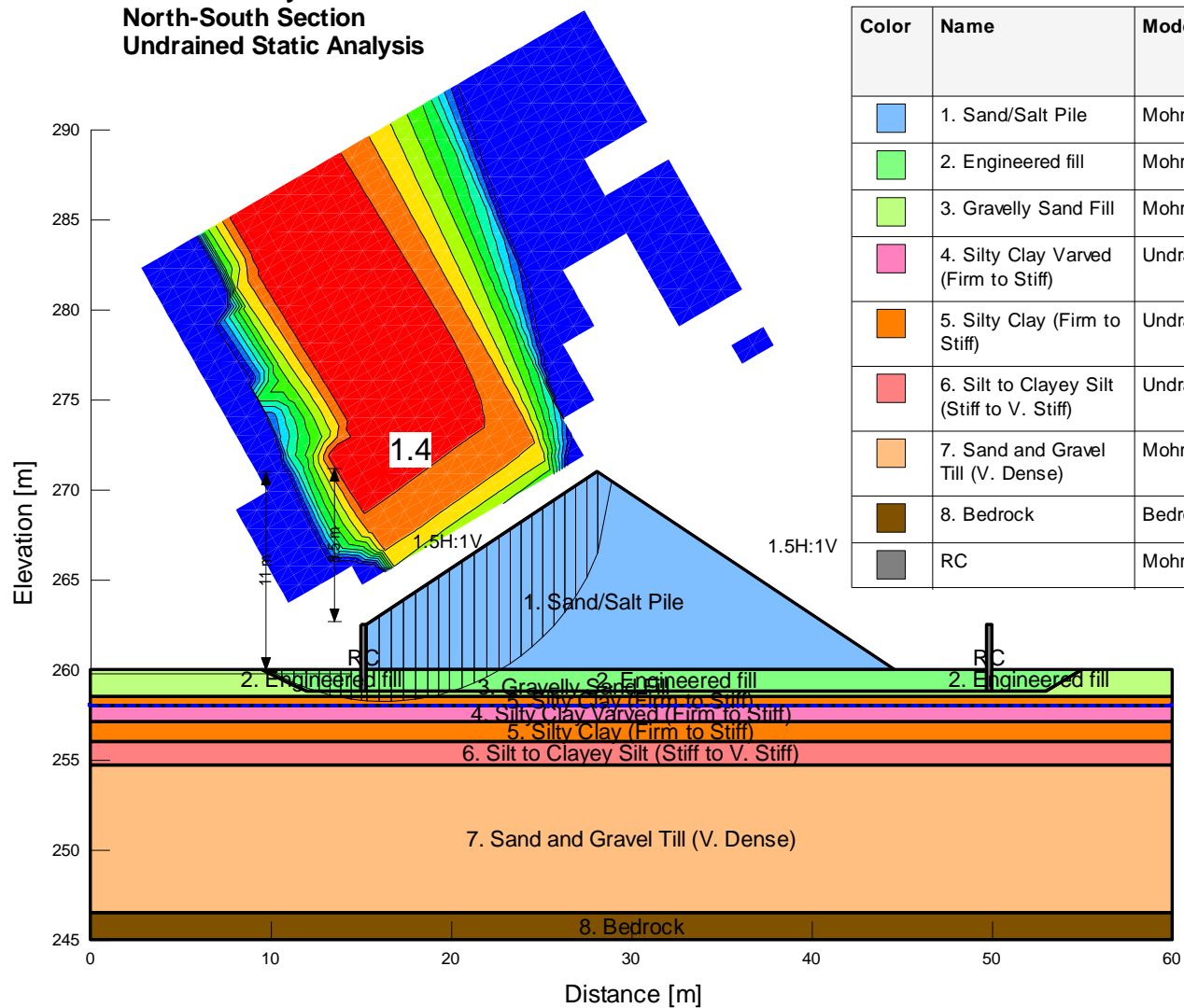


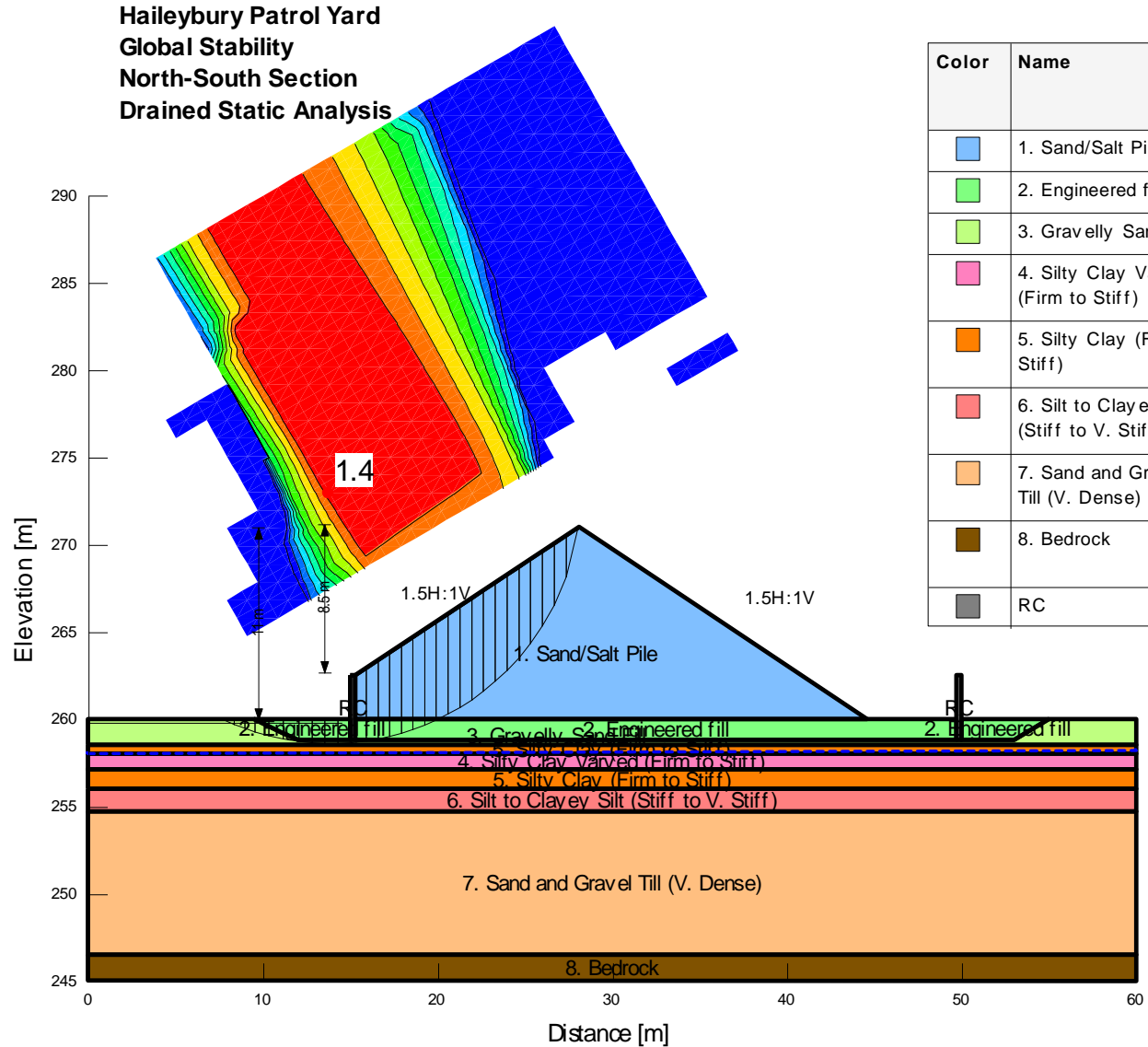
Figure F2 – Stockpile Stability for Haileybury Patrol Yard – Drained Static Analysis

**Haileybury Patrol Yard
Global Stability
North-South Section
Undrained Static Analysis**



Color	Name	Model	Unit Weight (kN/m ³)	Cohesion (kPa)	Phi' (°)
	1. Sand/Salt Pile	Mohr-Coulomb	20		33
	2. Engineered fill	Mohr-Coulomb	21		32
	3. Gravelly Sand Fill	Mohr-Coulomb	20		32
	4. Silty Clay Varved (Firm to Stiff)	Undrained (Phi=0)	18	50	
	5. Silty Clay (Firm to Stiff)	Undrained (Phi=0)	18	50	
	6. Silt to Clayey Silt (Stiff to V. Stiff)	Undrained (Phi=0)	18	65	
	7. Sand and Gravel Till (V. Dense)	Mohr-Coulomb	22		35
	8. Bedrock	Bedrock (Impenetrable)			
	RC	Mohr-Coulomb	24		0

Figure F3 – Global Stability for Haileybury Patrol Yard – Undrained Static Analysis












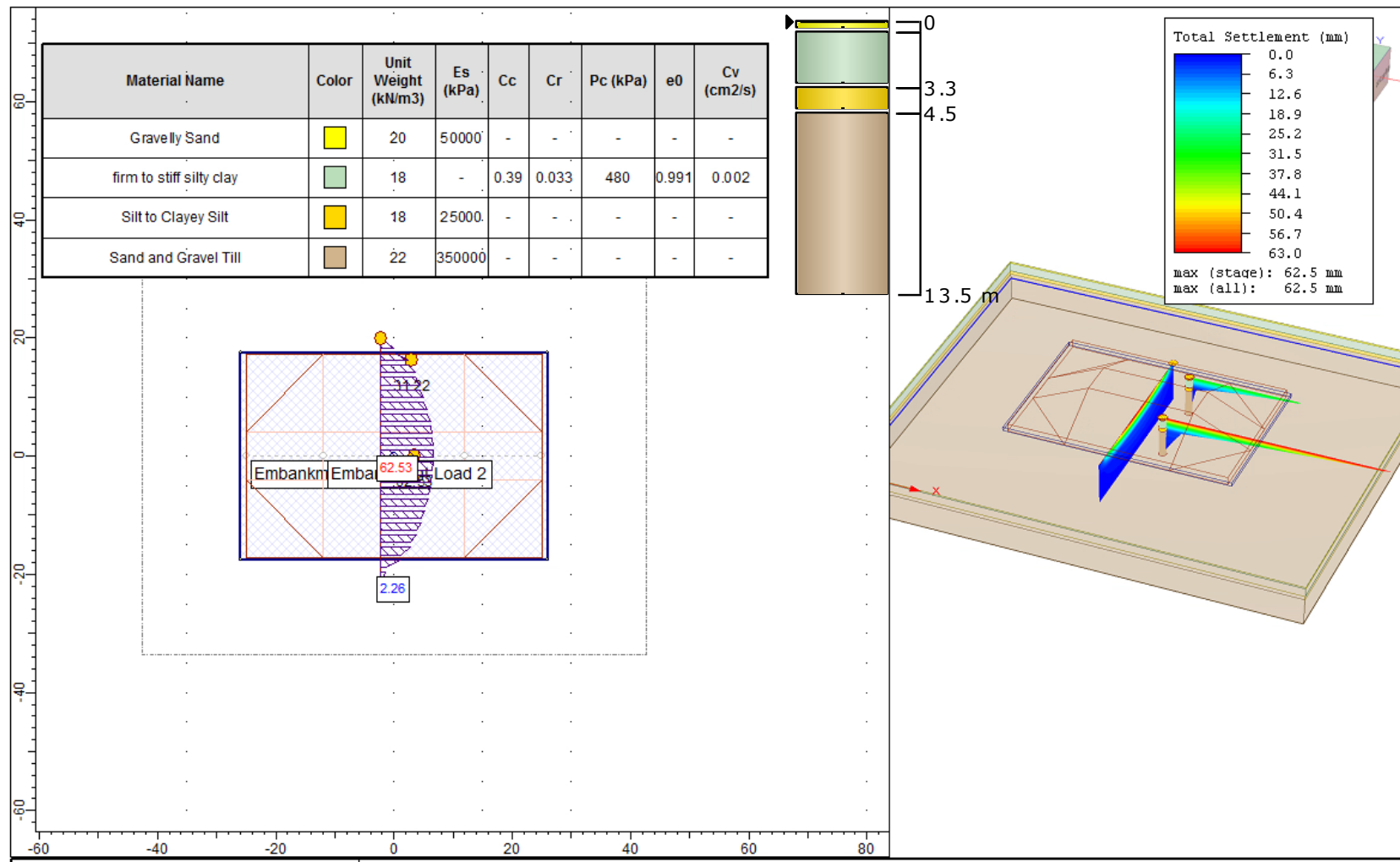
Color	Name	Model	Unit Weight (kN/m ³)	Phi' (°)
	1. Sand/Salt Pile	Mohr-Coulomb	20	33
	2. Engineered fill	Mohr-Coulomb	21	32
	3. Gravelly Sand Fill	Mohr-Coulomb	20	32
	4. Silty Clay Varved (Firm to Stiff)	Mohr-Coulomb	18	26
	5. Silty Clay (Firm to Stiff)	Mohr-Coulomb	18	24
	6. Silt to Clayey Silt (Stiff to V. Stiff)	Mohr-Coulomb	18	26
	7. Sand and Gravel Till (V. Dense)	Mohr-Coulomb	22	35
	8. Bedrock	Bedrock (Impenetrable)		
	RC	Mohr-Coulomb	24	0

Figure F4 – Global Stability for Haileybury Patrol Yard – Drained Static Analysis

Appendix G – Results of Settlement Analyses



Project: FIDR for Haileybury Patrol Yard

Analysis Description: Full loading – Total Settlement

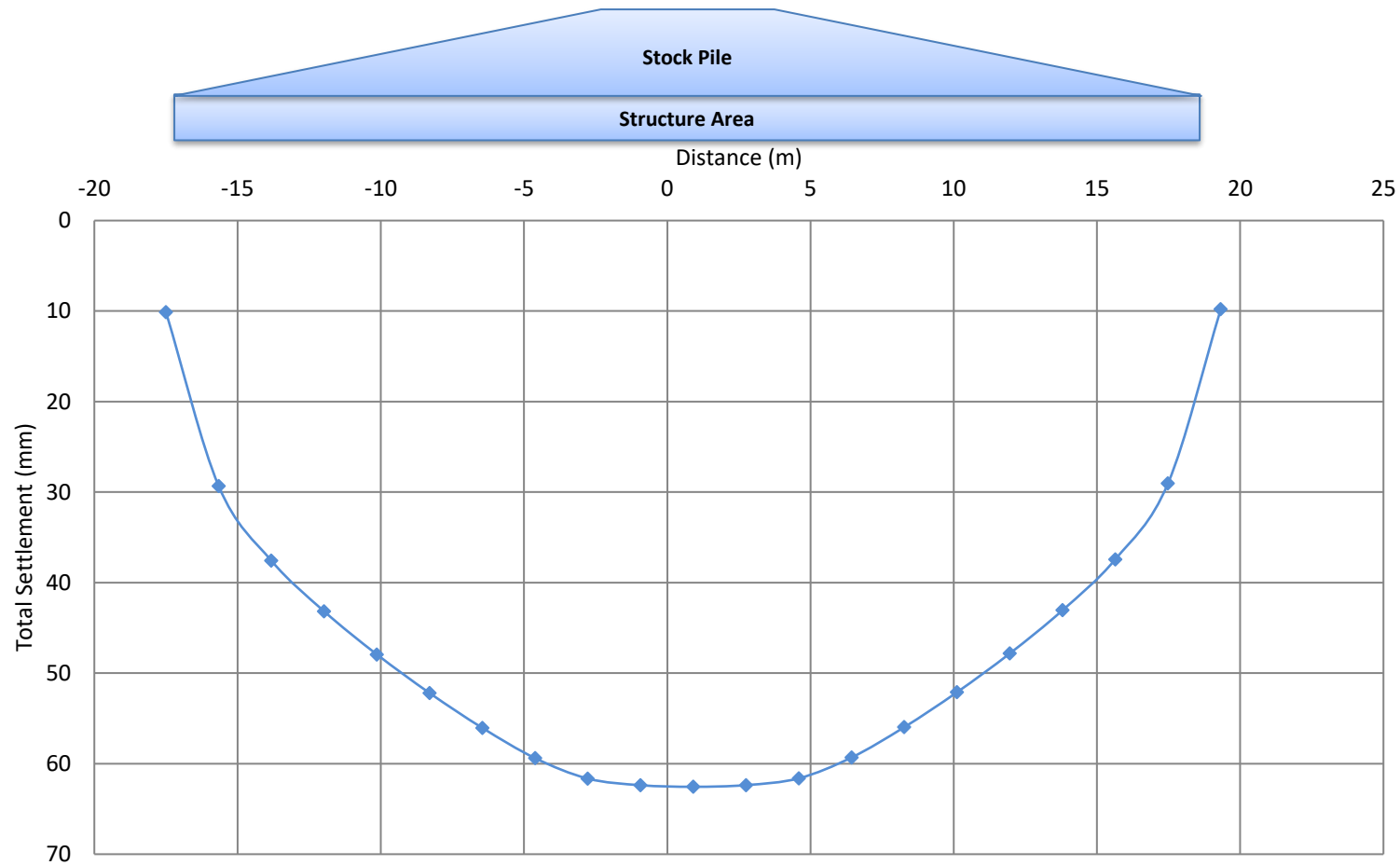
Figure No: G1

Date: May, 2019

Company: exp Services Inc.

File Name: Settlement Analysis – Assignment 10

Distance vs. Total Settlement



Project: FIDR for Haileybury Patrol Yard

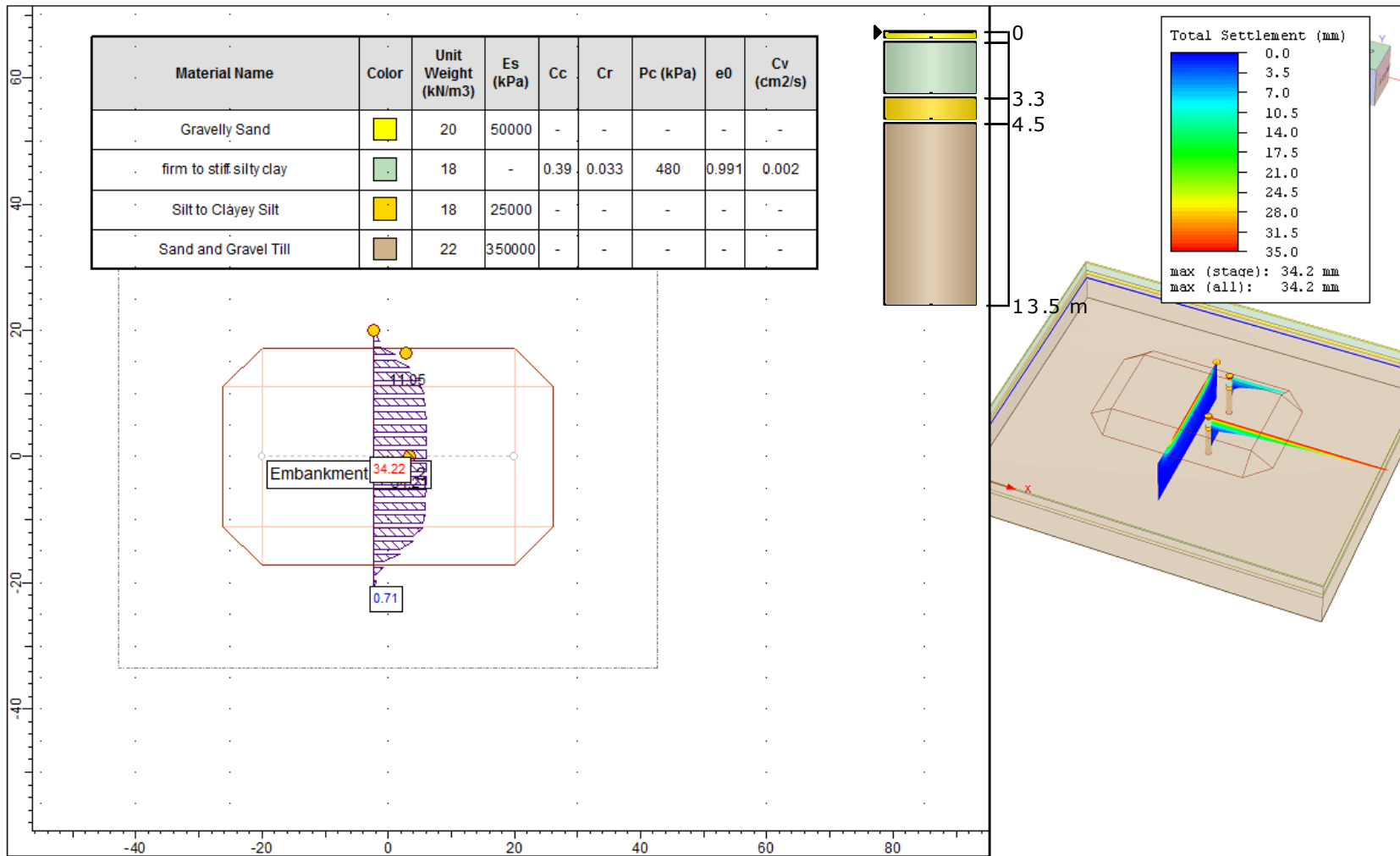
Analysis Description: Full loading – **Total Settlement**

Figure No: G2

Company: **exp** Services Inc.

Date: May, 2019

File Name: Settlement Analysis – Assignment 10



Project: FIDR for Haileybury Patrol Yard

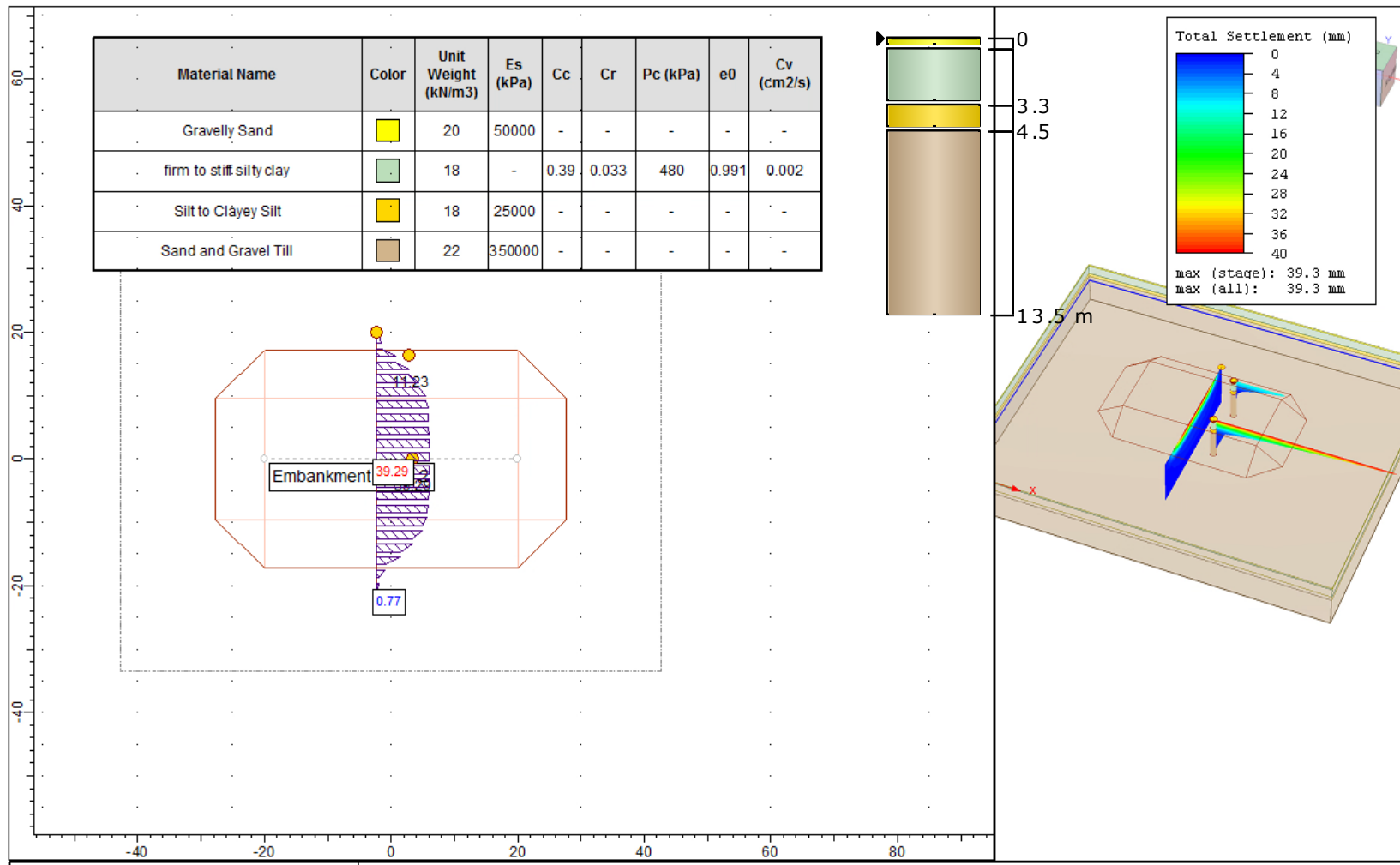
Analysis Description: preloading 4 m – **Total Settlement**

Figure No: G3

Date: May, 2019

Company: exp Services Inc.

File Name: Settlement Analysis – Assignment 10



Project: FIDR for Haileybury Patrol Yard

Analysis Description: Preloading 5 m – **Total Settlement**

Figure No: G4

Company: **exp** Services Inc.

Date: May, 2019

File Name: Settlement Analysis – Assignment 10

Appendix H – Records of Borehole from Previous Investigation

RECORD OF BOREHOLE No BH12-1

1 OF 1

METRIC

LOCATION HAILEYBURY PATROL YARD N 5 256 348.1; E 596 922.5



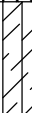



ORIGINATED BY DCL

BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT AND DCPT

COMPILED BY JW

DATUM GEODETTIC DATE 5.31.12 - 5.31.12

CHECKED BY RK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _P	W	W _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)					
259.9							20 40 60 80 100	30 60 90 120 150	10 20 30					
258.9	ASPHALT: 75 mm THICK		1	SS	32									
	GRANULAR FILL: GRAVELLY SAND TO SAND, SOME GRAVEL, TRACE SILT, BROWN, COMPACT, MOIST		2	SS	19									
258.5														
1.4	CLAYEY SILT TO SILTY CLAY: CLAYEY SILT TO SILTY CLAY, TRACE FINE SAND GREY TO BROWN GREY, FIRM TO STIFF, MOIST TO WET		3	SS	9									
255.5														
4.4	SILT: MOTTLED SILT, SOME CLAY, TRACE SAND BROWN GREY TO GREY, VERY STIFF, WET		7	SS	18									
254.2														
5.7	SILTY SAND TILL: SILTY FINE SAND TILL, SOME GRAVEL, TRACE CLAY, WITH FREQUENT COBBLES AND BOULDERS GREY, DENSE TO VERY DENSE, WET		8	SS	37									
250.9														
9.0	GRAVELLY SAND TILL: SOME SILT, TRACE CLAY, WITH FREQUENT COBBLES AND BOULDERS GREY, VERY DENSE, WET		10	SS	71									
248.7														
11.1	END OF BOREHOLE													

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

METRIC

ORIGINATED BY DCL

COMPILED BY JW

CHECKED BY RK

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No BH12-3

1 OF 1

METRIC

LOCATION HAILEYBURY PATROL YARD N 5 256 352.0; E 596 899.7

ORIGINATED BY DCL

BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT AND DCPT

COMPILED BY JW

DATUM GEODETIC DATE 6.1.12 - 6.4.12

CHECKED BY RK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _P	W	W _L		
260.0								20 40 60 80 100						
258.9	ASPHALT: 75 mm THICK		1	SS	37			30 60 90 120 150						30 61 (9)
	GRANULAR FILL: GRAVELLY SAND TO SAND AND GRAVEL, SOME COBBLES		2	SS	42									
	BROWN, DENSE TO COMPACT, MOIST		3	SS	10									
257.9														
2.1	SILTY CLAY TO CLAYEY SILT; SILTY CLAY TO CLAYEY SILT, TRACE SAND		4	SS	7									
	BROWN GREY TO BROWN, STIFF, WET		5	SS	10									
			6	SS	5									
			7	SS	6									
254.3														
5.7	SILT: SILT, SOME CLAY, TRACE SAND		8	SS	4									
	GREY, FIRM TO VERY STIFF, WET													
			9	SS	15									
251.5														
8.5	SILTY SAND TILL: SILTY SAND TILL, SOME GRAVEL, TRACE CLAY, WITH FREQUENT COBBLES AND BOULDERS		10	SS	22									
	GREY, COMPACT TO VEY DENSE, WET													
248.9			11	SS	100									
11.1	END OF BOREHOLE													

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH12-4

1 OF 1

METRIC

LOCATION HAILEYBURY PATROL YARD N 5 256 333.7; E 596 898.3












ORIGINATED BY DCL

BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT AND DCPT

COMPILED BY JW

DATUM GEODETIC DATE 6.4.12 - 6.4.12

CHECKED BY RK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE									
259.9																				
258.9	ASPHALT, 65 mm THICK		1	SS	35															
	GRANULAR FILL: GRAVELLY SAND, SOME COBBLES		2	SS	10															
258.6	BROWN, DENSE TO COMPACT, MOIST																35 58 (7)			
1.4	CLAYEY SILT TO SILTY CLAY: CLAYEY SILT TO SILTY CLAY, TRACE FINE SAND, TRACE ROOTLETS AT THE UPPER 0.5 m		3	SS	7															
	BROWN TO GREY, FIRM TO STIFF, MOIST TO WET		4	SS	6															
			5	SS	3															
	BROWN		6	TW	PH															
	GREY		7	SS	4															
254.2	SILTY SAND TILL: SILTY SAND TILL, SOME GRAVEL, TRACE CLAY		8	SS	21															
5.7	GREY, COMPACT TO VERY DENSE, WET		9	SS	15															
			10	SS	62															
250.2	DYNAMIC CONE PENETRATION TEST BELOW 9.8 m DEPTH.																			
9.8																				
249.6	END OF BOREHOLE																			
10.4																				

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE