FINAL REPORT

FOUNDATION INVESTIGATION AND DESIGN REPORT
New Material Storage Facility at Gravenhurst Patrol Yard, Gravenhurst, ON

Agreement No. 5015-E-0007
Assignment No. 10
Geocres No. 31E-404

Prepared for:
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EXP Services Inc.
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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 Gravenhurst Patrol Yard, located in Township of Muskoka, 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 Gravenhurst Patrol Yard is located on Highway 11, approximately 0.5 km south of the Muskoka Road 169, Gravenhurst, Township of Muskoka, Northeastern Ontario (see Key Map on Drawing 1, Appendix B). The site is bound by Highway 11 to the west.

A paved roadway lead from the site entrance on Highway 11 to existing 6-bay garages, which is located approximately 150 m northeast of the entrance gate. Gravel stock pile is present in the southwest area of the proposed material storage facility. The proposed new storage facility will be located approximately 250 m northeast from the site entrance.

The topography of the site is considered flat lying with elevations ranging from 255.5 to 255.7 m. The ground surface of the proposed material storage facility is paved from the east to west end of the facility. The area beyond the north, south and east boundary of the proposed facility consists of bush with mature trees. Photographs of the site are included in Appendix A.

1.2.2 Geological Setting

In accordance with the Ministry of Northern Development and Mines Map 2556, Quarternary Geology of Ontario, Southern Sheet, the site is generally glaciofluvial outwash deposits consisting of gravel and sand including proglacial river and deltaic deposits. In accordance with the Ministry of Northern Development and Mines Map 2544, Bedrock Geology of Ontario, Southern Sheet, the bedrock at the site consists of migmatitic rocks and gneisses of undetermined protolith consisting of layered biotite gneisses and migmatites, quartzofeldspathic gneisses, orthogneisses and paragneisses.

1.3 Available Documents of Previous Investigations

The available reports of the previous investigation for Gravenhurst Patrol Yard in the MTO GEOCRES library are:

1. *Geocres No. 31D-120: "Foundation Investigation Report for Proposed S Gravenhurst Patrol Yard, Highway 11, Lot 2 & 3, Con. E.N.R., Township of Muskoka, District #11", November 4, 1963*

2. *Geocres No. 31D-581: "Foundation Investigation and Design Report, Sand/Salt Storage Structure, Gravenhurst Patrol Yard, Highway 11, Township of Muskoka W.O. 2014-11033 prepared by Golder Associates", dated November 10, 2014*

The details of four boreholes completed by Golder Associates (Golder) for Gravenhurst Patrol Yard are outlined in Table 1.1 and the borehole locations are shown on Drawings in Appendix B. For the ground elevations mentioned in Table 1.1 the BM with elevation 257.308 m was used as noted in Golder's report. The borehole logs are included in Appendix G. As can be seen, the previous boreholes were drilled approximately 50 to 100 m southeast of the proposed location for the new storage building.

Table 1.1. Summary of boreholes completed by Golder Associates

BH #	MTM NAD83 Northing	MTM NAD83 Easting	Ground Elevation (m)	Borehole Depth (m)
BH-YARD1	4973399.2	315563.8	256.4	11.3
BH-YARD2	4973379.0	315663.4	256.4	11.3
BH-YARD3	4973372.9	315656.4	256.6	12.8
BH-YARD4	4973390.3	315642.6	256.8	12.8

1.4 Investigation Procedures

1.4.1 Fieldwork

The field investigation was performed between April 23 and 29, 2019. The field program consisted of drilling four (4) sampled boreholes (BH19-G-1 to BH19-G-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 temporary benchmark (TBM) established on the top of grey hydro box on the concrete pillar adjacent to the light post. The elevation of the TBM was considered 256.8 m based on the drawing provided with TOR. The TBM 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 auger. 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 1.2.

Table 1.2. 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-G-1	NW of North Existing Dome	4973470.2	315709.1	255.6	15.6
BH19-G-2	NE of North Existing Dome	4973478.7	315738.3	255.7	16.1
BH19-G-3	SW of South Existing Dome	4973405.8	315729.9	255.5	16.4
BH19-G-4	SE of South Existing Dome	4973415.3	315759.1	255.6	15.7

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. Water truck from Fowler Construction was used for soil sampling (wash boring).

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 1.6. 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.

1.4.2 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. 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.

1.5 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 fine grained sand, followed by sandy silt and silty sand. The findings are generally consistent with those reported in the previous investigation reports, even though the locations of investigations are different. A summary of the soil and groundwater conditions encountered in the current boreholes is provided below.

1.5.1 Pavement Structure

Asphaltic concrete was encountered at the surface of all boreholes BH19-G-1 to BH19-G-4, and ranged in thickness from approximately 65 mm to 100 mm. Asphalt thicknesses may further vary beyond the borehole locations.

Sand and gravel fill with trace silt was encountered below the asphaltic concrete on all boreholes BH19-1 to BH19-G-4, and ranged in thickness from approximately 510 mm to 545 mm. The total thickness of pavement structure in all boreholes is 0.6 m.

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

Moisture Content:

- 1% to 5%

Grain Size Distribution:

- 18% to 26% gravel;
- 59% to 67% sand;
- 21% silt; and
- 2% clay.

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.

1.5.2 Sand

A layer of native sand was encountered in all boreholes, below the pavement structure in all drilled boreholes (BH19-G-1 to BH19-G-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 1.3 below:

Table 1.3. Summary of sand layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-G-1	255.0	246.8	0.6	8.2
BH19-G-2	255.1	246.9	0.6	8.2
BH19-G-3	254.9	246.5	0.6	8.4
BH19-G-4	255.0	246.6	0.6	8.4

The composition of this layer is fine grained sand, with trace to some gravel, trace to some silt and trace clay. The material is brown to brown/grey in color with dark grey molting with depth, and moist to wet. The SPT "N" values within this layer were between 19 and 76 blows per 300 mm penetration, suggesting compact to very dense compactness condition.

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

Moisture Content:

- 3% to 30%

Grain Size Distribution:

- 0% to 17% gravel;
- 63% to 97% sand;
- 3% to 18% silt; and
- 0% to 3% clay

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 2, in Appendix D.

1.5.3 Sandy Silt

A layer of sandy silt was encountered in boreholes BH19-G-1, BH19-G-3 and BH19-G-4 below native sand. 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 sandy silt layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-G-1	246.8	245.0	8.8	1.8
BH19-G-3	246.5	243.5	9.0	3.0
BH19-G-4	246.6	245.0	9.0	1.6

The composition of this layer is fine-grained sandy silt, with trace clay. The material is brown/grey in color, and wet. The SPT "N" values within this layer were between 11 and 93 blows per 300 mm penetration, suggesting compact to very dense compactness condition.

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

Moisture Content:

- 16% to 20%

Grain Size Distribution:

- 0% to % gravel;
- 27 to 38% sand;
- 57% to 66% silt; and
- 5% to 7% clay

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 3, in Appendix D.

1.5.4 Silty Sand

A layer of silty sand was encountered in all boreholes, below native sand in borehole BH19-G-2 and below sandy silt in boreholes BH19-G-1, BH19-G-3 and BH19-G-4. Boreholes BH19-G-2 and BH19-G-3 was extended deeper with Dynamic Cone Penetration Test (DCPT) until DCPT refusal (100 blows per 229 mm and 279 mm penetration respectively). All the boreholes 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 1.5 below:

Table 1.5. Summary of silty sand layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-G-1	245.0	240.0	5.0	10.6
BH19-G-2	246.9	239.6	7.3	8.8
BH19-G-3	243.5	239.1	4.4	12.0
BH19-G-4	245.0	239.9	5.1	10.6

The composition of this layer is fine-grained silty sand with trace clay. The material is grey in color, and wet. The SPT "N" values within this layer were between 23 blows per 300 mm and 117 blows per 190 mm penetration, suggesting compact to very dense compactness condition.

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

Moisture Content:

- 14% to 24%

Grain Size Distribution:

- 0% gravel;
- 42 to 66% sand;
- 32% to 57% silt; and
- 1% to 2% clay

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 4, in Appendix D.

1.6 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 1.6 and on the borehole logs. Water levels measured in open boreholes might not be stabilized due to the relatively short period of observation.

Table 1.6 Groundwater data

Borehole	Date of Drilling	Ground surface Elevation (m)	Groundwater Elevation (m)	Groundwater Depth (m)
BH19-G-1	4/29/2019	255.6	253.5	2.1
BH19-G-2	4/25/2019	255.7	252.8	2.9
BH19-G-3	4/24/2019	255.5	252.8	2.7
BH19-G-4	4/23/2019	255.6	253.5	2.1

During investigation, few hours after borehole drilling, the unstabilized groundwater level was measured within the sand deposit approximately 2.1 m below ground surface (Elev. 253.5 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.

1.7 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-G-1 was analyzed for corrosivity chemical analysis. The analytical results are summarized in Table 1.7 below and are presented in Appendix D.

Table 1.7. Corrosivity chemical analysis

Sample Identification	pH (unitless)	Soluble Chloride (ppm)	Soluble Sulphate (ppm)	Resistivity (ohm-cm)	Conductivity (mS/cm)	Redox Potential (mV)
BH19-G-1-SS3 Sand	6.83	6	14	18900	0.053	233 to 249

1.8 Environmental Analyses

In addition to corrosivity testing, one (1) sample of native sand materials from borehole BH19-G-1 (SS2) was analyzed for metals and general inorganics parameters and BTEX/ Petroleum Hydrocarbons (PHCs) – (F1-F4). 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 material storage structure at the Gravenhurst Patrol Yard, located approximately 0.5 km south of the Muskoka Road 169 on Highway 11, Township of Muskoka, 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 material storage building will be a single 43.3 m diameter dome constructed at the MTO Gravenhurst Patrol Yard at the location of two existing domes. However, at the time of writing this report the exact location of the new dome was not defined, but it is assumed that it is going to be located in the middle of two existing domes as shown on Drawing 1 in Appendix B. It is further assumed, based on design drawings for similar structures provided by MTO, 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. 255.5 m and 255.7 m. It is assumed that finished top of floor will be at the current ground level of about Elev. 255.6 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^{o}.

2.2 Geotechnical Design Considerations for Foundations

The subsurface conditions at the site below the pavement structure generally consist of an 8.2 m to 8.4 m thick compact to very dense sand underlain by a 0 to 3 m thick layer of compact sandy silt followed by a layer of compact to very dense silty sand where the boreholes were terminated. The bedrock was not encountered within the explored depth of maximum 16.6 m. During current investigation, the unstabilized groundwater level was measured within the sand deposit approximately 2.1 m below ground surface (Elev. 253.5 m).

2.2.1 Foundations of New Storage Structure

Based on the subsurface conditions at this site and given that bedrock or very dense material was not encountered within the borehole termination depth (i.e. 16.6 m below the ground surface), deep foundations are not considered to be a practical foundation option since the founding strata within which deep foundation elements such as H-piles or caissons will be terminated provides low axial resistances. Therefore, we recommend that the new sand/salt storage structure be supported on shallow foundations comprised of spread footings founded on/within the native compact to dense sand deposit, as discussed in the following sections.

In general, the impact of settlement on the foundations of the structure will be influenced by the operating/stockpiling practices depending on the compressibility of the founding soil. 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 sand/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.

Since, the new proposed storage building lies within the footprint of existing buildings, the differential settlement between the existing stockpile areas and new area could be an issue. Therefore, preloading of the portion of proposed storage building within the virgin area (i.e. outside of the existing structure footprints) should be considered to enhance serviceability of the new structure.

2.2.1.1 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 1.7 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 compact to dense sand	253.8	~1.7 m

2.2.1.2 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. The ULS and SLS consequence factor of 1.0 and degree of site understanding of 0.9 were applied in accordance with Tables 6.1 and 6.2 in the CHBDC S6-14, respectively.

Table 2.3 Factored geotechnical resistances for a 2.1 m wide footing

Soil at Founding Level	Width of Footing (m)	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance* (kPa) (for 25 mm settlement)
Native compact to dense sand	2.1	550	380

*Note: * Factored serviceability geotechnical resistance value can be reviewed, 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.

2.2.1.3 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 δ, 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 δ
Cast-in-place concrete and native compact to dense sand	0.50

**- based on NAVFAC 1986, Table 1, pg. 7.2-63*

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/m^3
- Friction angle of sand/salt stockpile material= 33^o
- Lateral earth pressure coefficient (K_o) = 0.5

2.2.1.4 Frost Protection

According to Ontario Provincial Standard Drawing (OPSD – 3090.100), the frost depth in the Gravenhurst area is about 1.7 m. Consequently, all footings exposed to seasonal freezing conditions should be protected from frost action by at least 1.7 m of soil cover or equivalent insulation.

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 compact to very dense sand underlain by sandy silt and silty sand deposits. The reported N-values for the soil below 3 m of the founding level ranged from 22 to 76 blows for 300 mm of penetration, with an average value being around 43 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 Gravenhurst 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 15.6 m and 16.4 m deep. The total overburden thickness was between 15.6 m and 16.4 m at the tested locations and depths. The bedrock was not encountered within explored depths.

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. The values of the Spectral Response acceleration for different periods and the Peak Ground Acceleration (PGA) for the Gravenhurst area can be obtained from the National Building Code of Canada (2010).

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 255.6 m. Bellow the floor, a 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 80 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, a frost protection is not considered necessary.

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.

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 43.3 m diameter building assuming that the maximum sand/salt stockpile height could be 11 m having side slopes of 1.5H:1V as shown on in Appendix E. 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 were performed taking into consideration the subsoil conditions encountered directly beneath the proposed structure.

Tabulated below in Table 2.5 are the soil parameters used for the stability analyses. The soil parameters were generally estimated based on the results of field and laboratory investigation.

Table 2.5 Soil properties used in stability analyses

Material Type	Effective Stress Parameters		
	ϕ (degrees)	c (kPa)	γ (kN/m³)
Engineered Fill	32	0	21
Compact to Dense Sand	31	0	20
Compact to Very Dense Sandy Silt	30	0	20
Compact to Very Dense Silty Sand	31	0	20
Stockpile Material (Winter sand/salt)	33	0	20

The graphical results of these analyses can be seen in Appendix E. As shown on figures in Appendix E, 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/m³)	E (MPa)	C_c	C_r	P_c (kPa)	e_0
Engineered Fill	21	50	-	-	-	-
Compact to Dense Sand	20	45	-	-	-	-
Compact to Very Dense Sandy Silt	20	30	-	-	-	-
Compact to Very Dense Silty Sand	20	35	-	-	-	-

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 F1 included in Appendix F.

The results of the settlement analyses are plotted on Figures F1 and F2 (Appendix F). 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 Elastic Settlement (mm)	
	Edge	Centre
Compact to Dense Sand	20	76

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 settlement would occur after the footings have been constructed. Therefore, the footings for these structures should be designed under the full allowable stockpile loadings. The geometries of stockpiles under the full allowable loadings including their maximum heights are recommended above. Since, the proposed building lies within the footprint of existing storage domes, the post construction settlement within the existing stockpile area would be less than estimated above. As inferred by the geometric relationship (i.e. Drawing 1) between old and proposed structures, the potential for differential settlement between the existing stockpile area and new areas not previously loaded, exists. 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/differential settlement can be significantly reduced. For example, a settlement analysis assuming a 5 m high stockpile preloading was performed and the results are presented in Table 2.10 and attached Figures F3 in Appendix F. The results show that the total settlement of approximately 36 mm at the center could be achieved by placing the 5 m high stockpile. The total settlement of about 10 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 30 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)
5	36	~10

Assuming preloding of the virgin areas for a period of one month is undertaken there should be no significant settlement issues at this site. Some monitoring of the preloading and perimeter walls after construction is indicated to confirm expectation.

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. 252.8 m and Elev. 253.5 m, while the excavation to the foundation level has to be carried out to Elev. 253.8 m. Therefore, the excavations within the existing sand deposits are expected to be above the groundwater table. and dewatering is not expected to be required. However, it is anticipated that control of any seepage can be accomplished by using properly filtered sumps. Surface water should be directed away from the excavation.

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, if any, 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 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 high resistivity of the tested soil, which indicates a very low potential for corrosion of buried metallic elements (MTO Gravity Pipe Design Guidelines, Page 25). The maximum chloride content reported is 6 ppm (μg/g) which indicates no potential for additional corrosion. The soil pH was about 6.83 which is within what is considered the normal range for soil pH of 5.0 to 9.0. Based on these results it appears that there is no need for coatings and corrosion protection systems for buried steel objects.

The maximum water-soluble sulphate content of the soils tested is 26 ppm (μg/g), i.e. 0.0026% 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 native sand from BH19-G-1 was analyzed for metals and general inorganics parameters, as well as, 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 analytical results (Certificate of Analysis) are compiled in Appendix D.

The results were compared with soil criteria in Table 2 (Potable Groundwater Condition) and Table 3 (Non-Potable Groundwater Condition) of Ontario Regulation 153, and the conclusion was that the soil sample met all property use standards in Table 2 and Table 3.

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 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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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 EXPerienced 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. Gravenhurst Patrol Yard - Borehole BH19-G-1, facing northwest

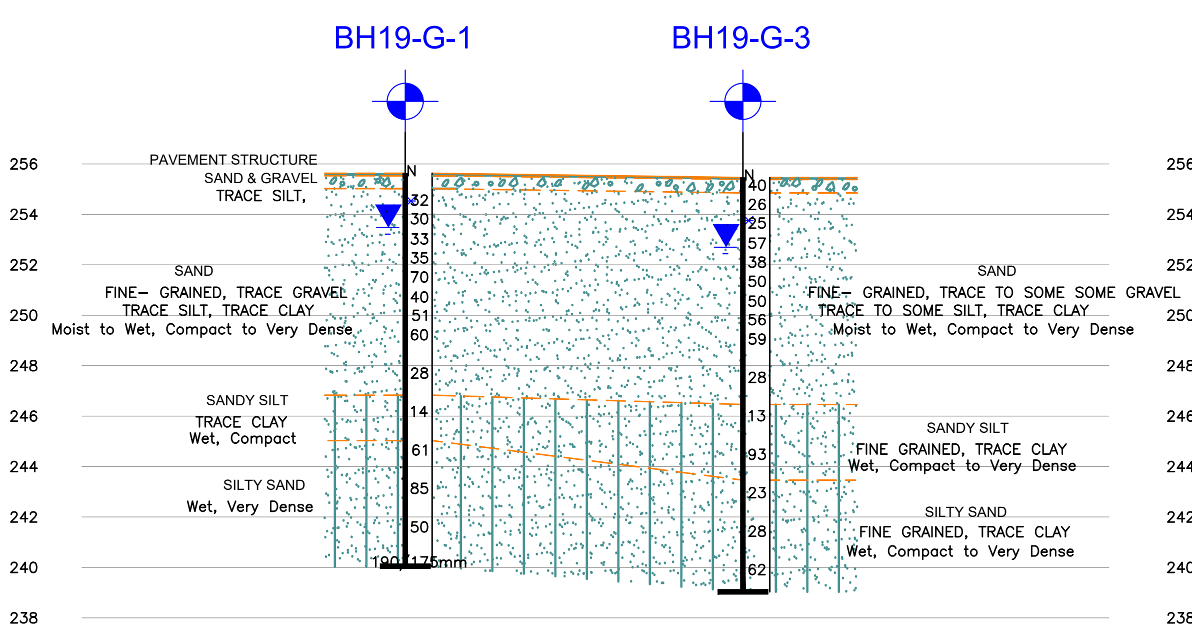
Photo 2. Gravenhurst Patrol Yard- Existing sand dome; Borehole BH19-G-2, facing southwest

Photo 3. Gravenhurst Patrol Yard - Borehole BH19-G-3, facing northwest

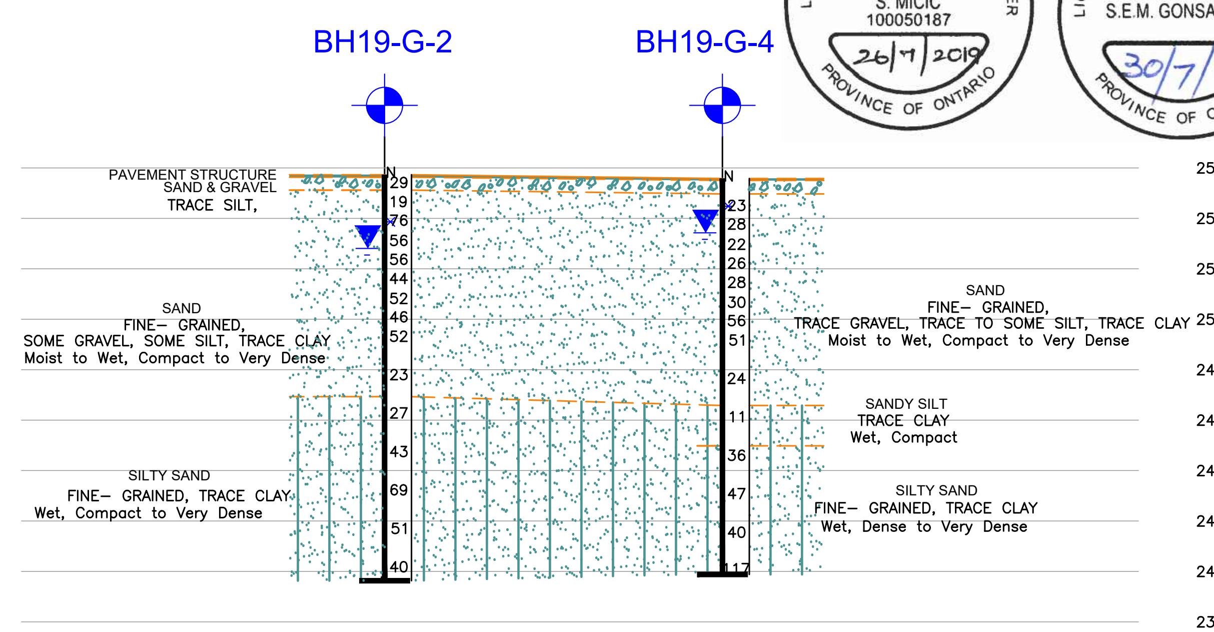
Photo 4. Gravenhurst Patrol Yard - Existing sand dome; Borehole BH19-G-4, facing east

Appendix B – Drawings

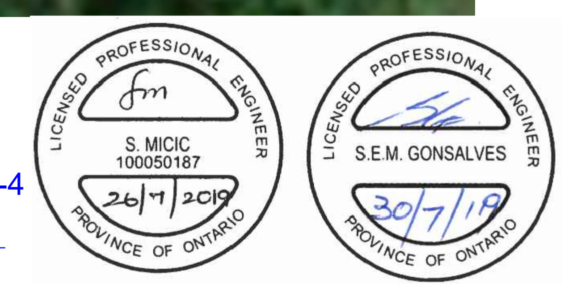
PLAN



SECTION A-A'



SECTION B-B'



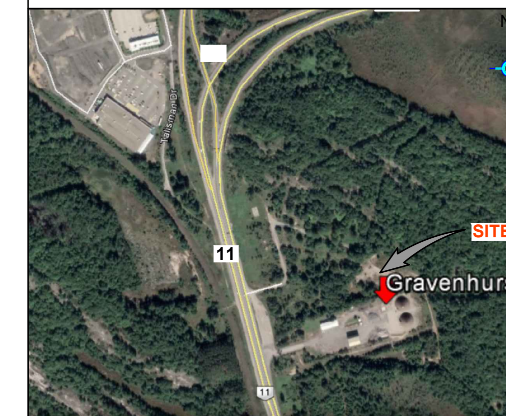
CONT. No. 5015-E-0007
GWP No. -
Assignment No. 10

Various Patrol Yards, Sudbury and North Bay Areas
PATROL YARD AT GRAVENHURST
ON HWY 11
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET 1

exp Services Inc.

KEY PLAN



LEGEND

- Borehole Location
- Existing Borehole Location
- N Standard Penetration Test (Blows/0.3 m)
- Groundwater level measured in open hole
- Temporary Bench Mark (Elev. 256.82m)

SOIL STRATA SYMBOLS

- PAVEMENT STRUCTURE
- SAND
- SAND AND GRAVEL
- SILTY SAND/ SANDY SILT

BH No.	ELEV.	MTM CO-ORDINATES (*ZONE ON-10*)	
		NORTHING	EASTING
BH19-G-1	255.6	4973470.2	315709.1
BH19-G-2	255.7	4973478.7	315738.3
BH19-G-3	255.5	4973405.8	315729.9
BH19-G-4	255.6	4973415.3	315759.1

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 1 6 m

	SM	SUBMISSION FOR MTO REVIEW
DATE	BY	DESCRIPTION
		GEOCRES NO. 31E-404
		PROJECT NO. ADM-00233185-K0
SUBM'D SH	CHECKED SM	DATE Jul. 26, 19
DRAWN SH	CHECKED SM	APPROVED SG / DWG. 1

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		

0.002 0.006 0.02 0.06 0.2 0.6 2.0 6.0 20 60 200

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 Canadian Foundation Engineering Manual (CFEM):

Table a: Percent or Proportion of Soil

	Criteria
Trace	1% - 10%
Some	10% - 20%
Little	20% - 35%
Some	>35% and main fraction

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≤N<10
Compact	10≤N<30
Dense	30≤N<50
Very Dense	50≤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:

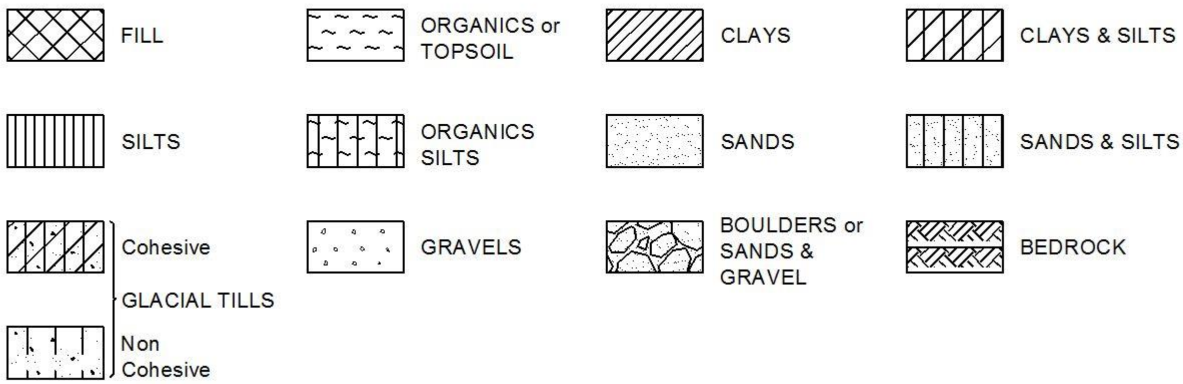
Table c: Consistency of Cohesive Soil

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

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

MECHANICALL PROPERIES 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

RECORD OF BOREHOLE No 19-G-1

METRIC

W.P.		LOCATION	Gravenhurst Patrol Yard, Highway 11, Gravenhurst ON, MTM ON10
ORIGINATED BY	PL		
DIST	Muskoka	HWY	11
BOREHOLE TYPE	CME 55, Hollow stem auger drill	COMPILED BY	LC/SA
DATUM	Geodetic	DATE	2019.04.29 - 2019.04.29
LATITUDE	44.901142	LONGITUDE	79.3618653
CHECKED BY	SM		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
255.6	Ground Surface
255.5 / 0.1	**PAVEMENT STRUCTURE** 100 mm asphaltic concrete - over 510 mm sand and gravel, trace silt
255.0 / 0.6	**SAND** fine-grained, trace gravel, trace silt, trace clay, dark grey mottling with depth, brown to brown/grey, moist to wet, compact to very dense - becoming wet
246.8 / 8.8	**SANDY SILT** trace clay, brown/grey, wet, compact
245.0 / 10.6	**SILTY SAND** grey, wet, very dense

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	AS		26	67	(7)	
2	SS	32				
3	SS	30				
4	SS	33				
5	SS	35	6	83	10	1
6	SS	70				
7	SS	40				
8	SS	51	0	93	5	2
9	SS	60				
10	SS	28				
11	SS	14	0	38	57	5
12	SS	61				

GROUND WATER CONDITIONS: water level symbol (∇) at approx. elevation 253.6

ELEVATION SCALE: 255, 254, 253, 252, 251, 250, 249, 248, 247, 246, 245, 244

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20, 40, 60, 80, 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER — 20, 40, 60, 80, 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%): 20, 40, 60

UNIT WEIGHT γ kN/m³

Continued Next Page

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

RECORD OF BOREHOLE No 19-G-1

METRIC

W.P. ______ LOCATION Gravenhurst Patrol Yard, Highway 11, Gravenhurst ON, MTM ON10 ORIGINATED BY PL

DIST Muskoka HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC/SA

DATUM Geodetic DATE 2019.04.29 - 2019.04.29 LATITUDE 44.901142 LONGITUDE 79.3618653 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
	SILTY SAND grey, wet, very dense *(continued)*	13	SS	85	243	~14
		14	SS	50	242, 241	~22
240.0 / 15.6		15	SS	190/175mm		~20
	End of borehole at 15.6 m depth.					

Notes:
1. Groundwater level was measured at 2.13 m below ground surface upon completion of drilling.

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × P. PENETROMETER; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL; STRAT PLOT; GROUND WATER CONDITIONS.

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

EXP Services Inc.
Brampton, Ontario

Foundation Design

RECORD OF BOREHOLE No 19-G-2

 METRIC

W.P. ______ LOCATION Dwight Patrol Yard, Highway 60, Dwight ON, MTM ON10 ORIGINATED BY PL

DIST Muskoka HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC/SA

DATUM Geodetic DATE 2019.04.25 - 2019.04.25 LATITUDE 44.901218 LONGITUDE 79.3614954 CHECKED BY SM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
255.7	Ground Surface						
255.6 / 0.1	**PAVEMENT STRUCTURE** 100 mm asphaltic concrete - over 510 mm sand and gravel, trace silt	1	SS	29			18 59 21 2
255.1 / 0.6	**SAND** fine-grained, some gravel, some silt, trace clay, dark grey mottling with depth, brown to brown/grey, moist to wet, compact to very dense	2	SS	19			
		3	SS	76			
	- becoming wet	4	SS	56	∇ (approx. 253)		17 62 18 3
		5	SS	56			
		6	SS	44			
		7	SS	52			
		8	SS	46			
		9	SS	52			
		10	SS	23			
246.9 / 8.8	**SILTY SAND** fine-grained, trace clay, grey, wet, compact to very dense	11	SS	27			
		12	SS	43			0 66 32 2

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO GRAVENHURST BH LOGS V1.GPJ ONTARIO MTO.GDT 7/23/19

RECORD OF BOREHOLE No 19-G-2

METRIC

W.P. ____ LOCATION Dwight Patrol Yard, Highway 60, Dwight ON, MTM ON10 ORIGINATED BY PL

DIST Muskoka HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC/SA

DATUM Geodetic DATE 2019.04.25 - 2019.04.25 LATITUDE 44.901218 LONGITUDE 79.3614954 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILTY SAND fine-grained, trace clay, grey, wet, compact to very dense *(continued)*	13	SS	69		~21				
					243					
					242					
		14	SS	51		~19				
					241					
		15	SS	40		~19	0	42	57	1
					240					
239.6 / 16.1	**End of borehole at 16.1 m depth.** Notes: 1. Groundwater level was measured at 2.9 m below ground surface upon completion of drilling.									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

RECORD OF BOREHOLE No 19-G-3

METRIC

W.P. ______ LOCATION Dwight Patrol Yard, Highway 60, Dwight ON, MTM ON10 ORIGINATED BY PL

DIST Muskoka HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC/SA

DATUM Geodetic DATE 2019.04.24 - 2019.04.24 LATITUDE 44.900563 LONGITUDE 79.3616033 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS GR	SA	SI	CL
255.5	Ground Surface									
255.4 / 0.1	**PAVEMENT STRUCTURE** 100 mm asphaltic concrete - over 535 mm sand and gravel, trace silt	1	SS	40		255				
254.9 / 0.6	**SAND** fine-grained, trace to some gravel, trace to some silt, dark grey mottling throughout, brown to brown/grey, moist to wet, compact to very dense	2	SS	26		254				
		3	SS	25						
	- becoming wet	4	SS	57	∇	253				
		5	SS	38		252	11	74	15	0
		6	SS	50		251				
		7	SS	50			1	96	3	0
		8	SS	56		250				
		9	SS	59		249				
		10	SS	28		248, 247				
246.5 / 9.0	**SANDY SILT** fine-grained, trace clay, grey, wet, compact to very dense	11	SS	13		246	0	27	66	7
		12	SS	93		245, 244				
243.5										

Column headings also include: STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%).

Continued Next Page

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

RECORD OF BOREHOLE No 19-G-3

METRIC

W.P. ______ LOCATION Dwight Patrol Yard, Highway 60, Dwight ON, MTM ON10 ORIGINATED BY PL

DIST Muskoka HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC/SA

DATUM Geodetic DATE 2019.04.24 - 2019.04.24 LATITUDE 44.900563 LONGITUDE 79.3616033 CHECKED BY SM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
12.0	**SILTY SAND** fine-grained, trace clay, grey, wet, compact to very dense										
			13	SS	23		243		o		
							242				
			14	SS	28				o		
							241				
			15	SS	62		240		o		
239.1 16.4	**End of borehole at 16.4 m depth.** Notes: 1. Groundwater level was measured at 2.74 m below ground surface upon completion of drilling.										

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

EXP Services Inc.
Brampton, Ontario

Foundation Design

RECORD OF BOREHOLE No 19-G-4

METRIC

W.P. ____ LOCATION Dwight Patrol Yard, Highway 60, Dwight ON, MTM ON10 ORIGINATED BY PL

DIST Muskoka HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC/SA

DATUM Geodetic DATE 2019.04.23 - 2019.04.23 LATITUDE 44.900648 LONGITUDE 79.3612334 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
255.6	Ground Surface										
255.6 / 0.1	**PAVEMENT STRUCTURE** 65 mm asphaltic concrete - over 545 mm sand and gravel, trace silt	1	AS				~1				
255.0 / 0.6	**SAND** fine-grained, trace gravel, trace to some silt, dark grey mottling throughout, brown to brown/grey, moist to wet, compact to very dense					255					
		2	SS	23			~3	7	79	14	0
						254					
		3	SS	28	▽		~4				
	- becoming wet	4	SS	22		253	~18				
		5	SS	26			~19				
						252					
		6	SS	28			~19	0	97	3	0
						251					
		7	SS	30			~18				
		8	SS	56		250	~22				
		9	SS	51			~21	1	86	12	1
						249					
						248					
		10	SS	24			~25				
						247					
246.6 / 9.0	**SANDY SILT** trace clay, brown/grey, wet, compact										
		11	SS	11		246	~29				
245.0 / 10.6	**SILTY SAND** fine-grained, trace clay, grey, wet, dense to very dense					245					
		12	SS	36			~19				
						244					

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

ONTARIO MTO GRAVENHURST BH LOGS V1.GPJ ONTARIO MTO.GDT 7/23/19

RECORD OF BOREHOLE No 19-G-4

METRIC

W.P. ____ LOCATION Dwight Patrol Yard, Highway 60, Dwight ON, MTM ON10 ORIGINATED BY PL

DIST Muskoka HWY 11 BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC/SA

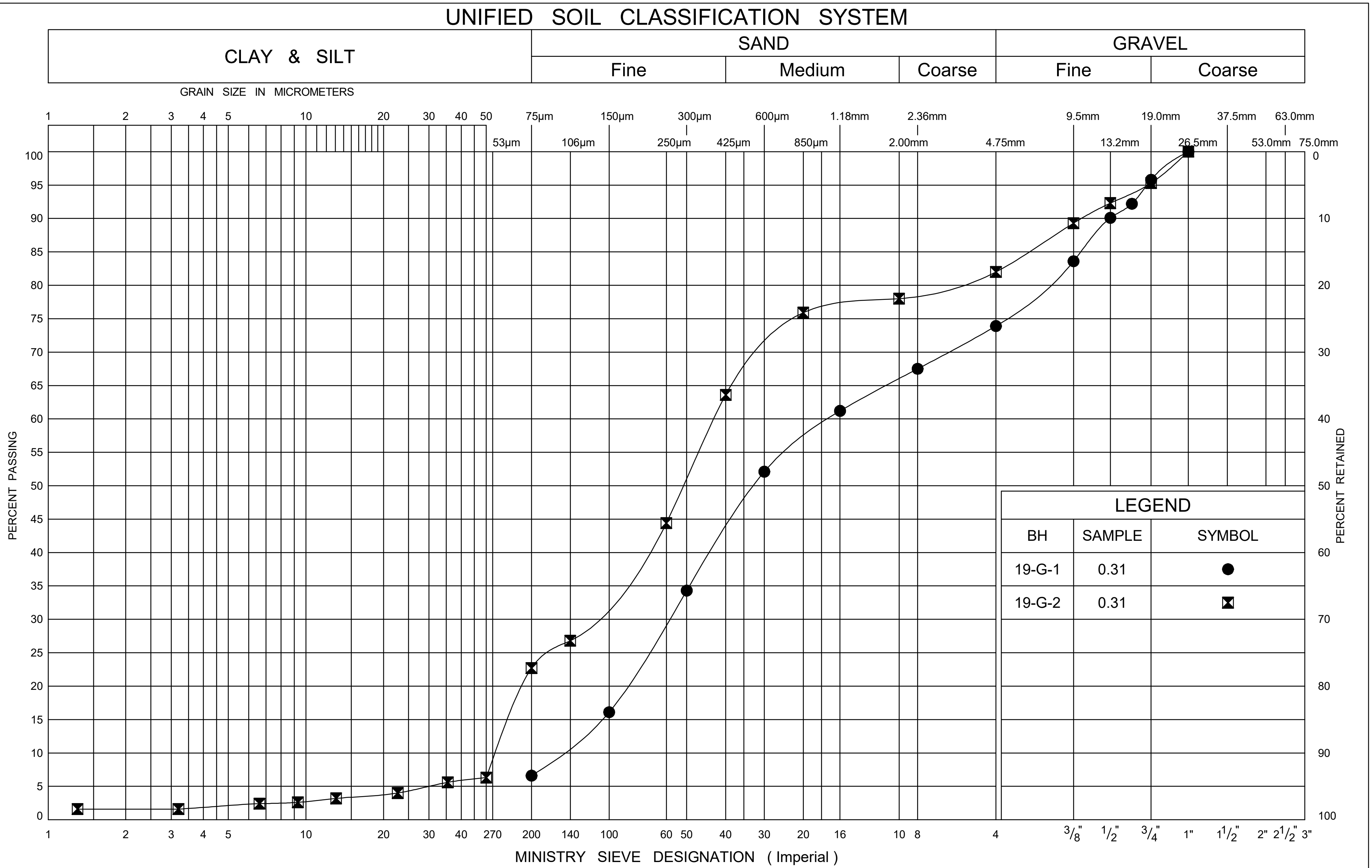
DATUM Geodetic DATE 2019.04.23 - 2019.04.23 LATITUDE 44.900648 LONGITUDE 79.3612334 CHECKED BY SM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILTY SAND fine-grained, trace clay, grey, wet, dense to very dense *(continued)*	13	SS	47	243	~20	0	61	37	2
					242					
		14	SS	40		~18				
					241					
239.9 15.7		15	SS	117	240	~20				
	End of borehole at 15.7 m depth. Notes: 1. Groundwater level was measured at 2.13 m below ground surface upon completion of drilling.									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

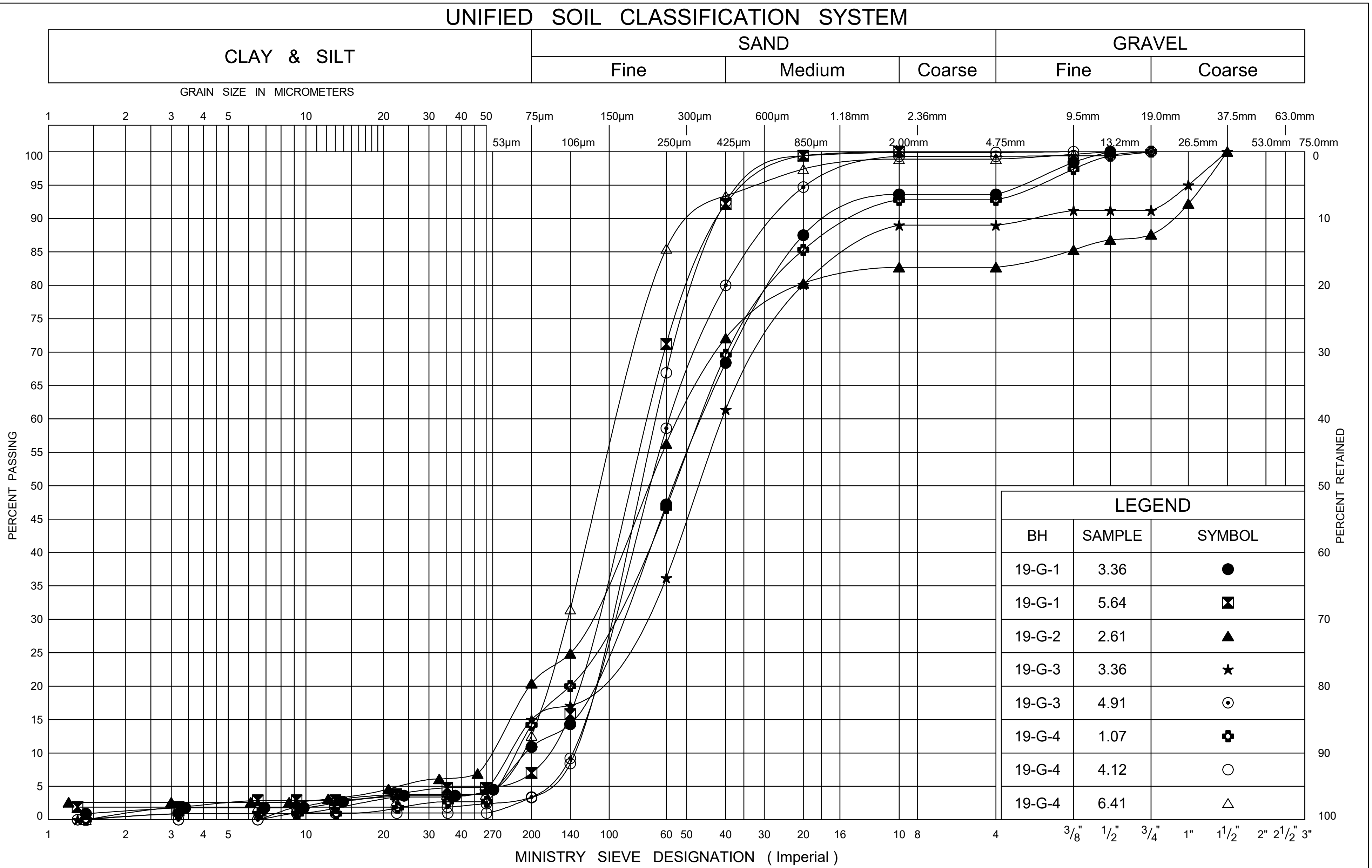
+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Appendix D – Laboratory Data



Ministry of Transportation Ontario	FIG No 1
GRAIN SIZE DISTRIBUTION	W P
Sand and Gravel (Fill)	5015-E-0007, Assignment 10

ONTARIO MOT GRAIN SIZE GRAVENHURST BH LOGS V1.GPJ ONTARIO MOT.GDT 6/24/19



BH	SAMPLE	SYMBOL
19-G-1	3.36	●
19-G-1	5.64	⊠
19-G-2	2.61	▲
19-G-3	3.36	★
19-G-3	4.91	⊙
19-G-4	1.07	✿
19-G-4	4.12	○
19-G-4	6.41	△

Ministry of Transportation
Ontario

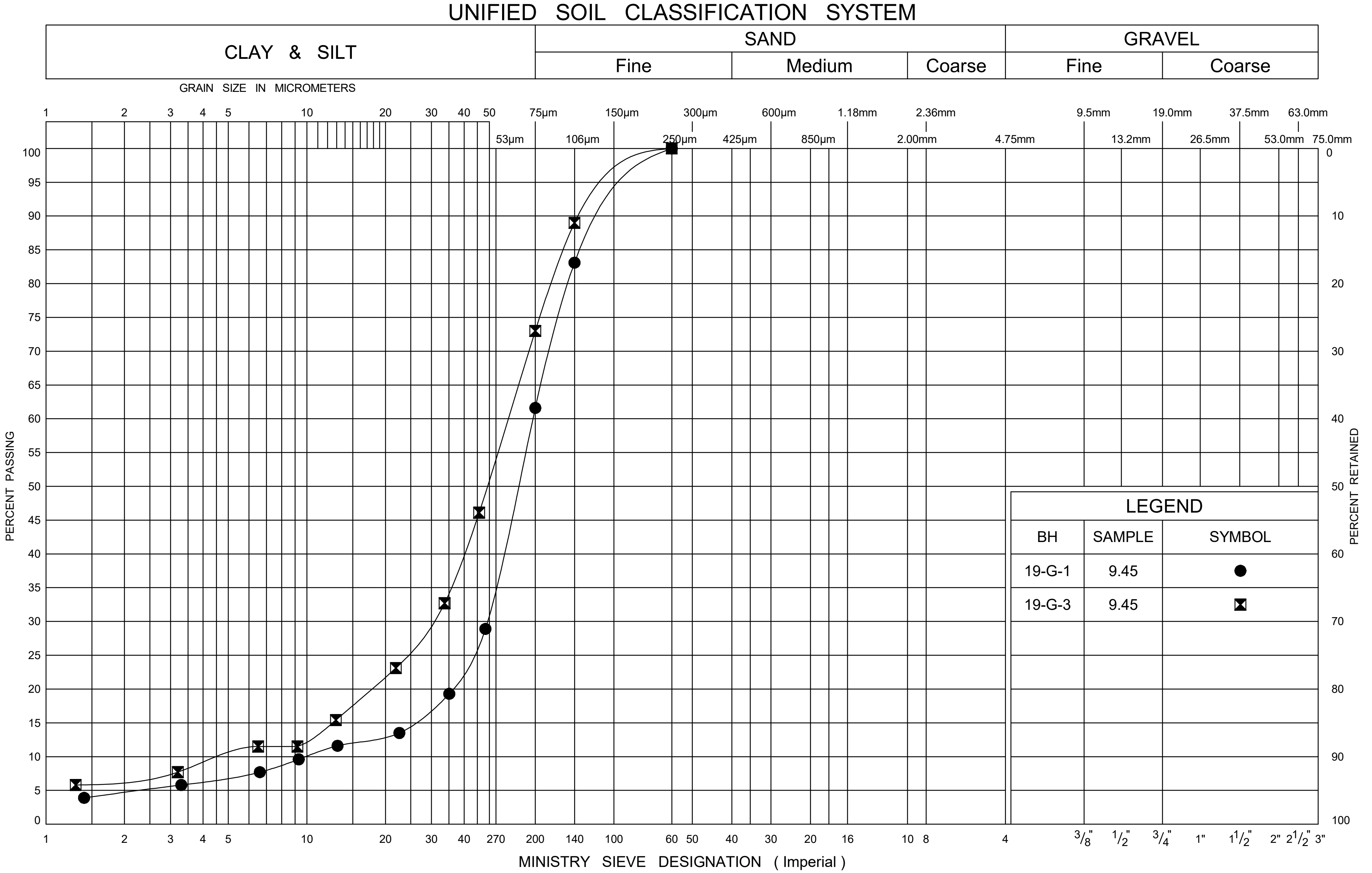
GRAIN SIZE DISTRIBUTION

Sand

FIG No 2

W P

5015-E-0007, Assignment 10



Ministry of Transportation
Ontario

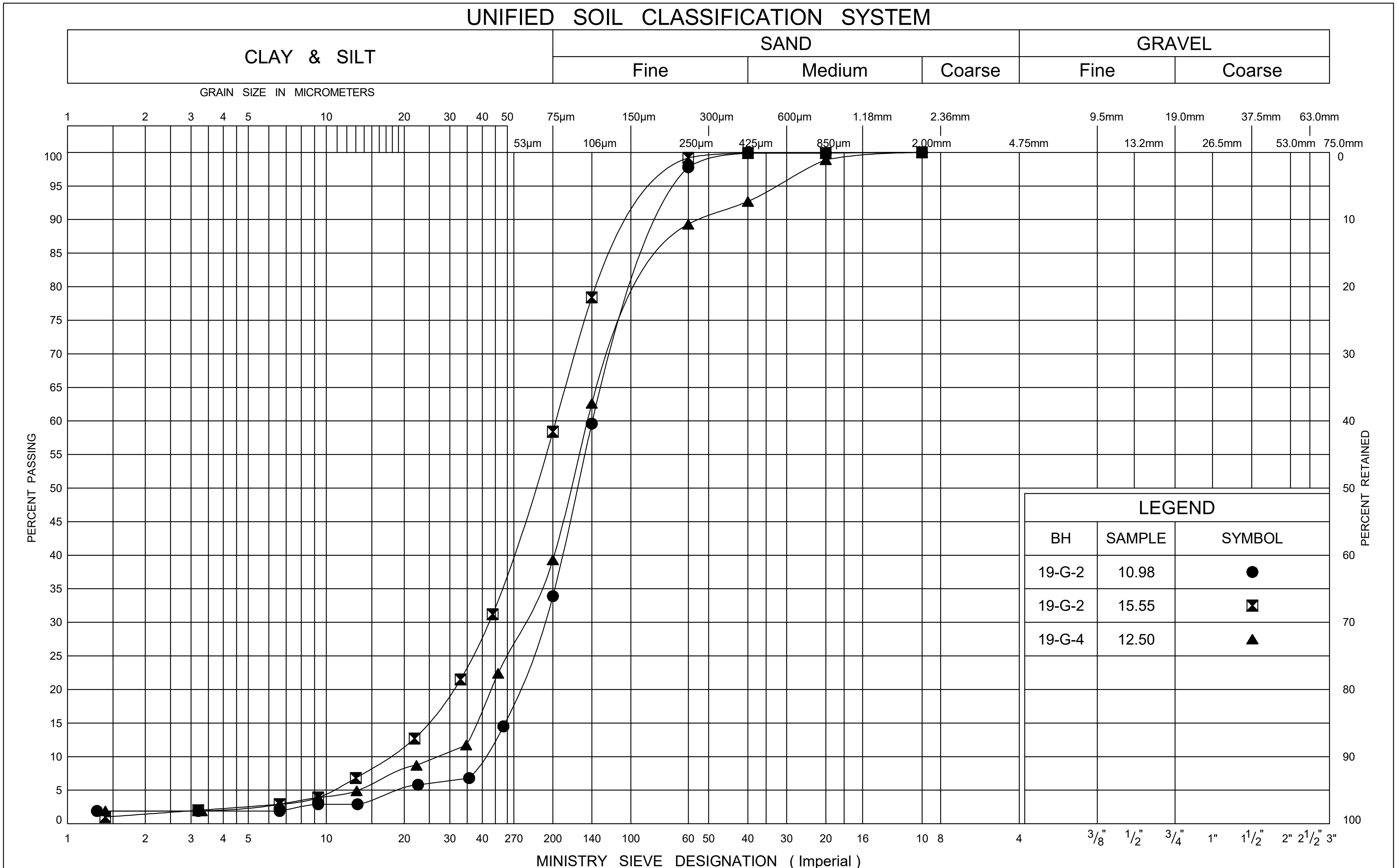
GRAIN SIZE DISTRIBUTION

Sandy Silt

FIG No 3

W P

5015-E-0007, Assignment 10



ONTARIO MOT GRAIN SIZE GRAVENHURST BH LOGS V1.GPJ ONTARIO MOT.GDT 6/24/19

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Sand

FIG No 4

W P

5015-E-0007, Assignment 10

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.
885 REGENT ST
SUDBURY, ON P3E5M4
(705) 674-9681

ATTENTION TO: Ian MacMillan

PROJECT: ADM-00233185-K0

AGAT WORK ORDER: 19U464857

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

TRACE ORGANICS REVIEWED BY: Pinkal Patel, Report Reviewer

DATE REPORTED: May 15, 2019

PAGES (INCLUDING COVER): 10

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.

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:

Corrosivity Package

DATE RECEIVED: 2019-05-08
DATE REPORTED: 2019-06-15

Parameter	Unit	G / S	RDL	19-D-2-SS4	19-PS-2-SS3	19-G-1-SS3	RDL	19-P-2-SS3
			SAMPLE TYPE:	Soil	Soil	Soil		Soil
			DATE SAMPLED:	2019-05-08	2019-05-08	2019-05-08		2019-05-08
				182124	182125	182126		182127
Sulfide (S2-)	%		0.05	<0.05	<0.05	<0.05	0.05	<0.05
Chloride (2:1)	µg/g		2	8	160	6	40	7470
Sulphate (2:1)	µg/g		2	26	15	14	40	157
pH (2:1)	pH Units		NA	6.04	6.26	6.83	NA	6.86
Electrical Conductivity (2:1)	mS/cm		0.005	0.040	0.368	0.053	0.005	13.4
Redox Potential 1	mV		5	204	142	233	5	255
Redox Potential 2	mV		5	228	179	245	5	247
Redox Potential 3	mV		5	214	181	249	5	259
Resistivity (2:1)	ohm.cm		1	25000	2720	18900	1	75

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

182124-182126 EC, pH, Chloride and Sulphate 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
Pl note: Redox Potential is not an accredited parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

182127 EC, pH, Chloride and Sulphate 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
Pl 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.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By: Amanjot Bhela — CHARTERED CHEMIST, AMANJOT BHELA, ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO

Certificate of Analysis

AGAT WORK ORDER: 19U464857
PROJECT: ADM-00233185-K0

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
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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) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-05-08
DATE REPORTED: 2019-05-13

			SAMPLE DESCRIPTION:	19-G-1-SS2	19-PS-1-SS2	19-P-1-SS2	19-D-2-SS2
			SAMPLE TYPE:	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2019-05-08	2019-05-08	2019-05-08	2019-05-08
Parameter	**Unit**	**G / S**	**RDL**	**182119**	**182121**	**182122**	**182123**
Antimony	µg/g		0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g		1	<1	1	<1	<1
Barium	µg/g		2	35	32	40	27
Beryllium	µg/g		0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg/g		5	<5	<5	<5	<5
Boron (Hot Water Soluble)	µg/g		0.10	<0.10	<0.10	<0.10	<0.10
Cadmium	µg/g		0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g		2	8	14	8	9
Cobalt	µg/g		0.5	3.2	4.9	1.9	4.5
Copper	µg/g		1	12	28	4	10
Lead	µg/g		1	4	2	1	1
Molybdenum	µg/g		0.5	<0.5	<0.5	<0.5	<0.5
Nickel	µg/g		1	6	10	4	6
Selenium	µg/g		0.4	0.6	<0.4	0.7	<0.4
Silver	µg/g		0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g		0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g		0.5	<0.5	<0.5	0.6	<0.5
Vanadium	µg/g		1	19	36	10	26
Zinc	µg/g		5	22	21	11	16
Chromium VI	µg/g		0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	µg/g		0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g		0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity	mS/cm		0.005	0.099	5.02	0.137	0.052
Sodium Adsorption Ratio	NA		NA	1.30	50.5	5.73	0.438
pH, 2:1 CaCl2 Extraction	pH Units		NA	5.59	5.81	7.18	5.12

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

182119-182123 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: Amanjot Bhela

CHARTERED AMANJOT BHELA CHEMIST — ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO

AGAT Laboratories

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

Certificate of Analysis

AGAT WORK ORDER: 19U464857
PROJECT: ADM-00233185-K0

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-G-1-SS2	19-H-1-SS2	19-PS-1-SS2	19-P-1-SS2	19-D-2-SS2
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2019-05-08	2019-05-08	2019-05-08	2019-05-08	2019-05-08
Parameter	**Unit**	**G / S**	**RDL**	**182119**	**182120**	**182121**	**182122**	**182123**
Benzene	µg/g		0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Toluene	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethylbenzene	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Xylene Mixture	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05
F1 (C6 to C10)	µg/g		5	<5	<5	<5	<5	<5
F1 (C6 to C10) minus BTEX	µg/g		5	<5	<5	<5	<5	<5
F2 (C10 to C16)	µg/g		10	<10	<10	<10	<10	<10
F3 (C16 to C34)	µg/g		50	<50	<50	<50	<50	<50
F4 (C34 to C50)	µg/g		50	<50	<50	<50	<50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA	NA	NA	NA	NA
Moisture Content	%		0.1	12.7	25.6	12.2	11.7	12.8
Surrogate	**Unit**	**Acceptable Limits**						
Terphenyl	%	60-140		112	96	87	120	100

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

182119-182123 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: Pinkal Patel

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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				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits 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	0.9%	< 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)	182264		0.31	0.33	NA	< 0.10	113%	60%	140%	100%	70%	130%	102%	60%	140%
Cadmium	182264		<0.5	<0.5	NA	< 0.5	99%	70%	130%	101%	80%	120%	99%	70%	130%
Chromium	182264		30	31	3.3%	< 2	103%	70%	130%	102%	80%	120%	112%	70%	130%
Cobalt	182264		10.0	10.3	3.0%	< 0.5	105%	70%	130%	105%	80%	120%	103%	70%	130%
Copper	182264		20	20	0.0%	< 1	95%	70%	130%	101%	80%	120%	97%	70%	130%
Lead	182264		9	9	0.0%	< 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	0.0%	< 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	4.8%	< 1	103%	70%	130%	112%	80%	120%	111%	70%	130%
Zinc	182264		52	52	0.0%	< 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	6.0%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	182119	182119	5.59	5.61	0.4%	NA	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.

PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Lower	Upper	Recovery	Lower	Upper	Recovery	Lower	Upper
Corrosivity Package															
Sulfide (S2-)	182124	182124	< 0.05	< 0.05	NA	< 0.05	100%	80%	120%						
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%	NA	99%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	182119	182119	0.099	0.108	8.7%	< 0.005	109%	90%	110%	NA			NA		
Redox Potential 1	1					< 5	100%	70%	130%		70%	130%		70%	130%

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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 (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

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:

AGAT Laboratories

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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 Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
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: Pinkal Patel

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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
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

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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

AGAT Laboratories ILG

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Laboratory Use Only

Work Order #: 19U464857

Cooler Quantity:
Arrival Temperatures: 9.1 | 9.0 | 9.1
Ice Pack 7.2 | 8 | 8.6
Custody Seal Intact: ☐Yes ☐No ☐N/A
Notes: ON ICE

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:
1. Email: Ian.Macmillan@exp.com
2. Email:

Regulatory Requirements:

☐ No Regulatory Requirement

(Please check all applicable boxes)

☐Regulation 153/04
Table *Indicate One*
☐Ind/Com
☐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

Turnaround Time (TAT) Required:

Regular TAT ☒ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: ADM-00233185-K0
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:

Bill To Same: Yes ☒ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

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

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI (Y/N)	Metals and Inorganics	☐ All Metals ☐ 153 Metals (excl. Hydrides) ☐ Hydride Metals ☐ 153 Metals (Incl. Hydrides)	ORPs: ☐ B-HWS ☐ Cl⁻ ☐ CN ☐ Cr⁶⁺ ☐ EC ☐ FOC ☐ Hg ☐ pH ☐ SAR	Full Metals Scan	Regulation/Custom Metals	Nutrients: ☐ TP ☐ NH₃ ☐ TKN ☐ NO₃ ☐ NO₂ ☐ NO₃+NO₂	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					
19-G-1-SS2	May 8/19		5	S	No rush		✓						✓	✓												
19-H-1-SS2	↓		2	↓	#Rush 2 day - no M&I								✓	✓												
19-PS-1-SS2	↓		5	↓	No rush		✓						✓	✓												
19-P-1-SS2	↓		↓	↓	↓		✓						✓	✓												
19-D-2-SS2	↓		↓	↓	↓		✓						✓	✓												
19-D-2-SS4	↓		↓	↓	↓																	✓				
19-PS-2-SS3	↓		↓	↓	↓																	✓				
19-G-1-SS3	↓		↓	↓	↓																	✓				
19-P-2-SS3	↓		↓	↓	↓																	✓				

Samples Relinquished By (Print Name and Sign): Jeff Newman [signature]	Date: May 8/19	Time: 235	Samples Received By (Print Name and Sign): B.Bowers [signature]	Date: 05/08/19	Time: 2:34	
Samples Relinquished By (Print Name and Sign):	Date:	Time:	Samples Received By (Print Name and Sign): Simon [signature]	Date: 19/5/9	Time: 847	Page 1 of 1
Samples Relinquished By (Print Name and Sign):	Date:	Time:	Samples Received By (Print Name and Sign):	Date:	Time:	Nº: T 087566

Appendix E –
Results of Stability Analyses

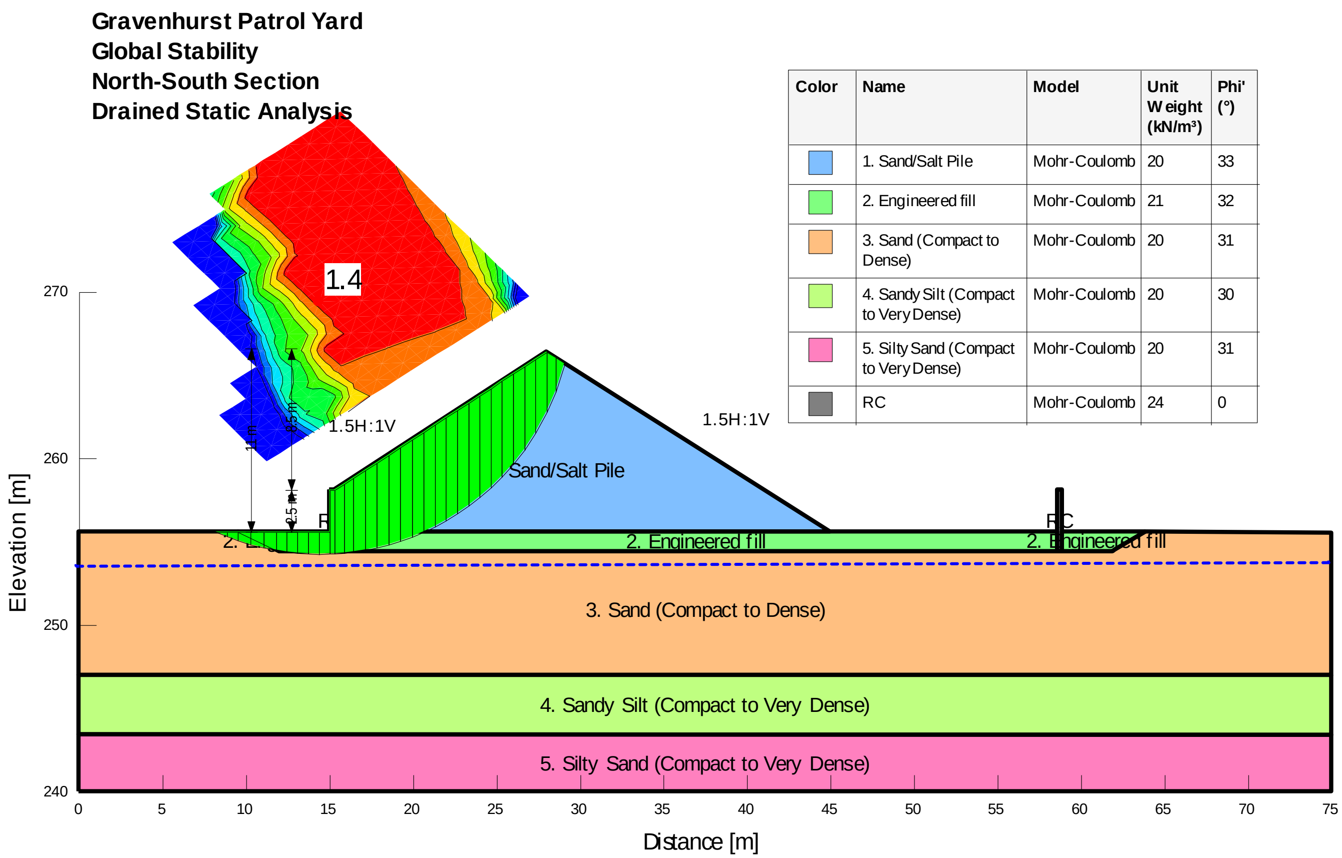
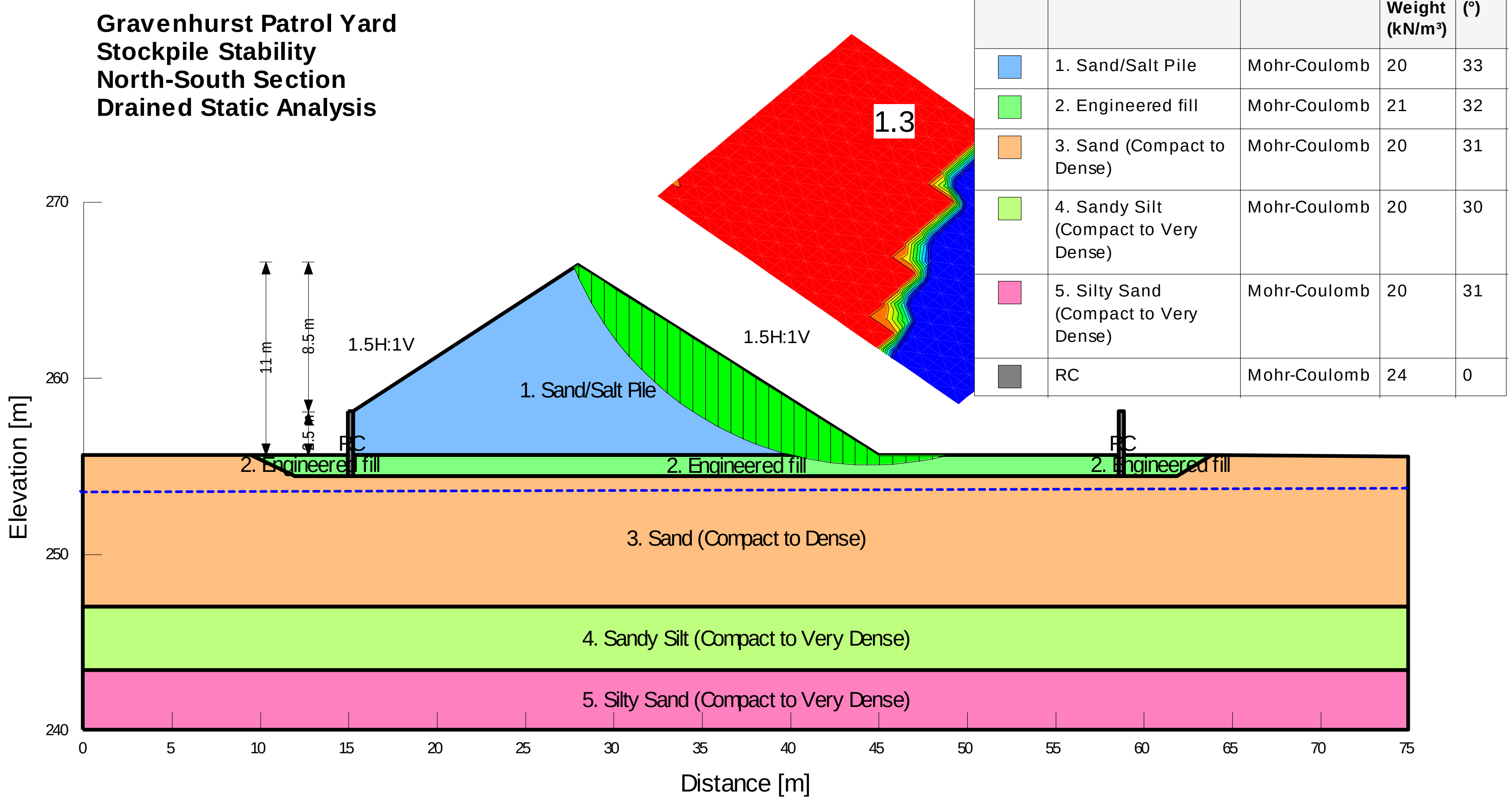


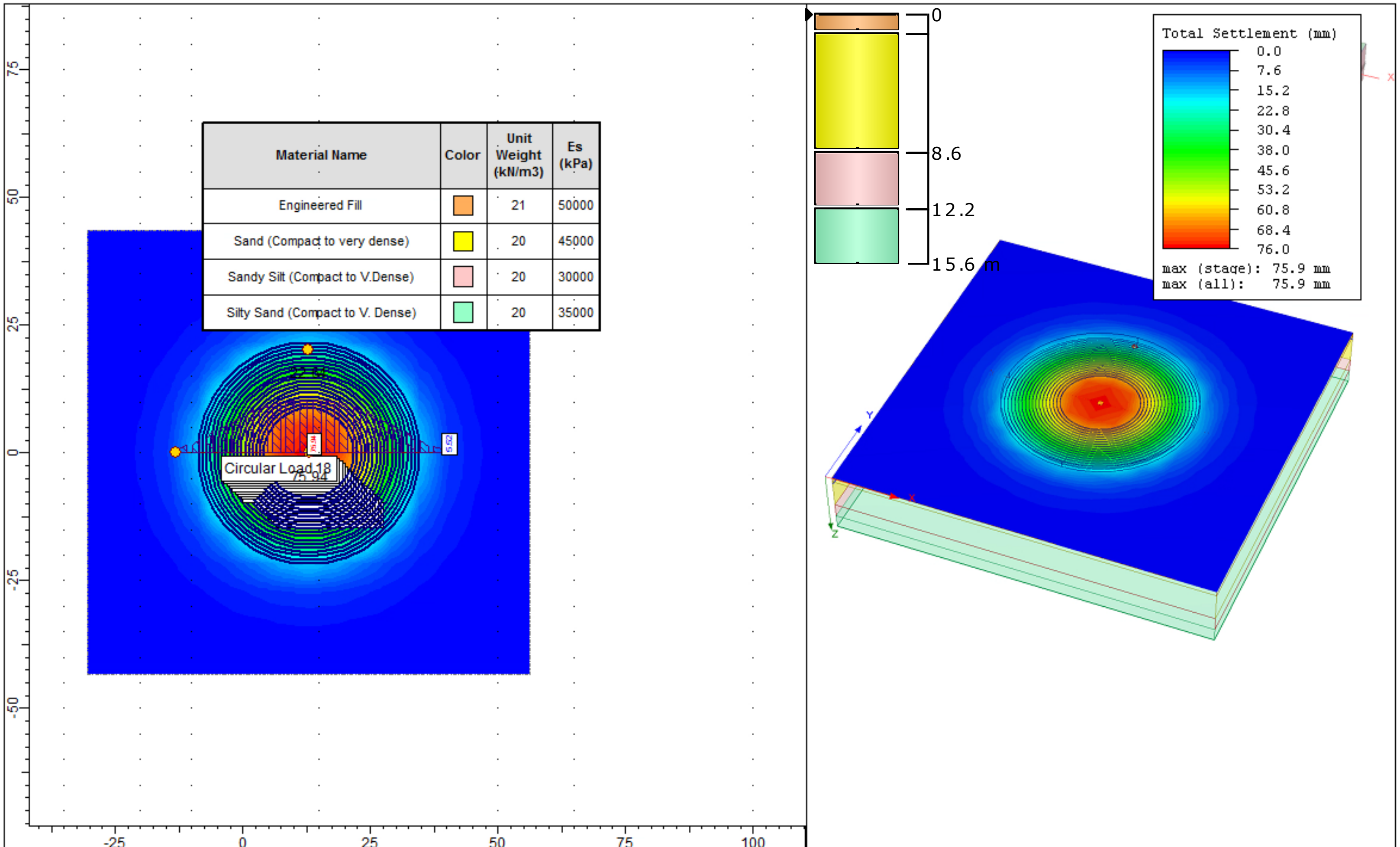
Figure E1. Global stability for Gravenhurst Patrol Yard – Drained static analysis



Color	Name	Model	Unit Weight (kN/m³)	Phi' (°)
	1. Sand/Salt Pile	Mohr-Coulomb	20	33
	2. Engineered fill	Mohr-Coulomb	21	32
	3. Sand (Compact to Dense)	Mohr-Coulomb	20	31
	4. Sandy Silt (Compact to Very Dense)	Mohr-Coulomb	20	30
	5. Silty Sand (Compact to Very Dense)	Mohr-Coulomb	20	31
	RC	Mohr-Coulomb	24	0

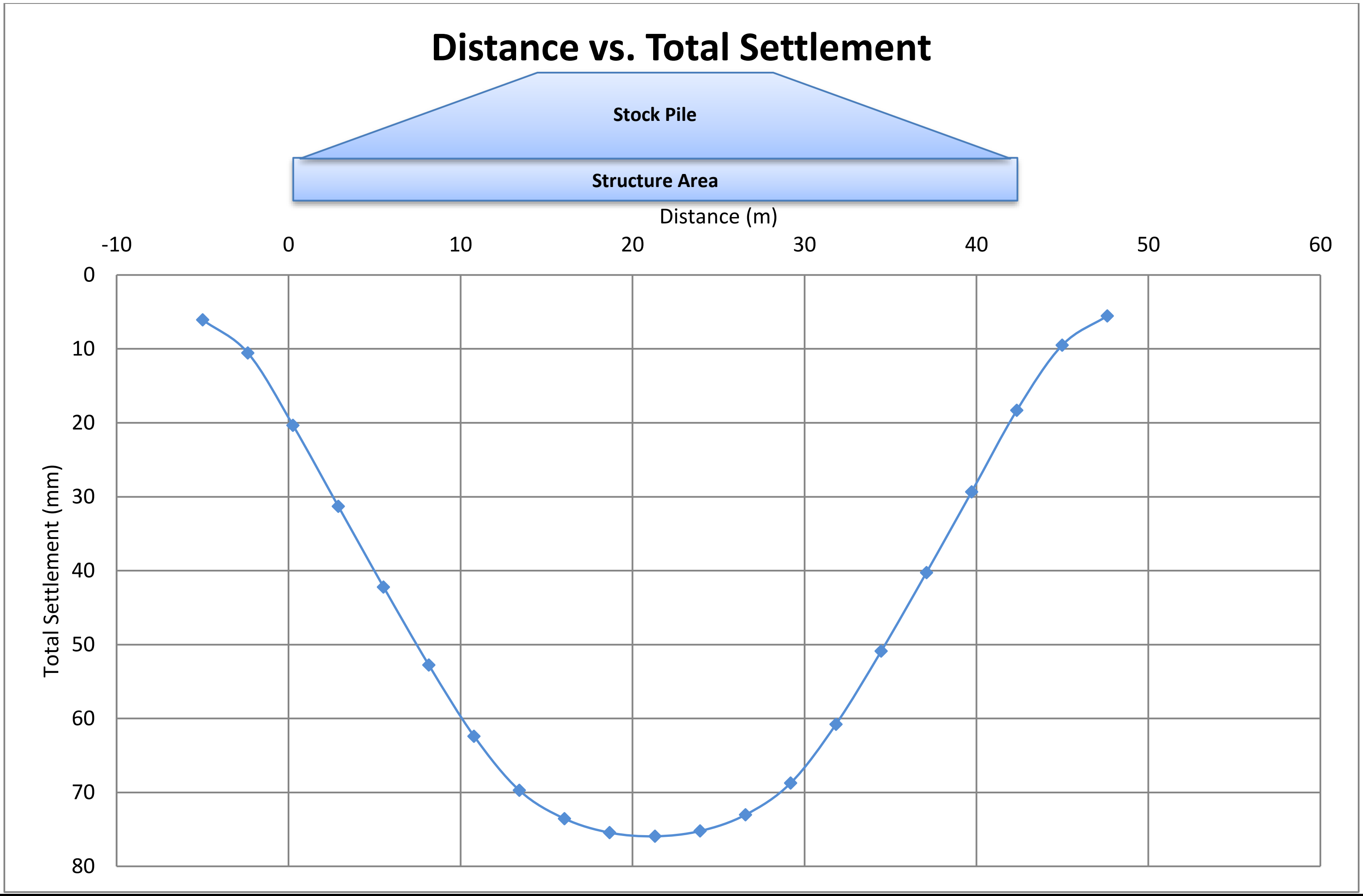
Figure E2. Stockpile stability for Gravenhurst Patrol Yard – Drained static analysis

Appendix F –
Results of Settlement Analyses

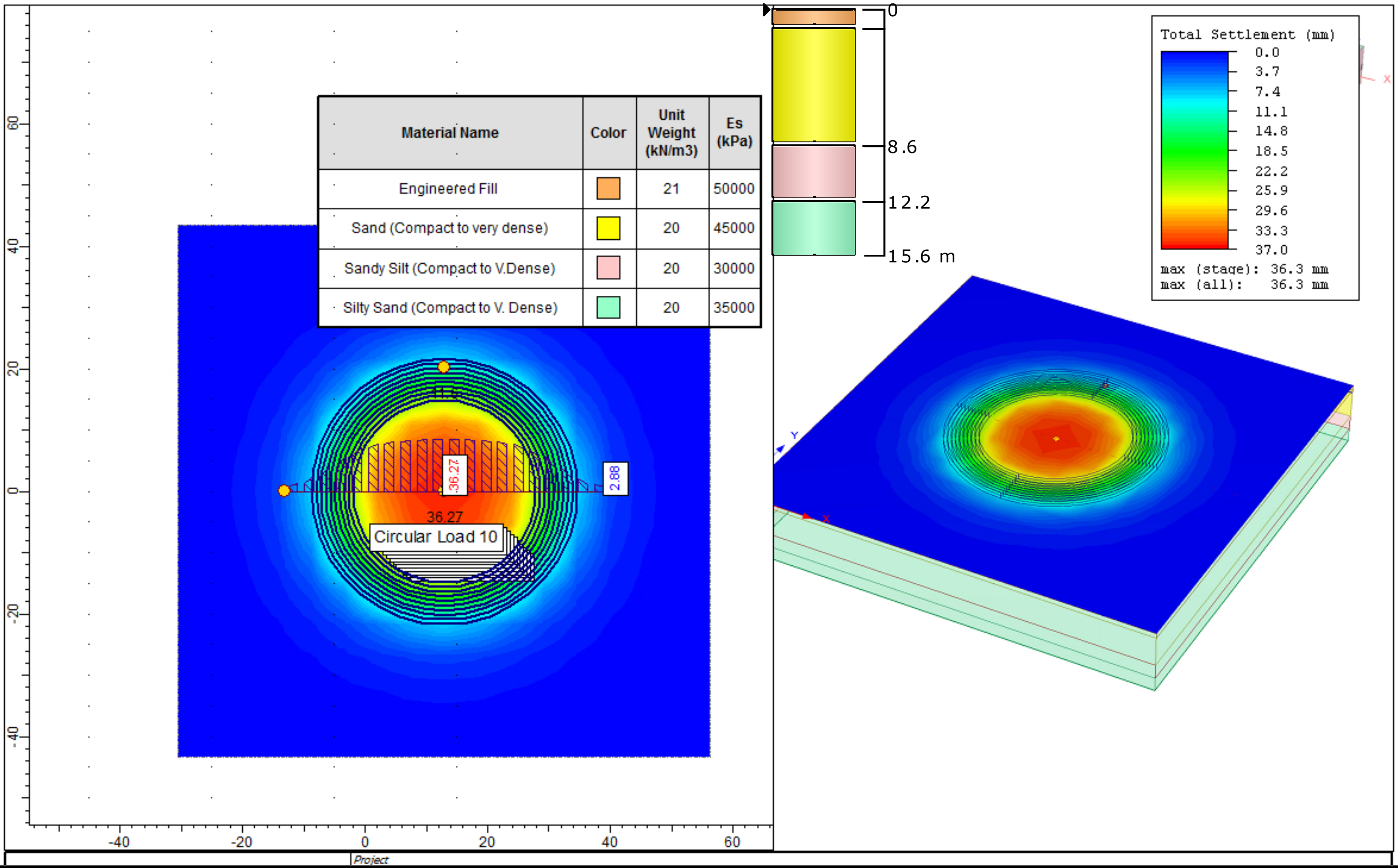


Material Name	Color	Unit Weight (kN/m3)	Es (kPa)
Engineered Fill		21	50000
Sand (Compact to very dense)		20	45000
Sandy Silt (Compact to V.Dense)		20	30000
Silty Sand (Compact to V. Dense)		20	35000

exp.	*Project:* FIDR for Gravenhurst Patrol Yard	
	Analysis Description: Full loading – **Total Settlement**	
	Figure No: F1	*Company:* **exp** Services Inc.
	Date: June, 2019	*File Name:* Settlement Analysis – Assignment 10



exp.	*Project:* FIDR for Gravenhurst Patrol Yard	
	Analysis Description: Full loading – **Total Settlement**	
	Figure No: F2	*Company:* **exp** Services Inc.
	Date: June, 2019	*File Name:* Settlement Analysis – Assignment 10



Material Name	Color	Unit Weight (kN/m3)	Es (kPa)
Engineered Fill		21	50000
Sand (Compact to very dense)		20	45000
Sandy Silt (Compact to V.Dense)		20	30000
Silty Sand (Compact to V. Dense)		20	35000

exp.

Project: FIDR for Gravenhurst Patrol Yard

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

Figure No: F3

Company: **exp** Services Inc.

Date: June, 2019

File Name: Settlement Analysis – Assignment 10

Appendix G –
Records of Borehole from Previous Investigation

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\,\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan\delta$
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)
A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index / Relative Density	N — Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils
Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

Foundation Design

RECORD OF BOREHOLE No BH-YARD1 1 OF 1 **METRIC**

PROJECT 14-1181-0014
W.O. 2014-11033
DIST ___ HWY 11
DATUM GEODETIC

LOCATION N 4973399.2; E 315653.8
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE September 3, 2014

ORIGINATED BY DM
COMPILED BY MT
CHECKED BY SEMP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
256.4	GROUND SURFACE							
0.0	Sand to Sand and gravel, trace silt (FILL) Compact to dense Brown Moist	1	SS	33		256	○	32 61 (7)
		2	SS	24		255		
		3	SS	20			○	0 96 (4)
		4	SS	26		254		
252.8		5	SS	43		253	○	
3.6	SAND, trace silt Compact to dense Grey Moist to wet				∇	252		
		6	SS	24		251	○	0 96 4 0
	Sand heaving inside augers at 6.1 m depth.	7	SS	25		250	○	
247.7		8	SS	46		249, 248	○	
8.7	Sandy SILT, trace clay Compact Brown Wet	9	SS	20		247, 246		
245.1		10	SS	21			○	0 28 68 4
11.3	END OF BOREHOLE							

Notes:

1. Water level at a depth of 3.8 m below ground surface (Elev. 252.6 m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

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

Golder Associates

RECORD OF BOREHOLE No BH-YARD2

 METRIC

PROJECT 14-1181-0014
W.O. 2014-11033
DIST ___ HWY 11
DATUM GEODETIC

LOCATION N 4973379.0; E 315663.4
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE September 3, 2014

ORIGINATED BY DM
COMPILED BY MT
CHECKED BY SEMP

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
256.4	GROUND SURFACE					
0.0	Sand to Sandy gravel, trace silt (FILL) Compact to very dense Brown Moist Recycled asphalt noted in Samples 1 and 2.	1	SS	58		
		2	SS	59		71 27 (2)
		3	SS	19		
		4	SS	23		0 97 (3)
		5	SS	29		
252.7 3.7	SAND, trace silt Compact to dense Brown Moist to wet				▽	
		6	SS	31		0 99 (1)
		7	SS	34		
		8	SS	38		
247.7 8.7	Sandy SILT, trace clay Loose to compact Grey Wet					
		9	SS	5		
		10	SS	22		0 26 70 4
245.1 11.3	END OF BOREHOLE Notes: 1. Water level at a depth of 3.8 m below ground surface (Elev. 252.6 m) upon completion of drilling.					

ELEVATION SCALE: 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

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

Golder Associates

RECORD OF BOREHOLE No BH-YARD3

 METRIC

PROJECT	14-1181-0014				
W.O.	2014-11033	LOCATION	N 4973372.9; E 315656.4	ORIGINATED BY	DM
DIST	HWY 11	BOREHOLE TYPE	108 mm I.D. Continuous Flight Hollow Stem Augers	COMPILED BY	MT
DATUM	GEODETIC	DATE	September 4, 2014	CHECKED BY	SEMP

Column headings: SOIL PROFILE (ELEV / DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
256.6	GROUND SURFACE				
0.0	Sand, trace to some gravel and silt (FILL) Compact to very dense Brown to black Moist Recycled asphalt noted in Samples 1 and 2.	1	SS	47	
		2	SS	87	
		3	SS	17	10 90 (10)
		4	SS	18	
		5	SS	29	
252.9 3.7	SAND, trace silt Compact to dense Brown Moist to wet				
		6	SS	32	
		7	SS	34	0 93 (7)
		8	SS	27	
247.9 8.7	SILT and SAND, trace clay Loose to compact Grey Wet				
		9	SS	9	
	Layer of SILT of slight plasticity at 10.7 m depth.	10	SS	10	0 34 55 11
		11	SS	26	
243.8 12.8	END OF BOREHOLE Notes: 1. Water level at a depth of 4.3 m below ground surface (Elev. 252.3 m) upon completion of drilling.				

Elevation scale: 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246, 245, 244

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

Golder Associates

RECORD OF BOREHOLE No BH-YARD4

METRIC

PROJECT 14-1181-0014
W.O. 2014-11033
DIST
HWY 11
DATUM GEODETIC
LOCATION N 4973390.3; E 315642.6
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE September 5, 2014
ORIGINATED BY DM
COMPILED BY MT
CHECKED BY SEMP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
256.8	GROUND SURFACE					
0.0	Sand, trace silt, trace gravel (FILL) Compact Brown Moist Recycled asphalt noted in Sample 1.	1	SS	66		
		2	SS	29		5 90 (5)
		3	SS	10		
		4	SS	26		0 97 (3)
		5	SS	29		
253.1 3.7	SAND, trace silt Dense Grey to brown Wet				∇ (252.8)	
		6	SS	31		
		7	SS	44		0 93 (7)
		8	SS	39		
248.1 8.7	SILT and SAND, trace clay Loose to compact Grey Wet					
		9	SS	18		0 51 45 4
	Zone of CLAYEY SILT to SILT at 10.7 m depth.	10	SS	6		
		11	SS	18		
244.0 12.8	END OF BOREHOLE Notes: 1. Water level at a depth of 4.0 m below ground surface (Elev. 252.8 m) upon completion of drilling.					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L
WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³
ELEVATION SCALE: 256 255 254 253 252 251 250 249 248 247 246 245 244

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

SUD-MTO 001 14-1181-0014.GPJ GAL-MISS.GDT 29/09/14 DATA INPUT: