Foundation Investigation and Design Report

New Material Storage Structure at Foleyet Patrol Yard, Highway 101, Foleyet, ON

Agreement No. 5021-E-0020
Assignment No. 5
Latitude: 48.257333; Longitude: -82.443660
Geocres No.: 42B08-001

EXP Project Number:
ADM-22006096-A4

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Prepared For:
Ontario Ministry of Transportation
Geotechnical Section, Northeastern Region
447 McKeown Avenue, Suite 301
North Bay, ON P1B 9S9
Attn: Jean Pierre Perron, P.Eng.

Prepared By:
EXP Services Inc.
1595 Clark Boulevard
Brampton, ON, L6T 4V1
Canada

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Ministry of Transportation Ontario
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1 FOUNDATION INVESTIGATION REPORT

1.1 Introduction

EXP Services Inc. (EXP) has been requested by the Ministry of Transportation, Ontario (MTO) to prepare a foundation investigation and design report to provide preliminary design recommendations for the design builder to use during bidding for the new winter sand/salt storage structure at the Foleyet Patrol Yard. The patrol yard is located on Highway 101, 77 km west of Highway 144 junction in Foleyet, Ontario (Latitude: 48.257333; Longitude: -82.443660). The Terms of Reference (TOR) was provided by MTO. This report was undertaken under Agreement # 5021-E-0020, Assignment No. 5.

The purpose of this investigation is to evaluate the subsurface conditions at the proposed location of the structure within Foleyet Patrol Yard. The proposed structure will be modelled after a recently constructed building at the Farleys Corner Patrol Yard in Farleys Corner, ON. The new building at the Foleyet Patrol Yard will be 20 m x 27 m. The site-specific geotechnical investigation consisted of field investigation including visual inspection, drilling, soil sampling, and laboratory testing.

This foundation investigation report has been prepared specifically and solely for the project described herein. It contains the factual results of the investigation and the laboratory testing completed for this project.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The Foleyet Patrol Yard is located on Highway 101, approximately 77 km west of the Highway 144 junction in Foleyet, Ontario (Key Map on Drawing 1, Appendix B). The site is bound by residential zones to the west, a commercial zone (single business) to the east, Highway 101 to the south and by undeveloped land consisting primarily of forest and rivers/lakes to the north.

A paved/gravel roadway and parking area lead from the site entrance on Highway 101 to two (2) buildings, a four-bay maintenance garage and a facility shop, located approximately 55 m and 100 m northwest of the site entrance, respectively. Two existing dome structures, salt dome and sand dome, are located approximately 100 m and 125 m northwest from the site entrance, respectively. The new storage building will be placed mostly at the location of the existing salt dome. Per the AutoCAD drawing of Foleyet Patrol Yard provided by MTO, the finish floor (FF) elevation of the existing salt dome is Elev. 331.965 m.

The topography of the proposed building site is considered generally flat lying with borehole elevations ranging from Elev. 331.7 m to 332.0 m. The ground surface of Foleyet Patrol Yard is paved around the existing structures with sand and gravel in the other areas. Photographs of the site are included in Appendix A.

1.2.2 Geological Setting

According to the Ministry of Northern Development and Mines Map 2555, Quaternary Geology of Ontario, East-Central Sheet, the site generally consists of till predominantly comprised of a sand to silty sand matrix, high content of clasts, often low in matrix carbonate content. According to the Ministry of Northern Development and Mines Map 2543, Bedrock Geology of Ontario, East-Central Sheet, the bedrock at the site consists of metasedimentary rocks: paragneiss and migmatites.

1.3 Available Documents of Previous Investigations

One previous foundation investigation report was available in the MTO GEOCRES library for the Foleyet Patrol Yard:

Geocres No. 42B-003: "Site Investigation, Proposed D.P.W. Patrol Garage, East of Foleyet on Secondary Hwy. 101, Twp. Of Foleyet, District of Sudbury" prepared by Dominion Soil Investigation Ltd. for Ministry of Transportation Ontario, June 23, 1959.

1.4 Investigation Procedures

1.4.1 Fieldwork

The site reconnaissance was completed on September 25, 2023 and field investigation was performed between September 25 and 27, 2023. The field program consisted of drilling four (4) sampled boreholes (BH23-F-1 to BH23-F-4). The boreholes were strategically located at the proposed location of the new building (i.e., at each corner of the building) 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 using a Trimble DA2 GNSS receiver with Trimble Catalyst GNSS positioning, having and accuracy of ±0.1 m in the horizontal and vertical directions. A reference was made with an existing benchmark (BM), established on the rail road spike in hydro pole facing east located along the southern edge of the property approximately 55 m west of the entrance gate. The elevation of the BM was Elev. 332.054 m based on the AutoCAD drawing. The BM location is shown on Drawing 1, in Appendix B.

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

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

BH ID	Location	Latitude	Longitude	MTM NAD83 Zone 12		Ground Elevation[1] (m)	Borehole Depth[2] (m)
				Northing	Easting		
BH23-F-1	Northeast corner of proposed building	48.257307	-82.443801	5347511.4	197604.7	331.7	10.8
BH23-F-2	Southeast corner of proposed building	48.257099	-82.443565	5347487.5	197620.2	331.9	9.8
BH23-F-3	Southwest corner of proposed building	48.256946	-82.443864	5347471.4	197599.3	331.9	8.8
BH23-F-4	Northwest corner of proposed building	48.257125	-82.444082	5347491.6	197583.4	331.9	10.5

Notes:

1. *The referenced ground surface elevations are geodetic.*
2. *Depths are relative to ground surface.*

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 compactness of non-cohesive soils. When a hard stratum was reached sampling of hard material was performed by diamond core drilling, using a 1.5 m long NQ double tube wireline core barrel. The water supply from the site was used for soil sampling and coring.

Groundwater level measurements were carried out in the boreholes before coring procedures (due to cobbles and boulders) and at the completion of the boreholes, in accordance with MTO guidelines. The recorded groundwater levels after completion of drilling boreholes are presented in the borehole log sheets in Appendix C. 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 an EXP geotechnical representative 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 Brampton laboratory for additional visual, textual and olfactory examination, and sampling for laboratory testing.

1.4.2 Laboratory Testing

All samples recovered from boreholes undertaken by EXP during this investigation were returned to the laboratory and subjected to visual examination and classification. The laboratory testing program on soil samples included the determination of natural moisture content and particle size distribution tests for approximately 25% of the collected soil samples. One (1) soil sample was selected for chemical analysis and tested at Bureau Veritas Laboratories (formerly Maxxam Analytics), a CALA-certified and accredited laboratory. 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. Appendix D also contains the results of chemical and environmental tests.

1.5 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix C. Laboratory test results of grain size analyses tests 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 cross section subsurface profiles are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and cross section stratigraphic profiles are inferred from semi-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. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

In general, the stratigraphic sequence at the proposed structure site consists of surface treatment/asphalt at the ground surface followed by cohesionless fill (gravelly sand to silty sand) underlain by loose to very dense native silt further underlain by cohesionless till (gravelly sand to silt and sand) with interbedded cobbles and boulders.

A detailed description of the subsurface conditions encountered is discussed further in subsequent sections. It should be noted that the following sections are based on the geotechnical investigation conducted by EXP.

1.5.1 Surface Treatment

Asphalt, approximately 50 mm to 80 mm thick, was encountered at the surface of boreholes BH23-F-1, BH23-F-3 and BH23-F-4. Asphalt thicknesses may further vary beyond the borehole locations.

1.5.2 Cohesionless Fill: Gravelly Sand to Silty Sand

Cohesionless fill consisting of gravelly sand to silty sand was encountered at the ground surface in borehole BH23-F-2 and below the asphalt in boreholes BH23-F-1, BH23-F-3 and BH23-F-4. The approximate elevations of the surface and base of the fill and the thickness of fill as encountered in boreholes are summarized in Table 1.2 below:

Table 1.2. Summary of cohesionless fill: gravelly sand to silty sand

Borehole No	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH23-F-1	331.6	329.9	0.1	1.7
BH23-F-2	331.9	331.2	0.0	0.7
BH23-F-3	331.8	331.1	0.1	0.7
BH23-F-4	331.8	330.3	0.1	1.5

Notes:

1. *The referenced ground surface elevations are geodetic.*
2. *Depths are relative to ground surface.*

The composition of this fill material generally consisted of sand and gravel with trace silt to silty and trace to some clay. Buried topsoil/organics were also encountered within this layer in boreholes BH23-F-1 and BH23-F-2. The fill was brown to dark brown in colour and moist to wet. The SPT "N" values within this layer ranged from 20 to 31 blows per 0.3 m penetration, suggesting that this fill layer was compact to dense in compactness.

Laboratory testing performed on selected samples consisted of ten (10) moisture content and one (1) grain size distribution tests. The test results are as follows:

Moisture Content:

- 2.5% to 21.1%

Grain Size Distribution:

- 23% gravel;
- 73% sand;
- 4% silt and clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test are also provided on Figure 1 in Appendix D.

1.5.3 Silt

Native silt was encountered below the fill in all boreholes. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.3 below:

Table 1.3. Summary of silt

Borehole No	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH23-F-1	329.9	327.1	1.8	2.8
BH23-F-2	331.1	325.8	0.8	5.3
BH23-F-3	331.1	326.6	0.8	4.5
BH23-F-4	330.3	324.3	1.6	6.0

Notes:

1. *The referenced ground surface elevations are geodetic.*
2. *Depths are relative to ground surface.*

The composition of this material generally consisted of silt with trace sand and trace clay. The native silt was grey to yellowish grey in colour, with trace oxidation, and was moist to wet. The SPT "N" values within this layer ranged from 9 to 62 blows per 0.3 m penetration, suggesting loose to very dense in compactness, but generally compact.

Laboratory testing performed on selected samples consisted of twenty-two (22) moisture content and six (6) grain size distribution tests. The test results are as follow:

Moisture Content:

- 14.8% to 23.0%

Grain Size Distribution:

- 0% gravel;
- 1% to 3% sand;
- 88% to 93% silt; and
- 6% to 9% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test are also provided on Figure 2 in Appendix D.

1.5.4 Cohesionless Till: Gravelly Sand to Sand and Silt

A layer of native cohesionless till consisting of gravelly sand to sand and silt was encountered below the silt layer in boreholes BH23-F-1, BH23-F-2 and BH23-F-4 and below the cobbles and boulders layer in BH23-F-3. 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 cohesionless till: gravelly sand to sand and silt

Borehole No	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH23-F-1	327.1	322.9	4.6	4.2
BH23-F-2	325.8	322.2	6.1	3.6[3]
BH23-F-3	325.1	323.1	6.9	2.0[3]
BH23-F-4	324.3	321.4	7.6	2.9[3]

Notes:

1. *The referenced ground surface elevations are geodetic.*
2. *Depths are relative to ground surface.*
3. *Terminated within this layer.*

The composition of this layer generally consisted of silt and sand with trace gravel to gravelly and trace clay. Additionally, cobbles and boulders were encountered within the cohesionless till layer in boreholes BH23-F-3 and BH23-F-4. The material is grey to brown in colour, with trace oxidation, and moist to wet. The SPT “N” values within this layer ranged from 23 blows per 0.3 m penetration to 140 blows per 0.1 m, suggesting compact to very dense in compactness.

Laboratory testing performed on selected samples consisted of eleven (11) moisture content and three (3) grain size tests. The test results are as follow:

Moisture Content:

- 7.2% to 11.0%

Grain Size Distribution:

- 2% to 15% gravel;
- 40% to 42% sand;
- 38% to 52% silt; and
- 5% to 6% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of grain size distribution tests performed are also provided on Figures 3 in Appendix D.

1.5.5 Cobbles and Boulders

A distinct, native layer of cobbles and boulders was encountered below the cohesionless till in borehole BH23-F-1 and below the silt in borehole BH23-F-3. 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 cobbles and boulders layer

Borehole No	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH23-F-1	322.9	320.9	8.8	2.0[3]
BH23-F-3	326.6	325.1	5.3	1.5

Notes:

1. *The referenced ground surface elevations are geodetic.*
2. *Depths are relative to ground surface.*
3. *Terminated within this layer.*

Cobbles and boulders were also observed within the cohesionless till layer. A combination of SPT and NW casing/NQ coring was carried out during the exploration of this layer. Where possible, split spoon sampling was attempted to obtain soil samples, however only one (1) could be obtained (from BH23-F-1). It should be noted that the obtained sample from this layer may not accurately represent the particle size distribution of this material as particles larger than 35 mm (inside diameter of SPT sampler) could not be obtained.

Refusal SPT “N” value of 120 blows per 0.3 m penetration was obtained within this layer, suggesting that this layer was very dense in compactness.

Laboratory testing performed on the recovered sample from BH23-F-1 consisted of one (1) moisture content test, and the test result is as follows:

Moisture Content:

- 9.8%

The results of the moisture content test are provided on the record of borehole sheets in Appendix C.

1.6 Groundwater Conditions

The groundwater levels in the boreholes were observed during drilling and upon completion of drilling. Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods. A summary of the groundwater levels observed during the investigation are summarized in Table 1.6 and are also presented on the record of borehole sheets in Appendix C.

Table 1.6. Summary of observed groundwater levels

Borehole No	Ground Surface Elevation[1] (m)	Water level Depth[2]/ Elevation[1] (m)	Date
BH23-F-1	331.7	5.2/326.5	9/26/2023
BH23-F-2	331.9	3.8/328.1	9/27/2023
BH23-F-3	331.9	4.0/327.9	9/25/2023
BH23-F-4	331.9	5.9/326.0	9/26/2023

Notes:

1. *The referenced ground surface elevations are geodetic.*
2. *Depths are relative to ground surface.*

1.7 Chemical Analyses

One (1) soil sample was selected for chemical analysis during the current investigation performed by EXP. The soil sample was collected by EXP and was tested by Bureau Veritas, a CALA-certified and accredited laboratory in Mississauga, Ontario. The analytical results are summarized in Table 1.7 below and are presented in Appendix D.

Table 1.7. Summary of chemical analysis results

Sample Identification	Depth (m)	pH	Soluble Chloride (ppm)	Soluble Sulphate (ppm)	Resistivity (ohm-cm)	Conductivity (mS/cm)	Redox Potential (mV)
BH23-F-2 (SS4)	1.5 – 2.1	7.85	180	35	1600	637	110

2 ENGINEERING DISCUSSION & RECOMMENDATIONS

2.1 General

This section of the report provides geotechnical design recommendations for the proposed sand/salt storage structure at the Foleyet Patrol Yard, located in Foleyet, Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation 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 a new winter sand/salt storage structure is proposed to be constructed at the MTO Foleyet Patrol Yard at the location defined by MTO. Additionally, the existing 17.6 m x 24.8 m (dimensions as per AutoCAD drawing) salt structure will be replaced by a building having a footprint of about 20 m x 27 m and modelled after a recently constructed building at the Farley's Corner Patrol Yard. As per the provided GA drawings of the Farley Yard Salt Storage Building, the proposed new structure at Foleyet will be about 11 m in height to the bottom of the trusses (underside of roof truss) and it will be encompassed by a 2.5 m high, cast-in-place concrete retaining wall along with 8.5 m high steel cladding wall around the perimeter, a total of 11 m (2.5 m + 8.5 m) above grade. The existing finished floor elevation at the structure location is approximately at Elev. 331.965 m and it is assumed that finished top of floor will be at that current ground level 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-S6-19), the Ontario Building Code (OBC) (2012), Guidelines for MTO Foundation Engineering Services, Version 03 (April 2022), 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, if necessary, as requested in the TOR.

The settlement and stability analyses were completed for a scenario in which the sand/salt would be loaded to a total height of 9.2 m at the centre of the stockpile (6.7 m above the concrete walls) with a maximum of 1.5H:1V slopes towards the concrete walls. It is assumed that the sand/salt will be level with concrete walls with the stockpile area covering the entire footprint of the building. The angle of repose for sand/salt was assumed to be 33°.

2.2 Geotechnical Design Considerations for Foundations

The subsurface conditions at the site below the pavement structure and/or gravelly sand to silty sand fill consists of by loose to very dense native silt further underlain by cohesionless till (gravelly sand to silt and sand) with interbedded cobbles and boulders. No bedrock was encountered within the depths of exploration in all boreholes (~8.8 m to 10.8 m below ground surface). The groundwater level was measured (in open hole prior to the use of water for casing/coring and upon completion of drilling) to range from 3.8 m to 5.9 m (Elev. 326.0 m to 328.1 m) below existing ground surface.

2.2.1 Structure Foundation Alternatives

Based on the results of this investigation, two (2) shallow foundation alternatives for the structure are evaluated in this report. Advantages, disadvantages, relative cost and risk/consequences of these options are presented in Table 2.1. Deep foundations are not considered to be practical/economical due to the presence of water bearing native silt layer and cobbles and boulders. The founding strata for the shallow foundation options should provide sufficient geotechnical resistances for the proposed material storage building. Considering the findings during the geotechnical investigation, as well as the high cost of pile foundations and the structure's operating life, deep foundations are not considered practical for this patrol yard structure and therefore not further discussed within the report.

2.2.2 Evaluation of Foundation Alternatives

In Table 2.1, the shallow foundation using strip/spread footings on the compact native silt (Option 1) is ranked as the preferred foundation design option if the geotechnical resistance is adequate. If higher geotechnical resistance is required, shallow foundation using strip footings on 1.0 m thick engineered granular fill over the compact native silt (Option 2) is recommended, as discussed in the following sections. In both options, the excavation depth should be below the frost depth of ~2.4 m (refer to Section 2.2.3.4). For shallow foundations on native soil and/or granular pad, polystyrene foam can be placed above the footing for protection against frost action (~25 mm of polystyrene foam is equivalent to 600 mm of soil cover, see Section 2.2.3.4) to reduce excavation depth. Both options require any topsoil/organic laden soil and existing fill encountered at the site.

Given the subsurface conditions at the site, the impact of settlement at the foundations of the structure will be influenced by the operating/stockpiling practices. It is our understanding that the structure will accommodate stockpiles of sand/salt within the structure. As mentioned in Section 2.1, it is assumed that the maximum loading condition is the sand/salt stockpile to be sloped a maximum of 1.5H:1V towards the concrete wall where the sand/salt is likely stockpiled to at least the level of the concrete wall over the full footprint. The centre of the stockpile would be a total height of 9.2 m (about 6.7 m above the concrete wall). Mounding in the centre at the angle of repose material of 33° beyond the height of the concrete wall is also a possibility. These types of structures generally have service lives of about 20 years. Due to the absence of cohesive soils at the new proposed building, post construction settlement within the stockpile area is expected to occur immediately.

Based on the provided typical design for the sand/salt storage structure for Farley's Corner Patrol Yard, it is understood that the strip/spread footings for the structure will be about 1.8 m. However, geotechnical resistances of different strip/spread footing sizes have been provided. As mentioned, the footings could be founded on the compact native silt, or on free draining engineered fill, such as Granular 'A' or Granular 'B' Type II (OPSS.PROV 1010).

Table 2.1 Evaluation of shallow foundation alternatives

Options	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Option 1 - Strip/Spread Footings on Compact Native Silt	1*	• Straightforward construction	• May require dewatering for the construction of footings if water level is above excavation depth	• Low	• Risk of differential settlements due to loading patterns in the past and during operations • Risk of subgrade disturbance
Option 2 - Strip/Spread	2	• Straightforward construction	• May require dewatering to allow	• Higher cost compared to	• Risk of groundwater and

Options	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Footings on Engineered Fill		• Higher geotechnical resistance than footing on native soil layer • Compaction control	the construction of footing in dry and prevention of subgrade disturbance	shallow foundation on native soil	subgrade disturbance

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

2.2.3 Shallow Foundation

2.2.3.1 Footing Elevation

Based on the results of the geotechnical investigation and a requirement for adequate protection against frost penetration in the project area (i.e., a minimum ~2.4 m below the lowest surrounding area or equivalent thermal insulation to be provided, see Section 2.2.3.4), 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 of Footing Below Existing Grade[4] (m)	Depth of Excavation/Elevation (m)
Option 1A (Deep Excavation) - Compact native silt	~Elev. 329.6	~2.4 m	~2.4 m/Elev. 329.6 m
Option 1B (Shallow Excavation)[3,4,5] - Engineered fill[1,2] over compact native silt (north) or compact native silt (south)	~Elev. 330.8	~1.2 m	~1.2 m/Elev 330.8 m (south side) & ~2.1 m/Elev. 329.9 m (north side)[2]
Option 2A (Deep Excavation) - 1.0 m thick engineered fill[1] over compact native silt	~Elev. 329.6	~2.4 m	~3.4 m/Elev. 328.6 m
Option 2B (Shallow Excavation)[3,4,5] - 1.0 m thick engineered fill[1] over compact silt	~Elev. 330.8	~1.2 m	~2.2 m/Elev. 329.8 m

Notes:

1. *Such as Granular 'A' or Granular 'B' Type II.*
2. *Varies in thickness from 0.35 m to 0.75 m, depending on excavation of all existing fill.*
3. *It is accepted that 25 mm of polystyrene foam placed above footing provides protection against frost which is equivalent to 600 mm of soil cover.*
4. *Based on frost depth of 2.4 m below ground surface or 1.2 m below ground if 50 mm of polystyrene foam is used.*
5. *Thickness of polystyrene is based on the minimum embedment depth as per the stability analyses (Section 2.5.1)*

2.2.3.2 Geotechnical Resistances

In the context of the CHBDC, a satisfactory foundation design would require, in terms of Limit States Design, the factored geotechnical resistance of its foundation to withstand and not exceed the imposed Ultimate Limit State

(ULS) Loads Design Approach, and its ability to deform acceptably under the Service Limit State (SLS) Loads Design Approach. These associated loads are typically known as unfactored and factored loads, respectively. Based on the subsurface stratigraphy encountered at this site and the proposed building, the following Table 2.3 summarizes the recommended resistances at founding elevations for the strip/spread footings. The geotechnical resistances provided are for vertical loading conditions only; load eccentricity and load inclination effects should be addressed in accordance with the CFEM, OBC and the CHBDC and its commentary. The ULS and SLS consequence factor of 1.0 and a typical degree of understanding factor of 0.5 at ULS and factor of 0.8 at SLS were applied in accordance with Tables 6.1 and 6.2 in the CHBDC S6-19, respectively.

Based on the GA drawings of the Farley Yard Salt Storage Building, the width of the footings is approximately 1.8 m wide. However, different footing widths up to 3.5 m are also provided. 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 2.5.2. In determining the settlement characteristics of the proposed building (tolerable total and differential settlement), the unfactored loads are required to be provided by the Structural or Design Engineer.

Table 2.3 Factored geotechnical resistances for shallow foundation options

Soil at Founding Level	Width of Footing (m)	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance (kPa) (for 25 mm settlement)
Option 1A (Deep Excavation) - Compact native silt	1.8	450	240
	2.5	500	265
	3.5	510	275
Option 1B (Shallow Excavation) - Engineered fill[1,2] over compact native silt (north) or compact native silt (south)	1.8	350	190
	2.5	385	205
	3.5	410	220
Option 2A (Deep Excavation) - 1.0 m thick engineered fill[1] over compact native silt	1.8	550	295
	2.5	600	320
	3.5	620	330
Option 2B (Shallow Excavation) - 1.0 m thick engineered fill[1] over compact silt	1.8	450	240
	2.5	500	265
	3.5	550	295

Notes:

1. *Such as Granular 'A' or Granular 'B' Type II.*
2. *Varies in thickness from 0.35 m to 0.75 m, depending on excavation of all existing fill.*

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 in accordance with OPSS.PROV 902 and SP 109S12. A Qualified Geotechnical Engineer should check that the design foundation elevation is achieved and all unsuitable soils including existing fill, organics and any other soft/very loose materials be removed.

2.2.3.3 Resistance to Lateral Loads

Resistance to lateral forces/sliding resistance between the subgrade and concrete should be calculated in accordance with Section 6.10.5 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 compact silt/engineered fill (e.g., Granular ‘A’ or Granular ‘B’ Type II) 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 compact native silt	0.45
Cast-in-place concrete and Granular ‘A’ or Granular ‘B’ Type II	0.60

The listed values are unfactored; in accordance with CHBDC (CAN/CSA S6-19), a factor of 0.8 should be applied when calculating the horizontal resistance.

2.2.3.4 Frost Protection

According to Ontario Provincial Standard Drawing (OPSD – 3090.100), the frost depth in the Foleyet area is about 2.4 m. Consequently, all footings exposed to seasonal freezing conditions should be protected from frost action by at least 2.4 m of soil cover or equivalent approved insulation for frost protection. Equivalent protection could be provided by using polystyrene foam as suggested by the “Canadian Foundation Engineering Manual 2006, Section 13.5.2. page 196”. It is accepted that 25 mm of polystyrene foam placed above footing provides protection against frost which is equivalent to 600 mm of soil cover.

2.2.3.5 Structure Backfill

The selection and placing of backfill should be in accordance with OPSS.PROV 902. For backfilling immediately behind the walls, it should consist of free-draining, non-frost susceptible granular materials conforming to OPSS.PROV 1010 (Granular A, Granular B Type I or Type II, or Selected Subgrade Material (SSM)). If existing fill material is used, a review should be conducted during excavation to ensure the material conforms to SSM in OPSS.PROV 1010. All granular backfill should be placed in thick lifts (i.e., not exceeding 300 mm before compaction). Each lift should be compacted to 100% of its Standard Proctor Maximum Dry Density (SPMDD) below the floor slab, while within outside/exterior areas the fill should be compacted to 98% of its SPMDD.

2.2.3.6 Lateral Earth Pressure

2.2.3.6.1 Lateral Earth Pressures for Static Design

Perimeter walls (for sand/salt stockpile), structure wall and temporary shoring (if required) should be designed to resist lateral earth pressure. The expression for calculating lateral earth pressure is given by:

$P = K(\gamma z + q)$

where,

P = earth pressure intensity at depth z, kPa
K = earth pressure coefficient
γ = unit weight of retained soil, kN/m^3
q = surcharge near wall, kPa
z = depth to point of interest, m

The above expression does not take into account hydrostatic pressure, which must be included for the groundwater levels measured on the site. Table 2.5 lists earth pressure parameters for the given materials assuming two cases: (i) a level ground surface on the retained side and (ii) a 1.5H:1V backfill slope on the retained side. These recommendations also assume wall friction is neglected, a level ground surface in front of the wall and on the retained side, and a vertical back face of the wall.

Table 2.5 Material types and earth pressure properties under static conditions

Material	Unfactored Friction Angle ϕ' (°)	Coefficient of Active Earth Pressure (K_a)	Coefficient of Passive Earth Pressure (K_p)	Coefficient of Earth Pressure At- Rest (K_o)	Unit Weight γ (kN/m^3)
With level backfill slope on retained side					
Granular A/B Type II	35	0.27	3.69	0.43	22.8
Engineered Fill (Granular B Type I or SSM)	32	0.31	3.26	0.47	21
Stockpiled Sand/Salt	33	0.30	3.39	0.46	20
With 1.5H:1V backfill slope on retained side					
Stockpiled Sand/Salt	33	0.65	-	0.70	20

The mobilization of full active or passive resistance requires a measurable and perhaps significant wall movement or rotation. Therefore, unless the structural element can tolerate these deflections, the at-rest earth pressure should be used in design. The coefficients of lateral earth pressure above are provided for level backfill behind the wall (perpendicular to the wall face plane) and should be adjusted in the case of sloping backfill and in the case of 1.5H:1V sloping backfill.

The effect of compaction surcharge should be taken into account in the calculations of active and at rest earth pressures during backfilling up to the finished grade. The lateral pressure due to compaction should be taken as at least 12 kPa at the surface, and its magnitude should be assumed to diminish linearly with depth to zero at the depth where the active (or at rest) pressure is equal to 12 kPa. This pressure distribution should be added to the calculated active (or at rest) pressure. Notwithstanding, lighter compaction equipment and smaller lifts should be used adjacent to retaining walls to prevent overstressing.

2.2.3.6.2 Lateral Earth Pressures for Seismic Design

The total lateral earth pressure should be calculated considering the static ($K(\gamma z + q)$) and seismic ($(K_{ae} - K_a)\gamma(h - z)$) components using the following equation below:

$$P = K(\gamma z + q) + (K_{ae} - K_a)\gamma(h - z)$$

where,

- P = earth pressure intensity at depth z, kPa
- K = earth pressure coefficient (K_a for yielding walls, K_0 for non-yielding walls)
- K_a = static active earth pressure coefficient
- K_{ae} = seismic active earth pressure coefficient
- γ = unit weight of retained soil, kN/m^3
- q = surcharge near wall, kPa
- h = total height of wall, m
- z = depth to point of interest, m

Seismic lateral earth pressure parameters yielding and non-yielding walls are provided in Sections 2.2.3.6.2.1 and 2.2.3.6.2.2.

2.2.3.6.2.1 Yielding Walls

Seismic loading should be taken into account in the design in accordance with Section 6.14.7 of the CHBDC. These estimates are based on the Mononobe-Okabe (M-O) pseudo-static method of analysis. The M-O method produces seismic loads that are more critical than the static loads that act prior to an earthquake. The M-O method of seismic lateral earth pressure coefficients for the structural design can be estimated in accordance with Section 6.14.7.2 and C6.14.7.2 of the CHBDC and its Commentary, respectively.

When calculating seismic lateral earth pressures on walls that are capable of moving 25 to 50 mm using the M-O formulation, the seismic horizontal acceleration coefficient (k_h) should be taken as half of the site-adjusted PGA, where, the site-adjusted PGA estimated at ground surface is given as F(PGA)*PGA, where, F(PGA) is the PGA-based amplification factor that corresponds to the applicable Site Class as defined in Table 4.8 of the Code. For this site, F(PGA) is 1.29 and PGA is 0.104 (further discussed in Section 2.3.1). Therefore, a site-adjusted PGA of 0.134 g (Site Class D), earthquake having a 2% probability of exceedance in 50 years (1 in 2,475-year return period) can be used in the calculation of the seismic active pressure coefficient. k_h is estimated to be 0.067 g and was used for lateral earth pressures for seismic design.

The effect of the seismic vertical acceleration coefficient (k_V) should be ignored when calculating the seismic lateral earth pressure coefficients. However, the minimum peak vertical acceleration coefficient can be taken as two-thirds of the peak horizontal acceleration coefficient, in accordance with Section 4.4.3.6 of the CHBDC when calculating the seismic lateral earth load.

It should be noted that in the computation of seismic earth pressure coefficients, the wall back-face geometry, backfill slope, and wall friction effects need to be addressed. For design purposes, the following unfactored seismic lateral earth pressure parameters in Table 2.6 can be used (assuming wall friction is neglected, a level ground surface in front of the wall and on the retained side and the back face of the wall is vertical).

Table 2.6 Material types and earth pressure properties under seismic conditions for yielding walls

Material	Unfactored Friction Angle ϕ' (°)	Coefficient of Seismic Active Earth Pressure (K_{ae})	Coefficient of Seismic Passive Earth Pressure (K_{pe})	Unit Weight γ (kN/m^3)
Granular A/B Type II	35	0.31	3.56	22.8
Engineered Fill (Granular B Type I or SSM)	32	0.35	3.13	21
Stockpiled Sand/Salt	33	0.33	3.33	20

2.2.3.6.2.2 Non-Yielding Walls

For walls that are restrained against lateral movement, the seismic lateral earth pressures should be obtained using the M-O formulation and using a seismic horizontal acceleration coefficient (k_h) equal to the site-adjusted PGA, where, the site-adjusted PGA estimated at the ground surface, given as F(PGA)*PGA = 0.134 g. The same values for F(PGA) and PGA are used from Section 2.2.3.6.2.1. The acceleration coefficient determined at the original ground surface should be the acceleration coefficient acting at the wall base. The seismic vertical acceleration coefficient (k_V) can be ignored when calculating the seismic lateral earth pressure coefficient. For design purposes, the following unfactored seismic lateral earth pressure parameters for non-yielding walls are provided in Table 2.7.

Table 2.7 Material types and earth pressure properties under seismic conditions for non-yielding walls

Material	Unfactored Friction Angle ϕ' (°)	Coefficient of Seismic Active Earth Pressure (K_{ae})	Coefficient of Seismic Passive Earth Pressure (K_{pe})	Unit Weight γ (kN/m^3)
Granular A/B Type II	35	0.35	3.42	22.8
Engineered Fill (Granular B Type I or SSM)	32	0.39	3.00	21
Stockpiled Sand/Salt	33	0.38	3.14	20

2.2.3.7 Resistance to Uplift

Resistance to uplift for the footings should be calculated based on the i) dead load on the footing ii) weight of the footing and iii) weight of soil above the footing (i.e., burial depth and soil unit weight). Unit weights and friction angles of soil, provided in Table 2.5, can be used to determine the uplift resistances. Uplift resistances should be calculated using the methodology described in Bowles (1997; pg 270).

2.3 Seismic Potential Consideration

2.3.1 Seismic Hazard Site Classification and Values

Seismic characterization of the site should be compliant with the OBC (2012) and CHBDC. The potential for seismic loading must be considered for design in accordance with Section 4.1.8 of the OBC (2012) and Section 6.14.7 of the CHBDC with respect to the soil conditions encountered at the site. Table 4.1.8.4.A in OBC (2012) and Table 4.1 CHBDC show site classification for seismic site response based on average soil properties in the top 30 m.

At this site, the subsoil generally consists of gravelly sand to silty sand fill consists of by loose to very dense native silt further underlain by cohesionless till (gravelly sand to silt and sand) with interbedded cobbles and boulders. No bedrock was encountered within the depths of exploration in all boreholes (~8.8 m to 10.8 m below ground surface). The groundwater level was measured (in open hole prior to the use of water for casing/coring and upon completion of drilling) to range from 3.8 m to 5.9 m (Elev. 326.0 m to 328.1 m) below existing ground surface. Based on soil characteristics, the site class for this site is estimated to be Class "D" according to Table 4.1.8.4.A of the OBC (2012) and Table 4.1 of the CHBDC.

From the Natural Resources Canada website, 2020 NBC seismic hazard values are obtained using the site location coordinates and the site-adjusted damped reference spectral accelerations for the project site are shown in Table 2.8 below:

Table 2.8. Seismic design values

Probability of Exceedance in 50 Years (Return Period)	Sa(0.2) (g)	Sa(0.5) (g)	Sa(1.0) (g)	Sa(2.0) (g)	PGA (g)
Latitude: 48.257333; Longitude: -82.443660					
2% (1 in 2475-year)	0.184	0.185	0.109	0.050	0.104

These values are associated with an earthquake having a 2% probability of exceedance in a 50-year period (1 in 2475-year) for Site Class D is also shown on the seismic hazard calculation data sheet for this site attached in Appendix G.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class and the reference peak ground acceleration (PGA_{ref}). At this site the PGA_{ref} is equal to 0.8*PGA=0.083 g since Sa(0.2)/PGA is less than 2.0. Therefore, as per Table 4.8 of the CHBDC (CAN/CSA-S6-19), the site coefficient F(PGA), for this site (Seismic Site Class D and PGA_{ref} = 0.083 g) is 1.29.

2.3.2 Liquefaction Considerations

Liquefaction of cohesionless soils below the groundwater table, including the native silt, cobbles and boulders and silt and sand/gravelly sand till, at the project site was evaluated through the SPT-based liquefaction triggering procedures described in Boulanger and Idriss (2014) using the site-adjusted PGA = 0.104 g (1 in 2475-year event). This involves comparing the cyclic stress ratio (CSR), which are the cyclic shear stresses within the soil induced by seismic forces, and the cyclic resistance ratio (CRR) of the soil.

Based on the SPT-based liquefaction triggering procedures, the saturated native soils below the proposed building location are not expected to be susceptible to liquefaction in the case of a PGA = 0.104 g (1 in 2475-year event).

2.4 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 Granular A/Granular B Type II. 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 (e.g., Granular A, Granular B Type I or Type II, or Selected Subgrade Material (SSM)) could be designed inside the structure. Based on available information, the floor slab/asphalt surface elevation will be around 331.965 m. Below 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 50 MPa/m may be assumed for preliminary assessment purposes. For design purposes, the value provided above needs to be modified to account for size effects as per standard design methods as outlined in the 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 footings 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 2.6). 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 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 an 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.

2.5 Stability and Settlement Analyses

2.5.1 Stability

To assess the global stability of the material storage facilities and to check that a minimum Factor of Safety (FOS) of 1.3 under static conditions and 1.1 under seismic conditions will be achieved for the maximum height winter sand/salt stockpiles, a series of slope stability analyses were performed. The static and seismic 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. For seismic conditions, a horizontal seismic coefficient, k_h, is half of the site-adjusted peak horizontal ground acceleration. In reference to the provided seismic design values in Section 2.3.1, k_h = 0.5*F(PGA)*PGA = 0.067 g was used when evaluating global stability of the stockpile under seismic conditions.

Stability assessments were performed for the proposed new structure of 20 m x 27 m dimensions assuming that the maximum sand/salt stockpile height could be 9.2 m total at centre of stockpile (6.7 m above the concrete walls) with 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.

Stability assessments were performed on recommended Option 2 (footing depth of 1.2 m), which is the more critical option from a stability point of view. The stability analyses show that a footing depth of 1.2 m is the minimum embedment required to achieve global stability requirements of a Factor of Safety of 1.3 under static conditions and 1.1 under seismic conditions. For footing depth of 1.2 m, ~50 mm of polystyrene foam is required to be placed above the footing to protect against frost action (see Section 2.2.3.4).

Given the subsurface conditions (i.e., cohesionless soils), effective stress analyses for a long-term stability assessment was performed taking into consideration the subsoil conditions encountered directly beneath and adjacent to the proposed structure. The areas extending at least 1.0 meters beyond the outside edge of any footings of the building should be stripped/excavated and cleared of asphalt, surface vegetation, peat, topsoil, excessive organics, existing fill, weak/ disturbed/ deleterious/ compressible or loose materials and debris prior to construction, should be replaced with engineered fill comprised of Granular A or Granular B Type II (below the groundwater table).

Tabulated below in Table 2.9 are the soil parameters used for the slope stability analyses. The soil parameters were generally estimated based on the results of field and laboratory testing. Table 2.10 below summarizes results of performed slope stability analyses.

Table 2.9. Soil properties used in slope stability analyses

Material Type	Effective Stress Parameters		
	ϕ (degrees)	c (kPa)	γ (kN/m3)
Granular A/B Type II	35	0	22.8
Engineered Granular Fill	32	0	21
Gravelly Sand/Silty Sand Fill	30	0	20
Silt (Compact)	29	0	19
Silt and Sand/Gravelly Sand Till (Compact to Very Dense)	32	0	21
Cobbles and Boulders	36	0	18
Stockpile Material (Winter sand/salt)	33	0	20

Table 2.10. Summary of results of slope stability analyses

Location	Max Height (m)	Conditions	Min FOS
North-South Section	9.2 m (6.7 m above concrete walls + 2.5 m high concrete walls)	Drained long-term conditions, static condition	1.4 (Figure E1)
		Drained long-term conditions, seismic condition	1.3 (Figure E2)
East-West Section		Drained long-term conditions, static condition	1.3 (Figure E3)
		Drained long-term conditions, seismic condition	1.2 (Figure E4)

The graphical results of these analyses can be seen on Figures E1 to E4 in Appendix E. The results of stability analyses for an approximately 9.2 m high winter sand/salt stockpile in the center with the side slopes of 1.5H:1V, restrained with 2.5 m high concrete walls on both sides of the building suggest that the factor of safety of minimum 1.3 can be obtained for a deep-seated failure surface/global stability for static conditions and a minimum 1.1 can be obtained for seismic conditions.

2.5.2 Settlement

To evaluate the maximum settlement and differential settlement values below the 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 laboratory and field tests as per CHBDC. The estimated parameters for settlement analyses are listed in Table 2.11.

Table 2.11 Soil properties used in settlement analyses

Material Type	γ (kN/m3)	E (MPa)
Engineered Granular Fill	21	50
Silt (Compact)	19	25
Silt and Sand/Gravelly Sand Till (Compact to Very Dense)	21	90

The geometry of the stockpiles was assumed based on its maximum allowable capacity which is a maximum height of approximately 9.2 m at the center (6.5 m above concrete walls) and 2.5 m along the sides at the wall. The model is illustrated on Figures F1 (north) and F2 (south) 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 2.12.

Table 2.12 Results of settlement analyses

Location	Foundation Soil Type	Estimated Elastic Settlement (mm)	
		Edge	Centre
North Side (BH23-F-4, BH23-F-1)	Engineering Granular Fill over Native Silt (Compact)	13	37
South Side (BH23-F-3, BH23-F-2)	Native Silt (Compact)	13	37

The calculated settlements are anticipated to occur immediately after the stockpile loadings are applied or within a period of one month. The footings for this structure should be designed under the full allowable stockpile loadings. The geometries of stockpiles under the full allowable loadings including their possible maximum heights are recommended above.

2.6 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, peat, 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 II (below the groundwater table). In particular, the west side of the proposed building (BH23-F-1 and BH23-F-2), organics/topsoil within the gravelly sand fill from 0.2 m to 1.6 m depth (Elev. 331.7 m to 329.9 m) from the ground surface has to be fully excavated. A mud slab consisting 0.1 m (4 inches) of concrete can be utilized under all the footings if and where required to protect the foundation soils from potential disturbance.

Granular A or Granular B Type II could be placed after stripping all topsoil, peat, 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. Granular A should be placed in accordance with OPSS.PROV 501 and SP 105S22 while Granular B Type II should be placed in accordance with OPSS.PROV 314. 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 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.

2.7 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 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.

2.8 Groundwater Control

The groundwater level was measured (in open hole prior to the use of water for casing/coring and upon completion of drilling) to range from 3.8 m to 5.9 m (Elev. 326.0 m to 328.1 m) below existing ground surface. Since the depth of excavation for footings could be up to 3.4 m (Elev. 328.6 m), the groundwater level is expected to be below the excavation depth. Therefore, it is anticipated that active dewatering will not be required.

If groundwater is above the excavation depth, then the groundwater level needs to be controlled to at least 0.5 m below the excavation level to avoid disturbance, and any groundwater seepage should be removed from the excavation such that the granular backfill is placed in the dry. In general, where the excavation base is within 0.5 m of the prevailing groundwater level at the time of construction, it is anticipated that control of seepage can be accomplished by using properly filtered sumps, and/or filtered drains placed along the base the excavation.

Surface water should be directed away from the excavation. Dewatering shall be carried out in accordance with OPSS.PROV 517 and SP 517F01. It is responsibility of the Contractor to propose a suitable dewatering system based on the time of construction, water levels and flow conditions. The method used should not undermine the existing utilities/structures (if any).

2.9 Corrosion Protection

As stated above, one (1) soil sample was selected for analyses of pH, water soluble sulphate, chloride concentrations, resistivity, conductivity and oxidation-reduction potential. The testing was completed to determine the potential for degradation of the concrete in the presence of soluble sulphate and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in Section 1.7 of this report and detailed results are included in Appendix D.

The chemical data presented in Section 1.7 indicates resistivity of the tested soil of 1600 ohm-cm, which suggests a severe potential for corrosion of buried metallic elements (MTO Gravity Pipe Design Guidelines, Page 34). The maximum chloride content reported is 180 ppm (µg/g) which indicates no potential for additional corrosion. The soil pH was about 7.82 which is within what is considered the normal range for soil pH (i.e., 7.5 to 8.5). The test results in Table 1.7 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. Based on the results of sample tested, and given that the structure is a salt/sand storage, consideration should be given by the designer to designing for a «C» type of exposure concrete class as defined by CSA A23.1 Table 1.

The maximum water-soluble sulphate content of the soils tested is 35 ppm (µg/g), i.e., 0.0035% 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.

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 Elvis Lu, 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 Daniel Mroz.

EXP Services Inc.

Elvis Lu, M.Eng., EIT
Technical Specialist

Silvana Micic, Ph.D., P.Eng.
Senior Geotechnical Engineer
Project Manager

LICENSED PROFESSIONAL ENGINEER
S. MICIC
100050187
February 27, 2024
PROVINCE OF ONTARIO

TaeChul Kim, M.E.Sc., P.Eng.
Senior Geotechnical/Foundation Specialist

Stan E. Gonsalves, M.Eng., P.Eng.
Executive Vice-President
Designated MTO Foundation Contact

LICENSED PROFESSIONAL ENGINEER
S.E.M. GONSALVES
February 27, 2024
PROVINCE OF ONTARIO

REFERENCES

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Ministry of Transportation, April 2014. MTO Gravity Pipe Design Guidelines. Circular Culverts and Storm Sewers.

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ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Ontario Provincial Standard Specifications (OPSS):

OPSS.PROV 314 Construction Specification for Untreated Subbase, Base, Surface, Shoulder, Selected Subgrade, and Stockpiling

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 517 Construction Specification for Dewatering

OPSS.PROV 902 Construction Specification for Excavating and Backfilling – Structures

OPSS.PROV 1002 Material Specification for Aggregates - Concrete

OPSS.PROV 1004 Material Specification for Aggregates – Miscellaneous

OPSS.PROV 1010 Material Specification for Aggregates - Base, Subbase, Select Subgrade, And Backfill Material

Ontario Provincial Standard Drawings (OPSD):

OPSD 3090.100 Foundation Frost Depths for Northern Ontario

Special Provisions (SP):

SP 105S22 AMENDMENT TO OPSS 501

SP 109S12 AMENDMENT TO OPSS 902

Ontario Water Resources Act:

R.R.O 1990, Regulation 903 Wells, under Ontario Water Resources Act, R.S.O. 1990, c. O.40

Ontario Occupational Health and Safety Act (OHSA):

Ontario Regulation 213/91 Construction Projects

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 –
Site Photographs

Photo 1. Foleyet Patrol Yard – Existing salt structure, facing north

Photo 2. Foleyet Patrol Yard – Existing salt structure, facing southeast

Photo 3.   Foleyet Patrol Yard – Existing salt structure, facing southwest

Photo 4.   Foleyet Patrol Yard – Drilling borehole 23-F-3, facing northeast

Photo 6. Foleyet Patrol Yard – Drilling borehole 23-F-2, facing northeast

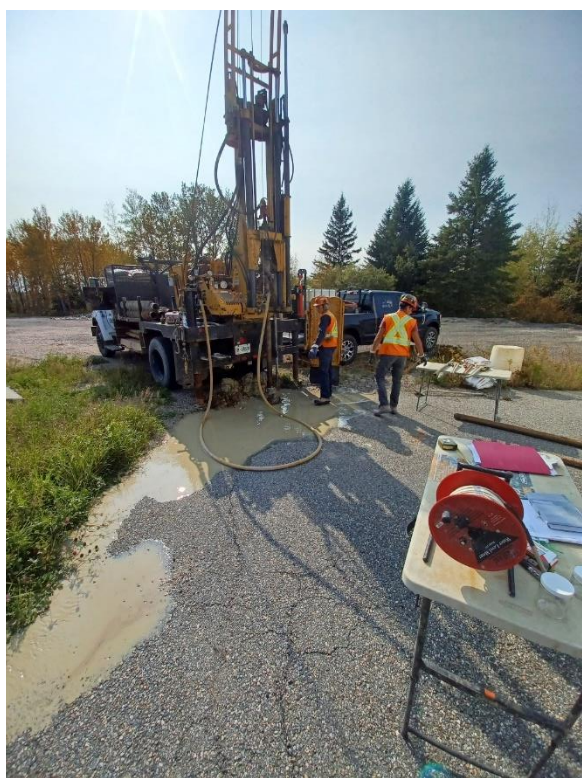


Photo 5. Foleyet Patrol Yard – Drilling borehole 23-F-3, facing southeast

Appendix B – Drawings

CONT No. 5021-E-0020
ASSIG No. 5
GWP No.

SHEET 1

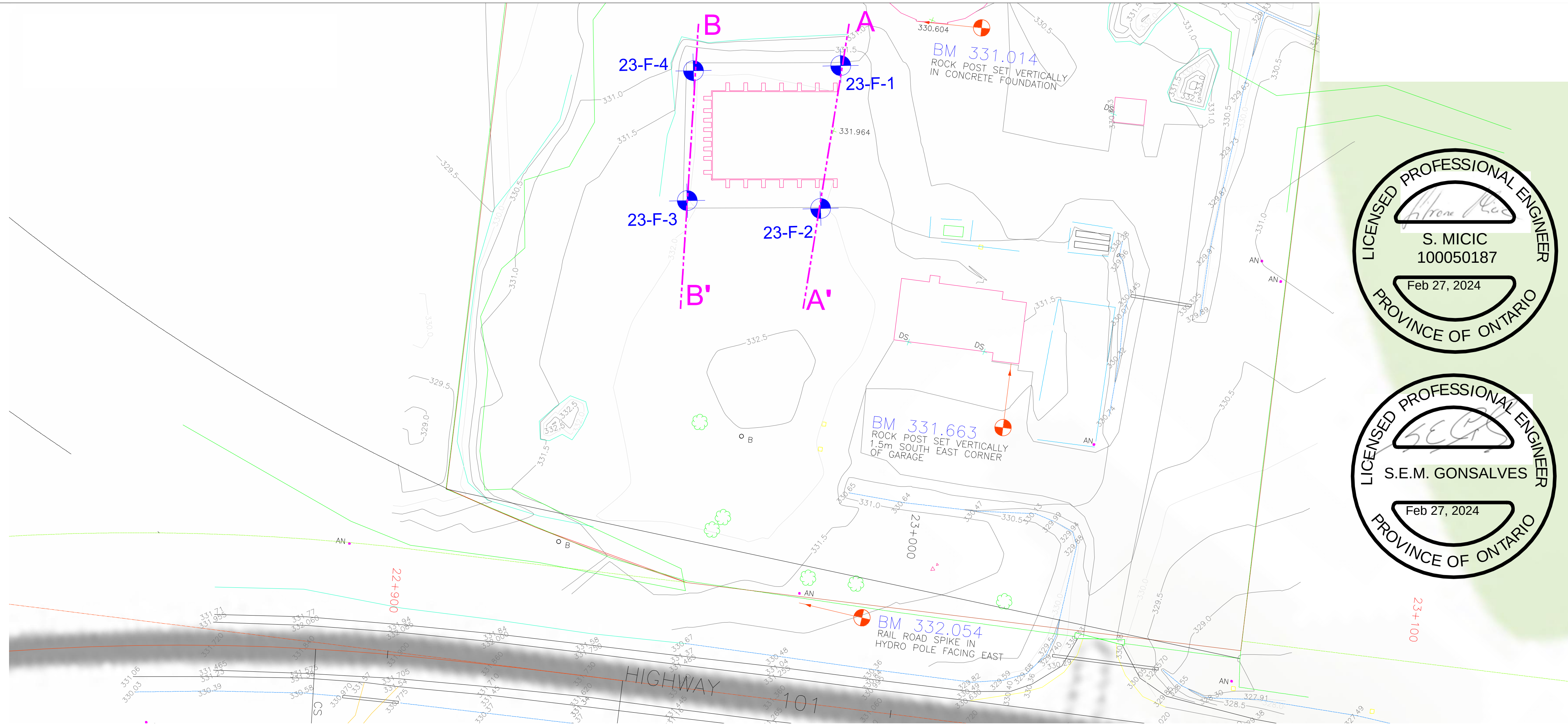
New Material Storage Structure at Foleyet Patrol Yard
Highway 101, Foleyet, ON
Latitude: 48.257333° ; Longitude: -82.443660°

BOREHOLE LOCATION PLAN & SOIL STRATA

exp. EXP SERVICES INC.

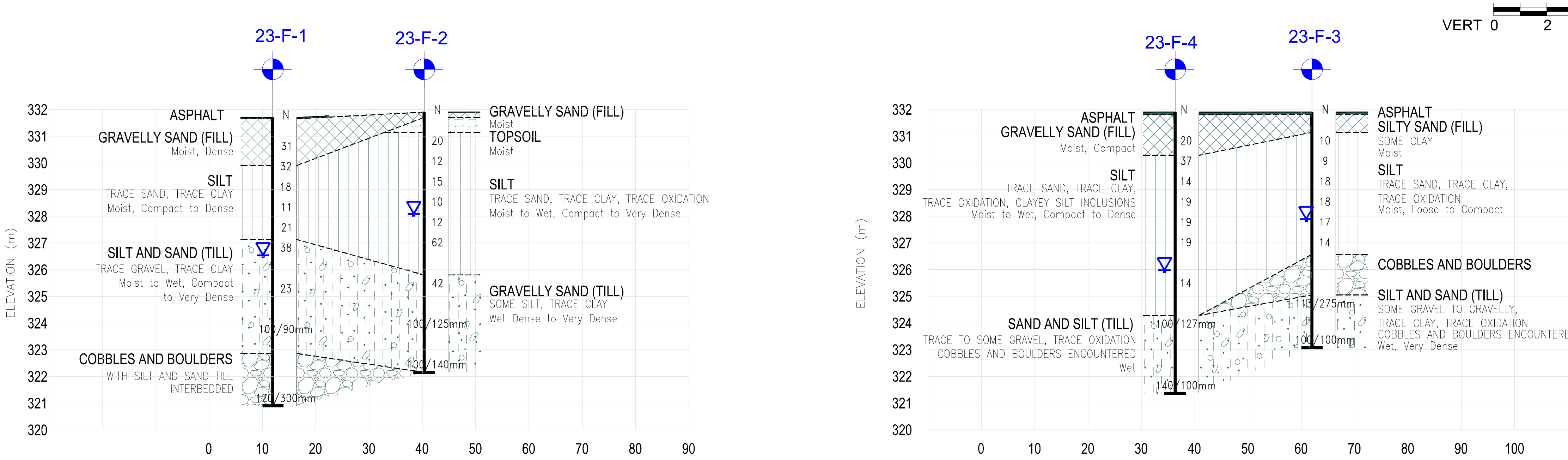
LICENSED PROFESSIONAL ENGINEER
S. MICIC
100050187
Feb 27, 2024
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S.E.M. GONSALVES
Feb 27, 2024
PROVINCE OF ONTARIO



PLAN

HOR 0 10 20 m
VERT 0 2 4 m



SECTION A-A'

SECTION B-B'

KEY PLAN
N.T.S.

LEGEND

Borehole Location

Water Level Upon Completion of Drilling (W. L. NOT STABILIZED)

N Blows/0.3m (Std. Pen. Test, 475 J/blow)

SOIL STRATA SYMBOLS

ASPHALT
TOPSOIL
FILL
SILT
SILT AND SAND/ GRAVELLY SAND (TILL)
COBBLES & BOULDERS
BEDROCK

BOREHOLE COORDINATES/ NAD 83/ MTM ON-12

BH No.	ELEV.	NORTHING	EASTING
23-ST-1	383.4	5268790	285211
23-ST-2	383.3	5268770	285213
23-ST-3	383.2	5268763	285191
23-ST-4A	383.4	5268782	285186
23-ST-4B	383.4	5268782	285187

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 boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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.

REVISIONS

NO	DATE	BY	DESCRIPTION
			SUBMISSION FOR MTO REVIEW

PROJECT No. ADM-22006096-A4		GEOCRES No. 42B08-001	
SUBM'D SH	CHKD. SM	DATE FEB. 27, 2024	SITE -
DRAWN SH	CHKD. TC	APPRD SG	DWG 01

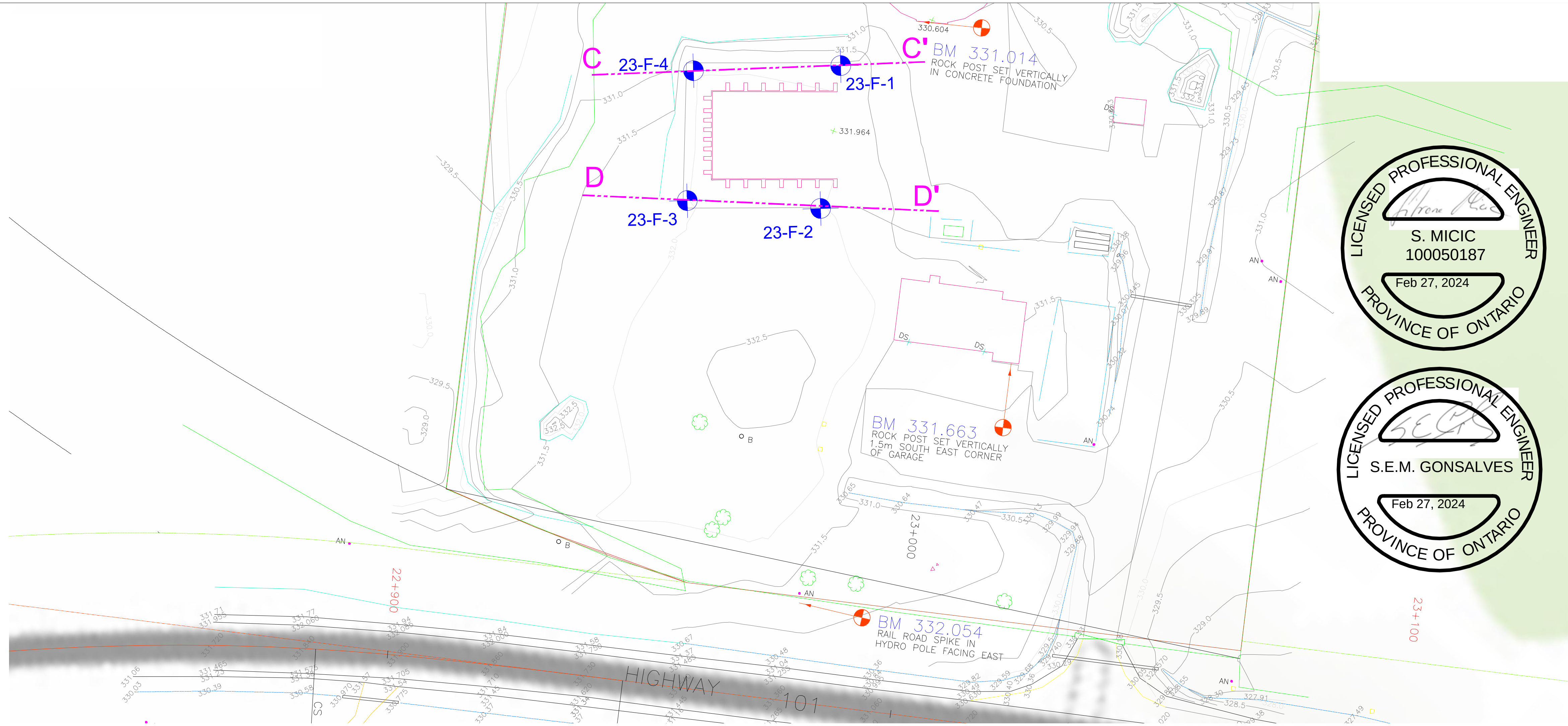
CONT No. 5021–E–0020
ASSIG No. 5
GWP No.

SHEET 2

New Material Storage Structure at Foleyet Patrol Yard
Highway 101, Foleyet, ON
Latitude: 48.257333° ; Longitude: -82.443660°

BOREHOLE LOCATION PLAN & SOIL STRATA

EXP SERVICES INC.



PLAN

KEY PLAN
N.T.S.

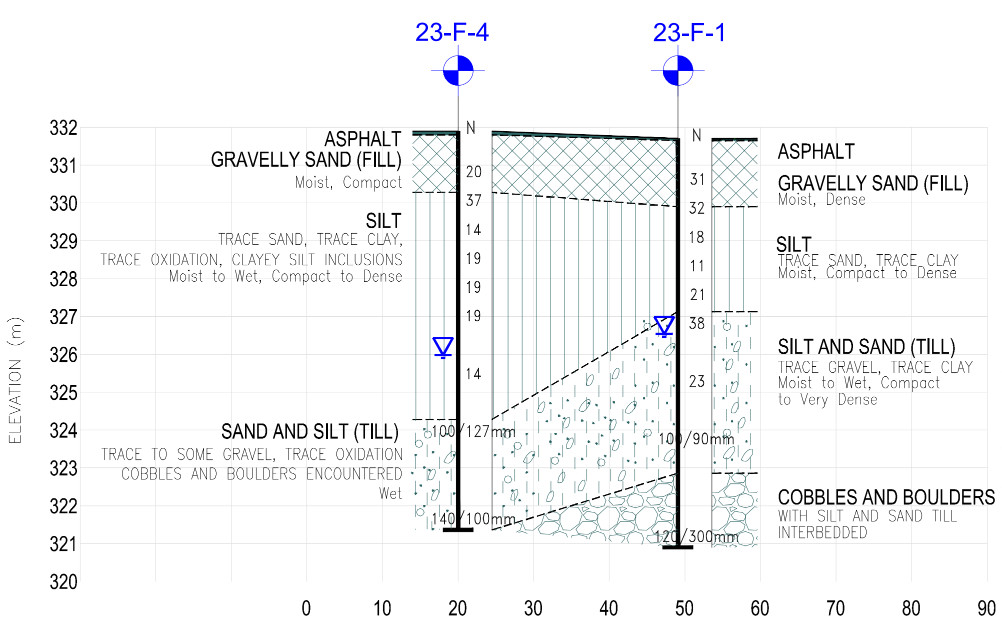
LEGEND

- Borehole Location
- Water Level Upon Completion of Drilling (W. L. NOT STABILIZED)
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)

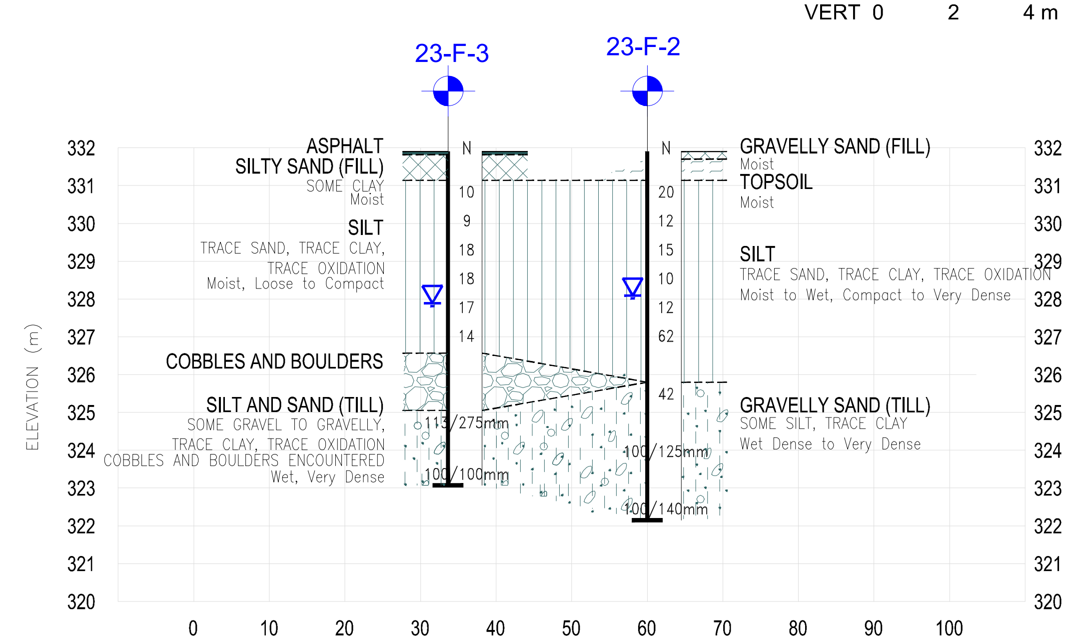
SOIL STRATA SYMBOLS

ASPHALT · TOPSOIL · FILL · SILT · SILT AND SAND/ GRAVELLEY SAND (TILL) · COBBLES & BOULDERS · BEDROCK

HOR 0 10 20 m
VERT 0 2 4 m



SECTION C-C'



SECTION D-D'

BOREHOLE COORDINATES/ NAD 83/ MTM ON–12

BH No.	ELEV.	NORTHING	EASTING
23–ST–1	383.4	5268790	285211
23–ST–2	383.3	5268770	285213
23–ST–3	383.2	5268763	285191
23–ST–4A	383.4	5268782	285186
23–ST–4B	383.4	5268782	285187

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.

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REVISIONS

NO	DATE	BY	DESCRIPTION
			SUBMISSION FOR MTO REVIEW

PROJECT No. ADM-22006096-A4		GEOCRES No. 42B08-001	
SUBM'D SH	CHKD. SM	DATE FEB. 27, 2024	SITE -
DRAWN SH	CHKD. TC	APPRD SG	DWG 02

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

Term	Description	Criteria
"trace"	trace gravel, trace sand, etc.	1% - 10%
"some"	some gravel, some sand, etc.	10% - 20%
Adjective	gravelly, sandy, silty and clayey	20% - 35%
"and"	and gravel, and sand, etc.	>35%
Noun	gravel, sand, silt, clay	>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:

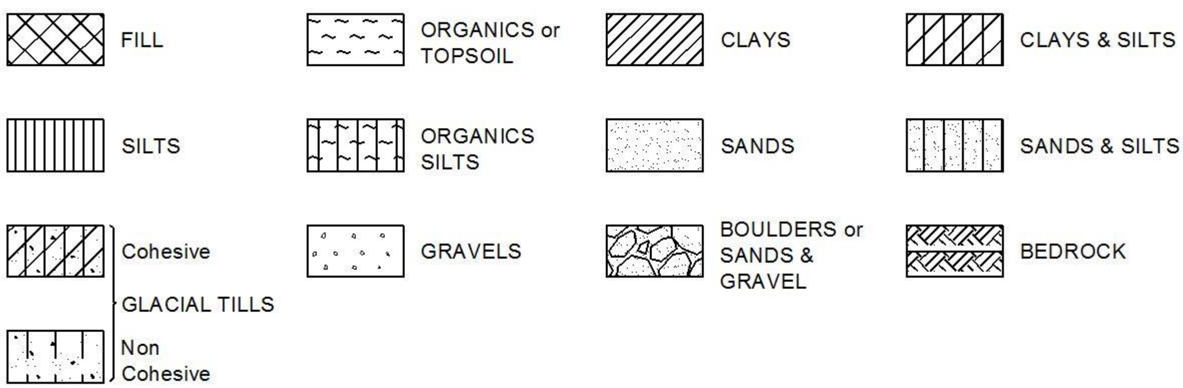
Table c: Consistency of Cohesive Soil

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'	$-^\circ$	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	$-^\circ$	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 23-F-1

METRIC

W.P. ADM-22006096-A4	LOCATION Foleyet Patrol Yard, Foleyet, ON, MTM ON12 (N5347511.4, E197604.7)		ORIGINATED BY DM
DIST Sudbury HWY 101	BOREHOLE TYPE CME55, Hollow Stem Auger, NW Casing and NQ Core Barrel		COMPILED BY IL
DATUM Geodetic	DATE 2023.09.26 - 2023.09.26	LATITUDE 48.257307 LONGITUDE -82.443801	CHECKED BY SM

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
331.7	GROUND SURFACE
331.6 / 0.1	**ASPHALT**, ~ 50 mm thick
	GRAVELLY SAND (FILL), brown, moist, dense
329.9	- 125 mm thick buried black topsoil
1.8	**SILT**, trace sand, trace clay, grey to yellowish grey, moist, compact to dense - becomes wet below ~3.0 m depth
327.1 / 4.6	**SILT AND SAND (TILL)**, trace gravel, trace clay, grey, moist to wet, compact to very dense - thin layer of interbedded coarse brown sand at ~6.1 m depth
322.9 / 8.8	**COBBLES AND BOULDERS**, with silt and sand till interbedded - casing/coring procedures commenced at 8.8 m depth
320.9 / 10.8	BOREHOLE TERMINATED AT ~10.8 m DEPTH

Notes:
1. Groundwater level measured at 5.2 m upon completion of borehole.
2. Borehole caved to depth of 6 m upon withdrawl of auger.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
AS1	AS		23 73 (4)
SS2	SS	31	
SS3	SS	32	
SS4	SS	18	0 1 92 7
SS5	SS	11	
SS6	SS	21	
SS7	SS	38	
SS8	SS	23	
SS9	SS	100/ 90mm	7 41 46 6
SS10	SS	120/ 300mm	

GROUND WATER CONDITIONS: ∇ at approx. elev. 326.5

ELEVATION SCALE: 331, 330, 329, 328, 327, 326, 325, 324, 323, 322, 321

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

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

RECORD OF BOREHOLE No 23-F-2

1 OF 1 **METRIC**

W.P. ADM-22006096-A4
LOCATION Foleyet Patrol Yard, Foleyet, ON, MTM ON12 (N5347487.5, E197620.2)
ORIGINATED BY DM
DIST Sudbury HWY 101
BOREHOLE TYPE CME55, Hollow Stem Auger, NW Casing and NQ Core Barrel
COMPILED BY IL
DATUM Geodetic
DATE 2023.09.26 - 2023.09.27 LATITUDE 48.257099 LONGITUDE -82.443565
CHECKED BY SM

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
331.9	GROUND SURFACE							
331.7 0.0	**GRAVELLY SAND (FILL)**, brown, moist							
0.2	**TOPSOIL**, black, moist		AS1	AS				
331.1 0.8	**SILT**, trace sand, trace clay, grey to yellowish brown, moist to wet, trace oxidation, compact		SS2	SS	20		331	
			SS3	SS	12		330	
			SS4	SS	15		329	0 1 92 7
			SS5	SS	10	∇	328	
			SS6	SS	12			
	- casing/coring procedures commenced at ~4.6 m depth due to heave - becomes very dense below ~4.6 m depth		SS7	SS	62		327	0 3 88 9
325.8 6.1	**GRAVELLY SAND (TILL)**, some silt, trace clay, brown, wet dense to very dense		SS8	SS	42		326 325	
	- sand becomes grey, finer and less clean at ~7.6 m depth		SS9	SS	100/ 125mm		324 323	
			SS10	SS	100/ 140mm			
322.2 9.8	BOREHOLE TERMINATED AT ~9.8 m DEPTH Notes: 1. Groundwater level measured at 3.8 m upon completion of borehole. 2. Borehole caved to depth of 4.8 m upon withdrawl of auger.							

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

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

EXP Services Inc.

Brampton, Ontario

Foundation Design

RECORD OF BOREHOLE No 23-F-3

METRIC

W.P. ADM-22006096-A4	LOCATION Foleyet Patrol Yard, Foleyet, ON, MTM ON12 (N5347471.4, E197599.3)		ORIGINATED BY DM
DIST Sudbury HWY 101	BOREHOLE TYPE CME55, Hollow Stem Auger, NW Casing and NQ Core Barrel		COMPILED BY IL
DATUM Geodetic	DATE 2023.09.25 - 2023.09.25	LATITUDE 48.256946 LONGITUDE -82.443864	CHECKED BY SM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
331.9	GROUND SURFACE					
331.8 / 0.1	**ASPHALT,** ~80mm thick					
	SILTY SAND (FILL), some clay, dark brown, moist	AS1	AS			
331.1 / 0.8	**SILT,** trace sand, trace clay, trace oxidation, yellowish brown, moist, loose to compact	SS2	SS	10		
		SS3	SS	9		0 1 91 8
	- becomes grey and wet at ~2.3 m depth	SS4	SS	18		
		SS5	SS	18		
		SS6	SS	17	▽ (El. ~327.9)	
		SS7	SS	14		0 1 93 6
326.6 / 5.3	**COBBLES AND BOULDERS** - casing/coring procedures commenced at ~5.3 m depth					
325.1 / 6.9	**SILT AND SAND (TILL),** some gravel to gravelly, trace clay, trace oxidation, wet, grey, very dense - cobbles and boulders encountered	SS8	SS	113/ 275mm		15 42 38 5
		SS9	SS	100/ 100mm		
323.1 / 8.8	BOREHOLE TERMINATED AT ~8.8 m DEPTH					

Notes:
1. Groundwater level measured at 4.0 m before coring.
2. Borehole caved to depth of 5.4 m upon withdrawl of auger.

ELEVATION SCALE: 331, 330, 329, 328, 327, 326, 325, 324

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

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

RECORD OF BOREHOLE No 23-F-4

METRIC

W.P. ADM-22006096-A4	LOCATION Foleyet Patrol Yard, Foleyet, ON, MTM ON12 (N5347491.6, E197583.4)		ORIGINATED BY DM
DIST Sudbury HWY 101	BOREHOLE TYPE CME55, Hollow Stem Auger, NW Casing and NQ Core Barrel		COMPILED BY IL
DATUM Geodetic	DATE 2023.09.26 - 2023.09.26	LATITUDE 48.257125 LONGITUDE -82.444082	CHECKED BY SM

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)

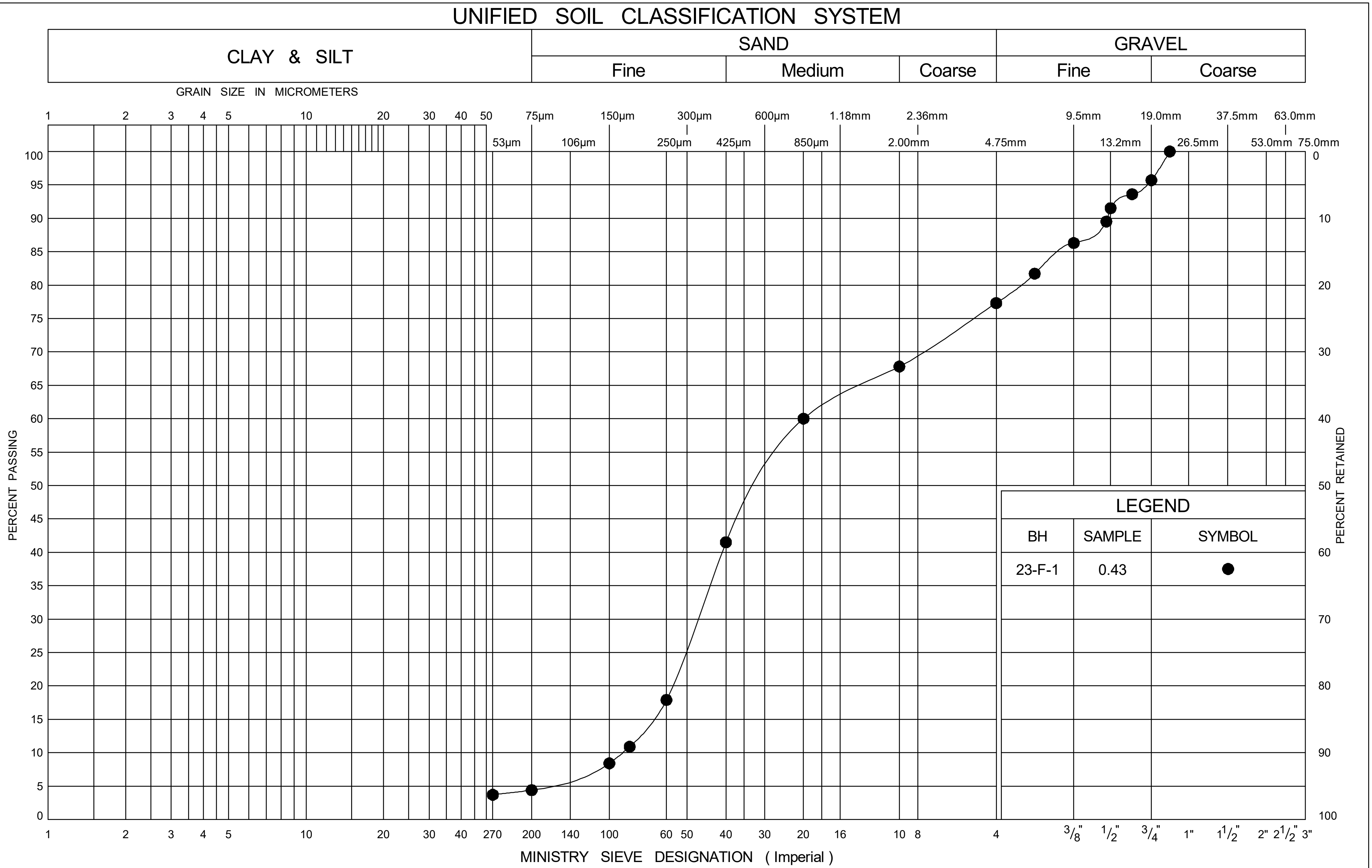
ELEV / DEPTH	DESCRIPTION
331.9	GROUND SURFACE
331.8 / 0.1	**ASPHALT** ~50 mm thick.
	GRAVELLY SAND (FILL), brown, moist, compact
330.3 / 1.6	**SILT ,** trace sand, trace clay, trace oxidation, grey, moist to wet, compact to dense - clayey silt inclusions from ~3.0 m to 3.8 m - wet below ~3.0 m depth
324.3 / 7.6	**SAND AND SILT (TILL),** trace to some gravel, trace oxidation, grey, wet - cobbles and boulders encountered - casing/coring procedures commenced at ~8.2 m depth
321.4 / 10.5	BOREHOLE TERMINATED AT ~10.5 m DEPTH Notes: 1. Groundwater level measured at 5.9 m before coring. 2. Borehole caved to depth of 5.9 m upon withdrawl of auger.

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
AS1	AS					
SS2	SS	20				
SS3	SS	37				
SS4	SS	14				
SS5	SS	19	0	1	90	9
SS6	SS	19				
SS7	SS	19				
SS8	SS	14				
SS9	SS	100/ 127mm	2	40	52	6
SS10	SS	140/ 100mm				

Elevation scale: 331, 330, 329, 328, 327, 326, 325, 324, 323, 322 (groundwater level symbol ∇ at approx. elevation 326).

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

Appendix D -
Laboratory Data



Ministry of Transportation
Ontario

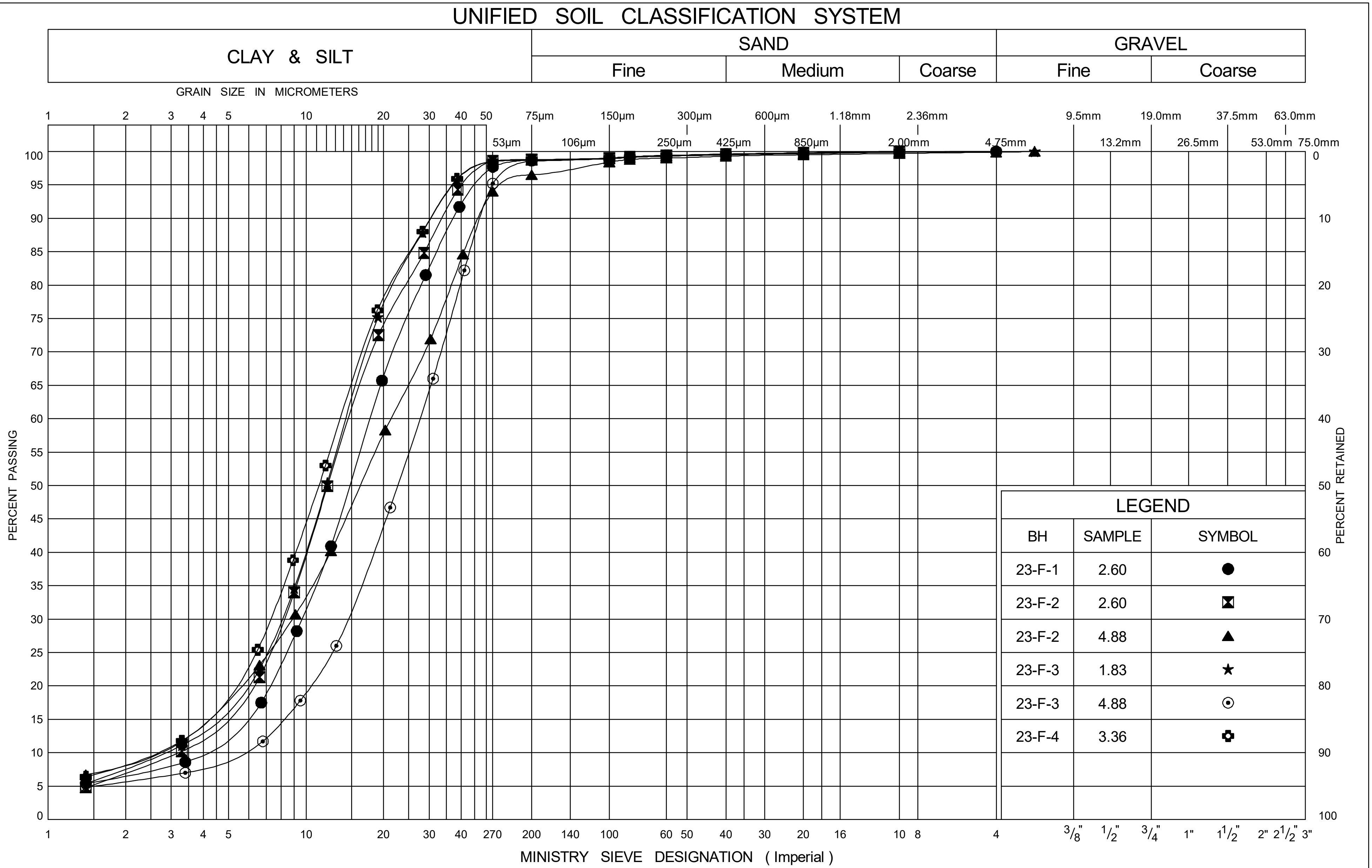
GRAIN SIZE DISTRIBUTION

Cohesionless Fill: Gravelly Sand to Silty Sand

FIG No 1

W P

5021-E-0020, Assignment 5



BH	SAMPLE	SYMBOL
23-F-1	2.60	●
23-F-2	2.60	⧗
23-F-2	4.88	▲
23-F-3	1.83	★
23-F-3	4.88	⊙
23-F-4	3.36	✿

Ministry of Transportation
Ontario

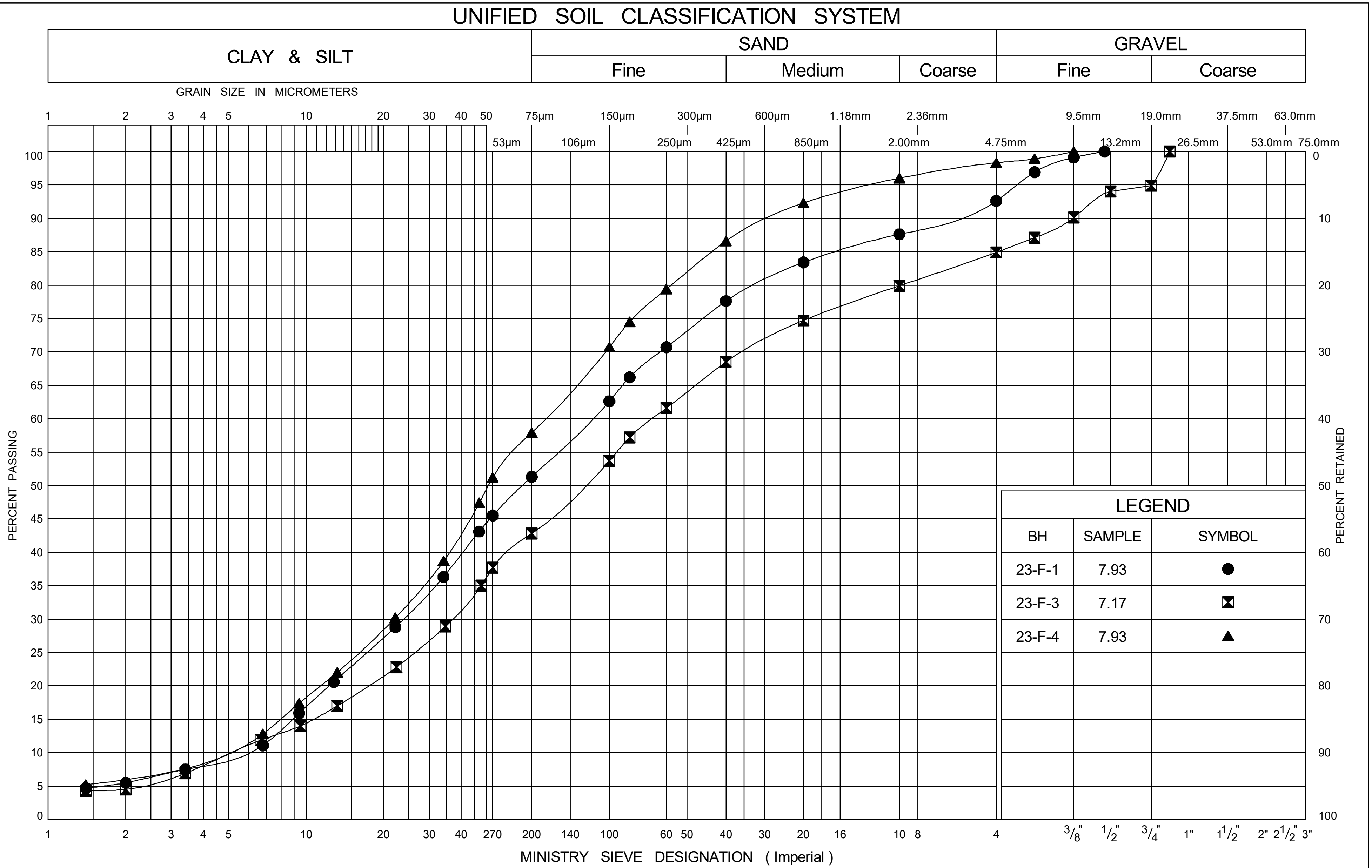
GRAIN SIZE DISTRIBUTION

Silt

FIG No 2

W P

5021-E-0020, Assignment 5



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Cohesionless Till: Gravelly Sand to Sand and Silt

FIG No 3

W P

5021-E-0020, Assignment 5

BUREAU VERITAS

Your Project #: ADM-22006096-A4
Site Location: SHINING TREE/ FOLERET
Your C.O.C. #: n/a

Attention: Silvana Micic

exp Services Inc
Brampton Branch
1595 Clark Blvd
Brampton, ON
CANADA L6T 4V1

Report Date: 2023/10/13
Report #: R7859618
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3V1572
Received: 2023/10/06, 15:06

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	2	2023/10/11	2023/10/13	CAM SOP-00463	MOE E3013 m
Conductivity	2	2023/10/11	2023/10/11	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	2	N/A	2023/10/12	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	2	N/A	2023/10/12	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	2	2023/10/12	2023/10/12	CAM SOP-00413	EPA 9045 D m
Redox Potential (3)	2	2023/10/11	2023/10/12	CAM SOP-00421	SM 2580 B
Resistivity of Soil	2	2023/10/07	2023/10/11	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	2	2023/10/11	2023/10/13	CAM SOP-00464	MOE E3013 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCCFP, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by Bureau Veritas Calgary (19th), 4000 19th Street NE , Calgary, AB, T2E 6P8
(2) Offsite analysis requires that subcontracted moisture be reported.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Your Project #: ADM-22006096-A4
Site Location: SHINING TREE/ FOLERET
Your C.O.C. #: n/a

Attention: Silvana Micic

exp Services Inc
Brampton Branch
1595 Clark Blvd
Brampton, ON
CANADA L6T 4V1

Report Date: 2023/10/13
Report #: R7859618
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3V1572
Received: 2023/10/06, 15:06

(3) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode. The test is therefore, not SCC accredited for this matrix.

Encryption Key AUTHORIZED REPORT RAPPORT AUTORISÉ Bureau Veritas 13 Oct 2023 17:46:21

Please direct all questions regarding this Certificate of Analysis to:
Patricia Legette, Project Manager
Email: Patricia.Legette@bureauveritas.com
Phone# (905)817-5799
==
This report has been generated and distributed using a secure automated process.
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

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Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Bureau Veritas Job #: C3V1572
Report Date: 2023/10/13

exp Services Inc
Client Project #: ADM-22006096-A4
Site Location: SHINING TREE/ FOLERET
Sampler Initials: DM

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		XFJ269			XFJ269			XFJ270		
Sampling Date		2023/09/26 17:00			2023/09/26 17:00			2023/10/03 10:38		
COC Number		n/a			n/a			n/a		
	UNITS	**BH23-F-2,SS3(5-7')**	**RDL**	**QC Batch**	**BH23-F-2,SS3(5-7') Lab-Dup**	**RDL**	**QC Batch**	**BH23-ST-4,SS3(5-6')**	**RDL**	**QC Batch**
Calculated Parameters										
Resistivity	ohm-cm	1600		8967955				670		8967955
CONVENTIONALS										
Redox Potential	mV	110	N/A	8972059				180	N/A	8972059
Inorganics										
Soluble (20:1) Chloride (Cl-)	ug/g	180	20	8972304				700	20	8972304
Conductivity	umho/cm	637	2	8972399	625	2	8972399	1500	2	8972399
Available (CaCl2) pH	pH	7.85		8975197				6.78		8975197
Soluble (20:1) Sulphate (SO4)	ug/g	35	20	8972308				57	20	8972308
Sulphide	mg/kg	1.3 (1)	0.5	8977771	1.4	0.5	8977771	<0.5	0.5	8977771

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Extracted past method specified hold time
Sample contained greater than 10% headspace at time of extraction.

Bureau Veritas ID		XFJ270	
Sampling Date		2023/10/03 10:38	
COC Number		n/a	
	UNITS	**BH23-ST-4,SS3(5-6') Lab-Dup**	**QC Batch**
Inorganics			
Available (CaCl2) pH	pH	6.82	8975197

QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

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Bureau Veritas Job #: C3V1572
Report Date: 2023/10/13

exp Services Inc
Client Project #: ADM-22006096-A4
Site Location: SHINING TREE/ FOLERET
Sampler Initials: DM

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		XFJ269	XFJ270		
Sampling Date		2023/09/26 17:00	2023/10/03 10:38		
COC Number		n/a	n/a		
	UNITS	**BH23-F-2,SS3(5-7')**	**BH23-ST-4,SS3(5-6')**	**RDL**	**QC Batch**
Physical Testing					
Moisture-Subcontracted	%	20	12	0.30	8977772

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Bureau Veritas Job #: C3V1572
Report Date: 2023/10/13

exp Services Inc
Client Project #: ADM-22006096-A4
Site Location: SHINING TREE/ FOLERET
Sampler Initials: DM

TEST SUMMARY

Bureau Veritas ID: XFJ269
Sample ID: BH23-F-2,SS3(5-7')
Matrix: Soil

Collected: 2023/09/26
Shipped:
Received: 2023/10/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8972304	2023/10/11	2023/10/13	Massarat Jan
Conductivity	AT	8972399	2023/10/11	2023/10/11	Leily Karimi
Moisture (Subcontracted)	BAL	8977772	N/A	2023/10/12	Surinder Singh
Sulphide in Soil	SPEC	8977771	N/A	2023/10/12	Bailey Morrison
pH CaCl2 EXTRACT	AT	8975197	2023/10/12	2023/10/12	Taslima Aktar
Redox Potential	COND	8972059	2023/10/11	2023/10/12	Gurparteek KAUR
Resistivity of Soil		8967955	2023/10/11	2023/10/11	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8972308	2023/10/11	2023/10/13	Alina Dobreanu

Bureau Veritas ID: XFJ269 Dup
Sample ID: BH23-F-2,SS3(5-7')
Matrix: Soil

Collected: 2023/09/26
Shipped:
Received: 2023/10/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	8972399	2023/10/11	2023/10/11	Leily Karimi
Sulphide in Soil	SPEC	8977771	N/A	2023/10/12	Bailey Morrison

Bureau Veritas ID: XFJ270
Sample ID: BH23-ST-4,SS3(5-6')
Matrix: Soil

Collected: 2023/10/03
Shipped:
Received: 2023/10/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8972304	2023/10/11	2023/10/13	Massarat Jan
Conductivity	AT	8972399	2023/10/11	2023/10/11	Leily Karimi
Moisture (Subcontracted)	BAL	8977772	N/A	2023/10/12	Surinder Singh
Sulphide in Soil	SPEC	8977771	N/A	2023/10/12	Bailey Morrison
pH CaCl2 EXTRACT	AT	8975197	2023/10/12	2023/10/12	Taslima Aktar
Redox Potential	COND	8972059	2023/10/11	2023/10/12	Gurparteek KAUR
Resistivity of Soil		8967955	2023/10/11	2023/10/11	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8972308	2023/10/11	2023/10/13	Alina Dobreanu

Bureau Veritas ID: XFJ270 Dup
Sample ID: BH23-ST-4,SS3(5-6')
Matrix: Soil

Collected: 2023/10/03
Shipped:
Received: 2023/10/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	8975197	2023/10/12	2023/10/12	Taslima Aktar

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	10.0°C

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**
8972059	Redox Potential	2023/10/12			102	95 - 105			4.9	35
8972304	Soluble (20:1) Chloride (Cl-)	2023/10/13	NC	70 - 130	97	70 - 130	<20	ug/g	8.4	35
8972308	Soluble (20:1) Sulphate (SO4)	2023/10/13	NC	70 - 130	97	70 - 130	<20	ug/g	8.5	35
8972399	Conductivity	2023/10/11			103	90 - 110	<2	umho/cm	1.8	10
8975197	Available (CaCl2) pH	2023/10/12			100	97 - 103			0.68	N/A
8977771	Sulphide	2023/10/12	117	75 - 125	111	75 - 125	<0.5	mg/kg	4.7	30
8977772	Moisture-Subcontracted	2023/10/12					<0.30	%		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Anastassia Hamanov, Scientific Specialist

Veronica Falk, B.Sc., P.Chem., QP, Scientific Specialist, Organics

Suwan (Sze Yeung) Fock, B.Sc., Scientific Specialist

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REC'D IN LONDON

REC'D IN LONDON

CHAIN OF CUSTODY RECORD

ENV COC - 00014v3

Page ____ of ____

905-793-9800

Invoice Information	Invoice to (requires report) ☐	Report Information (if differs from invoice)		Project Information	
Company:	#17488 exp Services Inc.	Company:	exp Services Inc.	Quotation #:	
Contact Name:	Accounts Payable	Contact Name:	Daniel Mroz	P.O. #/ AFE#:	
Street Address:	1595 Clark Blvd.	Street Address:		Project #:	ADM-22006096-A4
City:	Brampton Prov: ON Postal Code: L6T 4V1	City: Prov:	Postal Code:	Site #:	
Phone:	[illegible]	Phone:	519-317-6526	Site Location:	Shining Tree / Foleyet
Email:	AP@exp.com	Email:	daniel.mroz@exp.com	Site Location Province:	
Copies:		Copies:	silvana.micic@exp.com	Sampled By:	

06-Oct-23 15:06

Patricia Legette

C3V1572

WP ENV-748

Regulatory Criteria

REG 153: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ Res/Park ☐ Ind/Comm ☐ Agri/other ☐ Med/Fine ☐ Course ☐ For RSC

OTHER: ☐ CCME ☐ Reg 558* *min 3 day TAT ☐ MISA ☐ PWQO ☐ Reg 406, Table: ____ ☐ Sanitary Sewer Bylaw ☐ Storm Sewer Bylaw Municipality ____ ☐ Other: ____

Include Criteria on Certificate of Analysis (check if yes): ☐

SAMPLES MUST BE KEPT COOL (<10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

Analyses (columns 1–22): 1 FIELD FILTERED; 2 FIELD PRESERVED; 3 LAB FILTRATION REQUIRED; 4 BTEX/ F1; 5 F2 - F4; 6 VOCs; 7 Reg 153 metals and inorganics; 8 Reg 153 ICPMS metals; 9 Reg 153 metals (Hg, Cr VI, ICPMS metals, HWS - B); 10 Corrosivity Suite; 11–20 [blank]; 21 # OF CONTAINERS SUBMITTED; 22 HOLD - DO NOT ANALYZE

#	Sample Identification	YY	MM	DD	HH	MM	Matrix	10 Corrosivity Suite
1	BH23-F-2, SS3 (5-7')	23	09	26	17	00		X
2	BH23-ST-4, SS3 (5-6')	23	10	03	10	38		X
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Regular Turnaround Time (TAT): ☐ 5 to 7 Day ☐ 10 Day

Rush Turnaround Time (TAT) Surcharges apply: ☐ Same Day ☐ 1 Day ☐ 2 Day ☐ 3 Day ☐ 4 Day

Date Required: YY MM DD

Comments

*UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS AND CONDITIONS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/TERMS-AND-CONDITIONS OR BY CALLING THE LABORATORY LISTED ABOVE TO OBTAIN A COPY

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present		✓		9	11	10
Seal intact		✓				
Cooling media present	✓					

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present		✓		9	9	9
Seal intact		✓				
Cooling media present	✓					

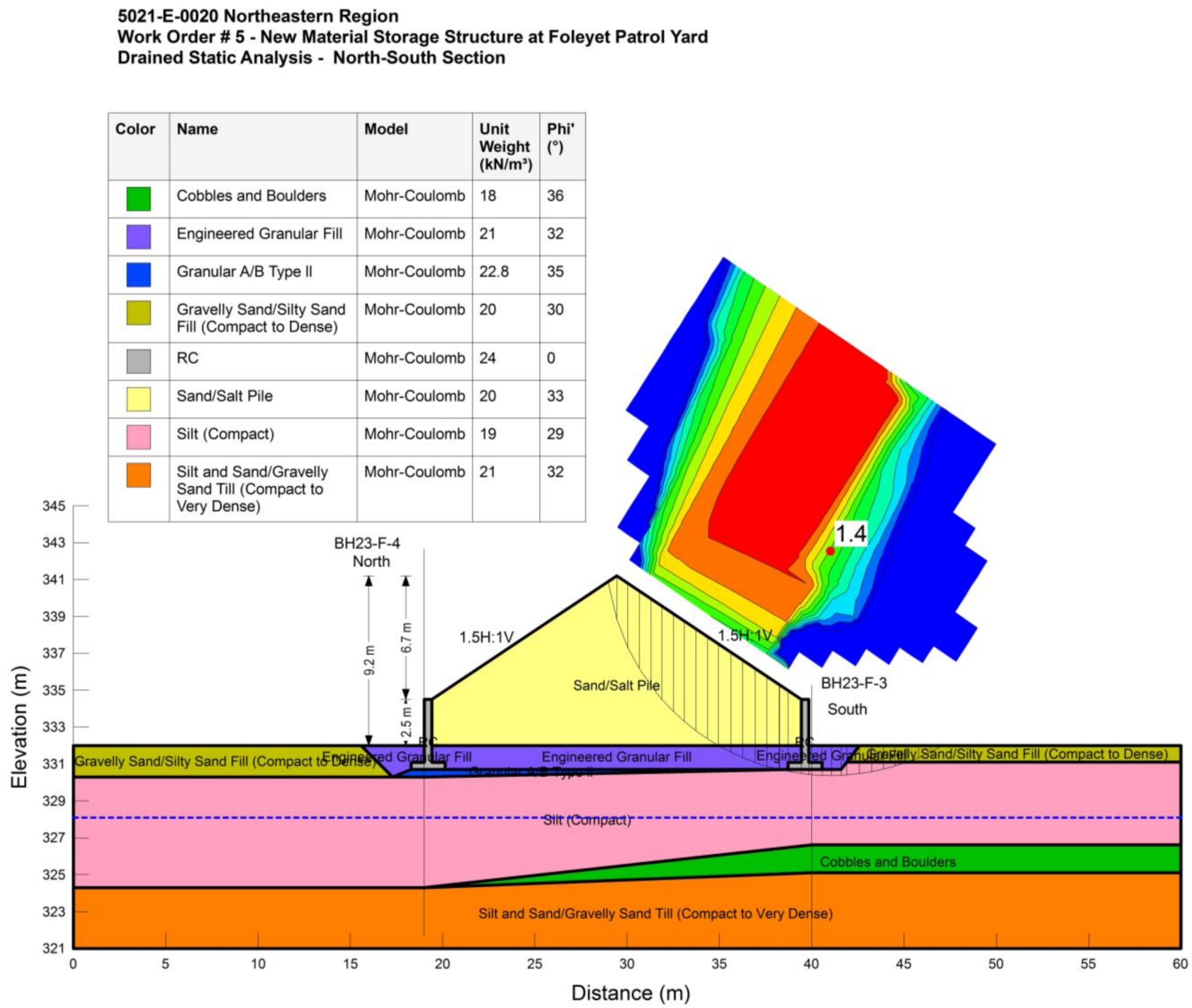
LAB USE ONLY	Yes	No	°C	1	2	3
Seal present						
Seal intact						
Cooling media present						

Temperature reading by:

	Relinquished by: (Signature/ Print)	YY	MM	DD	HH	MM	Received by: (Signature/ Print)	YY	MM	DD	HH	MM	Special instructions
1	[signature] Daniel Mroz	23	10	06	15	05	[signature] SOOMYA RAGAMONI	2023	10	06	15	06	
2							[signature] [illegible]	2023	10	06	19	16	

[illegible]

Appendix E –
Slope Stability Analyses



Color	Name	Model	Unit Weight (kN/m³)	Phi' (°)
(green)	Cobbles and Boulders	Mohr-Coulomb	18	36
(purple)	Engineered Granular Fill	Mohr-Coulomb	21	32
(blue)	Granular A/B Type II	Mohr-Coulomb	22.8	35
(olive)	Gravelly Sand/Silty Sand Fill (Compact to Dense)	Mohr-Coulomb	20	30
(grey)	RC	Mohr-Coulomb	24	0
(light yellow)	Sand/Salt Pile	Mohr-Coulomb	20	33
(pink)	Silt (Compact)	Mohr-Coulomb	19	29
(orange)	Silt and Sand/Gravelly Sand Till (Compact to Very Dense)	Mohr-Coulomb	21	32

Figure E1: Slope stability analysis of new material storage building – N-S section, west side wall – drained static analysis

5021-E-0020 Northeastern Region
Work Order # 5 - New Material Storage Structure at Foleyet Patrol Yard
Drained Seismic Analysis - North-South Section

Color	Name	Model	Unit Weight (kN/m³)	Phi' (°)
Green	Cobbles and Boulders	Mohr-Coulomb	18	36
Purple	Engineered Granular Fill	Mohr-Coulomb	21	32
Blue	Granular A/B Type II	Mohr-Coulomb	22.8	35
Olive	Gravelly Sand/Silty Sand Fill (Compact to Dense)	Mohr-Coulomb	20	30
Grey	RC	Mohr-Coulomb	24	0
Light yellow	Sand/Salt Pile	Mohr-Coulomb	20	33
Pink	Silt (Compact)	Mohr-Coulomb	19	29
Orange	Silt and Sand/Gravelly Sand Till (Compact to Very Dense)	Mohr-Coulomb	21	32

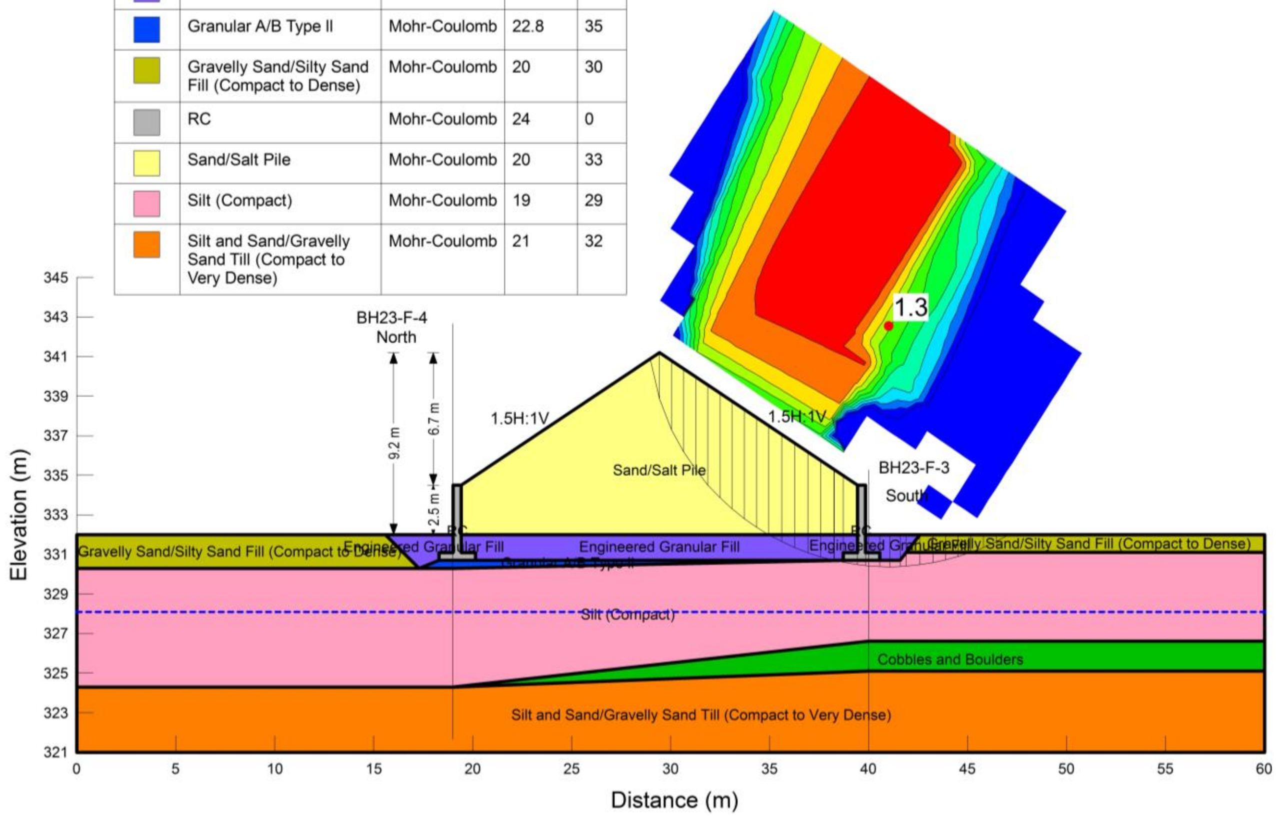


Figure E2: Slope stability analysis of new material storage building – N-S section, west side wall – drained seismic analysis

5021-E-0020 Northeastern Region
Work Order # 5 - New Material Storage Structure at Foleyet Patrol Yard
Drained Static Analysis - East-West Section

Color	Name	Model	Unit Weight (kN/m³)	Phi' (°)
Green	Cobbles and Boulders	Mohr-Coulomb	18	36
Purple	Engineered Granular Fill	Mohr-Coulomb	21	32
Olive	Gravelly Sand/Silty Sand Fill (Compact to Dense)	Mohr-Coulomb	20	30
Grey	RC	Mohr-Coulomb	24	0
Light yellow	Sand/Salt Pile	Mohr-Coulomb	20	33
Pink	Silt (Compact)	Mohr-Coulomb	19	29
Orange	Silt and Sand/Gravelly Sand Till (Compact to Very Dense)	Mohr-Coulomb	21	32

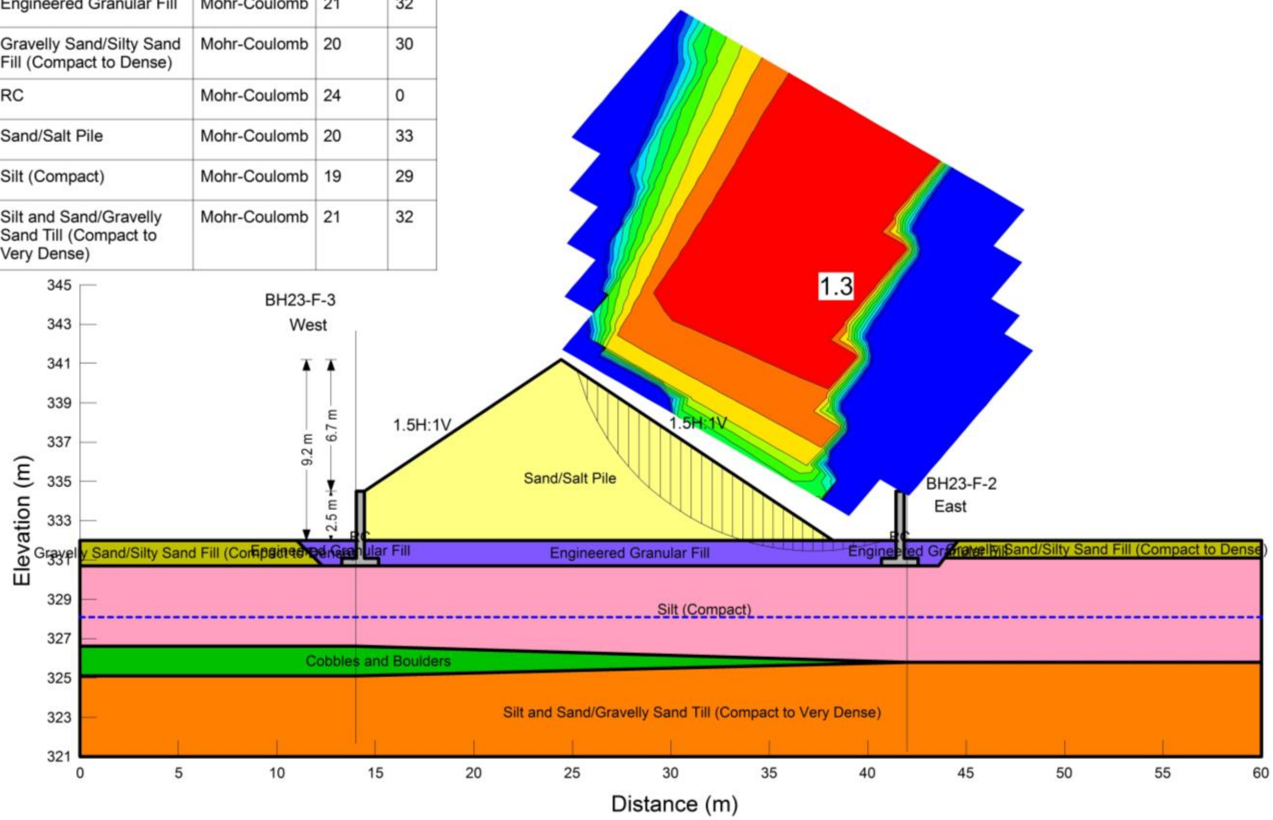


Figure E3: Slope stability analysis of new material storage building – E-W section, south side wall – drained static analysis

5021-E-0020 Northeastern Region
Work Order # 5 - New Material Storage Structure at Foleyet Patrol Yard
Drained Seismic Analysis - East-West Section

Color	Name	Model	Unit Weight (kN/m³)	Phi' (°)
Green	Cobbles and Boulders	Mohr-Coulomb	18	36
Purple	Engineered Granular Fill	Mohr-Coulomb	21	32
Olive	Gravelly Sand/Silty Sand Fill (Compact to Dense)	Mohr-Coulomb	20	30
Grey	RC	Mohr-Coulomb	24	0
Light yellow	Sand/Salt Pile	Mohr-Coulomb	20	33
Pink	Silt (Compact)	Mohr-Coulomb	19	29
Orange	Silt and Sand/Gravelly Sand Till (Compact to Very Dense)	Mohr-Coulomb	21	32

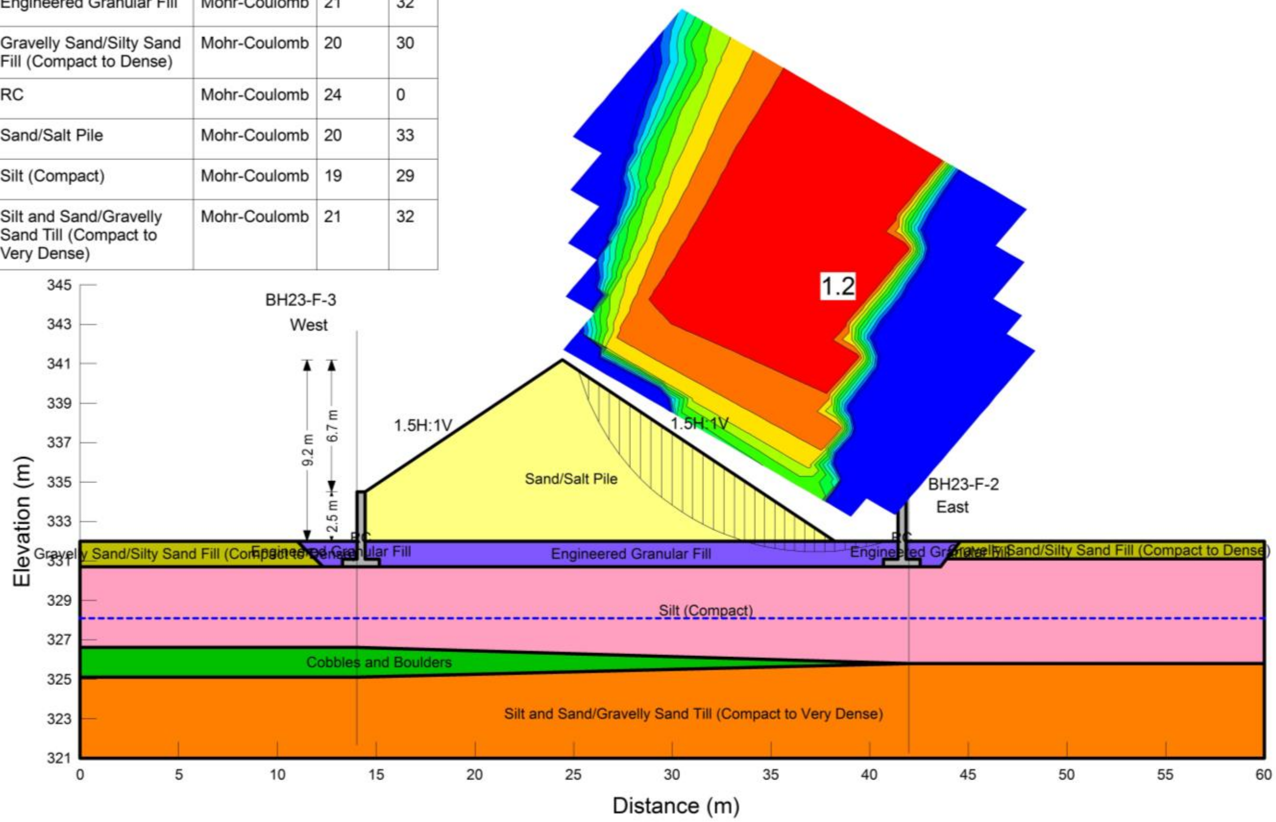
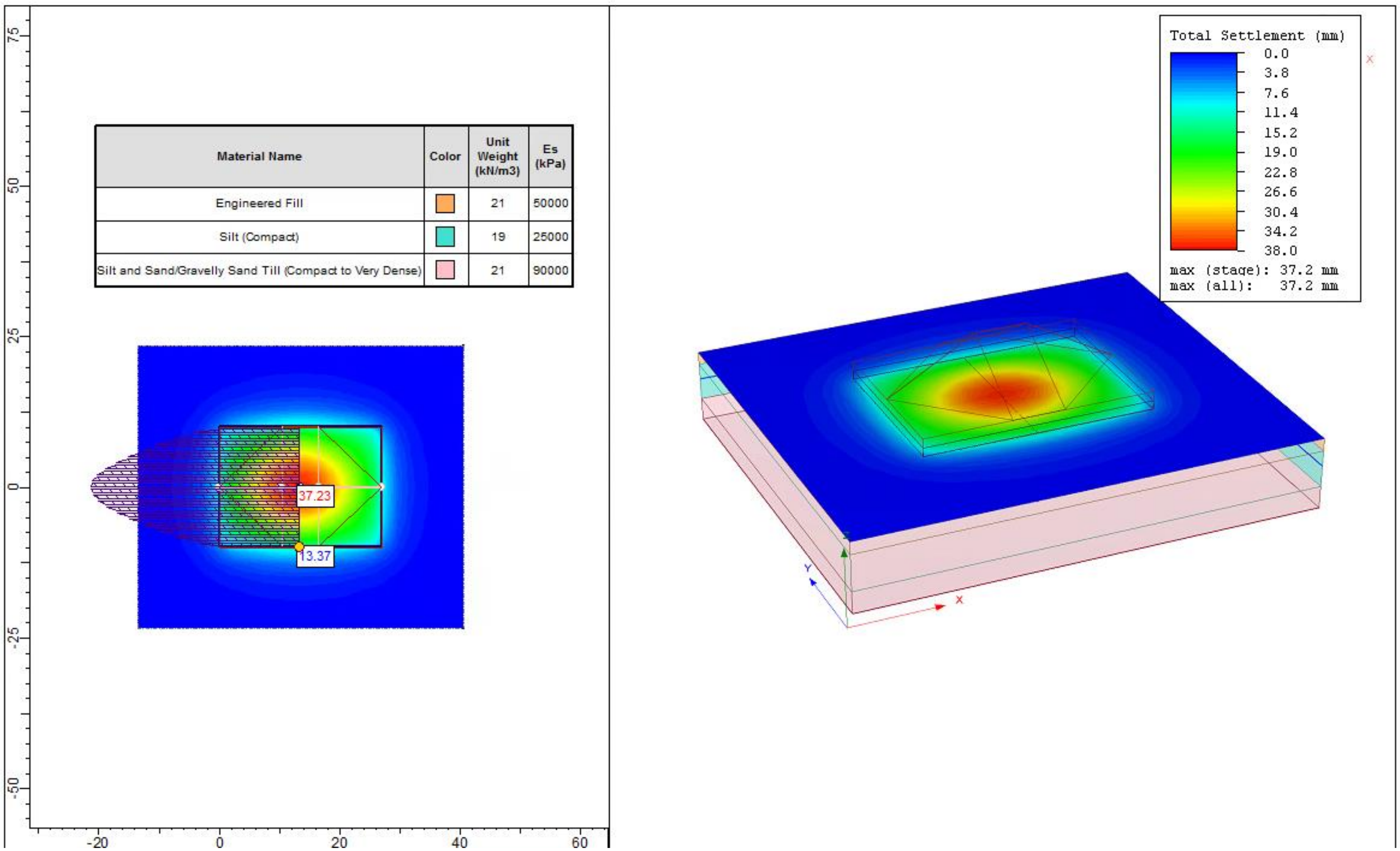


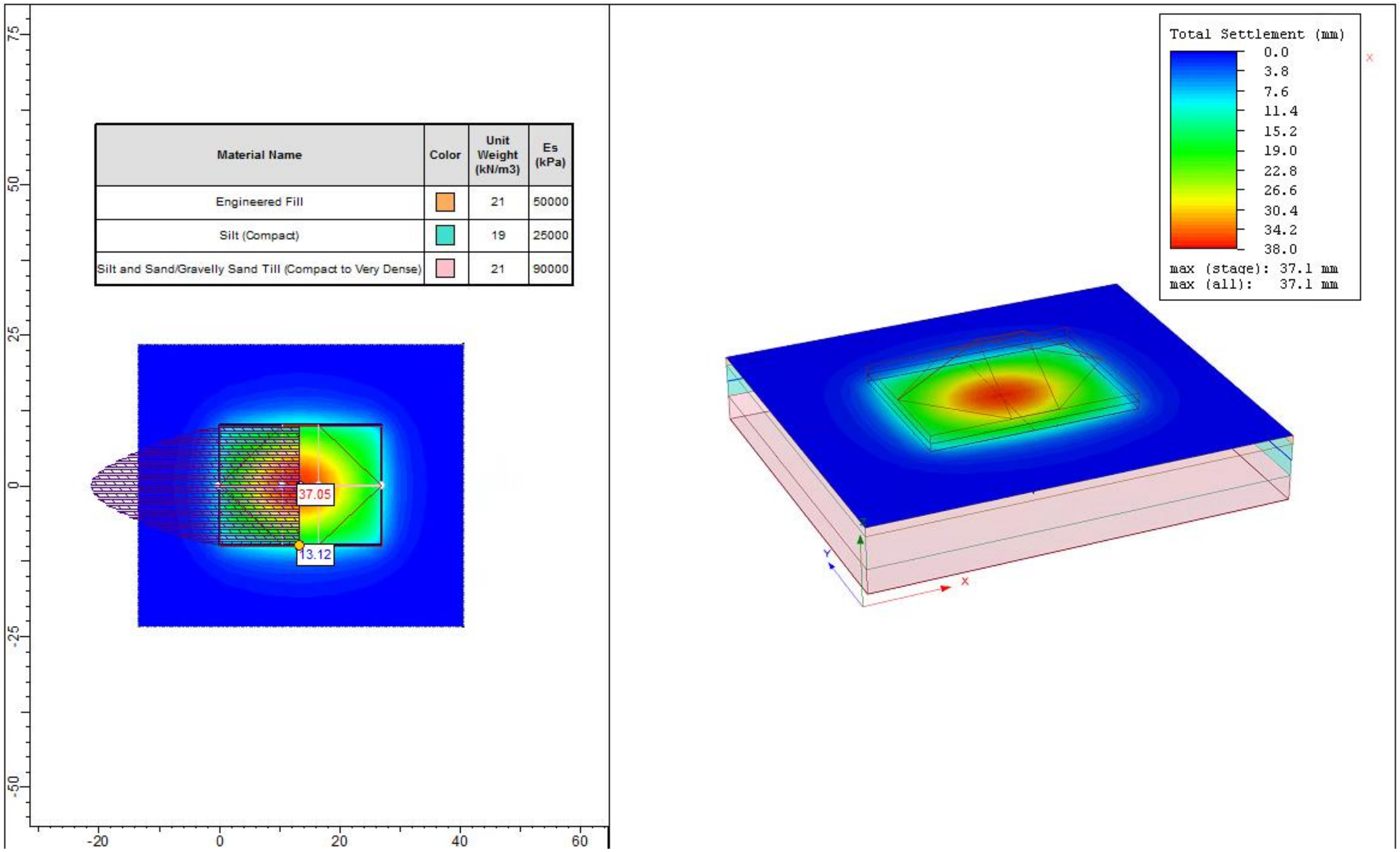
Figure E4: Slope stability analysis of new material storage building – E-W section, south side wall – drained seismic analysis

Appendix F –
Settlement Analyses



Material Name	Color	Unit Weight (kN/m3)	Es (kPa)
Engineered Fill		21	50000
Silt (Compact)		19	25000
Silt and Sand/Gravelly Sand Till (Compact to Very Dense)		21	90000

exp.	*Project:* Foleyet Patrol Yard	
	Analysis Description: Full loading (North side) – **Total Settlement**	
	Figure No: F1	*Company:* EXP Services Inc.
	Date: November, 2023	*File Name:* Settlement Analysis – Assignment 5



Material Name	Color	Unit Weight (kN/m3)	Es (kPa)
Engineered Fill		21	50000
Silt (Compact)		19	25000
Silt and Sand/Gravelly Sand Till (Compact to Very Dense)		21	90000

exp.		
	Project: Foleyet Patrol Yard	
	Analysis Description: Full Loading (South side) – **Total Settlement**	
	Figure No: F2	*Company:* EXP Services Inc.
	Date: November, 2023	*File Name:* Settlement Analysis – Assignment 5

Appendix G –
Seismic Hazard Calculation

Government of Canada Gouvernement du Canada

2020 National Building Code of Canada Seismic Hazard Tool

This application provides seismic values for the design of buildings in Canada under Part 4 of the National Building Code of Canada (NBC) 2020 as prescribed in Article 1.1.3.1. of Division B of the NBC 2020.

Seismic Hazard Values

User requested values

Code edition	NBC 2020
Site designation X_S	X_D
Latitude (°)	48.257
Longitude (°)	-82.444

Please select one of the tabs below.

NBC 2020 | Additional Values | Plots | API | Background Information

The 5%-damped spectral acceleration (S_a(T,X), where T is the period, in s, and X is the site designation) and peak ground acceleration (PGA(X)) values are given in units of acceleration due to gravity (g, 9.81 m/s^2). Peak ground velocity (PGV(X)) values are given in m/s. Probability is expressed in terms of percent exceedance in 50 years. Further information on the calculation of seismic hazard is provided under the *Background Information* tab.

The 2%-in-50-year seismic hazard values are provided in accordance with Article 4.1.8.4. of the NBC 2020. The 5%- and 10%-in-50-year values are provided for additional performance checks in accordance with Article 4.1.8.23. of the NBC 2020.

See the *Additional Values* tab for additional seismic hazard values, including values for other site designations, periods, and probabilities not defined in the NBC 2020.

NBC 2020 - 2%/50 years (0.000404 per annum) probability

$S_a(0.2, X_D)$	$S_a(0.5, X_D)$	$S_a(1.0, X_D)$	$S_a(2.0, X_D)$	$S_a(5.0, X_D)$	$S_a(10.0, X_D)$	$PGA(X_D)$	$PGV(X_D)$
0.184	0.185	0.109	0.0503	0.0125	0.00394	0.104	0.109

The log-log interpolated 2%/50 year $S_a(4.0, X_D)$ value is : **0.0175**

▼ Tables for 5% and 10% in 50 year values

NBC 2020 - 5%/50 years (0.001 per annum) probability

$S_a(0.2, X_D)$	$S_a(0.5, X_D)$	$S_a(1.0, X_D)$	$S_a(2.0, X_D)$	$S_a(5.0, X_D)$	$S_a(10.0, X_D)$	$PGA(X_D)$	$PGV(X_D)$
0.107	0.107	0.0608	0.0269	0.00612	0.00194	0.0592	0.0587

The log-log interpolated 5%/50 year $S_a(4.0, X_D)$ value is : **0.0088**

NBC 2020 - 10%/50 years (0.0021 per annum) probability

$S_a(0.2, X_D)$	$S_a(0.5, X_D)$	$S_a(1.0, X_D)$	$S_a(2.0, X_D)$	$S_a(5.0, X_D)$	$S_a(10.0, X_D)$	$PGA(X_D)$	$PGV(X_D)$

$S_a(0.2, X_D)$	$S_a(0.5, X_D)$	$S_a(1.0, X_D)$	$S_a(2.0, X_D)$	$S_a(5.0, X_D)$	$S_a(10.0, X_D)$	$PGA(X_D)$	$PGV(X_D)$
0.066	0.0659	0.036	0.0151	0.00315	0.00099	0.0362	0.0337

The log-log interpolated 10%/50 year $S_a(4.0, X_D)$ value is : **0.0046**

Download CSV

Go back to the seismic hazard calculator form

Date modified: 2021-04-06