



## Foundation Investigation Report

*Highway 11 – 2+1 Roadway Model Project: **Site SW8***

Assignment No. 5021-E-0038

GWP 5033-22-00

Geocres No. 31L13-002

(Latitude: 46.798949; Longitude: -79.801547)

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# 1 FOUNDATION INVESTIGATION REPORT

## 1.1 Introduction

This report presents the results of the geotechnical investigation completed by EXP Services Inc. (EXP) for the proposed widening of Highway 11 and the corresponding embankment/roadway construction at site SW8. The site is located approximately 5.5 km north of the intersection of Highway 64 and Highway 11 from approximately Station 19+950 to 20+235 in the Townships of Sisk and Station 10+000 to 10+015 in the township of Olive in the District of Nipissing, Ontario (Latitude: 46.798949; Longitude: -79.801547). The work was undertaken under Agreement No. 5021-E-0038 and the terms of reference (TOR) provided by AECOM. The AutoCAD drawings for Highway 11 were also provided by AECOM.

The purpose of the investigation was to evaluate the subsurface condition along the proposed widening of Highway 11, and based on this investigation, to provide a borehole location plan, cross section subsurface profile, record of boreholes, laboratory test results, and a written description of the subsurface conditions to permit detailed design and recommendations for the construction of the new proposed embankment/roadway associated with the widening of the highway. The site specific geotechnical investigation consisted of a field investigation program including visual inspections, 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 site is located approximately 5.5 km north of the intersection of Highway 64 and Highway 11 from approximately Station 19+950 to 20+235 in the Townships of Sisk and Station 10+000 to 10+015 in the township of Olive in the District of Nipissing, Ontario. At the site, Highway 11 generally runs in the north-south direction, with a speed limit of 90 km/h (unless otherwise posted). At the site, Highway 11 is approximately 8.5 m wide with a 3.2 m wide gravel shoulder on the east side (northbound lane) and a 4.3 m wide gravel shoulder on the west side (southbound lane). In total, the existing roadway with both shoulders included is about 16.0 m wide. The elevation of the highway pavement centerline at the site ranges approximately from Elev. 292.0 m to 291.2 m from south to north as per the AutoCAD drawings provided by AECOM. The roadway embankment at SW8 is estimated to be up to 3.5 m high on the west side and 2.8 m on the east side of the highway.

The general site conditions were assessed during a site visit September 13, 2023 as well as during the field investigation works between October 30, 2023, and April 25, 2024. Select photographs of the site are presented in Appendix A. The site plan and cross-section profiles along the existing highway are shown on the drawings attached in Appendix B.

Both sides of the embankment were observed to be mostly comprised of gravel and/or grass with boulder-sized rockfill. Marshland was observed on both sides of the embankment with vegetation consisting primarily of large conifers and wild bushes. In general, the highway is founded on top of a built-up embankment while the natural terrain in the surrounding area is relatively flat. No signs of sinkholes/instabilities were observed on the SW8 section of Highway 11. Bedrock outcrops were observed on the north and south end of the site beyond the extent of the drilled boreholes.



Photographs 1 to 6 in Appendix A shows the site and activities during drilling photographed between March and April 2024 by EXP. Photograph 1 shows the general existing roadway surface and the shoulder, embankment side slope, and ground conditions/vegetation beyond embankment toe along the NBL side. Photographs 2 and 3 show the existing embankment side slope and ground conditions/vegetation along the SBL side as well as the overhead power lines running adjacent to the SBL. Photograph 4 shows rockfill which is visible along the WBL side approximately between borehole BH8-12 and BH8-13. Photograph 5 shows the drilling of borehole BH8-4 which required the use of mat for access, while Photograph 6 shows the drilling of borehole BH8-9 with the rig placed directly on the ground surface.

### 1.2.2 Geological Setting

According to the Ministry of Northern Development and Mines, Map 2555 (Quaternary Geology of Ontario, East-Central Sheet, 1991) the surface conditions in the vicinity of the project area are expected to consist of glaciofluvial outwash deposits comprised of gravel and sand, including proglacial river and deltaic deposits, and Precambrian bedrock: undifferentiated igneous and metamorphic rock. The bedrock could be exposed at the surface or covered by a discontinuous, thin layer of drift. According to Map 2543 (Bedrock Geology of Ontario, East-Central Sheet, 1991), the bedrock geology of the site is of migmatitic rocks and gneisses of undetermined protolith: commonly layered biotite gneisses and migmatites; locally includes quartzofeldspathic gneisses, orthogneisses, and paragneisses.

### 1.3 Previous Investigations

There are no available previous geotechnical reports at the location of the site in the MTO GEOCRETS library; the nearest available reports on Highway 11 are approximately 5.9 km south and 4.4 km north, respectively, from the site:

- Geocres No. 31L-062: “Foundation Investigation Report for Marian Creek Culvert Extension, Proposed Widening of Highway 11, W.P. 60-87-00, Site 43-360, District 17, Sudbury”, Ministry of Transportation Ontario, Engineering Materials Office, Foundation Design Section, dated August 10, 1993.
- Geocres No. 31L-140: “Supplementary Preliminary Foundation Investigation Report for Re-Alignment of Highway 11 at Robin Creek, Sudbury Area, Agreement 5004-E-0058 (Assignment #7)”, Project: SPT1151G, Prepared by Shaheen & Peaker Ltd., dated April 26, 2006.
- Geocres No. 31L-141: “Foundation Investigation Report, Preliminary Field Investigation for Re-Alignment of Highway 11 at Three Locations Between Hwy 64 and Town of Latchford, Agreement 5004-E-0058 (Assignment #3)”, Project: SPT1151C, Prepared by Shaheen & Peaker Ltd., dated December 12, 2005.

### 1.4 Investigation Procedures

#### 1.4.1 Site Investigation and Field Testing

A site reconnaissance was conducted by an EXP representative on September 13, 2023 to evaluate the general site conditions for the proposed borehole locations.

The site investigation for the three (3) roadway boreholes was performed on between October 30 to November 1, 2023 while the investigation of the eleven (11) off-road boreholes was performed between March 4 and 12, 2024 along the east side and April 16 to 25 2024 along the west side of Highway 11. In total, the entire field program consisted of drilling fourteen (14) sampled boreholes, numbered BH1-1 to BH1-14. The boreholes were strategically located along the highway and slightly beyond the footprint of the proposed expansion to provide subsurface information for the widening of the highway.

Roadway boreholes BH8-2 and BH8-6 were advanced on the east side (northbound lane) of the highway while BH8-11 was advanced on the west side (southbound lane). Boreholes BH8-1, BH8-3 to BH8-5, and BH8-7 were advanced off-road beyond the toe of the existing embankment on the east side of the highway while boreholes BH8-8 to BH8-10 and BH8-12 to BH8-14 were advanced off-road beyond the toe of the existing embankment on the west side of the highway.

The locations of the boreholes drilled during this investigation are shown on Drawing 1 in Appendix B. Roadway boreholes BH8-2, BH8-6 and BH8-11 were advanced to depths of between 8.0 m and 10.4 m below ground surface. East side off-road boreholes BH8-1, BH8-3 to BH8-5, and BH8-7 were advanced to depths between 6.2 m and 14.9 m below ground surface and west side off-road boreholes BH8-8 to BH8-10 and BH8-12 to BH8-14 were advanced to depths between 5.4 m and 13.1 m below ground surface.

The roadway boreholes drilled during this fieldwork were advanced using a truck mounted CME 75 drill rig, while the off-road boreholes were advanced using a track mounted CME55 drill rig, both operated by specialist drilling contractor, Marathon Drilling Ltd. All drill rigs were equipped with hollow stem augers, NW casing/NQ coring or HW casing/HQ coring, and standard soil sampling equipment. Due to the relatively steep highway embankments with limited access for the drill rig and swamp conditions, access (swamp) mats were used to create access to and a stable working surface for off-road boreholes and were provided and installed by Northern Mat & Bridge. Traffic control was provided by Demora Construction Services Inc.

The borehole locations (referenced to the MTM NAD83 Zone 10) and their ground surface elevations were surveyed by EXP personnel using a Trimble DA2 GNSS receiver with Trimble Catalyst GNSS positioning, having an accuracy of  $\pm 0.1$  m in the horizontal and vertical directions. Elevations for each borehole were referenced from the benchmark "HCP 305", which was a stake located on the northbound lane shoulder at Elev. 291.027 m by the surveyor. Ground surface elevations of the boreholes are summarized in Table 1.1 below.

During the drilling of the boreholes, a combination of Standard Penetration Tests (SPT), thin-walled (Shelby) tubes, and rock coring was attempted to obtain soil and rock samples. Soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586) at intervals ranging from 0.75 m to 1.5 m in depth, as 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. 103) and used to provide an assessment of in-situ consistency of cohesive soils or compactness of non-cohesive soils. The SPT "N" values taken within the particles larger than diameter of split spoon sampler may not be reliable and collected samples are possibly not representative of the layer. Field vane shear tests (FVST) were conducted using a standard MTO vane at regular intervals where very soft to stiff cohesive materials were encountered. The original field (uncorrected) undrained shear strengths measured with the vane are presented on the borehole logs. Where very soft to firm soils were encountered, thin-walled (Shelby) tube samples were taken. When a hard stratum was reached (refusal of split spoon), sampling of hard material was performed by diamond core drilling using a 1.5 m long NQ double tube wireline core barrel.

Where possible, groundwater level measurements were carried out in the boreholes before coring and at the completion of the boreholes, in accordance with MTO guidelines. However, all boreholes at this site were advanced using diamond coring procedures. Water was used during advancement of cores from the ground surface, therefore groundwater was not measured in boreholes due to the drilling method. A standpipe piezometer was installed in BH8-4 and BH8-10 to permit monitoring of the groundwater level on the east and west side of Hwy 11, respectively. The recorded groundwater levels are presented in the borehole log sheets in Appendix C. All other drilled 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) upon completion of drilling.

The fieldwork was supervised by an EXP geotechnical representative who directed the drilling and sampling operations, 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 recovered soil samples were placed in labelled moisture-proof bags and returned to EXP's laboratory for additional visual, textual, and olfactory examination, and selective testing. The rock cores were placed in wooden core boxes and photographed as shown in Appendix E.

Table 1.1. Summary of boreholes completed

Borehole No.	Location	Location (MTM NAD 83 Zone 10)		Latitude	Longitude	Ground Surface Elevation <sup>1</sup> (m)	Borehole Depth <sup>2</sup> (m)
		Northing	Easting				
BH8-1	Off-road beyond toe of existing slope: east side of highway	5184571.2	281810.4	46.800292	-79.801181	289.3	6.9
BH8-2	East shoulder of Highway 11	5184509.6	281786.9	46.799736	-79.801487	291.4	10.4
BH8-3	Off-road beyond toe of existing slope: east side of highway	5184477.3	281799.8	46.799447	-79.801316	290.3	10.4
BH8-4	Off-road beyond toe of existing slope: east side of highway	5184425.3	281798.4	46.798979	-79.801331	289.9	13.4
BH8-5	Off-road beyond toe of existing slope: east side of highway	5184376.4	281797.6	46.798539	-79.801340	289.2	14.9
BH8-6	East shoulder of Highway 11	5184324.4	281776.8	46.798070	-79.801610	291.9	8.0
BH8-7	Off-road beyond toe of existing slope: east side of highway	5184297.4	281794.2	46.797828	-79.801381	289.3	6.2
BH8-8	Off-road beyond toe of existing slope: west side of highway	5184557.5	281763.9	46.800167	-79.801790	289.6	5.4
BH8-9	Off-road beyond toe of existing slope: west side of highway	5184511.6	281765.0	46.799754	-79.801774	289.5	7.2
BH8-10	Off-road beyond toe of existing slope: west side of highway	5184470.2	281763.6	46.799382	-79.801790	289.7	13.1
BH8-11	West shoulder of Highway 11	5184422.8	281775.6	46.798955	-79.801631	291.2	10.1

Borehole No.	Location	Location (MTM NAD 83 Zone 10)		Latitude	Longitude	Ground Surface Elevation <sup>1</sup> (m)	Borehole Depth <sup>2</sup> (m)
		Northing	Easting				
BH8-12	Off-road beyond toe of existing slope: west side of highway	5184374.3	281755.1	46.798518	-79.801896	289.0	13.0
BH8-13	Off-road beyond toe of existing slope: west side of highway	5184328.2	281747.1	46.798104	-79.801999	288.8	5.4
BH1-14	Off-road beyond toe of existing slope: west side of highway	5184276.5	281740.9	46.797638	-79.802077	288.5	7.7

Notes:

1. The ground surface elevations are referenced from HCP 305.
2. Depths are relative to ground surface.

#### 1.4.2 Laboratory Testing

All soil and rock samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content on all soil samples and particle size distribution for approximately 25% of the collected soil samples. Atterberg limits testing was done in conjunction with grain size distribution tests on select samples. All 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 and Atterberg limits are presented graphically in Appendix D.

### 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. 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 (SPT). 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.

Below the roadway, the subsurface conditions encountered within the investigated depths of the geotechnical investigation indicate the following subsurface sequence: cohesionless fill consisting of varying amounts of predominantly sand and gravel followed by rockfill, underlain by native clayey silt or sand and gravel over glacial till comprised of cobbles and boulders in a silt, sand, and gravel soil matrix followed by bedrock.

At the toe of the embankment along the east and west side of the highway, the encountered subsurface conditions were observed to generally consist of organic materials (topsoil, peat, organic silt) over clayey silt followed by glacial till comprised of cobbles and boulders in a silt, sand, and gravel soil matrix underlain by bedrock. The bedrock was

relatively shallow at the north and south extents of the site, while the organic layers (particularly peat) layers and clayey silt were significantly deeper towards the center of the site.

A detailed description of the subsurface conditions encountered is discussed further in subsequent sections.

### 1.5.1 Subsoils

#### 1.5.1.1 Asphalt Treatment

Asphalt treatment, approximately 100 mm to 175 mm thick, was encountered at the ground surface of borehole BH8-2 and BH8-6. Asphalt thicknesses may further vary beyond the borehole location.

#### 1.5.1.2 Topsoil

Topsoil, approximately 75 mm to 760 mm thick, was encountered at the ground surface of boreholes BH8-1, BH8-3, BH8-4, BH8-8 to BH8-10, BH8-13, and BH8-14.

Laboratory testing performed on selected samples consisted of four (4) moisture content tests. The test results are as follows:

Moisture Content:

- 50% to 396%

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

#### 1.5.1.3 Peat

Peat was encountered at the ground surface of boreholes BH8-5, BH8-7, and BH8-12, below topsoil in boreholes BH8-4 and BH8-10, and below the sand and gravel fill in borehole BH8-3. The depths and elevations of this layer encountered are listed in Table 1.2.

Table 1.2. Summary of peat

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-3	289.5	286.9	0.8	2.6
BH8-4	289.1	284.6	0.8	4.5
BH8-5	289.2	284.2	0.0	5.0
BH8-7	289.3	289.1	0.0	0.2

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-10	289.6	286.9	0.1	2.7
BH8-12	289.0	284.6	0.0	4.4

Notes:

1. The elevations are referenced from HCP 305.
2. Depths are relative to ground surface.

The peat encountered at the site ranged from fibrous to amorphous. The material was generally brown to black in colour and wet to saturated. The SPT “N” values obtained within this material ranged from WH (weight of hammer) to 5 blows per 0.3 m penetration suggesting that this layer was very soft to firm in consistency, but generally very soft to soft in consistency.

Laboratory testing performed on selected samples consisted of twenty-two (22) moisture content tests and five (5) organic content tests. The test results are as follows:

Moisture Content:

- 115% to 772%
- 24% (silty sand fill layer interbedded in peat)

Organic Content:

- 18.5% to 86.8%

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

#### 1.5.1.4 Organic Silt

A layer of organic silt was encountered below the peat in boreholes BH8-5 and BH8-10. The depths and elevations of this layer encountered are listed in Table 1.3.

Table 1.3. Summary of organic silt

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-5	284.2	283.7	5.0	0.5
BH8-10	286.9	286.0	2.8	0.9

## Notes:

1. The elevations are referenced from HCP 305.
2. Depths are relative to ground surface.

The composition of this material generally consisted of a mixture of organics with silt, trace sandy to being sandy, trace clay to being clayey. The organic silt was generally brown to dark brown in colour and wet. The SPT “N” values in this layer were WH indicating that this layer was very loose in compactness.

Laboratory testing performed on selected samples consisted of two (2) moisture content tests, two (2) organic content tests, two (2) grain size distribution tests, and two (2) Atterberg limit tests. The test results are as follows:

## Moisture Content:

- 70% to 147%

## Organic Content:

- 16.1% to 42.1%

## Grain Size Distribution (organic silt layer):

- 0% gravel to 13%
- 1% sand to 38%
- 45% to 79% silt
- 4% to 20% clay

## Atterberg Limits (organic silt layer):

- Liquid Limit: 29% to 260%
- Plastic Limit: 20% to 195%
- Plasticity Index: 8% to 65%

The results of the moisture content, organic content, grain size distribution, and Atterberg limit tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test and Atterberg limit test are also provided on Figure 1 and Figure 2, respectively, in Appendix D.

### 1.5.1.5 Cohesionless Fill: Sandy Gravel/Sand and Gravel/Gravelly Sand

Cohesionless fill material consisting of varying distributions of predominantly sand and gravel was encountered below the asphalt in boreholes BH8-2 and BH8-6 at the ground surface of borehole BH8-11. The depths and elevations of this layer encountered are listed in Table 1.4.

Table 1.4. Summary of cohesionless fill: sandy gravel/sand and gravel/gravelly sand

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-2	291.2	289.9	0.2	1.3
BH8-3	290.1	289.5	0.2	0.6
BH8-6	291.8	288.5	0.1	3.3
BH8-11	291.2	289.7	0.0	1.5

Notes:

3. The elevations are referenced from HCP 305.
4. Depths are relative to ground surface.

The composition of this fill material generally consisted of sand and gravel in varying amounts with trace to some silt. A silt layer with some sand, some silt, and trace gravel was encountered in sample SS2 in borehole BH2-6 at a depth of approximately 0.8 m. The fill was generally brown to grey in colour with pink/grey gravel (BH8-6) and ranging from damp to wet. The SPT “N” values obtained within this material ranged from 7 blows per 0.3 m penetration to 104 blows per 200 mm suggesting that this layer was loose to very dense, but generally compact to very dense in compactness.

Laboratory testing performed on selected samples consisted of seven (7) moisture content tests, and four (4) grain size distribution tests. The test results are as follows:

Moisture Content:

- 3% to 15%

Grain Size Distribution:

- 8% to 51% gravel
- 15% to 55% sand
- 67% silt
- 10% clay
- 12% to 24% 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 3 in Appendix D.

#### 1.5.1.6 Rockfill

Rockfill consisting of various sized fragments of rock in a soil matrix (gravel, sand and silt sized particles) was encountered in boreholes BH8-2 and BH8-11 below the cohesionless fill layer. The depths and elevations of this layer encountered are listed in Table 1.5.

Table 1.5. Summary of rockfill

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-2	289.9	287.4	1.5	2.5
BH8-11	289.7	288.2	1.5	1.5

Notes:

1. The elevations are referenced from HCP 305.
2. Depths are relative to ground surface.

The composition of this rockfill layer generally consisted of cobble to boulder sized rockfill with silt, sand and gravel sized particles within the in-fill soil matrix. The particle size within the rockfill varies from silt to boulder size (i.e. from 0.002 mm to greater than 300 mm).

A combination of SPT and coring was carried out during the exploration of this layer. Where possible, split spoon sampling was attempted to obtain samples from this layer. However, it should be noted that in most cases, obtained samples from this layer were either not adequate or did not accurately represent the particle size distribution of this material. The SPT “N” values obtained within this layer ranged from 10 to 31 blows per 0.3 m penetration, suggesting that this layer was compact to dense in relative density.

Laboratory testing was not performed on soil samples from this layer due to minimal sample recovery during the investigation.

#### 1.5.1.7 Clayey Silt

Native clayey silt was encountered below topsoil/peat in boreholes BH8-1, BH8-3 to BH8-5, BH8-7 to BH8-9, and BH8-12 to BH8-14, below the organic silt in borehole BH8-10, below the rockfill in borehole BH8-2, and below the gravelly sand to sandy gravel fill in borehole BH8-6. The depth and elevations of this layer encountered at this borehole location are listed in Table 1.6.

Table 1.6. Summary of clayey silt layer

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-1	289.1	288.5	0.2	0.6
BH8-2	287.4	285.4	4.0	2.0
BH8-3	286.9	283.0	3.4	3.9
BH8-4	284.6	277.1	5.3	7.5
BH8-5	283.7	275.8	5.5	7.9
BH8-6	288.5	287.1	3.4	1.4
BH8-7	289.1	286.7	0.2	2.4
BH8-8	289.4	287.5	0.2	1.9
BH8-9	289.4	285.7	0.1	3.7
BH8-10	286.0	281.4	3.7	4.6
BH8-12	284.6	278.8	4.4	5.8
BH8-13	288.7	286.4	0.1	2.3
BH8-14	288.4	286.1	0.1	2.3

## Notes:

1. The elevations are referenced from HCP 305.
2. Depths are relative to ground surface.

The composition of this material generally consisted of clay and silt with generally trace gravel, trace sand, and trace organics. This layer was generally brown to grey in colour and moist to saturated. The SPT “N” values obtained within this layer ranged from WR (weight of rods) to 17 blows per 0.3 m penetration, suggesting that this layer was very soft to very stiff in consistency. In-situ vane testing with this layer measured an undrained shear strength ranging

from approximately 25 kPa to over 120 kPa indicating this material is firm to very stiff in consistency. The clayey silt layer typically increases in consistency from very soft/soft to stiff/very stiff with depth.

Laboratory testing performed on selected samples consisted of thirty-six (36) moisture content tests, five (5) organic content tests, fourteen (14) grain size distribution tests, thirteen (13) Atterberg limit tests, and three (3) unit weight tests. The test results are as follows:

**Moisture Content:**

- 17% to 67%

**Organic Content:**

- 0.5% to 7.1%

**Grain Size Distribution:**

- 0% to 1% gravel
- 1% to 4% sand
- 64% to 82% silt
- 15% to 35% clay

**Atterberg Limits:**

- Liquid Limit: 27% to 35%
- Plastic Limit: 18% to 26%
- Plasticity Index: 5% to 9%

**Unit Weight:**

- 19.3 kN/m<sup>3</sup> to 19.9 kN/m<sup>3</sup>

The results of the moisture content, organic content, grain size distribution, Atterberg limit and unit weight tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test and Atterberg limit test are also provided on Figures 4 and 5 and Figures 6 and 7, respectively, in Appendix D.

#### **1.5.1.8 Gravelly Sand / Sand and Gravel / Sandy Gravel**

Native gravelly sand / sand and gravel / sandy gravel was encountered below the clayey silt in borehole BH8-1 and BH8-7 and below the rockfill in borehole BH8-11. The depth and elevations of this layer encountered at these borehole locations are listed in Table 1.7.

Table 1.7. Summary of gravelly sand / sand and gravel / sandy gravel layer

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-1	288.5	286.6	0.8	1.9
BH8-7	286.7	285.8	2.6	0.9
BH8-11	288.2	285.9	3.0	2.3

Notes:

1. The elevations are referenced from HCP 305.
2. Depths are relative to ground surface.

The composition of this material generally consisted of sand and gravel in varying amounts with some silt. The material was generally brown to grey in colour and wet to saturated. The SPT “N” values obtained within this material ranged from 6 blows per 0.3 m penetration to 100 blows per 0.1 m penetration, suggesting that this layer was loose to very dense, but generally compact to very dense in compactness.

Laboratory testing performed on selected samples consisted of three (3) moisture content tests. The test results are as follows:

Moisture Content:

- 10% to 13%

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

#### 1.5.1.9 Glacial Till: Cobbles and Boulders

Glacial till comprised of cobbles and boulders in a silt, sand, and gravel soil matrix were encountered below the clayey silt layer in boreholes BH8-2 to BH8-5, BH8-8 to BH8-10, and BH8-14, and below the native sand and gravel in borehole BH8-11. The depths and elevations of this layer encountered at these borehole locations are listed in Table 1.8.

Table 1.8. Summary of glacial till (cobbles and boulders) layer

Borehole	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-2	285.4	282.3	6.0	3.1
BH8-3	283.0	279.9	7.3	3.1

Borehole	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)	Layer Thickness (m)
	Top	Bottom		
BH8-4	277.1	276.5	12.8	0.6
BH8-5	275.8	274.3	13.4	1.5
BH8-8	287.5	286.6	2.1	0.9
BH8-9	285.7	284.9	3.8	0.8
BH8-10	281.4	280.0	8.3	1.4
BH8-11	285.9	281.1	5.3	4.8
BH8-14	286.1	284.1	2.4	2.0

Notes:

1. The elevations are referenced from HCP 305.
2. Depths are relative to ground surface.

The composition of this layer was generally comprised of cobbles and boulders with layers of silt, sand and gravel within the soil matrix. The particle size within the layer varied from clay to boulder size (i.e., from less 0.002 mm to greater than 300 mm).

A combination of SPT and coring was carried out during the exploration of this layer. Where possible, split spoon sampling was attempted to obtain samples from this layer. However, it should be noted that in most cases, obtained samples from this layer were either not adequate or did 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.

The SPT “N” values obtained within the layers of silt/sand/gravel ranged from 24 blows per 0.3 m penetration to 100 blows per 0.08 m penetration, suggesting that these layers within the cobbles and boulders are compact to very dense. In addition, refusal due to a cobble or boulder was likely encountered when the split spoon could not penetrate 0.3 m. It is also important to note that the use of water for coring through the cobbles and boulders layer may have affected some SPT ‘N’ values measured.

Laboratory testing performed on selected samples consisted of two (2) moisture content tests, one (1) organic content test, and one (1) grain size distribution test. The test results are as follows:

Moisture Content:

- 5% to 8%

#### Organic Content:

- 4.8%

#### Grain Size Distribution:

- 49% gravel;
- 41% sand;
- 10% silt and clay;

The results of the moisture content and grain size distribution tests performed by EXP are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests performed by EXP are also provided on Figure 8 in Appendix D.

### 1.5.2 Bedrock

Bedrock was encountered beneath the clayey silt in borehole BH8-6, BH8-12, and BH8-13, below the native granular soil in boreholes BH8-1 and BH8-7, and below the cobbles and boulders in boreholes BH8-2, BH8-8 to BH8-10, and BH8-14. Elevations at the top of bedrock were between 287.1 m to 278.8 m. The bedrock was investigated by coring about 1.3 m to 4.2 m into the stratum. The bedrock surface depths and elevations encountered at these borehole locations are listed in Table 1.9. Photographs of the rock cores are included in Appendix E.

Table 1.9. Summary of bedrock

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)
	Top	Bottom	
BH8-1	286.6	282.4	2.7
BH8-2	282.3	281.0	9.1
BH8-6	287.1	283.9	4.8
BH8-7	285.8	283.1	3.5
BH8-8	286.6	284.2	3.0
BH8-9	284.9	282.3	4.6
BH8-10	280.0	276.6	9.7
BH8-12	278.8	276.0	10.2

Borehole No.	Elevation <sup>1</sup> (m)		Layer Surface Depth <sup>2</sup> (m)
	Top	Bottom	
BH8-13	286.4	283.4	2.4
BH8-14	284.1	280.8	4.4

Notes:

1. The elevations are referenced from HCP 305.
2. Depths are relative to ground surface.

Based on the bedrock NQ cores (~ core diameter 47 mm) recovered, the bedrock at the site consisted of gneiss. In general, the rock samples are described as dark grey with pink/white in colour and moderately weathered to fresh. The Rock Quality Designation (RQD) measured on the core samples typically ranged from approximately 31% to 100%, indicating a rock mass of poor to excellent quality, but generally fair to excellent quality (as per CFEM). The total core recovery (TCR) of bedrock cores ranged from 77% to 100%.

## 1.6 Groundwater and Surface Water Conditions

All boreholes at this site were advanced using diamond coring procedures. Water was used during advancement of HQ casing and NQ cores from ground surface. Therefore, groundwater was not measured in open boreholes upon completion due to the drilling method.

The groundwater levels in the boreholes were observed in piezometers. The groundwater levels measured in piezometers installed in boreholes BH8-4 and BH8-10 are shown on the borehole logs and are presented below in Table 1.10.

Table 1.10. Groundwater levels measured in piezometers encountered at SW8

Borehole No.	Date Measured	Ground Surface Elevation <sup>1</sup> (m)	Groundwater Depth <sup>2</sup> /Elevation <sup>1</sup> (m)
East Side of Embankment			
BH8-4	March 27, 2024	289.9	0.1/289.8
	April 2, 2024		0.1/289.8
	April 24, 2024		0.2/289.7
	May 15, 2024		0.2/289.7
	May 29, 2024		0.2/289.7
	June 18, 2024		0.2/289.7
West Side of Embankment			
BH8-10	April 24, 2024	289.7	1.1/288.6
	May 15, 2024		1.2/288.5
	May 29, 2024		1.2/288.5
	June 18, 2024		1.2/288.5

*Foundation Investigation and Design Report  
Highway 11, 2+1 Roadway Model Project: **Site SW8**  
Assignment No. 5021-E-0038  
Date: October 24, 2024*

*Notes:*

- 1. The elevations are referenced from HCP 305.*
- 2. Depths are relative to ground surface.*

It should be noted that fluctuations in the level of the groundwater may occur due to seasonal variations, (precipitation, snowmelt, rainfall), local soil permeability, construction remediation activities, and other related factors.



## 2 CLOSURE

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 investigations and analyses.

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 Daniel Mroz, M.E.Sc., EIT, and Silvana Micic, Ph.D., P.Eng. It was reviewed by TaeChul Kim, M.E.Sc., P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Daniel Mroz, M.E.Sc., EIT, Elvis Lu, M.Eng., Stephen Fredericks, M.Eng, P.Eng., and Amirhossein Medghalchi, M.Sc., M.Eng., EIT.

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## REFERENCES

Canadian Geotechnical Society, 2023. Canadian Foundation Engineering Manual, 5th Edition. The Canadian Geotechnical Society, British Columbia.

Canadian Standards Association (CSA), 2019. Canadian Highway Bridge Design Code and Commentary on CAN/CSA-S6-19. CSA Special Publication.

Ministry of Northern Development and Mines, Map 2555. Quaternary Geology of Ontario, East-Central Sheet, 1991

Ministry of Northern Development and Mines Map 2543. Bedrock Geology of Ontario, East-Central Sheet, 1991

Ministry of Transportation, April 2022. Guideline for MTO Foundation Engineering Services, Version 03

### **ASTM International:**

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

### **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 utilized 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



Photograph 1. Roadway surface and shoulder, embankment side slope, and ground conditions beyond embankment toe along NBL (east) side, looking north (April 22, 2024)



Photograph 2. Embankment side slope and ground conditions beyond embankment toe along SBL (west) side for north half of SW8, looking north (March 27, 2024)





Photograph 3. Embankment side slope and ground conditions beyond embankment toe along SBL (west) side for south half of SW8, looking south (March 27, 2024)



Photograph 4. Rockfill along west (SBL) side of embankment approximately between BH8-12 and BH8-13, looking southwest (March 27, 2024)





Photograph 5. Drilling of BH8-4 on mats, looking northwest (March 7, 2024)



Photograph 6. Drilling of borehole BH8-9, looking southwest (April 25, 2024)

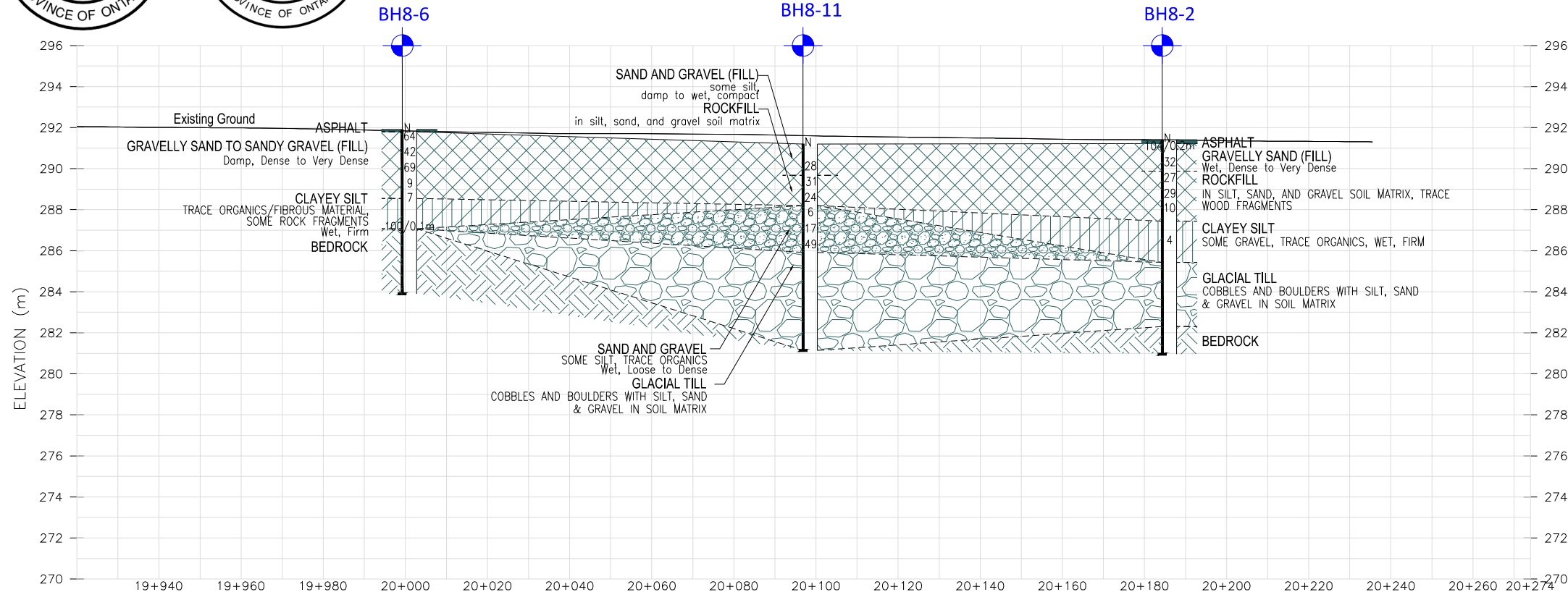
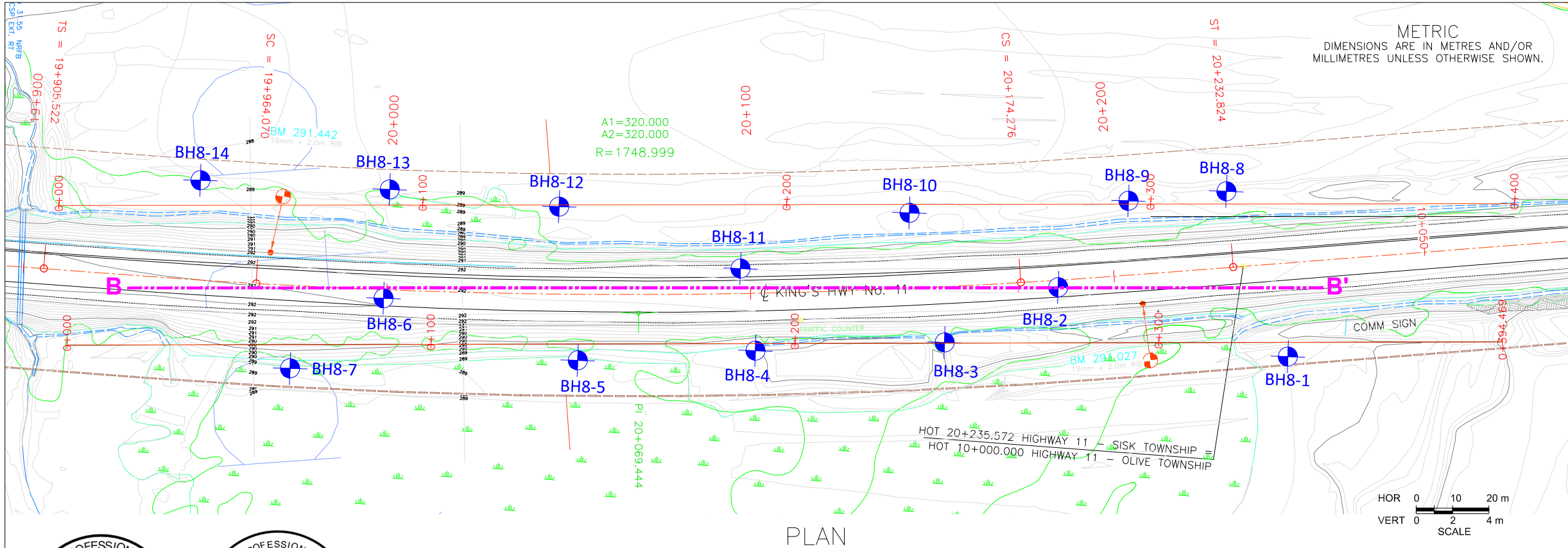


## Appendix B – Drawings





FILE NAME: \\PBRM50001\Data\_Zeus\2003-Brampton\Proposals\Projects\International\WFO Projects\WFO 5021-E-0038 - Hwy 11 with AECOM\60 Execution\64 CAD\Working drawings\SW8 - SW8 & SW11\605790011001&605690011001\_SW8\_plan & profile - V2.dwg  
MODIFIED: 2024-07-23 09:14



CONT No. 5021-E-0038  
ASSIG No.  
GWP No. 5033-22-00



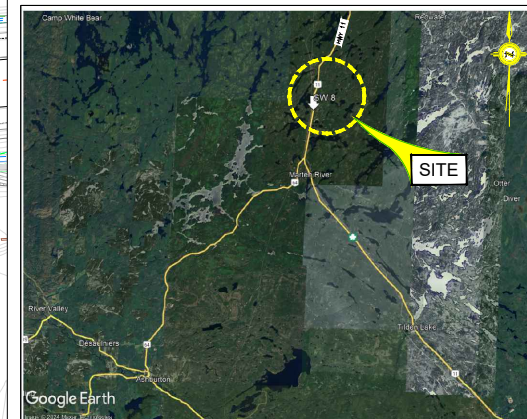
Highway 11 from Sand Dam Road Northerly 13.8 Km  
to Ellesmere Road (SW8)  
Latitude: 46.798949°; Longitude: -79.801547°

SHEET  
2

BOREHOLE LOCATION PLAN & SOIL STRATA



EXP SERVICES INC.



KEY PLAN  
N.T.S.

LEGEND

- Borehole Location (EXP)
- Water Level Upon Completion of Drilling  
(W. L. NOT STABILIZED)
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level in Piezometer (most recent)  
(W. L. STABILIZED)
- Piezometer
- HCP 305 (Benchmark)

SOIL STRATA SYMBOLS

TOPSOIL	CLAYEY SILT	SAND
WATER	SANDY SILT	SILT
ASPHALT	SANDY GRAVEL	COBBLES AND BOULDERS
FILL	SILTY SAND	BEDROCK
PEAT		

BOREHOLE COORDINATES/ NAD 83/ MTM ON-10

BH No.	ELEV.	NORTHING	EASTING
BH8-1	289.3	5184571.2	281810.4
BH8-2	291.4	5184509.6	281786.9
BH8-3	290.3	5184477.3	281799.8
BH8-4	289.9	5184425.3	281798.4
BH8-5	289.2	5184376.4	281797.6
BH8-6	291.9	5184324.4	281776.8
BH8-7	289.3	5184297.4	281794.2
BH8-8	289.6	5184567.5	281763.9
BH8-9	289.5	5184511.6	281765.0
BH8-10	289.7	5184470.2	281763.6
BH8-11	291.2	5184422.8	281775.6
BH8-12	289.0	5184374.3	281755.1
BH8-13	288.8	5184328.2	281747.1
BH8-14	288.5	5184276.5	281740.9

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.

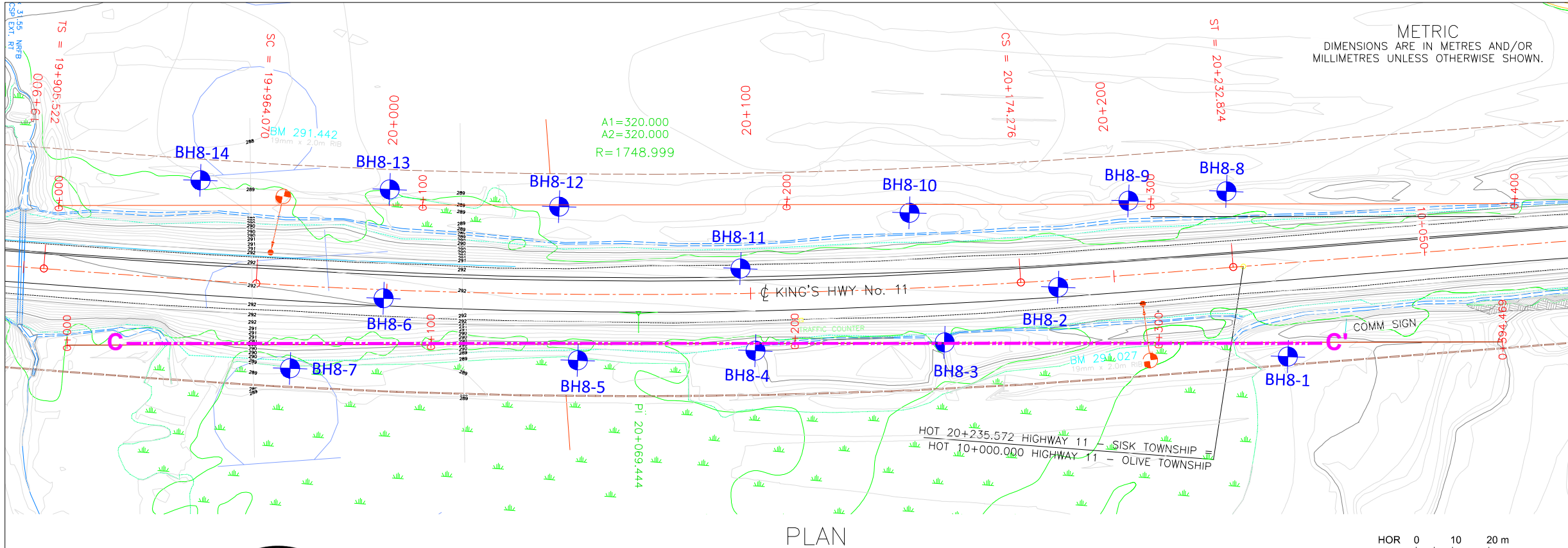
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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 the OPS Gen. Cond.

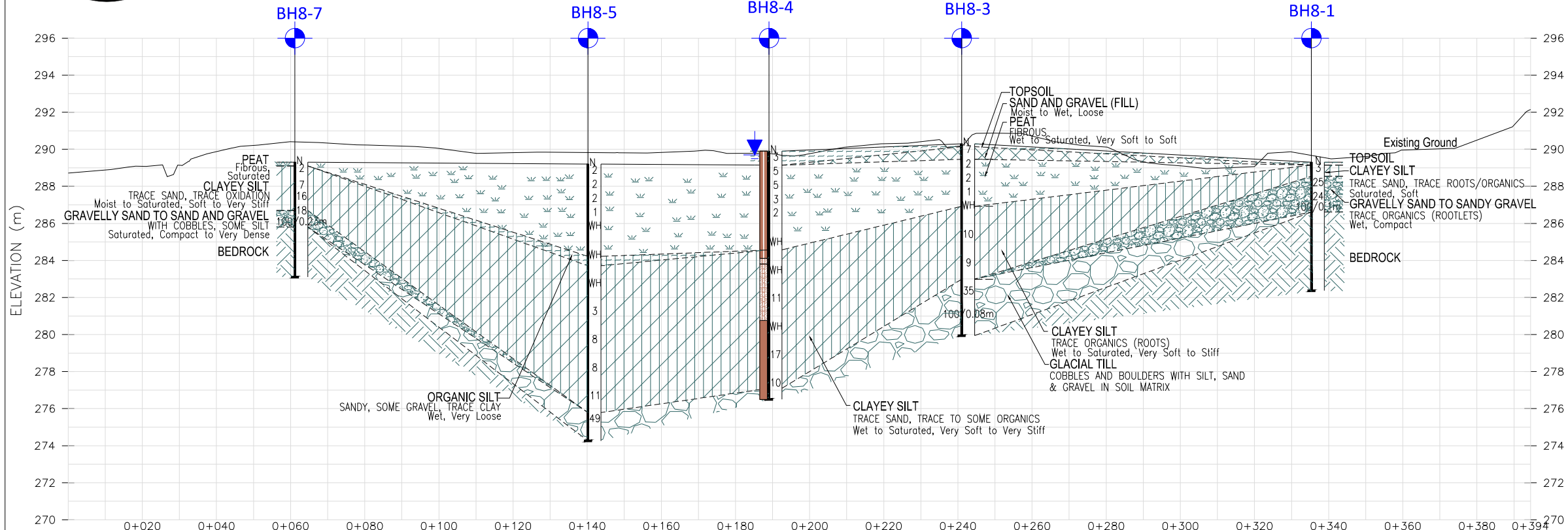
SUBMISSION FOR MTO REVIEW			
NO	DATE	BY	DESCRIPTION
PROJECT No.	ADM-23010055-A0	GEOCREs No.	31L13-002
SUBM'D SH	CHKD. TL	DATE	JULY 19, 2024 SITE SW8
DRAWN SH	CHKD. TL	APPRD SG	DWG 02



FILE NAME: \\PBRMFS001\Data\_Zeus\2003-Brampton\Proposals\Projects\International\WFO Projects\WFO 5021-E-0038 - Hwy 11 with AECOM\60 Execution\SW8 - SW8 & SW11\05790011001\05790011001\_SW8\_plan & profile - V2.dwg  
MODIFIED: 2024-07-23 09:14



PLAN



SECTION C-C'

CONT No. 5021-E-0038  
ASSIG No.  
GWP No. 5033-22-00

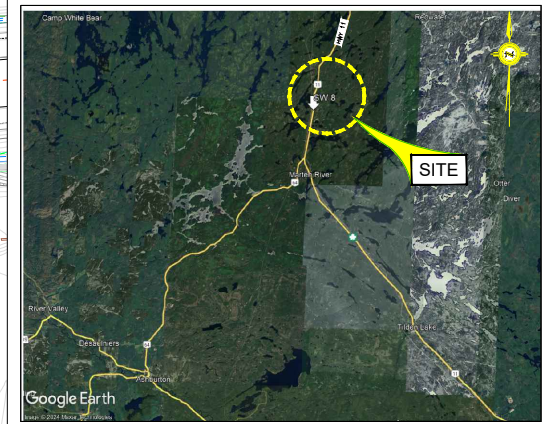
Highway 11 from Sand Dam Road Northerly 13.8 Km  
to Ellesmere Road (SW8)  
Latitude: 46.798949°; Longitude: -79.801547°

BOREHOLE LOCATION PLAN & SOIL STRATA

SHEET 3

exp.

EXP SERVICES INC.



KEY PLAN  
N.T.S.

LEGEND

- Borehole Location (EXP)
- Water Level Upon Completion of Drilling (W. L. NOT STABILIZED)
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level in Piezometer (most recent) (W. L. STABILIZED)
- Piezometer
- HCP 305 (Benchmark)

SOIL STRATA SYMBOLS			
TOPSOIL	CLAYEY SILT	SAND	
WATER	SANDY SILT	SILT	
ASPHALT	SANDY GRAVEL	COBBLES AND BOULDERS	
FILL	SILTY SAND	BEDROCK	
PEAT			

BOREHOLE COORDINATES/ NAD 83/ MTM ON-10			
BH No.	ELEV.	NORTHING	EASTING
BH8-1	289.3	5184571.2	281810.4
BH8-2	291.4	5184509.6	281786.9
BH8-3	290.3	5184477.3	281799.8
BH8-4	289.9	5184425.3	281798.4
BH8-5	289.2	5184376.4	281797.6
BH8-6	291.9	5184324.4	281776.8
BH8-7	289.3	5184297.4	281794.2
BH8-8	289.6	5184557.5	281763.9
BH8-9	289.5	5184511.6	281765.0
BH8-10	289.7	5184470.2	281763.6
BH8-11	291.2	5184422.8	281775.6
BH8-12	289.0	5184374.3	281755.1
BH8-13	288.8	5184328.2	281747.1
BH8-14	288.5	5184276.5	281740.9

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 the OPS Gen. Cond.

SUBMISSION FOR MTO REVIEW			
NO	DATE	BY	DESCRIPTION
PROJECT No.	ADM-23010055-A0	GEOCREs No.	31L13-002
SUBM'D SH	CHKD. TL	DATE	JULY 19, 2024 SITE SW8
DRAWN SH	CHKD. TL	APPRD SG	DWG 03

## 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.

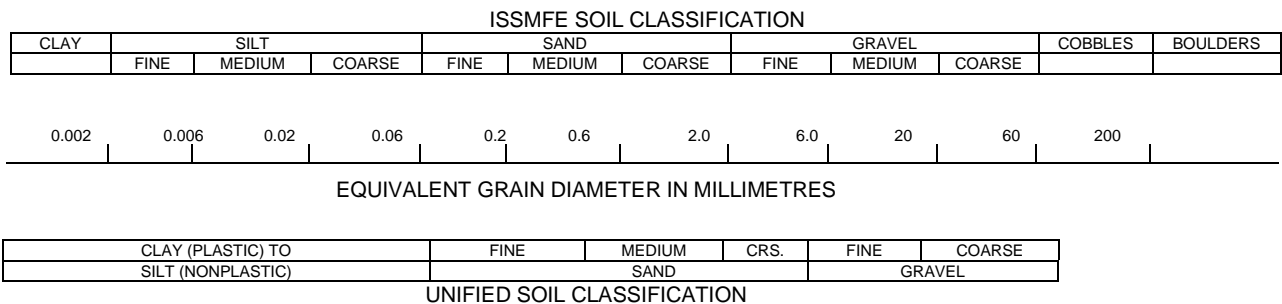
*Seam:* a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

*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.



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:

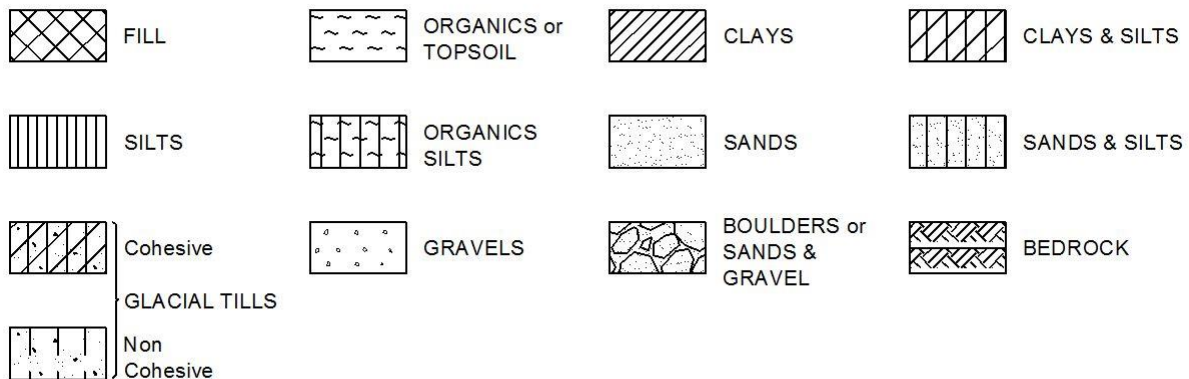
Table c: Consistency of Cohesive Soil

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



Open Borehole or Test Pit



Monitoring Well, Piezometer or Standpipe



## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	Coefficient of volume change
$c_c$	1	Compression index
$c_s$	1	Swelling index
$c_r$	1	Recompression index
$c_v$	m <sup>2</sup> /s	Coefficient of consolidation
H	m	Drainage path
$T_v$	1	Time factor
U	%	Degree of consolidation
$\sigma'_{v0}$	kPa	Effective overburden pressure
$\sigma'_p$	kPa	Preconsolidation pressure
$\tau_f$	kPa	Shear strength
$c'$	kPa	Effective cohesion intercept
$\phi'$	—°	Effective angle of internal friction
$c_u$	kPa	Apparent cohesion intercept
$\phi_u$	—°	Apparent angle of internal friction
$\tau_R$	kPa	Residual shear strength
$\tau_r$	kPa	Remoulded shear strength
$S_t$	1	Sensitivity = $c_u/\tau_r$

### PHYSICAL PROPERTIES OF SOIL

$P_s$	kg/m <sup>3</sup>	Density of solid particles
$\gamma_s$	kN/m <sup>3</sup>	Unit weight of solid particles
$\rho_w$	kg/m <sup>3</sup>	Density of water
$\gamma_w$	kN/m <sup>3</sup>	Unit weight of water
$\rho$	kg/m <sup>3</sup>	Density of soil
$\gamma$	kN/m <sup>3</sup>	Unit weight of soil
$\rho_d$	kg/m <sup>3</sup>	Density of dry soil
$\gamma_d$	kN/m <sup>3</sup>	Unit weight of dry soil
$\rho_{sat}$	kg/m <sup>3</sup>	Density of saturated soil
$\gamma_{sat}$	kN/m <sup>3</sup>	Unit weight of saturated soil
$\rho'$	kg/m <sup>3</sup>	Density of submerged soil
$\gamma'$	kN/m <sup>3</sup>	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 <sup>3</sup> /s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m <sup>3</sup>	Seepage force

Brampton, Ontario

## RECORD OF BOREHOLE No BH8-1

1 OF 1

METRIC

W.P. ADM-23010055-A0 LOCATION 5184571.2N, 281810.4E, NAD83 MTM Zone 10 ORIGINATED BY SF  
DIST NER HWY 11 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY DM  
DATUM Geodetic DATE 2024.03.12 - 2024.03.12 LATITUDE 46.800292 LONGITUDE -79.801181 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE								● QUICK TRIAXIAL		
289.3	GROUND SURFACE						20	40	60	80	100									
289.0	TOPSOIL ~150 mm thick																			
0.2	CLAYEY SILT, trace sand, trace roots/organics, brown, saturated, soft		SS1	SS	3											0 4 78 18				
288.5	GRAVELLY SAND TO SANDY GRAVEL, trace organics (rootlets), brown to grey, wet, compact																			
0.8			SS2	SS	25															
				SS3	SS	24														
				SS4	SS	100/														
286.6	- spoon bouncing on cobble, cobbles below ~2.5 m depth			NQ	0.1m/															
2.7	BEDROCK,																			
	Run 1: Start/End: 2.7 to 4.1 m Recovery: 100% RQD: 74%		RUN 1	NQ																
	Run 2: Start/End: 4.1 to 5.7 m Recovery: 100% RQD: 61%		RUN 2	NQ																
	Run 3: Start/End: 5.7 to 6.9 m Recovery: 100% RQD: 66%		RUN 3	NQ																
282.4	BOREHOLE TERMINATED AT ~ 6.9 m DEPTH																			
6.9	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

Brampton, Ontario

## RECORD OF BOREHOLE No BH8-2

1 OF 1

METRIC

W.P. ADM-23010055-A0 LOCATION 5184509.6N, 281786.9E, NAD83 MTM Zone 10 ORIGINATED BY EL  
 DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY IL  
 DATUM Geodetic DATE 2023.10.30 - 2023.10.31 LATITUDE 46.799736 LONGITUDE -79.801487 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
291.4	GROUND SURFACE						20	40	60	80	100					
290.0	ASPHALT ~175mm thick															
0.2	GRAVELLY SAND (FILL), trace asphalt fragments, brown, wet, dense to very dense		SS1	SS	104/ 0.2m		291									
289.9			SS2	SS	32		290									
289.9	ROCKFILL, in silt, sand, and gravel soil matrix, trace wood fragments		SS3	SS	27											
1.5			SS4	SS	29		289									
			SS5	SS	10		288									
287.4	CLAYEY SILT, some gravel, trace organics, wet, firm						287									
4.0			SS6	SS	4		286									
285.4	GLACIAL TILL, cobbles and boulders with silt, sand, and gravel in soil matrix			NQ			285									
6.0				NQ			284									
				NQ			283									
282.3	BEDROCK			NQ			282									
9.1	Run 1: Start/End: 9.1 to 10.4 m Recovery: 100% RQD: 55%		RUN 1	NQ			281									
281.0	BOREHOLE TERMINATED AT ~ 10.4 m DEPTH															
10.4	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.															

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

Brampton, Ontario

## RECORD OF BOREHOLE No BH8-3

1 OF 1

METRIC

W.P. ADM-23010055-A0 LOCATION 5184477.3N, 281799.8E, NAD83 MTM Zone 10 ORIGINATED BY DM  
DIST NER HWY 11 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY IL  
DATUM Geodetic DATE 2024.03.04 - 2024.03.06 LATITUDE 46.799447 LONGITUDE -79.801316 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
290.3	GROUND SURFACE						20	40	60	80	100	20	40	60		GR	SA	SI	CL	
290.0	TOPSOIL ~150 mm thick																			
0.2	SAND AND GRAVEL (FILL), brown to grey, moist to wet, loose		SS1	SS	7															
289.5																				
0.8	PEAT, fibrous, black to brown, wet to saturated, very soft to soft		SS2	SS	2															
	- becoming amorphous with fibrous layers at ~1.5 m depth		SS3	SS	2															
	- mixture of amorphous and fibrous at ~2.3 m depth		SS4	SS	1															
286.9			SS5	SS	WH															
3.4	CLAYEY SILT, trace organics (roots), grey, wet to saturated, very soft to soft																			
				VANE																
	- becoming stiff at ~4.6 m depth			TW																
			SS6	SS	10															
				VANE																
	- silty clay inclusions at ~6.1 m depth		SS7	SS	9															
283.0				VANE																
7.3	GLACIAL TILL, cobbles and boulders with silt, sand, and gravel in soil matrix			NQ																
	- sand and gravel, trace silt		SS8	SS	35															
				NQ																
			SS9	SS	100/0.08m															
				NQ																
279.9	BOREHOLE TERMINATED AT ~ 10.4 m DEPTH																			
10.4	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole terminated after three attempts: - First borehole attempt: core bit damaged and lost in hole at 8.1 m. - Second borehole attempt: moved 1 m east, tri-cone assembly stuck in hole at 10.4 m. - Third borehole attempt: moved 1 m north, casing shoe destroyed at 9.8 m. 3. WH = weight of hammer																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

Brampton, Ontario

## RECORD OF BOREHOLE No BH8-4

1 OF 2

METRIC

W.P. ADM-23010055-A0 LOCATION 5184425.3N, 281798.4E, NAD83 MTM Zone 10 ORIGINATED BY DM  
DIST NER HWY 11 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY IL  
DATUM Geodetic DATE 2024.03.07 - 2024.03.07 LATITUDE 46.798979 LONGITUDE -79.801331 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		w <sub>p</sub>	w	w <sub>L</sub>			
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						WATER CONTENT (%)
289.9	GROUND SURFACE							20 40 60 80 100							
0.0	TOPSOIL ~760 mm thick		SS1	SS	3								99		
289.1	PEAT, amorphous with fibers, brown to black, saturated, soft to firm		SS2	SS	5								115		
0.8			SS3	SS	5									383	Organic Content = 79.5%
			SS4	SS	3										
			SS5	SS	2									731	
	SS6	SS	WH									772			
284.6	CLAYEY SILT, trace sand, trace to some organics, wet to saturated, grey, very soft to very stiff  - no organics below 6.1 m depth		VANE										131	0 2 77 21	
5.3			TW												
			SS7	SS	WH										
			VANE												
			SS8	SS	11										
			VANE												
			SS9	SS	WH										
			VANE												
		SS10	SS	17										0 2 80 18	
277.1	GLACIAL TILL, cobbles and boulders with silt, sand, and gravel in soil matrix														
12.8															
276.5	BOREHOLE TERMINATED AT ~ 13.4 m DEPTH														
13.4															
Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process 2. Casing shoe destroyed during advancement through cobbles and															

Continued Next Page

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

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

Brampton, Ontario

RECORD OF BOREHOLE No BH8-42 OF 2METRIC

W.P. ADM-23010055-A0LOCATION 5184425.3N, 281798.4E, NAD83 MTM Zone 10ORIGINATED BY DM

DIST NER HWY 11BOREHOLE TYPE Track Mounted CME 55COMPILED BY IL

DATUM GeodeticDATE 2024.03.07 - 2024.03.07LATITUDE 46.798979LONGITUDE -79.801331CHECKED BY TL

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMITNATURAL MOISTURE CONTENTLIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
							20	40	60	80	100					
	boulders. Borehole terminated due to risk of further equipment damage. 3. WH = weight of hammer 4. Monitoring Well Readings: DateDepthElev. Mar 27/240.1289.8 m Apr 2/240.1289.8 m Apr 24/240.2289.7 m May 15/240.2289.7 m May 29/240.2289.7 m Jun 18/240.2289.7 m															

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

Brampton, Ontario

## RECORD OF BOREHOLE No BH8-5

1 OF 2

METRIC

W.P. ADM-23010055-A0 LOCATION 5184376.4N, 281797.6E, NAD83 MTM Zone 10 ORIGINATED BY DM/SF  
DIST NER HWY 11 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY IL  
DATUM Geodetic DATE 2024.03.07 - 2024.03.11 LATITUDE 46.798539 LONGITUDE -79.80134 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%)			
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×			LAB VANE			
289.2	GROUND SURFACE						20	40	60	80	100		20	40	60	195		
0.0	PEAT, fibrous, brown to black, wet to saturated, very soft to soft - thin layer of (~115 mm) silty sand fill at ~ 0.3 m depth		SS1	SS	2											290		
			SS2	SS	2													
			SS3	SS	2												182	
			SS4	SS	1													
			SS5	SS	WH													
284.2	- becoming amorphous at ~4.6 m depth		SS6	SS	WH											323		
5.0	ORGANIC SILT, sandy, some gravel, trace clay, dark brown, wet, very loose															147		
283.7	CLAYEY SILT, trace sand, grey, wet to saturated, very soft to firm			TW														
				SS7	SS	WH												
					VANE													
					SS8	SS	3											
						VANE												
					SS9	SS	8											
						VANE												
			SS10	SS	8													
				VANE														
			SS11	SS	11													
275.8	GLACIAL TILL, cobbles and boulders with silt, sand, and gravel in soil matrix		SS12	SS	49													
13.4																		
274.3																		

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24



Brampton, Ontario

RECORD OF BOREHOLE No BH8-52 OF 2METRIC

W.P. ADM-23010055-A0LOCATION 5184376.4N, 281797.6E, NAD83 MTM Zone 10ORIGINATED BY DM/SF

DIST NER HWY 11BOREHOLE TYPE Track Mounted CME 55COMPILED BY IL

DATUM GeodeticDATE 2024.03.07 - 2024.03.11LATITUDE 46.798539LONGITUDE -79.80134CHECKED BY TL

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMITNATURAL MOISTURE CONTENTLIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
							20	40	60	80	100					
14.9	BOREHOLE TERMINATED AT ~ 14.9 m DEPTH DUE TO REFUSAL  Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole terminated due to inability to core into layer. 3. WH = weight of hammer															

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

Brampton, Ontario

## RECORD OF BOREHOLE No BH8-6

1 OF 1

METRIC

W.P. ADM-23010055-A0 LOCATION 5184324.4N, 281776.8E, NAD83 MTM Zone 10 ORIGINATED BY EL  
 DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY IL  
 DATUM Geodetic DATE 2023.10.30 - 2023.10.30 LATITUDE 46.79807 LONGITUDE -79.80161 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE												
291.9	GROUND SURFACE						20	40	60	80	100									
290.4	ASPHALT ~100mm thick		SS1	SS	64															
0.1	GRAVELLY SAND TO SANDY GRAVEL (FILL), brown to grey sand with pink and grey gravel, damp, dense to very dense - silt, some sand, trace gravel, trace clay at ~0.8 m depth		SS2	SS	42															
			SS3	SS	69															
			SS4	SS	9															
		- becoming loose, wet at ~2.3 m depth		SS5	SS	7														
288.5	CLAYEY SILT, trace organics/fibrous material, some rock fragments, grey, wet, firm																			
3.4																				
287.1	-spoon refusal on bedrock		SS6	SS	100/ 0.1m															
4.8	BEDROCK																			
	Run 1: Start/End: 4.8 to 6.3 m Recovery: 93% RQD: 87%		RUN 1	NQ																
	Run 2: Start/End: 6.3 to 8.0 m Recovery: 100% RQD: 94%		RUN 2	NQ																
283.9	BOREHOLE TERMINATED AT ~ 8.0 m DEPTH																			
8.0	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Brampton, Ontario

RECORD OF BOREHOLE No BH8-71 OF 1METRIC

W.P. ADM-23010055-A0LOCATION 5184297.4N, 281794.2E, NAD83 MTM Zone 10ORIGINATED BY DM

DIST NER HWY 11BOREHOLE TYPE Track Mounted CME 55COMPILED BY IL

DATUM GeodeticDATE 2024.03.04 - 2024.03.04LATITUDE 46.797828LONGITUDE -79.801381CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMITNATURAL MOISTURE CONTENTLIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20406080100	20406080100	Wp	W	WL	WATER CONTENT (%)				
289.3	GROUND SURFACE																
289.0	PEAT, fibrous, black, saturated																
0.2	CLAYEY SILT, trace sand, trace oxidation, grey, moist to saturated, soft to very stiff		SS1	SS	2		289										
	- Measured vane shear strength greater than 120 kPa at 0.8 m			VANE													
	- becoming wet, increase in oxidation at ~1.5 m depth		SS2	SS	7		288								0 2 70 28		
			SS3	SS	16												
286.7			SS4	SS	18		287										
2.6	GRAVELLY SAND TO SAND AND GRAVEL, with cobbles, some silt, grey, saturated, compact to very dense		SS5	SS	100/0.23m		286										
285.8	BEDROCK		RUN 1	NQ			285										
3.5	Run 1: Start/End: 3.5 to 4.1 m Recovery: 100% RQD: 100%		RUN 2	NQ			284										
	Run 2: Start/End: 4.1 to 5.6 m Recovery: 100% RQD: 100%		RUN 3	NQ													
	Run 3: Start/End: 5.6 to 6.2 m Recovery: 100% RQD: 100%																
283.1	BOREHOLE TERMINATED AT ~ 6.2 m DEPTH																
6.2	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process																

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

Brampton, Ontario

RECORD OF BOREHOLE No BH8-8

1 OF 1

METRIC

W.P. ADM-23010055-A0

LOCATION 5184557.5N, 281763.9E, NAD83 MTM Zone 10

ORIGINATED BY AM

DIST NER HWY 11

BOREHOLE TYPE Track Mounted CME 55

COMPILED BY EL

DATUM Geodetic

DATE 2024.04.25 - 2024.04.25

LATITUDE 46.800167

LONGITUDE -79.80179

CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	Wp	W	WL		
289.6	GROUND SURFACE																
289.4	TOPSOIL, ~225 mm thick																
0.2	CLAYEY SILT, trace sand, trace organics, brown to grey, saturated, firm to very stiff		SS1	SS	5											Organic Content = 7.1%	
			SS2	SS	14											Organic Content = 2.3%	
	-Measured vane shear strength greater than 120 kPa at 1.5 m			VANE												0 1 82 17	
287.5	GLACIAL TILL, cobbles and boulders with silt, sand, and gravel in soil matrix																
2.1				NQ													
286.6	BEDROCK		RUN 1	NQ													
3.0	Run 1: Start/End: 3.0 to 3.5 m Recovery: 100% RQD: 90%																
	Run 2: Start/End: 3.5 to 4.9 m Recovery: 100% RQD: 100%		RUN 2	NQ													
	Run 3: Start/End: 4.9 to 5.4 m Recovery: 100% RQD: 88%		RUN 3	NQ													
284.2	BOREHOLE TERMINATED AT ~ 5.4 m DEPTH																
5.4	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process																

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

+ 3, X 3: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

Brampton, Ontario

RECORD OF BOREHOLE No BH8-9

1 OF 1

METRIC

W.P. ADM-23010055-A0

LOCATION 5184511.6N, 281765.0E, NAD83 MTM Zone 10

ORIGINATED BY AM

DIST NER HWY 11

BOREHOLE TYPE Track Mounted CME 55

COMPILED BY EL

DATUM Geodetic

DATE 2024.04.22 - 2024.04.22

LATITUDE 46.799754

LONGITUDE -79.801774

CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
289.5	GROUND SURFACE																
289.4	TOPSOIL, ~75 mm thick		SS1	SS	7											1 2 82 15	
	CLAYEY SILT, trace sand, trace organics/topsoil, grey, moist to saturated, soft to firm		SS2	SS	3												
	- becoming stiff to hard at ~1.5 m depth		SS3	SS	18											0 1 79 20	
			VANE														
	- some sand and trace gravel		SS4	SS	34												
285.7	GLACIAL TILL, cobbles and boulders with silt, sand, and gravel in soil matrix																
284.9	BEDROCK		RUN 1	NQ													
	Run 1: Start/End: 4.6 to 5.7 m Recovery: 100% RQD: 74%																
	Run 2: Start/End: 5.7 to 7.2 m Recovery: 100% RQD: 93%		RUN 2	NQ													
282.3	BOREHOLE TERMINATED AT ~7.2 m DEPTH																
	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process																

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Brampton, Ontario

## RECORD OF BOREHOLE No BH8-10

1 OF 2

METRIC

W.P. ADM-23010055-A0 LOCATION 5184470.2N, 281763.6E, NAD83 MTM Zone 10 ORIGINATED BY AM  
DIST NER HWY 11 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY DM  
DATUM Geodetic DATE 2024.04.16 - 2024.04.17 LATITUDE 46.799382 LONGITUDE -79.80179 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20   40   60   80   100	W <sub>P</sub> W   W <sub>L</sub>	WATER CONTENT (%)					
								SHEAR STRENGTH kPa							
							○ UNCONFINED   + FIELD VANE								
							● QUICK TRIAXIAL   × LAB VANE								
289.7	GROUND SURFACE														
289.0	TOPSOIL ~100 mm thick		SS1	SS	2								132	Organic Content = 86.8%	
	PEAT, fibrous, black to brown, wet to saturated, very soft to soft		SS2	SS	2								520		
			SS3	SS	WH								419		
			SS4	SS	WH								165		
286.9	ORGANIC SILT, clayey, trace sand, brown, wet, very loose		SS5	SS	WH									Organic Content = 42.1%  0   1   79   20	
286.0															
3.7	CLAYEY SILT, trace to some organics, brown, saturated, very soft to firm			VANE											
	- becoming grey at ~4.6 m depth		SS6	SS	WH										
				TW										19.3  0   1   79   20	
	- becoming stiff at ~6.1 m depth		SS7	SS	10										
				VANE											
281.4	GLACIAL TILL, cobbles and boulders with silt, sand, and gravel in soil matrix			NQ											
280.0	- no sample recovery		SS8	SS	100/0.13m										
9.7	BEDROCK		Run1	NQ											
	Run 1: Start/End: 9.7 to 10.1 m Recovery: 100% RQD: 63%														
	Run 2: Start/End: 10.1 to 11.6 m Recovery: 100% RQD: 31%		Run2	NQ											
	Run 3: Start/End: 11.6 to 13.1 m Recovery: 100% RQD: 70%		Run3	NQ											
276.6	BOREHOLE TERMINATED AT ~ 13.1 m DEPTH														
13.1	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. WH - weight of hammer 3. Monitoring Well Readings: Date   Depth   Elev. Apr 24/24   1.1   288.6 m May 15/24   1.2   288.5 m														

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

## METRIC

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



Brampton, Ontario

## RECORD OF BOREHOLE No BH8-11

1 OF 1

METRIC

W.P. ADM-23010055-A0 LOCATION 5184422.8N, 281775.6E, NAD83 MTM Zone 10 ORIGINATED BY EL  
 DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY IL  
 DATUM Geodetic DATE 2023.11.01 - 2023.11.01 LATITUDE 46.798955 LONGITUDE -79.801631 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
291.2	GROUND SURFACE						20	40	60	80	100					
0.0	<b>SAND AND GRAVEL (FILL)</b> , some silt, dark grey to brown, damp, compact															
	- becoming wet at ~0.9 m depth		SS1	SS	28											
289.7																
1.5	<b>ROCKFILL</b> , in silt, sand, and gravel soil matrix		SS2	SS	31											
	- no sample recovery, rock obstructed sample entry		SS3	SS	24											
288.2																
3.0	<b>SAND AND GRAVEL</b> , some silt, trace organics, grey, wet, loose to dense		SS4	SS	6											
	- no sample recovery		SS5	SS	17											
			SS6	SS	49											
285.9																
5.3	<b>GLACIAL TILL</b> , cobbles and boulders with silt, sand, and gravel in soil matrix			NQ												

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

1 OF 1

**METRIC**

W.P.	ADM-23010055-A0	LOCATION	5184374.3N, 281755.1E, NAD83 MTM Zone 10			ORIGINATED BY	EL			
DIST	NER	HWY	11	BOREHOLE TYPE	Track Mounted CME 55		COMPILED BY	DM		
DATUM	Geodetic		DATE	2024.04.22 - 2024.04.22	LATITUDE	46.798518	LONGITUDE	-79.801896	CHECKED BY	TL

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

ONTARIO MTO HWY 11 -SW8 .GPJ ONTARIO MTO.GDT 7/19/24

Brampton, Ontario

RECORD OF BOREHOLE No BH8-13										1 OF 1		METRIC				
W.P. ADM-23010055-A0		LOCATION 5184328.2N, 281747.1E, NAD83 MTM Zone 10						ORIGINATED BY AM								
DIST NER HWY 11		BOREHOLE TYPE Track Mounted CME 55						COMPILED BY DM								
DATUM Geodetic		DATE 2024.04.17 - 2024.04.17		LATITUDE 46.798104		LONGITUDE -79.801999		CHECKED BY TL								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
288.8	GROUND SURFACE							20	40	60	80	100				
288.8	TOPSOIL ~75 mm thick		SS1	SS	2											
288.8	CLAYEY SILT, trace organics, brown to grey, saturated, soft to stiff		SS2	SS	7											
				VANE												
286.4	- cobble/boulder encountered		SS3	SS	100/0.10m											
286.4	BEDROCK															
	Run 1: Start/End: 2.4 to 3.9 m Recovery: 77% RQD: 40%		RUN 1	NQ												
	Run 2: Start/End: 3.9 to 5.4 m Recovery: 100% RQD: 65%		RUN 2	NQ												
283.4	BOREHOLE TERMINATED AT ~ 5.4 m DEPTH															
5.4	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.															

ONTARIO MTO HWY 11-SW8.GPJ ONTARIO MTO.GDT 7/19/24

Brampton, Ontario

## RECORD OF BOREHOLE No BH8-14

1 OF 1

METRIC

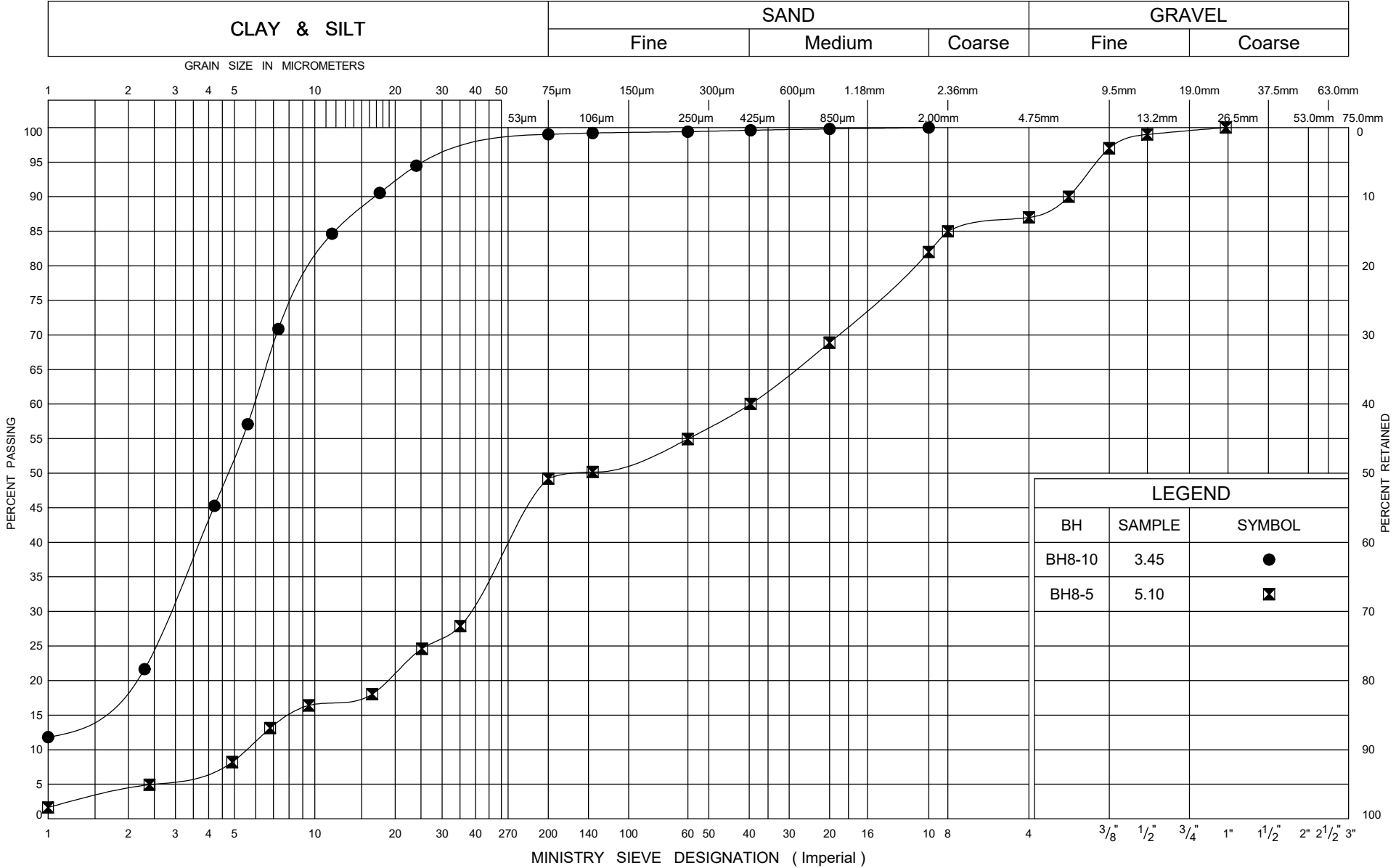
W.P. ADM-23010055-A0 LOCATION 5184276.5N, 281740.9E, NAD83 MTM Zone 10 ORIGINATED BY AM  
DIST NER HWY 11 BOREHOLE TYPE Track Mounted CME 55 COMPILED BY DM  
DATUM Geodetic DATE 2024.04.17 - 2024.04.17 LATITUDE 46.797638 LONGITUDE -79.802077 CHECKED BY TL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>P</sub>	W	W <sub>L</sub>			
288.5	GROUND SURFACE							20	40	60	80	100			
288.4	TOPSOIL ~100 mm thick		SS1	SS	3		288								Organic Content = 2.9%
0.1	CLAYEY SILT, trace organics, brownish grey, saturated, soft		SS2	SS	14										Organic Content = 0.5%
	- stiff to very stiff below ~0.8 m depth						287								0   1   81   18
	- Measured vane shear strength greater than 120 kPa at 1.7 m			VANE											
286.1															
2.4	GLACIAL TILL, cobbles and boulders with silt, sand, and gravel in soil matrix		SS3	SS	24		286								
			SS4	SS	53		285								
				NQ											
284.1	BEDROCK		RUN 1	NQ			284								
4.4	Run 1: Start/End: 4.4 to 4.7 m Recovery: 100% RQD: 100%		RUN 2	NQ			283								
	Run 2: Start/End: 4.7 to 6.2 m Recovery: 100% RQD: 90%		RUN 3	NQ			282								
	Run 3: Start/End: 6.2 to 7.7 m Recovery: 100% RQD: 100%						281								
280.8	BOREHOLE TERMINATED AT ~ 7.7 m DEPTH														
7.7	Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.														

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

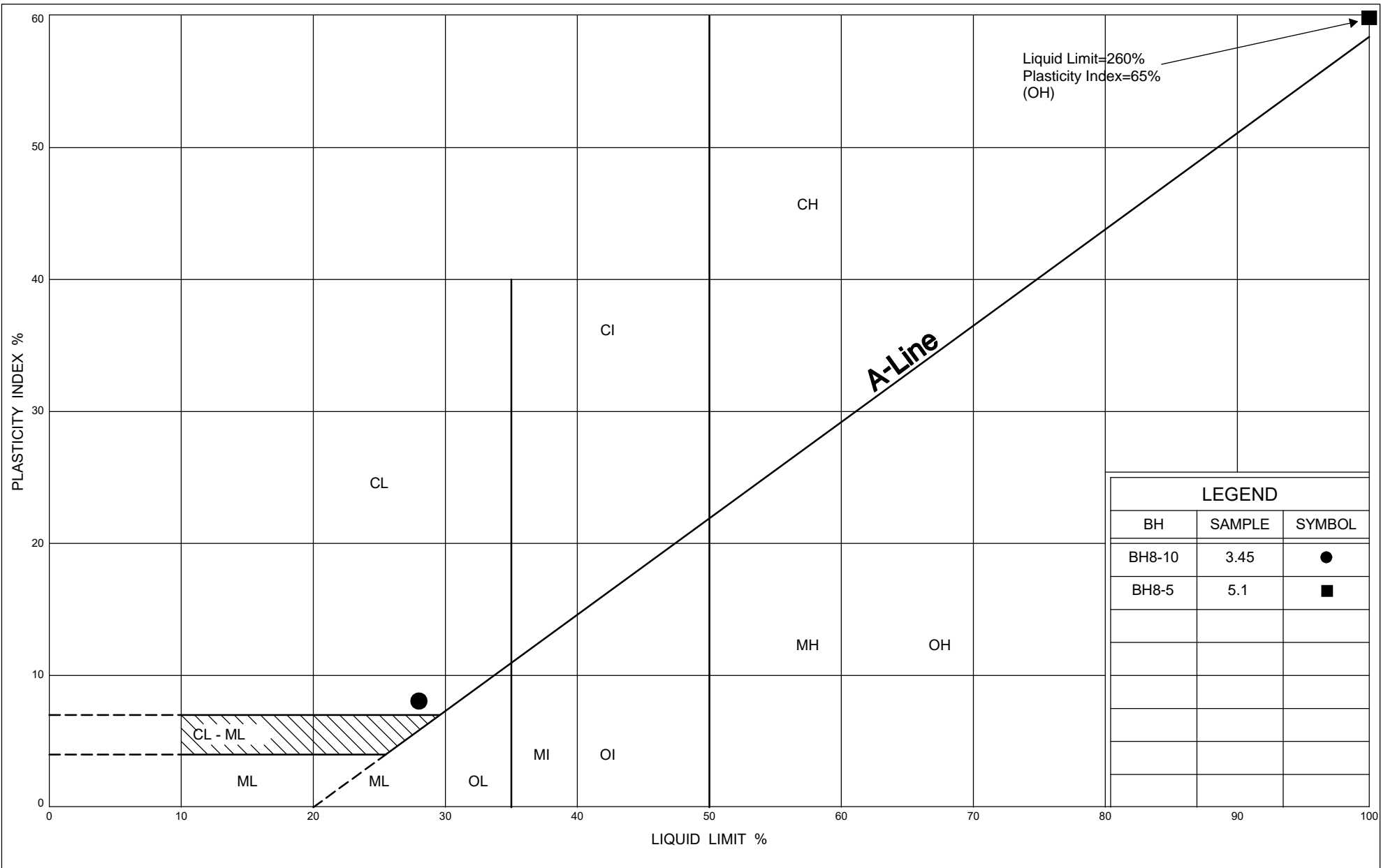
## Appendix D – Laboratory Data

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
Organic Silt

FIG No 1  
GWP 5033-22-00  
Highway 11 2+1, SW8



Ministry of  
Transportation

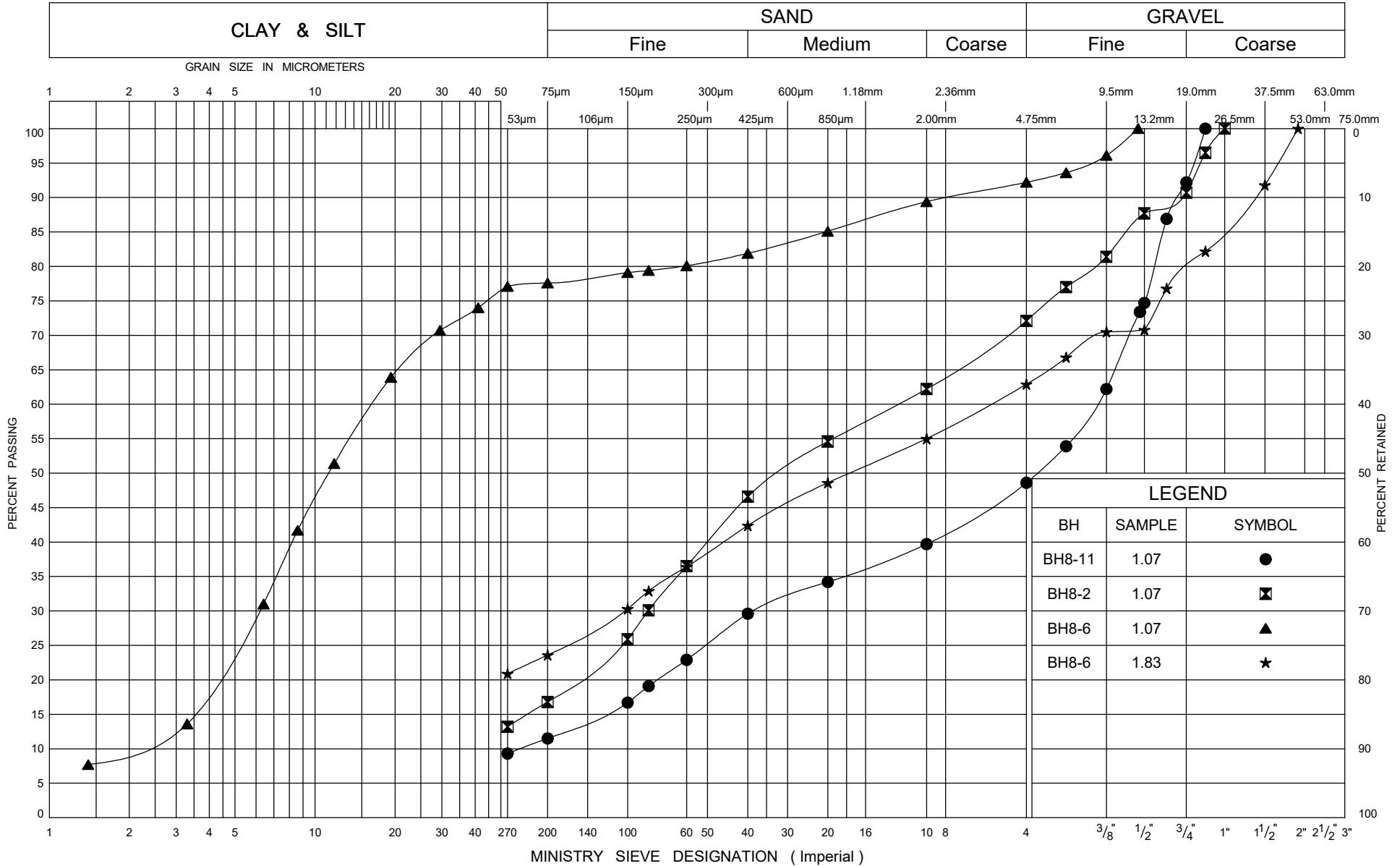
# PLASTICITY CHART

Organic Silt

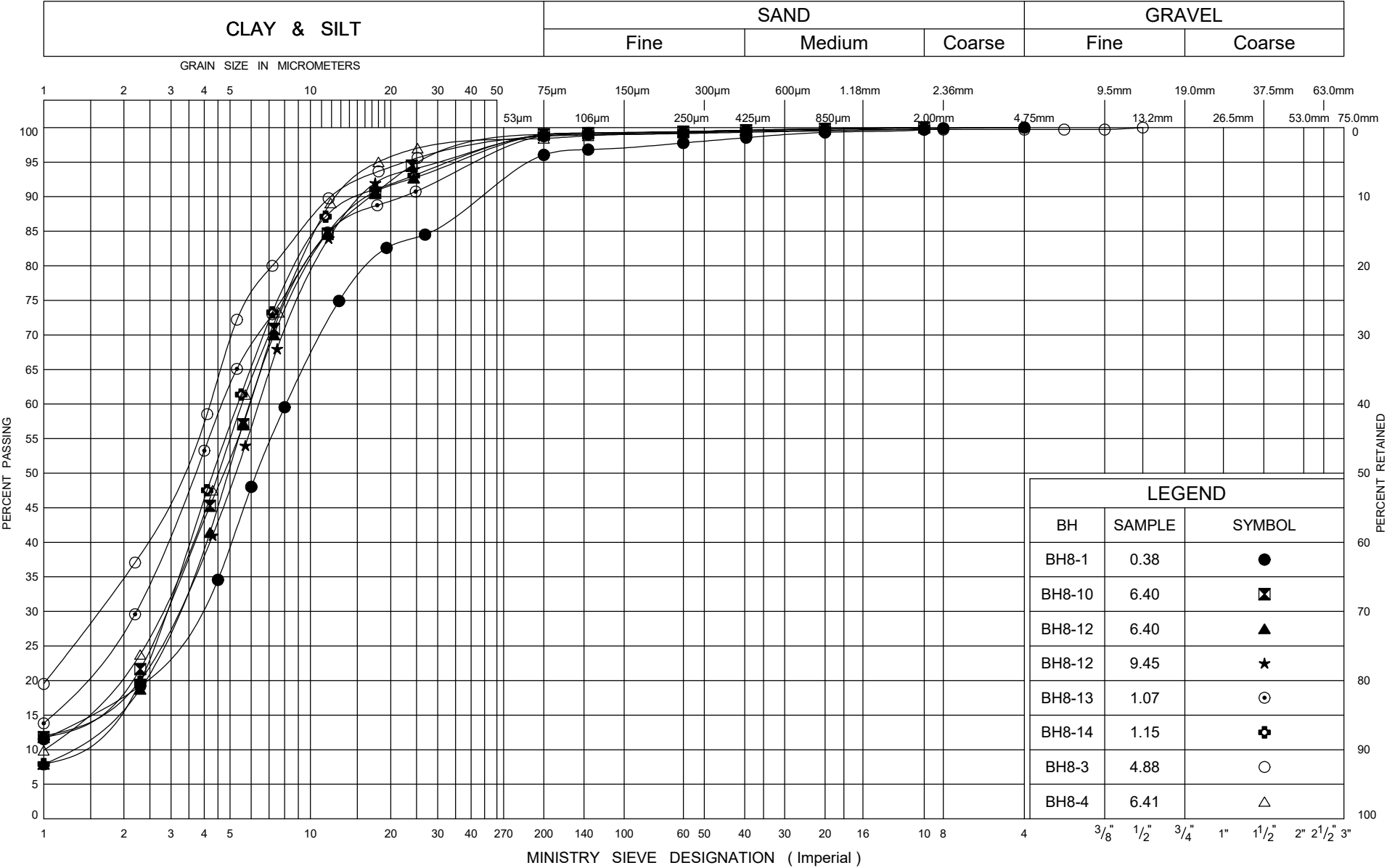
FIG No 2  
GWP 5033-22-00  
Highway 11 2+1, SW8



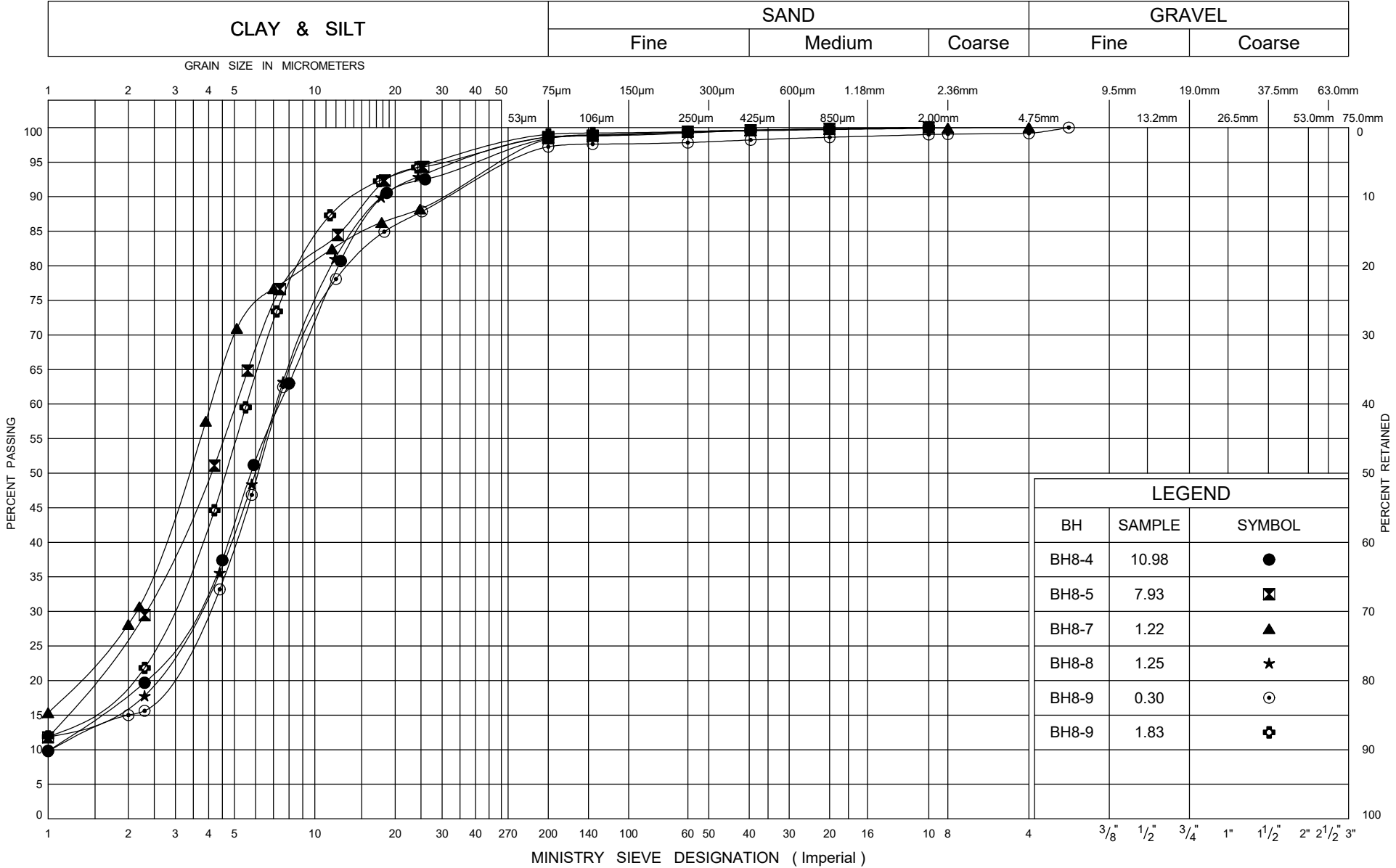
# UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



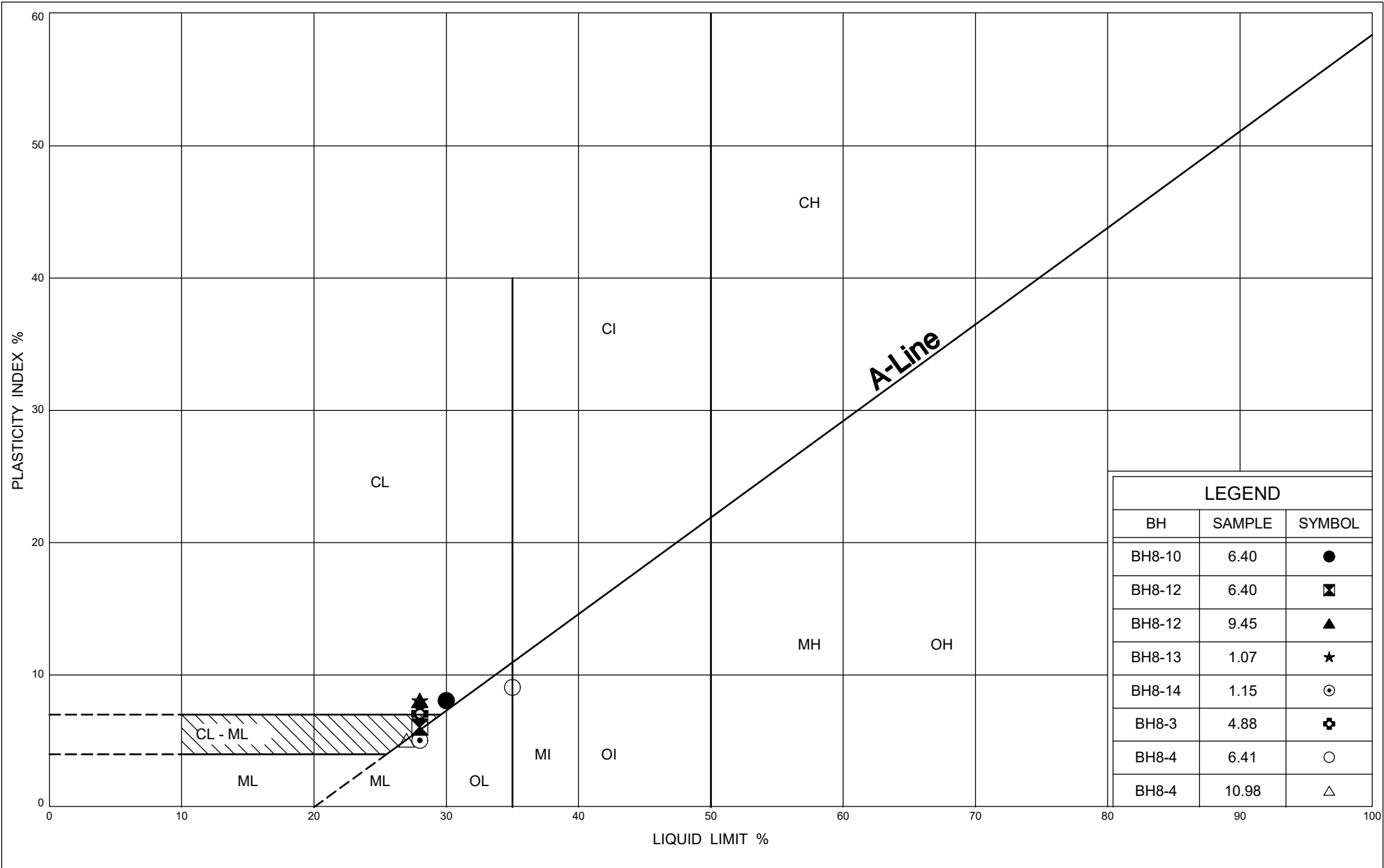
GRAIN SIZE DISTRIBUTION

Clayey Silt

FIG No 5

GWP 5033-22-00

Highway 11 2+1, SW8



Ministry of  
Transportation

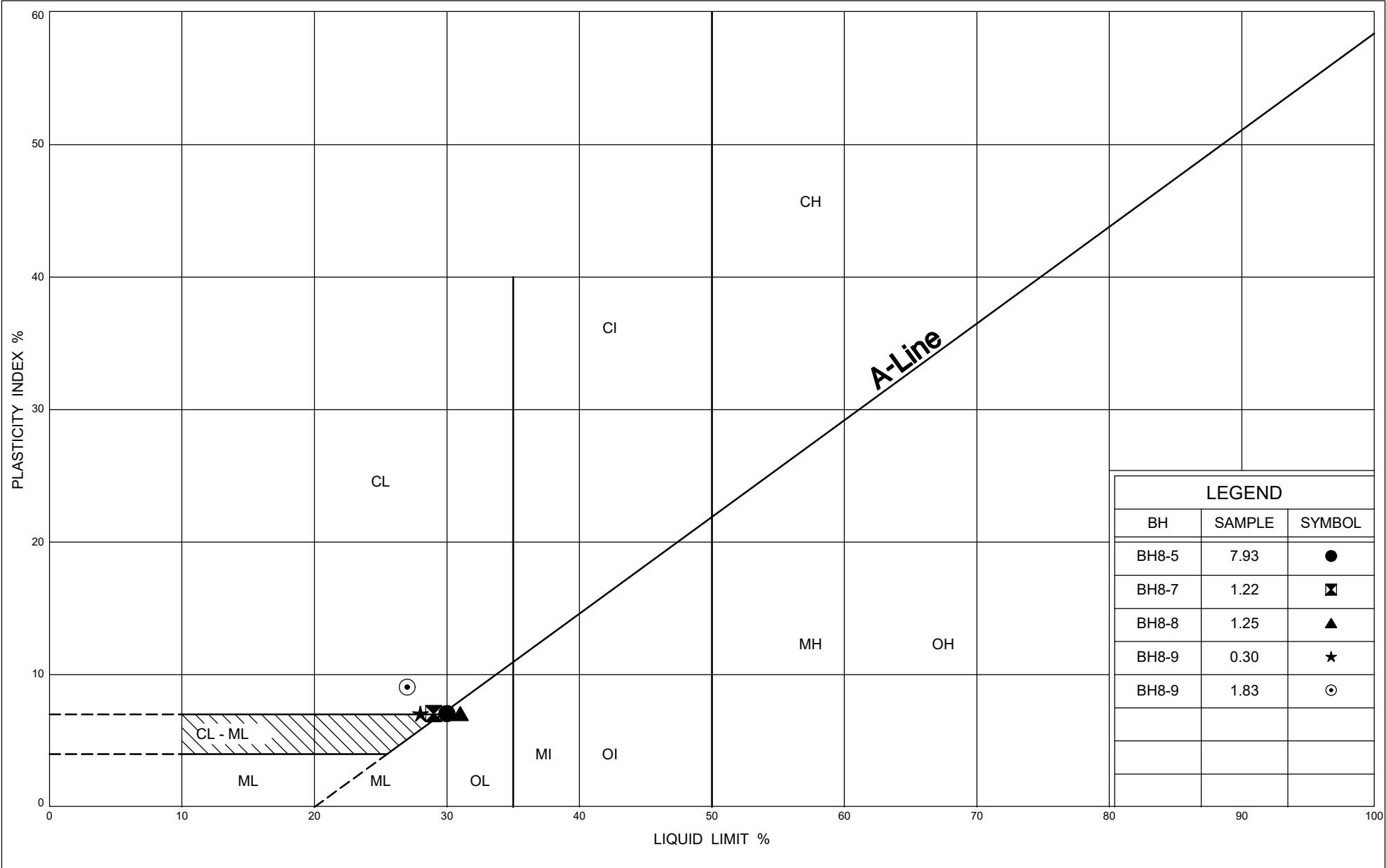
## PLASTICITY CHART

Clayey Silt

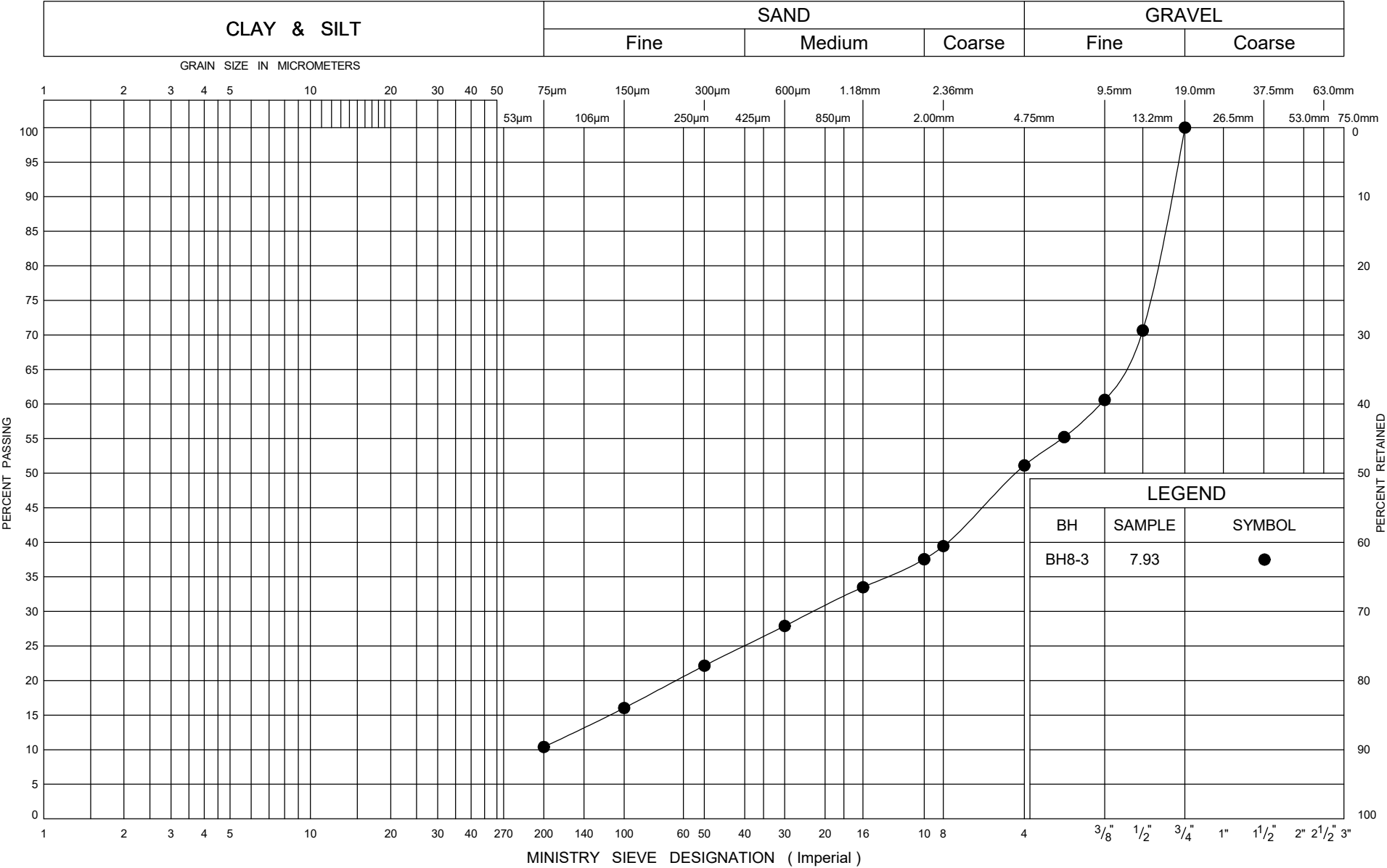
FIG No 6

GWP 5033-22-00

Highway 11 2+1, SW8



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION

Cobbles and Boulders (Soil Matrix)

FIG No 8

GWP 5033-22-00

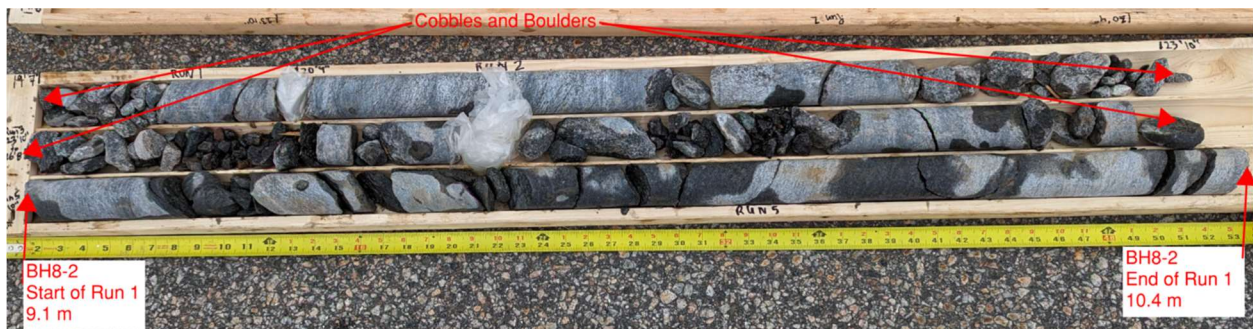
Highway 11 2+1, SW8



## Appendix E – Bedrock Core Photographs



Photograph E1. Rock cores from BH8-1. Top: Run 1, Middle/Bottom: Run 2, Bottom: Run 3.



Photograph E2. Rock cores from BH8-2. Top: Cobbles and Boulders, Middle: Cobbles and Boulders, Bottom: Run 1.

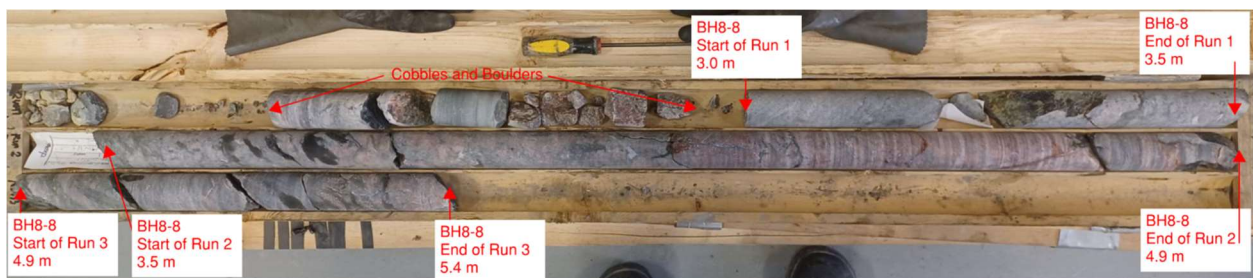


Photograph E3. Rock cores from BH8-6. Top: Run 1, Middle/Bottom: Run 2.





Photograph E4. Rock cores from BH8-7. Top: Run 1, Middle: Run 2, Bottom: Run 3.



Photograph E5. Rock cores from BH8-8. Top: Run 1, Middle: Run 2, Bottom: Run 3.



Photograph E6. Rock cores from BH8-9. Top: Cobbles and Boulders, Middle: Run 1, Bottom: Run 2.





Photograph E7. Rock cores from BH8-10. Top: Run 1, Middle: Run 2, Bottom: Run 3.



Photograph E8. Rock cores from BH8-12. Top: Run 1, Middle/Bottom: Run 2.



Photograph E9. Rock cores from BH8-13. Top: Run 1, Middle/Bottom: Run 2.



Photograph E10. Rock cores from BH8-14. Top: Run 1, Middle/Bottom: Run 2.