Foundation Investigation and Design Report

Highway 11 – 2+1 Roadway Model Project: ***Site SW12***

Assignment No. 5021-E-0038
GWP 5033-22-00
Geocres No. 31L13-008
(Latitude: 46.834600; Longitude: -79.797120)

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AECOM

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PART I - FOUNDATION INVESTIGATION REPORT

1 FACTUAL INFORMATION

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 and extension of the existing culverts at site SW12. The site is located approximately 9.5 km north of the intersection of Highway 64 and Highway 11 from approximately Station 13+630 to 14+160 in the Township of Olive in the District of Nipissing, Ontario (Latitude: 46.834600; Longitude:-79.797120). The work was undertaken under Agreement No. 5021-E-0038, and the terms of reference (TOR) were provided by AECOM. The AutoCAD drawings for Highway 11 were also provided by AECOM.

The purpose of the investigation was to evaluate the subsurface conditions along the proposed widening of Highway 11 and the existing culvert alignment, and based on this data, 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 and the extension of the existing culvert. 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 9.5 km north of the intersection of Highway 64 and Highway 11 from approximately Station 13+660 to 14+160 in the Township of Olive in the District of Nipissing, Ontario. At the site, Highway 11 generally runs in a north-south direction, with a speed limit of 90 km/h (unless otherwise posted). At the site, Highway 11 is approximately 8.6 m wide with a 2.9 m wide gravel shoulder on the east side (northbound lane) and a 2.6 m wide gravel shoulder on the west side (southbound lane). In total, the existing roadway with both shoulders included is about 14.1 m wide.

As per drawings provided by AECOM, the site is divided into two segments: SW12-1, spanning from Sta. 13+630 to Sta. 14+004, and SW12-2, spanning from Sta. 14+004 to Sta. 14+160. Based on the AutoCAD drawings, the elevation of the highway pavement centerline along segment SW12-1 ranges from approximately Elev. 289.1 m to Elev. 291.1 m from south to north. The elevation of the highway pavement centerline along segment SW12-2 ranges from approximately Elev. 289.1 to Elev. 291.4 m from south to north. The height of the embankment generally ranges from 3 m to 5 m high on the west side and less than 1 m up to 5 m on the east side with side slopes ranging from approximately 2H:1V to 3H:1V.

A concrete box culvert crosses Highway 11 at Station 14+154 which runs in the east-west direction nearly perpendicular to the highway centreline. Additionally, a corrugated steel pipe (CSP) culvert crosses Highway 11 at Station 14+037, skewed approximately 35 degrees to the highway centerline in a northeast-southwest direction.

Based on the CAD drawings provided by AECOM, the existing concrete box culvert at Station 14+154 has a width and height of 1.25 m and total length of about 21.36 m. The fill cover at the culvert is about 3.75 m to 3.9 m high with the top of embankment being at Elev. 291.2 m. The invert of the culvert is approximately at Elev. 286.1 m and Elev. 285.8 m on the inlet (east) and outlet (west) side, respectively. The side slopes of the embankment at the concrete box culvert location were at approximately 1.25H:1V to 2H:1V on the east side and ranged from 1.8H:1V to 2.5H:1V on the west side. The corrugated steel pipe (CSP) culvert located at about Station 14+037 has a diameter of 0.9 m and total length of about 29.95 m. The fill cover is about 1.1 m with the top of embankment being at Elev. 289.0 m. The invert of the existing corrugated steel culvert is approximately at Elev. 287.0 m and Elev. 286.9 m on the inlet/east and outlet/west side, respectively. Select photographs of the site and existing culvert are presented in Appendix A. The site plan and cross-section profiles along the existing highway and culvert alignments are shown on the drawings attached in Appendix B.

The general site conditions were assessed during a site visit on September 13, 2023 as well as during the field investigation works between May 5, 2024, and July 30, 2024. During the site visit and field investigation works, the flow through the concrete box culvert was observed from east to west. In June 2024, the approximate top of water of the creek was measured to be at Elev. 286.4 m on the east (inlet) and west (outlet) side. Water was not observed to be flowing through the CSP at Station 14+037, but water was pooled at the base of the embankment at the outlet at approximately the same level as the creek/lake water level (~Elev. 286.4 m).

Both sides of the embankment were observed to be mostly comprised of gravel and/or grass with boulder-sized rock fill/riprap to protect against scour or erosion around the culvert. The west side of the embankment is adjacent to Red Canoe Lake with marshland predominantly existing directly at the toe of the embankment and adjacent to the lake and natural vegetation consisting of bushes and large conifers. The east side of the embankment is predominately adjacent to dense forests beyond the toe of the embankment with a section of marshland existing near the north end of the site near the creek flowing into the concrete box culvert. Large bedrock outcrops were observed approximately between Station 13+825 and 14+000.

Photographs 1 to 12 in Appendix A depict the site, culvert, road, and activities during drilling, taken by EXP between May and July 2024. Photographs 1 and 2 show the existing roadway surface shoulder, embankment side slope, and ground conditions/vegetation beyond embankment toe along the SBL side as well as the overhead power lines running adjacent to the SBL. Photographs 3 and 4 show the existing roadway surface and shoulder, cut side slope, bedrock outcrops and ground conditions/vegetation beyond the embankment toe along the NBL side. Photograph 5 shows the drilling of borehole BH12-3 which required the use of mats for access, while Photograph 6 shows the drilling of borehole BH12-11 with the Explo portable rig which was placed on a platform constructed on the swampy ground surface. Photograph 7 shows the locations of boreholes BH12-5, BH12-11, and BH-13, which needed to be accessed using an Argo ATV via the marshy and watery terrain. Photographs 8 and 9 show the inlet and outlet of the existing culvert and the surrounding area of the west and east side of the highway embankment, including the existing rip rap and vegetation. Photograph 10 was taken in May and shows the creek on the east side of the highway. Photographs 11 and 12 show the inlet and outlet of the existing CSP culvert, respectively.

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 in the vicinity of the site consists of migmatic rocks and gneisses of undetermined protolith: commonly layered biotite gneisses and migmatites; locally includes quartzofeldspathic gneisses, orthogneisses, paragneisses. The site is also adjacent to foliated tonalite suite: tonalite to granodiorite which is foliated to massive and felsic igneous rocks: tonalite, granodiorite, monzonite, granite, syenite, and derived gneisses.

1.3 Previous Investigations

There are no available previous geotechnical reports at the location of the site in the MTO GEOCRES library; the nearest available reports on Highway 11 are approximately 1.5 km southeast and 0.8 km northwest, respectively, from the site:

- *Geocres No. 31L00-141: "Preliminary field investigation for re-alignment of Highway 11 at three locations between HWY 64 and town of Latchford, Agreement NO.5004-E-0058", prepared by Shaheen & Peaker Limited., dated December 12,2005.*
- *Geocres No. 31L-123: "Foundation Investigation Report, Highway 11 at Pan Lake,10.6 km north of Highway 64, Station 14+750 to 14+950 in Olive township", prepared by AMEC Americas Limited. dated September 03, 2008.*

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 eight (8) roadway boreholes was performed between May 5 and 13, 2024 while the investigation of seven (7) off-road boreholes was performed between May 7 and July 30, 2024. In total, the entire field program consisted of drilling fifteen (15) sampled boreholes. The boreholes were strategically located along the highway and as close as possible to the existing culvert footprints to provide subsurface information for the widening of the highway and the culvert extensions. Boreholes BH12-6, BH12-12, BH12-15, BH12-16, BH12-17 and BH12-19 were advanced on the west side (southbound lane) of the highway while BH12-4 and BH12-8 were advanced on the east side (northbound lane). Boreholes BH12-11, BH12-13 and BH12-20 were advanced off-road beyond the toe of the existing embankment on the west side of the highway and boreholes BH12-1 and BH12-2 were advanced off-road beyond the toe of the existing embankment on the east side of the highway. BH12-6 was advanced on top of the embankment in the west (southbound) lane of the highway, about 7.5 m south of the existing culvert. Boreholes BH12-3 and BH12-5 were advanced at the inlet and outlet locations of the existing concrete box culvert, respectively, at the bottom of the roadway embankment. BH12-3 was located approximately 8.5 m southeast of the culvert inlet and BH12-5 was located approximately 7.3 m southwest of the culvert outlet.

The locations of the boreholes drilled during this investigation are shown on Drawing 1 in Appendix B. Roadway boreholes BH12-4, BH12-6, BH12-8, BH12-12, BH12-15, BH12-16, BH12-17 and BH12-19 were advanced to depths between 4.6 m and 15.6 m below ground surface. Off-road boreholes BH12-1, BH12-2, BH12-3, BH12-5, BH12-11, BH12-13 and BH12-20 were advanced to depths between 9.0 m and 13.9 m below ground surface.

The roadway boreholes drilled during this investigation were advanced using a truck mounted CME 75 drill rig, operated by a specialist drilling contractor Marathon Drilling Ltd. while the off-road boreholes drilled during the site investigation were advanced using a track mounted D50 drill rig, track mounted CME 55 drill rig, or a EXPLO 691

portable rig, also operated by 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 ±0.1 m in the horizontal and vertical direction. Elevations for each borehole were referenced from the benchmark "HCP 123", which was a stake located on the southbound lane shoulder at Elev. 288.757 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) 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. 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 borehole BH12-1 to permit monitoring of the groundwater level on the east side of Hwy 11. 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[1] (m)	Borehole Depth[2] (m)
		Northing	Easting				
BH12-1	Off-road beyond toe of existing slope: east side of highway	5188610.6	282183.2	46.836644	-79.7964979	287.3	13.3
BH12-2	Off-road beyond toe of existing slope: east side of highway	5188562.9	282177.5	46.836215	-79.7965700	287.5	9.0
BH12-3	Off-road beyond toe of existing slope: east side of highway	5188654.4	282175.0	46.837038	-79.7966073	286.6	13.7
BH12-4	East (northbound) lane of highway	5188457.8	282150.9	46.835267	-79.7969139	289.2	4.6
BH12-5	Off-road beyond toe of existing slope: west side of highway	5188654.4	282144.0	46.837036	-79.7970150	286.6	11.7
BH12-6	West (southbound) lane of highway	5188654.2	282157.5	46.837034	-79.7968367	290.9	15.6
BH12-8	East (northbound) lane of highway	5188259.2	282144.3	46.833481	-79.7969897	290.0	7.7
BH12-11	Off-road beyond toe of existing slope: west side of highway	5188604.3	282137.9	46.836586	-79.7970906	288.4	11.9
BH12-12	West (southbound) lane of highway	5188562.8	282150.4	46.836212	-79.7969255	289.0	9.2
BH12-13	Off-road beyond toe of existing slope: west side of highway	5188522.2	282133.8	46.835846	-79.7971410	286.4	13.9
BH12-15	West Shoulder (southbound) lane of highway	5188413.3	282136.3	46.834867	-79.7971024	289.2	6.0
BH12-16	West (southbound) lane of highway	5188362.2	282140.3	46.834407	-79.7970483	289.6	7.7
BH12-17	West (southbound) lane shoulder of highway	5188312.2	282133.0	46.833957	-79.7971413	289.6	7.7
BH12-19	West (southbound) lane shoulder of highway	5188213.2	282133.6	46.833066	-79.7971287	290.2	9.1
BH12-20	Off-road beyond toe of existing slope: west side of highway	5188165.4	282115.6	46.832638	-79.7973600	286.7	11.4

Notes:

1. *The ground surface elevations are referenced from HCP 123.*
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.

One (1) soil sample was selected for corrosivity analysis and sent to Bureau Veritas, a CALA-certified and accredited laboratory in Mississauga, Ontario. The selected soil sample for the analytical testing was placed in laboratory prepared glass jars, labelled and stored in a secure cooler.

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

1.5 Subsurface Conditions

The detailed subsurface 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: sand and gravel to gravelly sand fill followed by either rock fill directly over bedrock or cohesionless fill consisting of varying amounts of predominantly silt and sand underlain by native soil comprised predominantly of silt and sand followed by glacial till consisting predominantly of cobbles and boulders in a silt, sand and gravel matrix underlain by bedrock. Peat was located under the fill in one borehole (BH12-19).

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 silt and sand followed by glacial till comprised of cobbles and boulders in a silt, sand, and gravel soil matrix underlain by bedrock.

At the culvert inlet, outlet, and below the roadway (BH12-3,BH12-5,BH12-6) the encountered subsurface conditions were observed to generally consist of topsoil or organic silt followed by native soil consisting predominantly of silt and/or sand which is underlain by glacial till followed by bedrock.

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, ranging from approximately 75 mm to 150 mm in thickness, was encountered at the ground surface of roadway boreholes. Asphalt thicknesses may further vary beyond the borehole locations.

1.5.1.2 Topsoil

Topsoil, approximately 75 mm to 190 mm thick, was encountered at the ground surface of boreholes BH12-1 to BH12-3, BH12-11, BH12-13, and BH12-20.

Laboratory testing performed on a selected sample consisted of one (1) moisture content test. The test results are as follows:

Moisture Content:

- 117%

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

1.5.1.3 Peat

Peat was encountered below the silt fill in borehole BH12-19 and below the topsoil in borehole BH12-20. The approximate elevation of the surface and base of the peat and thickness as encountered in the boreholes are summarized below in Table 1.2.

Table 1.2. Summary of peat

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-19	287.2	286.2	3.0	1.0
BH12-20	286.6	284.2	0.1	2.4

Notes:

1. *The elevations are referenced from HCP 123.*
2. *Depths are relative to ground surface.*

The peat encountered at the site ranged from fibrous to amorphous. The peat was mixed with silt and sand at the bottom of the layer in borehole BH12-20. The material was generally dark brown to dark grey in colour and wet. The SPT “N” values obtained within this material ranged from 1 to 7 blows per 0.3 m penetration suggesting that the peat layers were very soft to firm in consistency.

Laboratory testing performed on selected samples consisted of four (4) moisture content tests and two (2) organic content tests. The test results are as follows:

Moisture Content:

- 83% to 236%

Organic Content:

- 11.8% to 41.4%

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 at the ground surface of borehole BH12-5, below the topsoil in boreholes BH12-11 and BH12-13, and below the peat in borehole 12-20. The approximate elevation of the surface and base of the organic silt layer and thickness as encountered in the boreholes are summarized below in Table 1.3.

Table 1.3. Summary of organic silt

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-5	286.6	283.6	0.0	3.0
BH12-11	288.3	282.3	0.1	6.0
BH12-13	286.2	280.3	0.2	5.9
BH12-20	284.2	283.3	2.5	0.9

Notes:

1. *The elevations are referenced from HCP 123.*
2. *Depths are relative to ground surface.*

The composition of this material generally consisted of a mixture of organics with silt, a sand content ranging from trace sand to sandy, a clay content ranging from trace clay to being clayey, and trace gravel. The organic silt was generally dark brown to grey to black in colour and wet to saturated. The SPT “N” values in this material ranged from WH (weight of hammer) to 9 blows per 0.3 m penetration suggesting that this layer was very loose to loose, but generally very loose in consistency.

Laboratory testing performed on selected samples consisted of seventeen (17) moisture content tests, thirteen (13) organic content tests, four (4) grain size distribution tests, and three (3) Atterberg limit tests. The test results are as follows:

Moisture Content:

- 32% to 243%

Organic Content:

- 3.6% to 14.4%

Grain Size Distribution:

- 0% gravel to 7%
- 3% sand to 32%
- 58% to 96% silt
- 1% to 5% clay

Atterberg Limits:

- Non-plastic

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 tests are also provided on Figure 1 in Appendix D.

1.5.1.5 Cohesionless Fill: Gravelly Sand/Sand and Gravel/Silt and Gravel

Cohesionless fill material consisting of varying distributions of predominantly sand and gravel was encountered below the asphalt treatment in boreholes BH12-4, BH12-8, BH12-12 and BH12-16, and at the ground surface of Borehole BH12-15, BH12-17 and BH12-19. The approximate elevation of the surface and base of the fill and thickness as encountered in the boreholes are summarized below in Table 1.4.

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

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-4	289.0	288.0	0.2	1.0
BH12-8	289.8	288.8	0.2	1.0
BH12-12	288.8	287.5	0.2	1.3

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-15	289.2	287.4	0.0	1.8
BH12-16	289.4	287.9	0.2	1.5
BH12-17	289.6	288.8	0.0	0.8
BH12-19	290.2	287.9	0.0	2.3

Notes:

1. *The elevations are referenced from HCP 123*
2. *Depths are relative to ground surface.*

The composition of this fill material generally consisted of sand, gravel and silt in varying amounts with trace to some clay. Cobbles were also encountered in this layer. The fill was generally brown to dark brown to grey in colour and moist to wet. The SPT "N" values obtained within this material ranged from 13 blows per 0.3 m penetration to 100 blows per 0.13 m penetration (refusal on likely cobble), suggesting that this layer was compact to very dense but generally compact to dense in compactness.

Laboratory testing performed on selected samples consisted of fifteen (15) moisture content tests and five (5) grain size distribution tests. The test results are as follows:

Moisture Content:

- 3% to 14%

Grain Size Distribution:

- 30% to 39% gravel
- 5% to 65% sand
- 55% silt
- 3% clay
- 3% 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 tests are also provided on Figure 2 in Appendix D.

1.5.1.6 Cohesionless Fill: Sand/Sandy Silt/Silt

Cohesionless fill material consisting of varying distributions of predominantly silt and/or sand was encountered below the asphalt treatment in borehole BH12-6 and below the sand and gravel/gravelly sand fill in borehole BH12-

17 and BH12-19. The approximate elevation of the surface and base of the fill and thickness as encountered in the boreholes are summarized below in Table 1.5.

Table 1.5. Summary of cohesionless fill: sand/sandy silt/silt

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-6	290.8	286.3	0.1	4.5
BH12-17	288.8	287.3	0.8	1.5
BH12-19	287.9	287.2	2.3	0.7

Notes:

1. *The elevations are referenced from HCP 123*
2. *Depths are relative to ground surface.*

The composition of this fill material predominantly consisted of silt and/or sand with a gravel content ranging from trace gravel to becoming gravelly and trace to some clay. Cobbles were also encountered within the fill. The fill was generally grey in colour and moist to saturated. The SPT "N" values obtained within this material ranged from 4 to 64 blows per 0.3 m penetration, suggesting that this layer was very loose to very dense, but generally loose to compact in compactness.

Laboratory testing performed on selected samples consisted of seven (7) moisture content tests and two (2) grain size distribution test. The test results are as follows:

Moisture Content:

- 7% to 26%

Grain Size Distribution:

- 0% to 22% gravel
- 2% to 22% sand
- 49% to 87% silt
- 7% to 11% 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.

1.5.1.7 Rock Fill

Rock fill consisting of various sized fragments of rock in a soil matrix (gravel, sand and silt sized particles) was encountered below the sand and gravel/gravelly sand fill in boreholes BH12-4, BH12-8 BH12-12, and BH12-15. The

approximate elevation of the surface and base of the rock fill and thickness as encountered in the boreholes are summarized below in Table 1.6.

Table 1.6. Summary of rock fill

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-4	288.0	287.1	1.2	0.9
BH12-8	288.8	285.6	1.2	3.2
BH12-12	287.5	281.7	1.5	5.8
BH12-15	287.4	285.5	1.8	1.9

Notes:

1. *The elevations are referenced from HCP 123.*
2. *Depths are relative to ground surface.*

The composition of this rock fill layer generally consisted of cobble to boulder sized rock fill with silt, sand and gravel sized particles within the in-fill soil matrix. The particle size within the rock fill 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 5 to over 100 blows per 0.3 m penetration, suggesting that this layer was loose to very dense in relative density. In addition, refusal due to a cobble or boulder was likely encountered when the split spoon could not penetrate 0.3 m.

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

1.5.1.8 Sand / Silty Sand / Silt and Sand

Native sand to silty sand to silt and sand was encountered below the topsoil in boreholes BH12-1, BH12-2 and BH12-3, below the fill in borehole BH12-19, below the organic silt/peat in boreholes BH12-5 and BH12-19, below the silt in borehole BH12-1, and below the sandy silt in borehole BH12-6. The approximate elevation of the surface and base of this layer and thickness as encountered in the boreholes are summarized below in Table 1.7.

Table 1.7. Summary of sand/silty sand layer/silt and sand layers

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-1	287.2 280.4	285.8 279.0	0.1 6.9	1.4 1.4
BH12-2	287.4	286.7	0.1	0.7
BH12-3	286.4	281.3	0.2	5.1
BH12-6	284.0	281.0	6.9	3.0
BH12-19	286.2	284.1	4.0	2.1

Notes:

1. *The elevations referenced from HCP 123.*
2. *Depths are relative to ground surface.*

The composition of this material generally consisted of sand and silt with trace gravel to becoming gravelly, trace clay, and trace organics. Cobbles/boulders were also encountered. These layers were generally brown to grey in colour and moist to saturated. The SPT "N" values obtained within this material ranged from 2 to 25 blows per 0.3 m penetration, suggesting that this layer was very loose to compact in compactness.

Laboratory testing performed on selected samples consisted of ten (10) moisture content tests, four (4) grain size distribution test, one (1) Atterberg limit test, two (2) unit weight tests, and three (3) organic content tests. The test results are as follows:

Moisture Content:

- 14% to 43%

Grain Size Distribution:

- 0% to 21% gravel
- 41% to 54% sand
- 34% to 53% silt
- 0% to 4% clay

Atterberg Limits:

- Non-plastic

Unit Weight:

- 17.5 kN/m^3 to 18.7 kN/m^3

Organic Content:

- 1.6% to 4.9%

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

1.5.1.9 Silt/Sandy Silt

Native silt was encountered below the native sand/silty sand/silt and sand layer in boreholes BH12-1, BH12-2, BH12-3, BH12-6, below organic silt in boreholes BH12-5, BH12-11, BH12-13 and BH12-20, and below the fill material in borehole BH12-6, BH12-16, and BH12-17. The approximate elevation of the surface and base of this layer and thickness as encountered in the boreholes are summarized below in Table 1.8.

Table 1.8. Summary of silt/sandy silt layers

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-1	285.8	280.4	1.5	5.4
BH12-2	286.7	280.0	0.8	6.7
BH12-3	281.3	277.5	5.3	3.8
BH12-5	283.6	280.5	3.0	3.1
BH12-6	286.3 281.0	284.0 280.2	4.6 9.9	2.3 9.9
BH12-11	282.3	276.8	6.1	5.5
BH12-13	280.3	273.6	6.1	6.7
BH12-16	287.1	283.9	2.5	3.2
BH12-17	287.3	286.5	2.3	0.8

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-20	283.3	277.1	3.4	6.2

Notes:
1. *The elevations referenced from HCP 123.*
2. *Depths are relative to ground surface.*

The composition of this material predominantly consisted of silt with trace sand to becoming sandy, trace to some gravel, trace to some clay, and trace organics. These layers were generally brown to grey in colour and were moist to saturated. The SPT "N" values obtained within this material ranged from WH (weight of hammer) to 39 blows per 0.3 m penetration, suggesting that this layer was very loose to dense, but generally loose to compact in compactness.

Laboratory testing performed on selected samples consisted of twenty-eight (28) moisture content tests, thirteen (13) grain size distribution tests, seven (7) Atterberg limit tests, and two (2) unit weight tests. The test results are as follows:

Moisture Content:

- 15% to 50%

Grain Size Distribution:

- 0% to 11% gravel
- 1% to 20% sand
- 72% to 94% silt
- 1% to 16% clay

Atterberg Limits:

- Non-plastic

Unit Weight:

- 16.4 kN/m^3 to 20.3 kN/m^3

The results of the moisture 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 tests are also provided on Figure 5 and Figure 6 in Appendix D.

1.5.1.10 Clayey Silt

Native clayey silt was encountered below native silt in borehole BH12-5. The approximate elevation of the surface and base of this layer and thickness as encountered in borehole BH12-5 are summarized below in Table 1.9.

Table 1.9. Summary of clayey silt

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-5	280.5	278.2	6.1	2.3

Notes:

1. *The elevations are referenced from HCP 123.*
2. *Depths are relative to ground surface.*

The composition of this material generally consisted of clay and silt with trace sand. This layer was grey in colour and saturated. The SPT "N" values obtained within this layer ranged from 2 to 6 blows per 0.3 m penetration, suggesting that it was very soft to firm in consistency.

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

Moisture Content:

- 20% to 30%

Grain Size Distribution:

- 0% gravel
- 3% sand
- 74% silt
- 23% clay

Unit Weight:

- 17.7 kN/m^3

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

1.5.1.11 Glacial Till: Cobbles and Boulders

Glacial till comprised of cobbles and boulders in a silt, sand, and gravel soil matrix were encountered below the native silt, clayey silt, and sandy silt layers in boreholes BH12-2, BH12-3, BH12-5, BH12-6, BH12-11, BH12-13, BH12-16, BH12-17 and BH12-20, and below the native sand in borehole BH12-1. Boreholes BH12-2, BH12-5, BH12-6, BH12-11, and BH12-13 were terminated within this layer. The approximate elevation of the surface and base of this layer and thickness as encountered in the boreholes are summarized below in Table 1.10.

Table 1.10. Summary of glacial till (cobbles and boulders) layer

Borehole	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH12-1	279.0	276.6	8.3	2.4
BH12-2	280.0	278.5	7.5	1.5
BH12-3	277.5	276.1	9.1	1.4
BH12-5	278.2	274.9	8.4	3.3
BH12-6	280.2	275.3	10.7	4.9
BH12-11	276.8	276.5	11.6	0.3
BH12-13	273.6	272.5	12.8	1.1
BH12-16	283.9	283.6	5.7	0.3
BH12-17	286.5	285.6	3.1	0.9
BH12-20	277.1	276.5	9.6	0.6

Notes:

1. *The elevations are referenced from HCP 123.*
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 was 100 blows per 0.125 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.

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

1.5.2 Bedrock

Bedrock was encountered beneath the silty sand in borehole BH12-19, below the rock fill in borehole BH12-4, BH12-8, BH12-12, and BH12-15, and below the glacial till in boreholes BH12-1, BH12-3, BH12-16, BH12-17 and BH12-20. Elevations at the top of bedrock were between 276.1 m to 287.1 m. The bedrock was investigated by coring about 1.2 m to 3.7 m into the stratum. The bedrock surface depths and elevations encountered at these borehole locations are listed in Table 1.11. Photographs of the rock cores are included in Appendix E.

Table 1.11. Summary of bedrock

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)
	Top	Bottom	
BH12-1	276.6	274.0	10.7
BH12-3	276.1	272.9	10.5
BH12-4	287.1	284.6	2.1
BH12-8	285.6	282.3	4.4
BH12-12	281.7	279.8	7.3
BH12-15	285.5	283.2	3.7
BH12-16	283.6	281.9	6.0
BH12-17	285.6	281.9	4.0
BH12-19	284.1	281.1	6.1
BH12-20	276.5	275.3	10.2

Notes:

1. *The elevations referenced from HCP 123.*
2. *Depths are relative to ground surface.*

Based on the bedrock NQ cores (~ core diameter 47 mm) recovered, the bedrock at the site generally consisted of felsic igneous rocks and migmatic rocks and gneisses. In general, the rock samples are described as light to dark grey and reddish/pink in colour. The Rock Quality Designation (RQD) measured on the core samples typically ranged from

approximately 21% to 100%, indicating a rock mass of very poor to excellent quality, but generally poor to good quality. The total core recovery (TCR) of bedrock cores ranged from 38% to 100%.

1.6 Groundwater and Surface Water Conditions

All boreholes at this site were advanced using diamond coring procedures. Water was used during the advancement of HQ casing and NQ cores from the 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 a piezometer. The groundwater levels measured in the piezometer installed in borehole BH12-1 are shown on the borehole logs and are presented below in Table 1.12.

Table 1.12. Groundwater levels measured in the piezometer

Borehole No.	Date Measured	Ground Surface Elevation[1] (m)	Groundwater Depth[2]/Elevation[1] (m)
East side of Embankment			
BH12-1	May 15, 2024 June 18, 2024 July 31, 2024	287.3	0.5/286.8 0.5/286.8 0.4/286.9

Notes:

1. *The elevations are referenced from HCP 123.*
2. *Depths are relative to ground surface.*

The top of creek water level at the existing culvert location was measured to be at Elev. 286.4 m on the east (inlet) and west (outlet) side in June 2024.

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.

1.7 Chemical Analyses

One (1) soil sample was selected for chemical analyses during field investigation. The soil sample collected by EXP was tested at Bureau Veritas, a CALA-certified and accredited laboratory in Mississauga, Ontario.

Sample SS8 from borehole BH12-6 was subjected to corrosivity chemical analyses. The analytical results are summarized in Table 1.13 below and are presented in Appendix D.

Table 1.13. Summary of chemical analysis results

Sample Identification	pH (unitless)	Soluble Chloride (ppm)	Soluble Sulphate (ppm)	Resistivity (ohm-cm)	Conductivity (mS/cm)	Redox Potential (mV)
BH12-6 SS8	7.40	170	<20	2200	451 - 452	440 - 470

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 to assess this additional information and our recommendations as appropriate. It may then be necessary to conduct 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.

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PART II - FOUNDATION DESIGN REPORT

3 ENGINEERING DISCUSSION & RECOMMENDATIONS

3.1 General

This section of the report provides geotechnical design recommendations for the design and construction of the proposed embankment widening and the extensions of two (2) existing culverts on Highway 11 at site SW12. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation at the site performed by EXP between May 5, 2023, and July 30, 2024. The compiled factual data is presented in **Part I-Foundation Investigation Report** of this report. The interpretation and recommendations provided are intended solely for the design of the proposed embankment widening and culvert extension. Comments on construction are only provided to highlight issues that could affect the design. Contractors should make their own assessments of the factual data and how it might affect construction means and methods, scheduling and the like.

At the time of preparing this report, the widening alignment is not finalized. However, as per "'Final' Realignment Evaluation Report Highway 11 from 400 m south of Tonomo Lake Road northerly for 2.6 km", Project Number: 60713279, prepared by AECOM and dated January 2025, it is recommended that Option 3 - Moderate Realignment to the east be carried forward for this project.

As per drawings provided by AECOM, the site is divided into two segments: SW12-1, spanning from Sta. 13+630 to Sta. 14+004, and SW12-2, spanning from Sta. 14+004 to Sta. 14+160. Based on preliminary design sections for Option 3, segment SW12-1 will require rock excavation into the bedrock outcrops for widening to the east, while segment 12-2 will require up to ~20 m of widening to the east with approximately 1 to 5 m of fill placed above the existing ground surface. The grade of Highway 11 will be raised by up to approximately 1 m. At site SW12, two culverts exist: a concrete box culvert at Station 14+154 and a CSP culvert at Station 14+037. Due to widening, extension of these two culverts is required.

Site conditions and a site description are provided in Section 1.2.

This part of the report addresses the geotechnical design of the foundation for the proposed embankment widening and culvert extension 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 *Canadian Highway Bridge Design Code (CHBDC) (CAN/CSA-S6-19)*, the *Canadian Foundation Engineering Manual (CFEM) (2023), MTO Gravity Pipe Design Guidelines (April 2014), Guideline for MTO Foundation Engineering Services, Version 02 (October 2020) and Version 03 (April 2022),* and generally accepted good practice. Pertinent construction issues from a geotechnical standpoint were examined in general accordance with the Terms of Reference. The assessment involved a review of different types of culvert options for the extension of the existing culvert and other geotechnical and construction considerations such as an assessment of slope stability and settlement of the widened embankments, lateral earth pressure on structures, site preparation, excavation, and frost protection.

A "typical consequence level" is considered appropriate for the culvert extension and embankment widening at this site, as outline in Section 6.5 of the CHBDC (CAN/CSA-S6-19) and a MTO memorandum from Materials Engineering Research Office (MERO) #2020-01 dated March 23, 2020, respectively. Further, given the scope of work of the foundation field investigation and laboratory testing program a "typical degree of site and prediction model understanding" has been utilized. Accordingly, the appropriate corresponding ULS and SLS consequence factor, Ψ, from Table 6.1 and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs} from Table 6.2 of the CHBDC (CAN/CSA-S6-19) for

the culvert. Additionally, an appropriate geotechnical resistance factor, ϕ_{gu}, for global stability – permanent was obtained from Table 1 in MERO #2020-01.

3.2 Seismic and Liquefaction Potential Consideration

3.2.1 Seismic Hazard Site Classification and Values

Seismic characterization of the site must comply with the CHBDC (CAN/CSA-S6-19). The potential for seismic loading should be considered in the design according to Section 4.4 of the CHBDC (CAN/CSA-S6-19), considering the soil conditions encountered at the site. Table 4.1 in the CHBDC (CAN/CSA-S6-19) (see Clause 4.4.3.2) provides site classifications for seismic site response based on the average properties of the top 30 meters of soil.

Below the roadway, the encountered subsurface conditions consisted of sand and gravel to gravelly sand fill followed by either rock fill directly over bedrock or cohesionless fill consisting of varying amounts of mainly silt and sand underlain by native soil comprised of silts and sands followed by glacial till consisting predominantly of cobbles and boulders in a silt, sand and gravel matrix underlain 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 silt and sand followed by glacial till underlain by bedrock. The depth to the top of bedrock ranged from 2.1 m to 10.7 m below ground surface at the site. Therefore, based on these soil characteristics, the site class for this site is estimated to be Class "D" according to Table 4.1 of the CHBDC (CAN/CSA-S6-19).

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 3.1 below:

Table 3.1 Seismic design values

Probability of Exceedance in 50 Years (Return Period)	Sa(0.2) (g)[1]	Sa(0.5) (g)	Sa(1.0) (g)	Sa(2.0) (g)	PGA (g)
Latitude: 46.834600; Longitude: -79.797120					
2% (1 in 2475-year)	0.42	0.363	0.21	0.0983	0.257

Note:

1. *g = acceleration due to gravity (9.81 m/s²)*

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 and is also shown on the seismic hazard calculation data sheet for this site attached in Appendix H.

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}). Since Sa(0.2)/PGA is less than 2.0 at this site, PGA_{ref} is equal to 0.8*PGA=0.206 g, as per Section 4.4.3.3. of the CHBDC (CAN/CSA-S6-19). The site coefficient F(PGA), for this site (Seismic Site Class D and PGA_{ref} = 0.206 g) is 1.09.

3.2.2 Liquefaction/Cyclic Softening Potential

Liquefaction of cohesionless soils below the groundwater table, including the native cohesionless soils (silts and sands), clayey silt, and glacial till layers at the project site was evaluated through the SPT-based liquefaction triggering procedures described in Boulanger and Idriss (2014) using the site's PGA = 0.257 g (1 in 2475-year event). Additionally, cyclic softening of cohesive soils (native clayey silt), at the project site was also assessed based on empirically estimating cyclic resistance ratio (CRR) based on the measured undrained shear strength profile, as described in Boulanger and Idriss (2007).

The SPT 'N' values for the native soils consisting predominantly of silt and sand were recorded as follows:

- Beyond the toe of the west side of the existing embankment (from 3.0 m to 6.1 m below ground)
  - 0 (weight of hammer) to 28 blows per 0.3 m of penetration
- Below the existing embankment (from 2.3 m to 4.6 m below ground)
  - 5 to 25 blows per 0.3 m of penetration
- Beyond the toe of the east side of the embankment (from 0.1 m to 0.2 m below ground)
  - 0 (weight of hammer) to 39 blows per 0.3 m of penetration

The SPT 'N' values for the native clayey silt layer located on the northwest end of the site at a depth of 6.1 m below ground ranged from 2 to 6 blows per 0.3 m of penetration.

All organic laden soil (organic silt/peat) is to be excavated prior to any fill placement for widening/culvert extension. Susceptibility to seismically induced liquefaction is not expected to significantly impact the overall project design due to the presence of shallow bedrock and low seismic risk.

3.3 Culvert Extensions

3.3.1 Culvert Extension Options

Two existing culverts at Station 14+154 and Station 14+037 must be extended to accommodate the Highway 11 embankment widening at site SW12. The culvert at Station 14+154 is a concrete box culvert, with invert elevations at the inlet and outlet approximately Elev. 286.1 m and Elev. 285.8 m, respectively. The culvert at Station 14+037 is a CSP culvert, with invert elevations at the inlet and outlet approximately Elev. 287.0 m and Elev. 286.9 m, respectively. The widening of the alignment is not finalized; however, it is understood that a moderate realignment to the east is recommended for this project. For this option, both culverts will be extended on the east side. For completeness, geotechnical resistances, excavation, and bedding recommendations are provided for both the east and west sides.

The choice of culvert extension type and size depends on the type of existing culvert, its hydraulic performance, staging requirements, geotechnical resistance available in the foundation soils, initial cost, maintenance costs, ease of construction, water and soil corrosiveness, salvageability, and local availability of materials and equipment. However, for preliminary design purposes, the following possible options for culvert extension are presented below, with the advantages and disadvantages of each summarized in Table 3.2.

- Corrugated steel pipe (CSP) culvert
- Precast rigid frame concrete box culvert,
- Cast-in-place rigid frame concrete box culvert, and
- Cast-in-place rigid frame open footing concrete culvert supported on shallow foundations

Table 3.2 Evaluation of structure type options for culvert extension

Option	Rank		Advantages	Disadvantages	Risk/Consequences
	Existing Concrete Box (Station 14+154)	Existing CSP (Station 14+037)			
Precast rigid frame concrete box culvert	1	2	• Reduced construction period than cast-in-place open footing option, consequently water control period will be reduced • Reduced excavation depth, protection system and dewatering requirement compared to open footing option • Can be more readily installed during cold weather conditions • Existing culvert can be used to maintain flow during construction	• Greater disturbance to natural streambed than for open footing culvert option • Potential of undermining at the connection of existing open footing culvert • Though founding level higher than open footing, excavation would still require below the water level, requiring dewatering scheme to enable construction in dry conditions	• Risk of leaking from joints if not properly installed • Risk of unacceptable differential settlements if the entire foundation is not supported on the competent soil
Cast-in-place rigid frame concrete box culvert	2	3	• Suitable if precast sections are relatively larger for transportation and installation of heavier units and if site is not appropriate to heavy equipment for installation of precast sections • Culvert design can be customized in the field for high	• Require longer duration for construction, including traffic management and water control period • Required time for forming, placing and curing of concrete	• Risk of disturbance of base during construction • Risk of unacceptable differential settlements if the entire foundation is not supported on the competent soil

Option	Rank		Advantages	Disadvantages	Risk/Consequences
	Existing Concrete Box (Station 14+154)	Existing CSP (Station 14+037)			
			stress or load conditions or other site-specific requirements, temporary protection system requirements	• Greater disturbance to natural streambed than for open footing culvert option • Potential of undermining at the connection of existing open footing culvert	
Cast-in-place rigid frame open footing concrete culvert supported on shallow foundation	3	4	• Reduced disturbance of creek channel during excavation, as compared with wider span for box culvert • Wider span may consider maintaining existing channel and so allows for natural streambed to remain intact • Less accumulation of sediments in the upstream of culvert	• Deeper excavation than box culvert options would be required, consequently increased in excavation support and dewatering requirements • Potential for undermining existing culvert during construction • Require longer duration for construction, including traffic management and water control period • Risk of differential settlement	• Risk of disturbance of existing structure founding soils. • Higher scour risk • Risk of unacceptable differential settlements if the entire foundation is not supported on the competent soil

Option	Rank		Advantages	Disadvantages	Risk/Consequences
	Existing Concrete Box (Station 14+154)	Existing CSP (Station 14+037)			
Corrugated Steel Pipe (CSP) culvert	4	1	• Straightforward construction • Reduced construction period, consequently, traffic management and water control period • Reduced excavation depth	• Requires bedding material • Limited design life • Potential for corrosion • Difficult connection between CSP and existing concrete culvert	• Risk of structure segment loss due to corrosion • Risk of unacceptable differential settlements if the entire foundation is not supported on competent soil

Based on subsurface information obtained from the investigation conducted at this site, support for the culvert extensions is feasible at a shallow depth on native silt, silty sand, and silt and sand. However, mitigation measures addressing settlement of foundation soils resulting from embankment widening will be required to meet the settlement design criteria outlined in Section 3.5.3.6.

In general, any loose and/or soft soils encountered below the culvert extension should be excavated and replaced with engineered fill. If the depth of excavation to remove unstable soils is excessive, using a geotextile fabric in accordance with OPSS.PROV 1860, Class II Non-Woven (OPSS 1860 II-N), in conjunction with engineered fill can be considered to assist in providing a stable base for the new culvert extension. Based on previous experience, typically it should consist of Granular A or Granular B Type II (OPSS.PROV 1010) with a minimum thickness of 300 mm beneath the culvert structure and extend a minimum of 500 mm horizontally on either side of the culvert edge. The fabric should be installed a manner to mitigate the migration of fines from adjacent material.

Table 3.2 presents a comparison of possible structure options for the culvert extensions, evaluating their advantages and disadvantages from a foundation design and constructability perspective, with key findings and conclusions for the two existing culvert types summarized below:

- Closed box culverts, either precast or cast-in-place, installed with appropriate granular bedding over the subgrade were determined to be feasible and ranked the highest for the criteria evaluated for the eastward extension of the existing box culvert at Station 14+154.
- Extension with a CSP is ranked the highest for the eastward extension of the existing CSP culvert at Station 14+037 to maintain consistency with the existing structure, as alternative options such as concrete box culverts or cast-in-place rigid frame open footing concrete culverts are not optimal due to their larger size and differing shape. It should be noted that the proposed structures must meet the required flow capacity and hydraulic requirements.
- An open-footed concrete culvert on spread footings is feasible at this site. However, it is likely more expensive than other options due to deeper excavations required for casting the footings with dewatering.
- Construction of the widened embankment will induce settlement of the foundation soils below the culvert footprint which some differential settlement, as further discussed in Section 3.5.3.

3.3.2 Foundation Design Recommendations

3.3.2.1 Geotechnical Resistances

Based on the subsurface stratigraphy encountered at this site and the assumed invert elevation of the culvert extensions, Table 3.3 summarizes the recommended founding levels and geotechnical resistances for different culvert types at the inlet (east) and outlet (west) sides of two existing culverts. The geotechnical resistances provided are for vertical loading conditions only; load eccentricity and load inclination effects should be addressed in accordance with the CHBDC (CAN/CSA-S6-19) and its commentary. The geotechnical resistances provided in sections below were factored with typical consequence factors of 1.0 at ULS and SLS and typical degree of understanding (factor of 0.5 at ULS and factor of 0.8 at SLS) in accordance with Table 6.1 and 6.2 of the CHBDC (CAN/CSA-S6-19).

Table 3.3 Recommended shallow foundation design parameters

Culvert Type	Relevant Borehole	Location	Invert Elevation/ Excavation Elevation (m)	Footing Size (m)	Founding Soil Type	Factored Geotechnical Resistance at ULS (kPa)	Factored Geotechnical Resistance at SLS[1] (kPa)
Extension of Concrete Box Culvert (Sta. 14+154)							
Precast or cast-in-place rigid frame concrete box culvert	BH12-3	Inlet (East)	~286.1/285.8	~1.3[2]	~0.3 m thick bedding of Granular 'A' or 'B' Type II[(5)] over loose silty sand	210	110
	BH12-5	Outlet (West)	~285.8/283.6[3]		~0.3 m thick bedding of Granular 'A' or 'B' Type II[(5)] followed by 1.9 m thick rock fill over very loose silt		
Cast-in-place rigid frame open footing concrete culvert on shallow foundation	BH12-3	Inlet (East)	~286.1/284.0[3]	1	Very loose to compact silt and sand	260	140
	BH12-5	Outlet (West)	~285.8/283.6[4]		Very loose silt		
Extension of CSP Culvert (Sta. 14+037)							
Precast or cast-in-place rigid frame concrete box culvert/CSP culvert	BH12-2	Inlet (East)	~287.0/286.7	~0.9[2]	~0.3 m thick bedding of Granular 'A' or 'B' Type II[(5)] over compact silt	200	105
	BH12-13	Outlet (West)	~286.9/280.3		~0.3 m thick bedding of Granular 'A' or 'B' Type II[(5)] followed by 6.3 m thick rock fill over very loose silt		
Cast-in-place rigid frame open footing concrete culvert on shallow foundation	BH12-2	Inlet (East)	~287.0/284.9[3]	1	Loose to compact silt	275	150
	BH12-13	Outlet (West)	~286.9/280.3[3]		~0.3 m thick bedding of Granular 'A' or 'B' Type II[(5)] followed by 4.2 m thick rock fill over very loose silt		

Notes:

1. *For maximum settlement of 25 mm*
2. *Assumed based on existing culvert dimensions.*
3. *Below the frost line (~2.1 m)*
4. *Depth of 2.2 m to top of native silt (i.e. organic silt removed)*
5. *The granular material used for the granular pad shall be Granular 'A' or Granular B Type II conforming to OPSS.PROV 1010 and compacted according to OPSS.PROV 501.*

The geotechnical resistance at SLS was computed on the basis of limiting the settlement of an individual culvert footing to 25 mm under the applied load. The actual settlement of the culverts will be governed by compression of the foundation soils under the weight of the road embankment fill. In this regard, some mitigation measures should be applied along the culvert extension to accommodate a potential differential settlement between the crest and toe of the new embankment fill required for widening.

3.3.2.2 Resistance to Lateral Loads

Resistance to lateral forces/sliding should be calculated in accordance with Section 6.10.5 of the CHBDC (CAN/CSA S6-19), using the parameters in Table 3.4.

Table 3.4 Recommended parameters for calculation of unfactored horizontal resistance

Interface and Loading Conditions	Parameters
Between Granular A and pre-cast concrete	Coefficient of friction (tan δ)=0.55
Between Granular A and cast-in-place concrete	Coefficient of friction (tan δ)=0.6

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

3.3.2.3 Frost Protection

The frost depth in the area of the culvert is estimated to be approximately 2.1 m in accordance with OPSD 3090.100. A minimum 2.1 m of soil cover or equivalent frost protection should be provided using thermal insulation only to the rigid frame open footing culvert option. For the box culvert and CSP culvert options, frost protection is not required.

3.3.3 Culvert Bedding

OPSDs 803.010, 802.010, and 802.034, which are included in Appendix I provide the bedding, embedment, cover and backfill standards for concrete box and pipe culverts. According to these standards the culvert bedding should consist of Granular A (OPSS.PROV 1010) with a minimum thickness of 300 mm beneath the culvert and extend a minimum of 300 mm horizontally on either side of the culvert edge. The bedding material should be placed in layers not exceeding 200 mm in thickness, loose measurement, and compacted in accordance with OPSS.PROV 501 before a subsequent layer is placed in accordance with OPSS. PROV 401. Based on the existing conditions at the site, Granular B Type II is preferred material for the culvert bedding below the water table.

The culvert extension installation shall be carried out in accordance with OPSS.PROV 902 with SP 109S61. Therefore, prior to placing any fill material, the exposed subgrade should be inspected according to OPSS.PROV 902. A non-woven geotextile separator is to be placed between the approved subgrade and the compacted fill to assist in material placement and maintain the integrity of the founding soil along the entire length of the culvert. The geotextile separator is to be a Class II non-woven material in accordance with OPSS.PROV 1860 with a filtration opening size (FOS) as specified in the contract documents.

3.3.4 Culvert Backfill

The selection and placing of the backfill and cover should be in accordance with OPSS.PROV 902, OPSS.PROV 421, OPSS.PROV 422 and OPSS.PROV 206, and OPSDs 802.034 and 803.010 for different culvert materials. The backfill should consist of free-draining, non-frost susceptible granular materials conforming to OPSS.PROV 1010.

For fills immediately below any roadway, it is recommended that Granular A or B Type II materials be used. As noted below, proper tapering as per standards should be provided. Below a depth of about 2.1 m from any finished road grade, approved compactable fill, such as select subgrade materials (OPSS.PROV 1010) or imported fill can be used.

All granular backfill materials should be placed in thin lifts (i.e., not exceeding 300 mm before compaction) and each lift should be compacted in accordance with OPSS. PROV 501. The final lift of embankment fill prior to placing pavement sub-base should be compacted to 100 % SPMDD. The Granular A base and Granular B sub-base courses (for pavement) should be compacted to 100% of the material's SPMDD.

The use of heavy compaction equipment should be avoided immediately adjacent and above the culvert, as per MTO practice. The minimum height of fill cover above the crown of the culvert before power operated tractors or rolling equipment shall be 900 mm, unless otherwise noted by the Structural Engineer. During backfill placement, the height of the backfill should be maintained at approximately the same level on both sides of the structure, to avoid lateral displacement of the structure.

Where less than 2.1 m (the frost depth) of earth cover is provided above the top of the culvert, a frost taper should be included as per OPSD 803.031, and MTOD 803.021, whichever is applicable. If the frost taper exists at the site, it will be reinstalled within the zone of excavation in accordance with OPSD 803.031.

3.3.5 Lateral Earth Pressures

Culvert walls and temporary shoring (if any) should be designed to resist lateral earth pressure. The expression for calculating lateral earth pressure in accordance with the CHBDC (CAN/CSA-S6-19) is given by:

$P = K(\gamma h + q)$ for non-braced cut, or $K (0.65\gamma h + q)$ for a braced cut

where,

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

The above expression does not consider hydrostatic pressure, which must be included for the groundwater levels measured on the site. Table 3.5 lists earth pressure parameters for given materials. These recommendations assume wall friction is neglected, a level ground surface in front and behind the walls and the back face of the wall is vertical.

Table 3.5 Material types and earth pressure properties under static conditions

Material	Unfactored Friction Angle ϕ' (°)	Coefficient of Active Earth Pressure (K_a)[1]	Coefficient of Passive Earth Pressure (K_p)[1]	Coefficient of Earth Pressure At-Rest (K_o)[1]	Unit Weight γ (kN/m^3)
Granular A / B Type II	35	0.27	3.69	0.43	22.8
Granular B Type I	32	0.31	3.26	0.47	21
Gravelly Sand/Sand and Gravel Fill (generally compact to dense)	32	0.31	3.26	0.47	22
Sand/Sandy Silt/Silt Fill (generally loose to compact)	29	0.35	2.88	0.52	20
Existing Rock Fill	40	0.22	4.60	0.36	18
Peat	23	0.44	2.28	0.61	14
Organic Silt (very loose to loose)	23	0.44	2.28	0.61	16
Sand/Silty Sand/Silt and Sand (very loose to compact)	29	0.35	2.88	0.52	19
Silt/Sandy Silt (very loose to compact)	29	0.35	2.88	0.52	18
Clayey Silt (Soft to Firm)[2]	28	0.36	2.77	0.53	18
Glacial Till - Cobbles and Boulders	36	0.26	3.85	0.41	18

Notes:

1. *K_a = active earth pressure coefficient; K_p= passive earth pressure coefficient; K_o = coefficient of earth pressure at rest.*
2. *Assumes long term conditions. In short term conditions $K_a = K_p = 1$.*

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. This would normally be the case for concrete box culverts.

The effect of compaction surcharge should be considered in the calculations of active and at rest earth pressures. 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 culvert walls to prevent overstressing.

It is likely that bracing for the temporary support system (if any) will be required at a maximum interval of 5 m. For multiple support systems refer to Canadian Foundation Engineering Manual (CFEM) 5th Edition for apparent earth pressure distributions (CFEM, Section 20.8.1.4).

3.4 Site Considerations: Construction/Mitigation Options

Based on currently available information, the Highway 11 widening at site SW12 is expected to proceed on the east side. However, for completeness, both sides of the site were investigated and assessed from a geotechnical perspective. Subsurface investigations on the east side revealed no significant peat/organic soil layers, and the existing native soils (i.e. loose to dense silt, silty sand and silt and sand) are capable of supporting the new embankment fill without requiring significant excavation. In contrast, the west side presents more challenging conditions, with organic-rich soils up to 6.1 m thick. These soils cannot adequately support the new fill unless ground improvement measures are implemented.

Table 3.6 summarizes the construction and mitigation options which could be considered for improving soil conditions within the footprint of the proposed widening fill on the west side, if required. Each option is evaluated in terms of its advantages, disadvantages, risks, relative cost, and overall ranking. Among the options, excavation of peat and other weak or soft soils and replacement with competent materials such as rock fill is recommended as the most practical and cost-effective solution. While stone column installation is also feasible, it is assessed to be more expensive. Other options listed in Table 3.6 were deemed either impractical or prohibitively costly for this site.

Table 3.6. Considered construction/mitigation measures at the west side of SW12

Mitigation Technique		Advantages	Disadvantages	Risk	Relative Cost	Ranking
Sub-excavation and replacement of peat/organic material	Excavate peat/organic material up to 5.5 m within the widening footprint and place rock fill	• Strengthening the soil within the footprint • Steeper side slope (1.25H:1V) is possible, smaller footprint, less material • Ability to place under water • Increase stability for appropriately defined process and sequence. • Straightforward construction • Use of available fill material • More control of construction	• During excavation the stability of existing embankment could be jeopardized. Special Provisions required defining staged construction and sequence to be followed. • Requires deep excavation. • Need more material. Assume rock fill; need to define placement approach. • Later settlement of Fill itself	Moderate with appropriate approach	Low to Moderate	1
Ground Improvement	Stone columns	• Possible one single stage construction • Less settlement	• Require specialty construction methodology	Moderate	High	2
	Vacuum Consolidation	• Speed up the consolidation	• Requires specialty construction methodology • Very difficult to install in swampy area • Difficult to maintain vacuum	High	Very High	N/A
	Electroosmotic Treatment	• Speed up the consolidation	• Require specialty construction methodology • Very difficult to install electrodes through rock fill • Limited application	High	Very High	N/A

Mitigation Technique	Advantages	Disadvantages	Risk	Relative Cost	Ranking
Chemical Grouting/Deep Mixing	• Increase soil strength	• Soil type • Expensive • Can cause ground heave	High	High	N/A
Vibro Compaction	• An effective treatment for soft/weak soils at depths of 2m > 20m. • Optimised and localised treatment solution for different soils • Highly economical and often results in greater time savings • Reduces the risk of seismically induced liquefaction • Minimal noise and vibration • Allows high production rates being quicker to complete than piling	• Vibro-compaction is only effective on granular and non-cohesive soils • Densification generally cannot be achieved when the granular soil contains more than 12-15% silt or more than 2% clay • A comprehensive analysis of the soil profile is needed with continuous sampling or in-situ testing • Not suitable for sites with contaminated land if vibratory techniques use water jetting	High	Moderate to High	N/A

3.5 Embankment Widening

3.5.1 General

At the time of preparing this report, the widening alignment is not finalized. However, it is understood that it is recommended that a moderate realignment to the east be carried forward for this project (Option 3 as per "'Final' Realignment Evaluation Report Highway 11 from 400 m south of Tonomo Lake Road northerly for 2.6 km", Project Number: 60713279, prepared by AECOM and dated January 2025).

Based on preliminary design cross-sections for Option 3, Segment 12-2 (Station 14+004 to Sta. 14+160) will require up to 20 m of widening to the east of the current alignment with approximately 1 to 5 m of fill placed above the existing ground surface. The grade of Highway 11 will be raised by up to approximately 1 m. The geometry analyzed in this report is defined based on EXP's geotechnical investigation, observations at the site, and the cross-sections provided by AECOM.

Design analyses and recommendations for the embankment widening have been carried out using rock fill in accordance with OPSD 203.020 and OPSD 203.030, since the existing embankment materials below the granular base/subbase material consist primarily of rock fill. The side slopes of rock fill should not be steeper than 1.25H:1V. Since embankments are less than 10 m in height, a 2 m wide mid-height bench is not required.

The design of embankment widening through the swampy area should allow for sub-excavation of peat/organic soils. Based on the results of the current investigation, the thickness of peat/organic soils at the west side was encountered to be up to 6.1 m. Thick organic layers were not encountered on the east side in segment SW12-2. However, it should be noted that the thickness of peat/organic soils below the new embankment footprint could vary between these borehole locations.

3.5.2 Stability Considerations

Preliminary slope stability analyses were performed to assess the global stability of the widened embankment to check if a minimum Factor of Safety of 1.5 for static and 1.1 for seismic conditions is achieved as per MTO criteria for typical degree of understanding. The static and seismic slope stability analyses were performed using the Morgenstern-Price method developed on the basis of limit equilibrium. The SLOPE/W computer program developed by GeoSlope International was employed for computation.

The stability analyses were performed for widening to the east of the Highway 11 alignment since this is the current recommendation at the time of preparing this report. The embankment widening at the concrete box culvert at Station 14+154 was identified as the critical case for slope modeling because this location features the highest embankment and generally weaker subsoil conditions.

The stratigraphy and groundwater conditions at the site were developed based on the results of the geotechnical investigation presented in Part I – Foundation Investigation Report. The parameters were selected based on the empirical correlations with SPT and engineering judgement for the effective stress assessments. Organic silt friction angle (including recommended strength reductions) were employed based on correlations from Mesri & Ajlouni (2007). The seismic properties given in Appendix H (Section 3.2.1) were obtained from the Natural Resources Canada website, 2020 NBC, using the site location coordinates. Tabulated below in Table 3.7 are the soil parameters used for the slope stability analyses.

Table 3.7. Soil properties used in slope stability analyses

Material Type	Effective Stress Parameters		Undrained Shear Strength, C_u (kPa)	γ (kN/m3)
	ϕ' (degrees)	c' (kPa)		
Engineered Fill	32	-	-	21
New Rock Fill	42	-	-	18
Existing Sand/Sandy Silt Fill (Loose to Very Dense)	30	-	-	20
Organic Silt	23	-	-	14
Silt (very loose to loose)	28	-	-	18
Sandy Silt/Silt and Sand/Silty Sand (very loose to compact)	29	-	-	19
Clayey Silt (Soft to Firm)	28	-	N/A[1]	18
Glacial Till (Cobbles and Boulders)	36	-	-	21

Note:

1. *Not Applicable - Material not encountered below widening on east side of embankment.*

Based on the borehole information, the subsoils encountered below the widening/extension footprint consist of cohesionless fill and native soils above the bedrock. Therefore, effective stress (drained conditions) analyses for a long-term assessment of the slopes were performed taking into consideration the subsoil conditions encountered at the site. The analyses assume that all peat/organic and loose materials will be removed prior to construction. In addition, a traffic surcharge pressure of 16 kPa was adopted in the slope stability assessments. Table 3.8 summarizes the results of performed slope stability analyses. The SLOPE/W graphical printouts for the analyses are included in Appendix F (Figures F1 and F2).

Table 3.8. Summary of results of embankment slope stability analyses

Location	Max Height (m)	Conditions	Min FOS
East Side Culvert Extension, Station 14+154 (1.25H:1V)	~5	Drained long-term conditions, static condition	1.5 (Figure F1)
		Drained long-term conditions, seismic condition	1.2 (Figure F2)

As seen in Table 3.4, embankment widening of Highway 11 using rock fill with 1.25H:1V side slopes can be considered stable for static and seismic conditions (i.e., calculated FOS ≥ 1.5 for static and FOS ≥ 1.1 for seismic with k_h = 0.5*F(PGA)*PGA=0.129 g), assuming that all loose soils and any organic material are excavated and replaced with properly compacted rock fill. Additionally, slope stability analyses and design commentary may be required for the embankment once finalized cross-sections at SW12 are available and/or if the embankment widening and culvert extension will occur to the west of the existing embankment.

3.5.3 Settlement Considerations

3.5.3.1 General

Based on the post-construction settlement criteria for embankment widening stipulated in MTO's "Embankment Settlement Criteria for Design", the maximum settlement limits during the pavement design life of the widened embankment are 75 mm for the total settlement and 100:1 for the differential settlement rate for non-freeways (i.e., including this segment of Highway 11). The differential settlement rate is applicable to both the new widened embankment and the differential settlement rate between the existing and the new embankment. The settlement across the widened embankment shall transition uniformly from the widening point (existing highway embankment rounding) to the new embankment rounding such that surface drainage is not impeded. Although a portion of the total estimated settlement is expected to occur post-construction, the differential movements should be able to be accommodated during the paving process and an appropriate delay between embankment construction and final paving.

To determine whether the newly constructed embankment at the site meets the specified criteria, the settlement of the foundation soil beneath the widened embankment and the settlement of the embankment itself (i.e., rock fill material) were evaluated. The following sections present the methods and results of these settlement analyses, along with a discussion of the total predicted settlement in relation to the MTO criteria.

3.5.3.2 Settlement of Foundation Soils

Fill to be placed on native soils for the new embankment widening will induce some settlement of the foundation soils (cohesionless soil predominantly comprised of silt and/or sand). Therefore, settlement analyses were carried out to calculate the predicted settlement considering the construction of the rock fill embankment having a unit weight of 18 kN/m^3 with approximately 1 m of granular material having a unit weight of 22.8 kN/m^3 being placed above the rock fill.

The settlement analyses were performed for widening to the east of the Highway 11 alignment. The segment between Station 14+050 and 14+150 on the east side of the existing Highway 11 embankment were considered the critical sections in terms of settlement magnitude considering the height of the existing embankment and the generally weaker subsoils. The settlement was estimated at Station 14+070, Station 14+110, and Station 14+150 (i.e. box culvert location), having an embankment height of approximately 3.5 m, 4.5 m, and 5.0 m, respectively, as per the preliminary design sections provided by AECOM. At Station 14+150, two soil treatment scenarios were analyzed to assess their impact on settlement behavior. In the first scenario (Soil Model 3A, Table 3.9), it was assumed that only the topsoil and weak surface soils would be stripped, and the widened embankment would be constructed directly over the existing native silt and sand deposits. In the second scenario (Soil Model 3B, Table 3.9), the upper 1.0 m of very loose to loose silty sand was assumed to be sub-excavated and replaced with compacted Granular B Type II material to improve foundation conditions and reduce potential settlement.

A computer program, Settle3D (Rocscience) was employed for settlement calculation of foundation soils due to construction of new embankment/widening at the site. Settle3D is a 3-dimensional program for the analysis of immediate and consolidation settlement (if any) under foundations, embankments and surface loads. The program combines the simplicity of one-dimensional analysis with the power and visualization capabilities of more sophisticated three-dimensional programs.

A representative site stratigraphy was developed based on the Record of Borehole logs with material properties based on the results of in-situ field testing and laboratory testing. The magnitude of total settlement for the widened embankment has been assessed based on SPTs and engineering judgement. The parameters used in the settlement analyses are summarized in Table 3.9. These parameters were estimated using empirical relationships with measured soil properties at the site and the available data in EXP and MTO libraries obtained in the area.

Table 3.9. Soil strength parameters used in settlement analyses

Material Type	γ (kN/m^3)	E (MPa)
Model 1: Station 14+070 (BH12-2)		
Silty Sand (very loose)	19	5
Silt (loose to compact)	18	10
Silt (compact to dense)	19	20
Glacial Till (cobbles and boulders)	21	75
Model 2: Station 14+110 (BH12-1)		
Sand (very loose to loose)	19	10
Silt (very loose to loose)	18	7
Sand (compact)	18	30
Glacial Till (cobbles and boulders)	21	75
Model 3: Station 14+150 (BH12-3)		
(A) Without 1 m Sub-Excavation of Very Loose to Loose Silty Sand and Replacement with Granular B Type II		
Silty Sand/Silt and Sand (very loose to loose)	19	8
Silt and Sand (compact)	19	20
Silt (very loose to loose)	18	10
Glacial Till (cobbles and boulders)	21	75
(B) With 1 m Sub-Excavation of Very Loose to Loose Silty Sand and Replacement with Granular B Type II		
Silty Sand/Silt and Sand, 1m subexcavation of (very loose to loose)[1]	19	10
Silt and Sand (compact)	19	20
Silt (very loose to loose)	18	10
Glacial Till (cobbles and boulders)	21	75
Granular B Type II	22.8	50

Note:

1. *Assumes average compaction in layer increases to 10 MPa due to removal of upper very loose portion for replacement with Granular Type II*

The summary of results of settlement analyses is given in Table 3.10. The Settle 3D results of these cases can be seen in Figures G1 to G4 in Appendix G.

Table 3.10. Results of settlement analyses

Location	Granular Fill Thickness (m)	Rock fill Thickness (m)	Calculated Settlement of Foundation Soils at Widened Portion (mm)[1]		
			At Edge of Existing Embankment	Maximum Value Within Widening	At Edge of Widened Embankment
Model 1: East Side of Existing Embankment (Sta. 14+070)	1	2.5	18	45	31
Model 2: East Side of Existing Embankment (Sta. 14+110)	1	3.5	26	78	59
Model 3A: East Side of Existing Embankment, Culvert (Sta. 14+150)	1	4	25	80	62
Model 3B: East Side of Existing Embankment/Culvert, 1 m Sub-Excavation of Very Loose to Loose Silty Sand and Replacement with Granular B Type II (Sta. 14+150)	1	4	21	64	49

Note:

1. *Immediate settlement*

As noted in Table 3.10, the differential settlement between edges of existing and new widened portion of embankment is estimated to be about 13 mm, 33 mm, and 37 mm at Station 14+070, Station 14+110, and Station 14+150 under soil Model 3A conditions, respectively. It is anticipated that these differential settlements will be further reduced by the time of paving. Although the exact timing of paving is not known at this stage of reporting, it is reasonable to assume that it will occur approximately 4 to 6 months following the construction of the widened embankment. The maximum magnitude of settlement which typically occurs near the center of the widened portion of the embankment was estimated to be 45 mm, 78 mm, and 80 mm at Station 14+070, Station 14+110, and Station 14+150 under soil Model 3A conditions, respectively. At Station 14+150, the implementation of Soil Model 3B, where the upper 1.0 m of very loose to loose silty sand is sub-excavated and replaced with compacted Granular B Type II material, can reduce the differential settlement to approximately 28 mm and the maximum settlement to 64 mm, thereby improving overall embankment performance.

All this settlement is expected to occur during and immediately following construction of the embankment widening. This settlement will be accompanied by settlement of the embankment itself. These magnitudes were estimated in the section below.

3.5.3.3 Settlement of Embankment Fill

The fill is also expected to experience some settlement. It is estimated that the embankment itself will compress by about 0.5 to 1 percent of the embankment height under its self-weight, depending on material type and assuming

placement as per MTO practices. More granular material fills would compress less and over a shorter time, typically within the period of embankment construction.

Settlement in rock fill embankments is associated with the crushing of points of contact and rearrangement of rock fragments under the load or a change in moisture content. If groundwater rises, poorly compacted, unsaturated rock fill is likely to be susceptible to settlement. The magnitude of settlement manifested in this form depends on the type and nature of the rock fill, the thickness of the rock fill, gradation, the method of construction and subgrade conditions.

Generally, for rock fill embankments constructed on compressible soils and non-compressible soils, the MTO Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates dated September 14, 2010 should be followed. Table 3.11 presents the short-term settlements (i.e., within about 1 year following completion of construction to full height) and long-term settlements (i.e., after 1 year, over the life of the embankment) provided in this guideline in terms of the relative embankment height for compacted and dumped rock fills. For rock fill embankments built on a compressible subgrade, the estimated settlement must account for both the compression of the rock fill (short-term and long-term, as described above) in addition to the settlement of the compressible foundation soils.

At the site, new rock fill will be placed on non-compressible soils encountered on the east side of Highway 11. However, if the widening includes the west side, the rock fill will be predominantly placed on compressible soils, consisting of very loose to compact silt and sand layers, along with a layer of soft to firm clayey silt identified in borehole BH12-5, following the removal of peat and organic materials. Generally, when the embankment is placed on non-compressible soil, settlement due to the rock fill is expected to be negligible or within the limits outlined in Table 3.11. In contrast, if placed on compressible soil, additional settlement from the foundation soils must be considered in the total anticipated settlement. Table 3.12 provides estimates for both short-term and long-term settlement of the rock fill itself.

Table 3.11. Short- and long-term rock fill settlement

Height of Rock Fill, H (m)	Compacted Rock Fill		Dumped Rock Fill	
	Short-term Settlement[1] (m)	Long-term Settlement[2] (m)	Short-term Settlement[1] (m)	Long-term Settlement[2] (m)
Up to 5[3]	0.5% H	0.1% H	1.0%·H	0.2% H
>5 to 10	0.75% H		1.5%·H	
>10 to 15	1.0% H		2.0%·H	

Notes:

1. *Approximately 90% of the short-term settlement may be expected to be complete within 6 months following construction to full height.*
2. *Defined as being after 1 year following construction to full height, over the life of the embankment.*
3. *Applicable to SW12*

Table 3.12. Estimated short- and long-term settlement of rock fill

Location	Approx. Thickness of Compacted Rock Fill (m)	Short-term Settlement of Rock Fill (mm)	Long-term Settlement of Rock Fill (mm)	Total (mm)
Model 1: East Side of Existing Embankment (Sta. 14+070)	3.5	18	3	21
Model 2: East Side of Existing Embankment (Sta. 14+110)	4.5	23	4	27
Model 3A/3B: East Side of Existing Embankment, Culvert Location (Sta. 14+150)	5	25	5	30

Note:

1. *Assumes base/subbase granular material below pavement will settle at approximately the same rate as rock fill.*

The surcharge load from the weight of the new fill is up to 100 kN/m^2 where the embankment will be widened on the east side. The ultimate bearing capacity of the silt/sand layers (i.e., assuming that any encountered peat/organics/topsoil will be completely excavated) is higher than the estimated surcharge load, and therefore failure against bearing capacity is not anticipated because of embankment widening.

3.5.3.4 Discussion of Settlement Results

Table 3.13 presents the anticipated settlement of both the compressible, very loose to compact silt and sand layers within the foundation soils and the rock fill material used for the embankment. Since thick peat or organic layers were not encountered beyond the embankment toe on the east side of Highway 11 (as indicated by boreholes BH12-1 to BH12-3), sub-excavation and rock fill replacement are considered unnecessary. Consequently, all rock fill placed for the embankment widening on the east side will be compacted.

The maximum value within widening corresponds to the largest magnitude of settlement within the widened portion cross-section. Assuming settlement at edge of existing travelled lane due to placement of rock fill is negligible, the settlement magnitude at edge of new embankment can also be considered the differential settlement between the existing and new edge of embankment.

As described in MTO Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates, approximately 90% of the short-term settlement may be expected to be complete within 6 months following construction to full height. As mentioned in Section 3.5.3.2, settlement is expected to occur during and immediately following construction of the embankments (i.e. within 6 months). Therefore, the remaining settlement after 6 months in Table 3.13 is estimated to be only occur within the newly placed rock fill itself.

Table 3.13. Settlement results for foundation soils and rock fill

Station	Location	Immediate Settlement At Completion of Embankment Construction (mm)	Settlement 6 Months Post-Construction (mm)	Remaining Settlement after 6 Months[2] (mm)	Total Differential Settlement (mm)
		Foundation Soil[1]	Rock Fill[2,3]	Rock Fill[2,4]	
Model 1: East Side of Existing Embankment (Sta. 14+070)	Maximum Value Within Widening [1]	45	16	5	14
	At Edge of Widening	31	16	5	
Model 2: East Side of Existing Embankment (Sta. 14+110)	Maximum Value Within Widening [1]	78	21	6	19
	At Edge of Widening	59	21	6	
Model 3A: East Side of Existing Embankment, Culvert Location (Sta. 14+150)	Maximum Value Within Widening [1]	80	23	7	18
	At Edge of Widening	62	23	7	
Model 3B: East Side of Existing Embankment/ Culvert, 1 m Sub-Excavation of Very Loose to Loose Silty Sand and Replacement with Granular B Type II (Sta. 14+150)	Maximum Value Within Widening [1]	64	23	7	15
	At Edge of Widening	49	23	7	

Notes:

1. *Foundation soil settlement is expected to be immediate (occurring during construction), with negligible long-term settlements.*
2. *Any post-construction settlement is anticipated to occur only within the newly placed rockfill embankment material.*
3. *Considers 90% of the short-term settlement of the rock fill itself as per MTO Guideline Rock Fill Settlement and Rock Fill Quantity Estimates.*
4. *Remaining settlements based on remaining settlement of rock fill after 6 months (i.e. 10% of short-term) plus long-term settlements.*

The settlement magnitude at the center of the widened portion of the embankment is higher than at the edge, therefore consideration should be given to hinderance to surface runoff. However, considering that the foundation soil settlement is expected to occur during and shortly following construction of the embankment widening, and that the rock fill settlement will be relatively uniform, the estimated post-construction settlement and differential settlement between the edge of existing and widened embankment, including settlement of the rock fill itself, meets the MTO Embankment Settlement Criteria for Design maximum limit of 75 mm for the pavement and a differential settlement rate of 100:1. Any differential movements should be able to be accommodated during the paving process.

As discussed in Section 3.5.3.2, the settlement of the native soil is expected to occur during and immediately after construction of the embankment. Considering the anticipated short-term settlement of the rock fill, if the final paving is proposed six (6) months after embankment construction, no further mitigation is required. Monitoring can check the estimated settlements and may support earlier paving if that is required.

3.5.3.5 Monitoring Program

The computed settlements are based on best assumptions and findings on the nature, consistency, compressibility, characteristics and thickness of the identified deposits within the zone of influence of loading. Actual settlements can differ somewhat, given the nature of soil and its deposition and construction practice. As such, a program of instrumentation and monitoring can be used to verify that the actual settlements are as predicted. The program will include a series of surface monitoring points. The settlement monitoring can be terminated when the measured settlement is consistent with the predicted settlement for the embankment construction. For this location monitoring is only considered necessary if paving is scheduled before six months of embankment completion.

3.5.3.6 Settlement Mitigation at Culvert Extension

As noted in Section 3.5.3.4, the settlement of the foundation soil due to widening at the culvert location (~Station 14+154) is up to 80 mm which is greater than the limit of 25 mm. Therefore, the following mitigation measures to reduce the settlement of the foundation soils at the culvert extension footprint could be considered:

- Helical Piles: Helical piles founded on glacial till could be used to support the culvert extension.
- Preloading: The embankment should be constructed prior to installation of the culvert extension. Once the widened embankment has reached sufficient settlement, the culvert extension should be installed as per discussions in Section 3.3. The surface water should be conveyed to the next culvert along the toe of the embankment.
- Camber culvert to account for settlements: In accordance with Table 3.13, the culvert for Model 3A should be cambered to accommodate an estimated settlement of 80 mm at the connection and 62 mm at the inlet. A connection detail incorporating flexible joints will be required to accommodate this movement. This option provides the greatest potential savings in both schedule and cost.
- Sub-Excavation: Settlement magnitudes can be partially reduced by sub-excavating 1 m of very loose to loose silty sand and replacing it with compacted Granular B Type II, as outlined in Section 3.5.3.2. This sub-excavation and backfilling can be used in combination with culvert cambering to ensure the culvert achieves the proper positive slope for water flow after installation. As shown in Table 3.13, for Model 3B, the culvert should be designed to accommodate 64 mm of settlement at the connection and 49 mm at the inlet.

3.6 Construction Considerations

3.6.1 Excavation

All excavations must be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety (OHSA) and good construction practice.

Temporary excavation side slopes through peat/organic soil shall be in accordance with the OHSA, OPSD 203.020 (Embankment Over Swamp; Existing Slope Excavated) and/or OPSD 203.030 (Embankments Over Swamp; Existing Slope Maintained). The peat/organic soil encountered in the lower area can be classified as Type 4 soil using OHSA classification, as it is usually deposited below the groundwater table. Type 4 soils must be sloped 3H:1V or flatter. The existing fill and native soils are considered as Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. Temporary excavations in those soils (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.

Excavation of the soils at the project site may be carried out using conventional excavation equipment. During excavation, no excavated material should be piled close to the top of excavated slope. All excavated surfaces should be kept free from frost. In addition, runoff and surface flow shall be directed away from open excavations.

All unsuitable, deleterious, and organic material are to be removed from the base/below the culvert extension (and bedding) footprint along its entire alignment such that excavations may be extended below the existing culvert invert. In such cases, appropriate measures will be required during construction to support the soil below the existing culvert during excavation, to prevent undermining of the existing culvert.

It is recommended that a NSSP be included in the Contract Documents to alert the Contractor to the presence of peat and organic deposits along the lower area on the west side of the site, and to outline the required procedures for their excavation and backfilling with suitable fill material. This work is to be executed in narrow sections, approximately 3 to 5 meters wide, running parallel to the existing highway, with each section immediately backfilled with rock fill upon excavation. An example NSSP for peat excavation is provided in Appendix J.

3.6.2 Site Dewatering

3.6.2.1 Groundwater Control

The groundwater level on the east side of the embankment observed in the piezometer installed in borehole BH12-1 ranged from 0.4 m to 0.5 m below the ground surface (~Elev. 286.9 m to 286.8 m). The top of creek water level at the existing concrete box culvert location (Station 14+154) was measured to be at Elev. 286.4 m on the east (inlet) and west (outlet) sides during the site investigation. Water was not observed to be flowing through the CSP at Station 14+037, but water was pool at the base of the embankment at the outlet at approximately the same level as the creek/lake water level (Elev. 286.4 m). Construction for the widening of the embankment and extension of the culverts is recommended during the low water level season.

For the concrete box culvert at Station 14+154, the excavation to the foundation level for the culvert extension on the east side must be carried out to approximately Elev. 285.8 m if concrete box or CSP culverts are selected for extension, or to Elev. 284.0 m if open footing concrete culverts are selected.

For the CSP culvert at Station 14+037, the excavation to the foundation level for the culvert extension on the east side must be carried out to approximately Elev. 286.7 m if concrete box or CSP culverts are selected for extension, or to Elev. 284.9 m if open footing concrete culverts are selected.

The soils encountered at the site and within potential excavation depths consist of sand/sandy silt/silt fill and native organic silt, sand, silt and sand, silty sand, and silt for which hydraulic conductivity has been estimated to be between 10^{-1} to 10^{-4} m/s in the sand/sandy silt fill and native sand/silt and sand/silty sand and 10^{-3} to 10^{-6} m/s.

The soils at the site are susceptible to disturbance from groundwater and mobilized equipment, and in those cases the groundwater level needs to be controlled to 0.5 m below the excavation level to avoid disturbance. Any surface or groundwater seepage should be removed from the excavation prior to the placement of granular backfill in the dry condition. Granular B Type II or clear stone with geotextile wrapping can be used in the wet condition.

Based on the proposed foundation depths and the water level observed during the investigation, excavations for the eastward extension of the concrete box culvert at Station 14+154 are expected to reach approximately 0.6 m below the creek level if concrete box or CSP culverts are selected, or up to 2.4 m below the creek level if open footing culverts are used. Given that surface water will be managed using cofferdams, groundwater inflow through native soils and/or cobbles and boulders is anticipated to be manageable by pumping from filtered sumps positioned behind the cofferdams at the inlet.

Excavations for the CSP culvert (Station 14+037) extension will extend up to approximately 0.2 m below the creek level if concrete box or CSP culverts are selected for extension or 2.0 m if open footing culverts are selected (with respect to groundwater measured in BH12-1 piezometer). Water was not observed to be entering or pooled in front of the CSP culvert inlet (see photograph). Therefore, assuming construction takes place during lower groundwater period, it is anticipated that control of seepage can be accomplished by conventional pumping from sumps in oversize excavations, where the excavation base is within 0.6 m of the prevailing groundwater level at the time of construction. This dewatering can likely be achieved by gravity drainage and pumping from strategically placed sumps with side ditches. Confirmation of control should be verified before general excavation to final levels.

Dewatering requirements behind the cofferdams to keep the construction site dry will be impacted by water levels in the creek at the time of construction activities. 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. Dewatering should be carried out in accordance with OPSS.PROV 517 as amended by SP517F01 (i.e., included in Appendix J for reference). It is the responsibility of the Contractor to propose a suitable dewatering system based on the time of construction, water levels and flow conditions in the creek. The method used should not undermine the existing culvert, highway embankment or adjacent side slopes. The provision of toe protection at the side slopes during drawdown may be required to minimize sloughing and undercutting during dewatering.

Highway and transit projects are required to be registered in the EASR under O. Reg. 63/16 for surface water takings greater than 50,000 L/day that meet specific criteria related to the purpose, rate, or location of the water taking. This project is a highway project involving embankment widening and culvert extension. The activity of diverting the waters of a water body to create and maintain a dewatered work area is not considered a water taking under O. Reg. 64/16, section 2, provided the regulatory conditions detailed in that section are met. As of July 1, 2025, an amendment to O. Reg. 63/16 has come into effect to move additional construction site dewatering activities to a registration-first approach by removing the volumetric restriction, requiring proponents to self-register construction dewatering activities on the EASR regardless of volume and allowing operations to begin immediately without a

PTTW or an ECA. To check applicability a hydrogeological review/assessment should be undertaken to estimate anticipated water taking needs, support the applicable PTTW or EASR process, and provide the necessary technical documentation.

Erosion and sediment control during culvert construction should be as per the MTO Drainage Manual, Volume 2. Silt fences and other sediment control measures should be included to protect the downstream environment from the construction activities.

3.6.2.2 Cofferdams

At the existing box culvert at Station 14+154, temporary cofferdams will be necessary to enclose the construction area and maintain a dry work environment during the embankment construction and culvert extension. Two cofferdam types may be considered for this purpose: (i) a sheet pile wall and (ii) a rock fill or earth dam. Throughout construction, creek flow must be continuously diverted through a temporary culvert system to ensure uninterrupted water passage.

Design and construction specifications for the chosen temporary cofferdam system should be prepared in accordance with OPSS.PROV 517 as amended by SP517F01 by the Contractor. Design and construction specifications for the chosen temporary cofferdam system should be prepared in accordance with OPSS.PROV 539 (Construction Specification for Temporary Protection Systems) by the Contractor.

Based on the geotechnical conditions, suitably designed steel sheet pile walls can be used as a cofferdam at this site. If a cantilever system is used, an embedded depth of sheet piles can be approximately 2.0 to 2.5 times its exposed height. The required minimum section modulus and embedment pile length should be designed based on the recommended design parameters. Cobbles and/or boulders were noted to be contained within the fill; however, there is possibility that some cobbles and boulders are present in overburden soils as well, so care should be taken during installation of sheet piles. It is recommended that a NSSP be included in the Contract Documents to warn the Contractor of the presence of cobbles and/or boulders within the overburden soils. An example of a NSSP for obstructions is provided in Appendix I.

The rock fill/earth cofferdam will have to be constructed to accommodate all topographic constraints. The size of material suitable for use depends on the erosion potential, stream flow velocity, etc. The rock fill/earth cofferdam should be designed with a more impervious water barrier at the outside face to create a more watertight enclosure. Schemes involving 2-inch minus crusher run with finer facing material upstream have been successfully used in similar settings. Any required permitting must be determined. The proposed rock fill/earth cofferdam should be at least one meter above the designed high-water level (HWL) defined by the hydraulic engineer.

Besides design and construction of the temporary cofferdam system, the Contractor is also responsible for its materials, maintenance, monitoring and removal. The temporary cofferdam shall be fully removed, unless it is specified in the Contract Documents that the cofferdam system may be partially left in place. The method and sequence of removal shall be so that there shall be no damage to the new work, existing work, and facility being protected.

3.6.3 Subgrade Preparation

Prior to construction of the embankment widening, the site will need to be cleared and grubbed of any existing bushes, trees, and vegetation. All surficial topsoil, peat, organics, existing fill, and softened or loosened soils should be sub-excavated from below the proposed widening footprint. Considering the findings at the site, the anticipated sub-excavation depths/elevations at the borehole locations are presented in Table 3.14.

Table 3.14. Anticipated sub-excavation depths/elevations at borehole locations

Location	Borehole No.	Existing Ground Elevation at Borehole Location (m)	Recommended Stripping Depth/Excavation (m)
West Side[1]	BH12-20	286.7	3.4/283.3
	BH12-13	286.4	6.1/280.3
	BH12-11	288.4	6.1/282.3
	BH12-5	286.6	3.0/283.6
East Side[2]	BH12-2	287.5	0.1/287.4
	BH12-1	287.3	0.1/287.2
	BH12-3	286.6	0.2/286.4

Notes:

1. *Boreholes ordered from south to north extent of site (Station 13+630 to 14+160).*
2. *Boreholes ordered from south to north extent of site (Station 14+050 to 14+160).*

Peat and organic soils shall be excavated along the sides of the existing embankment and across the entire footprint of the proposed embankment widening, following the guidelines outlined in OPSD 203.020 (excavated existing slope) and OPSD 203.030 (maintained existing slope), as provided in Appendix I. The stabilized groundwater is expected to be near the ground surface based on the readings in the piezometers and the observed surface water.

3.6.4 Embankment Construction

The removal of peat/organic deposits within the proposed footprint and backfilling of the excavation shall be carried out simultaneously in accordance with OPSS.PROV 209. Rock fill can be used as a backfill for embankments 1.2 m or higher given that the largest dimension should be limited to 0.5 m (NSSP should be included in the Contract Document; an example is provided in Appendix J). If the embankment is lower than 1.2 m, the embankment should be constructed from engineered fill consisting of Granular A or Granular B Type ll. As mentioned before, the example of NSSP for excavation of peat/organic material and backfilling is also attached in Appendix J. Excavations should be carried out in accordance with Ontario Regulation 213 with appropriate traffic control as applicable.

Based on borehole investigations conducted on the west side of the embankment, thick organic soil layers were identified, indicating the presence of unsuitable foundation materials. While boreholes on the east side revealed inorganic subsoils beneath the topsoil, the potential for peat or organic layers between or beyond these borehole locations cannot be ruled out. If embankment widening is undertaken on the west side, it is recommended to sub-excavate up to 6.1 m below grade to remove soft and loose soils, extending at least 1 m beyond the toe of the new

embankment footprint. The Contractor must avoid over-excavation and limit the depth strictly to the extent of peat or organic material encountered (e.g., if only 1 m of organic soil is present, excavation should stop at that depth). Sub-excavation and backfilling with rock fill should be performed simultaneously up to the water level near the toe, executed as a continuous operation in strip sections up to 10 m wide (perpendicular to the highway). Each strip should be divided in half and excavated/backfilled from the outside toward the center, as illustrated in Appendix J. In accordance with OPSS.PROV 209, compaction of the rock fill is not required until it reaches at least 600 mm above the water level. Therefore, groundwater inflow into the sub-excavation is not expected to pose significant challenges during construction

Grading and embankment construction should be conducted in accordance with OPSS.PROV 206 and OPSS.PROV 501. Except for the top 1.0 m, where a pavement structure should be placed, the embankment fills should consist of an approved rock fill. Rock embankments shall be constructed by placing embankment materials full width in successive uniform layers. As per OPSS.PROV 206, layers of rock embankment should not exceed 1.5 m thickness prior to construction. The surface of the existing rock fill side slopes to be widened should be scratched to remove any soil/vegetation to provide a good bond between the existing rock fill and the rock fill placed for the widening. Material in each layer should be fully compacted prior to the succeeding layer is placed. Each rock fill layer should be compacted with a tractor bulldozer with a minimum number of complete passes of 6 and the maximum passes of 8. A complete pass should be defined as 100% coverage of layer surface. Quality assurance should be provided as per MTO standard 501.08 (OPSS.PROV 501). Inspection and field density should be carried out by qualified personnel during placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

Adequate chinking at the top of the rock fill should be provided before the placement of Granular B Type II for the pavement. The objective of chinking of rock fill exposed to the subgrade level is to form a dense, compact mass which reduces the potential migration of surrounding soils into the existing rock fill which could cause future settlement/soil movements/sinkholes. Alternatively, a suitably robust geotextile can be placed for separation purposes. Transitions between earth fill and rock fill or granular fill, if any, should be constructed in accordance with OPSD 205.040.

3.6.5 Platform Widening

Northern Region Engineering Directive NRE98-200, indicates that there may be need for future road grade raise to restore design alignment, due to compression/settlement of the embankment fill, and the foundation soils, and to address future pavement overlays up to 200 mm thick. Platform width if unaltered, may then result in substandard shoulders. Practical and economic considerations indicate that overbuild at original construction is the preferred approach.

The requirement for widening on each side is based on compression/settlement of the embankment fill, the estimated consolidation settlement of founding soils including long term creep and the 200 mm pavement overlay allowance, multiplied by the horizontal component of the side slope of the pavement structure and the minimum set by NRE-98-200 in swamp environments, (i.e. 2 m per side, for Highway 11). The minimum requirements noted can be waived for cases of full excavation to bedrock and backfill with granular. For the embankments proposed the minimum requirements under NRE-98-200 of 2 m would apply.

3.6.6 Scour/Erosion Protection

3.6.6.1 Embankment Side Slope

For the embankment construction comprising of granular material, the side slopes should be provided with adequate erosion protection against surface water runoff. These exposed slope surfaces should be covered with straw or plastic sheets as soon as the slope face is exposed. To reduce surface erosion on the embankment side slopes, prompt seed and cover (OPSS.PROV 804) or sodding (OPSS.PROV 803) should be carried out as soon as possible after construction of the embankment.

3.6.6.2 Culvert Extension

Scour/erosion protection should be provided at the culvert extension. The erosion/scour protection should be designed by a specialist hydraulic engineer (as erosion and scour largely depend on the velocity of water in the watercourse and its regime) who is familiar with the findings of this report. The following are some general suggestions, considering that the boreholes indicate that the main soil type consists of silt and sand.

The need for and nature of scour and erosion protection systems must be assessed and where required, must be designed, implemented, and remain effective for the design life of the culvert. The potential for scour below foundations must be incorporated into the design.

Rip-rap protection should be provided where the culvert discharges into the open creek and where the open creek enters the culvert. The design should be finalized by the hydraulics engineer. For preliminary guidance, the rip-rap should extend approximately 5 m beyond the ends of the culvert and line the embankment slope to the spring line of the culvert. Such protection may involve 0.5 m thick rock (OPSS.PROV 511) extending from 1 m above the high-water level to the toe of the slope and into the stream bed within the plan limits of the culvert. The rip-rap configuration at the creek bed should generally follow OPSD 810.010. The slope of the riprap shall follow the embankment fill slope.

As noted above, the scour design, nature and extent of the required protection is the responsibility of a qualified hydraulic design engineer experienced in this field. Geotechnical soil parameters necessary for the scour analyses are: SPT N-value, in-situ moisture content, percent passing the No. 200 sieve (%200), mean grain size diameter (D_{50}), liquid limit (LL), plastic limit (PL), and plasticity index (PI). These parameters can be determined based on the soils encountered at the site during the investigation and presented in Part I of this report.

The erosion protection should consider the possible installation of seepage protection measures at both upstream and downstream ends. The native sand and silt soils have a high potential for migration with high seepage gradients. For the new culvert extension installation, it is prudent to examine possible methods to avoid piping of material resulting from seepage along the culvert. For culverts, the following are typical methods: (i) clay seal, (ii) steel or wooden sheet pile cutoff at the upstream end of culvert, (iii) cut-off wall incorporated in the apron slab (if one is used) of the culvert, (iv) cut-off trench constructed with geotextile, and (v) rock fill at the upstream end of the culvert barrel to terminate below the granular bedding of the culvert. Only the clay seal and cut-off trench will be addressed since the sheet pile cut-off will require the understanding of the hydraulics of the stream. However, the actual solution for the culvert extension at this site will depend on the seepage protection of the existing culvert, if any.

Clay Seal

Where readily available, a clay seal should be placed at the contact of new extension and existing culvert to prevent the migration of material along the face of the culvert, the formation of flow paths, and any potential internal erosion within the highway embankment. OPSS.PROV 1205 specifies that material used for clay seals shall be natural clay, clay mixture (1 part Bentonite powder and 3.5 parts Granular "A") or a Geosynthetic Clay Liner (GCL). The coefficient of permeability shall not exceed 1 x 10^{-6} cm/s.

The following outlines the installation procedures and minimum material requirement of the clay seal:

- The clay seal should be placed along the sides and top of the culvert a minimum of 1.0 m along the side of the culvert and extending out laterally 1.0 m from the culvert extension.
- The clay should have a Liquid Limit greater than 40% and a Plasticity Index greater than 0.73 x (Liquid Limit – 20%).
- The clay seal is to be placed in maximum 150 mm thick lifts and compacted to 95% SPMDD within 2% of the optimum moisture content.

If a GCL is used as a clay seal its material specifications containing the physical, mechanical and hydraulic properties shall be obtained from the manufacturer. It is estimated that an approximately 12 mm thick GCL should be installed a minimum of 1.0 m along the side of the culvert.

Cut-off Trench/Wall

A cut-off trench/wall can be used at the downstream end of the culvert extension and can be incorporated when the rip-rap apron at that end of the culvert is being installed. In general, a trench is dug across the stream alignment to well beyond the walls of the culvert and a geomembrane liner is laid on the side of the trench keyed into the culvert at the top and on the base of the trench. The trench is then backfilled with graded rip-rap.

3.6.7 Corrosion Potential and Cement Type

One (1) soil sample was selected for chemical analyses during this investigation. The testing was completed to determine the potential degradation of the concrete in the presence of soluble sulphates and the potential of corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in Table 1.13 of this report.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH value measured at the site was 7.40 which is within the normal range of soil pH of 5.5 to 8.5 (AASHTO, 2000/MTO Gravity Pipe Design Guidelines, May 2007). The chemical data indicates moderate (4500>R>2000 ohm-cm) resistivity of the tested soil which suggests moderate potential for corrosion of buried metallic elements as per Table 3.2 of the MTO Gravity Pipe Design Guideline.

These chemical test results may be used to aid in the selection of coatings and corrosion protection systems for buried steel culverts, if selected. If the concrete culvert option is selected, consideration should be given by the designer to designing for a « C » type of exposure class of concrete as defined by CSA A23.1:19 Table 1, since the culvert will be exposed to de-icing salt. The maximum water-soluble sulphate content of the soils tested less than 20 ppm (µg/g), i.e. 0.0002%, and being less than 0.10% (as per CSA A23.1:19, Table 3) does not require sulphate resistant cement.

3.6.8 Obstructions During Construction

Cobbles and boulders were encountered during the site investigation. Therefore, care must be taken since the presence of these obstructions may affect the excavation for the culvert extension and installation of temporary dewatering/unwatering systems. It is recommended that a NSSP be included in the Contract Documents to warn the Contractor of the presence of cobbles and boulders within the embankment and native soil. An example of a NSSP for obstructions is provided in Appendix J.

4 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 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., P.Eng., 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.

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Intermediate Foundation Engineer

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Senior Geotechnical/Foundation Specialist

Stan E. Gonsalves, M.Eng., P.Eng.
Principal Engineer
Designated MTO Foundation Contact



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Ministry of Transportation, October 2020. Guideline for MTO Foundation Engineering Services, Version 02.

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 Provincial Standard Specifications (OPSS):

OPSS.PROV 206 Construction Specification for Grading

OPSS.PROV 209 Construction Specification for Embankments Over Swamps and Compressible Soils

OPSS.PROV 401 Construction Specification for Trenching, Backfilling and Compacting

OPSS.PROV 421 Construction Specification for Pipe Culvert Installation in Open Cut

OPSS.MUNI 422 Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 511 Construction Specification for Rip Rap, Rock Protection and Granular Sheeting

OPSS.PROV 517 Construction Specification for Dewatering and Temporary Flow Passage Systems

OPSS.PROV 803 Construction Specification for Vegetative Cover

OPSS.PROV 804 Construction Specification for Temporary Erosion Control

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

OPSS.PROV 905 Construction Specification for Steel Reinforcement for Concrete

OPSS.PROV 1010 Materials Specification for Aggregates – Base, Subbase Select Subgrade, and Backfill Material

OPSS.PROV 1205 Material Specification for Clay Seal

OPSS.PROV 1350 Material Specification for Concrete – Materials and Production

OPSS.PROV 1860 Material Specification for Geotextiles

Ontario Provincial Standard Drawings (OPSD):

OPSD 203.020 Embankments Over Swamp; Existing Slope Excavated

OPSD 203.030 Embankments Over Swamp; Existing Slope Maintained

OPSD 205.040 Transition Treatment, Earth Fill to Rock Fill, and Earth Fill to Granular Fill

OPSD 802.010 Flexible Pipe Embedment and Backfill Earth Excavation

OPSD 802.034 Rigid Pipe Bedding and Cover in Embankment, Original Ground, Earth or Rock

OPSD 803.010 Backfill and Cover for Concrete Culverts with Span Less Than or Equal to 3.0 m

MTOD 803.021 Bedding and Backfill for Precast Concrete Box Culverts

OPSD 803.031 Frost Treatment – Pipe Culverts Frost Penetration Line Between Top of Pipe and Bedding Grade

OPSD 810.010 Rip-Rap Treatment for Sewer and Culvert Outlets

OPSD 3090.100 Foundation Frost Penetration Depths for Northern Ontario

Special Provisions (SP):

SP 517F01 Amendment to OPSS.PROV 517

SP 109S61 Amendment to OPSS.PROV 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



Photograph 1. Roadway surface and shoulder, embankment side slope, and ground conditions beyond embankment toe along SBL (west) side, looking north (April 24, 2024)



Photograph 2. Roadway surface and shoulder, embankment side slope, and ground conditions beyond embankment toe along SBL (west) side, looking north (April 24, 2024)



Photograph 3. Roadway surface and shoulder, embankment side slope, and ground conditions beyond embankment toe along NBL (east) side, looking north (May 6, 2024)



Photograph 4. Roadway surface and shoulder SBL (west) side, looking south (May 8, 2024)



Photograph 5. East side of embankment at Borehole BH12-3 Location facing north (May 7, 2024)



Photograph 6. West side of embankment at Borehole BH12-5 Location facing west (June 5, 2024)



Photograph 7. West side of embankment at Borehole BH12-5 Location facing south (June 5, 2024)



Photograph 8. Concrete box culvert inlet and east side of embankment, facing west (May 7, 2024)



Photograph 9. Culvert outlet and west side of embankment, facing northeast (May 7, 2024)



Photograph 10. Concrete box culvert outlet and west side of embankment, facing east (May 7, 2024)

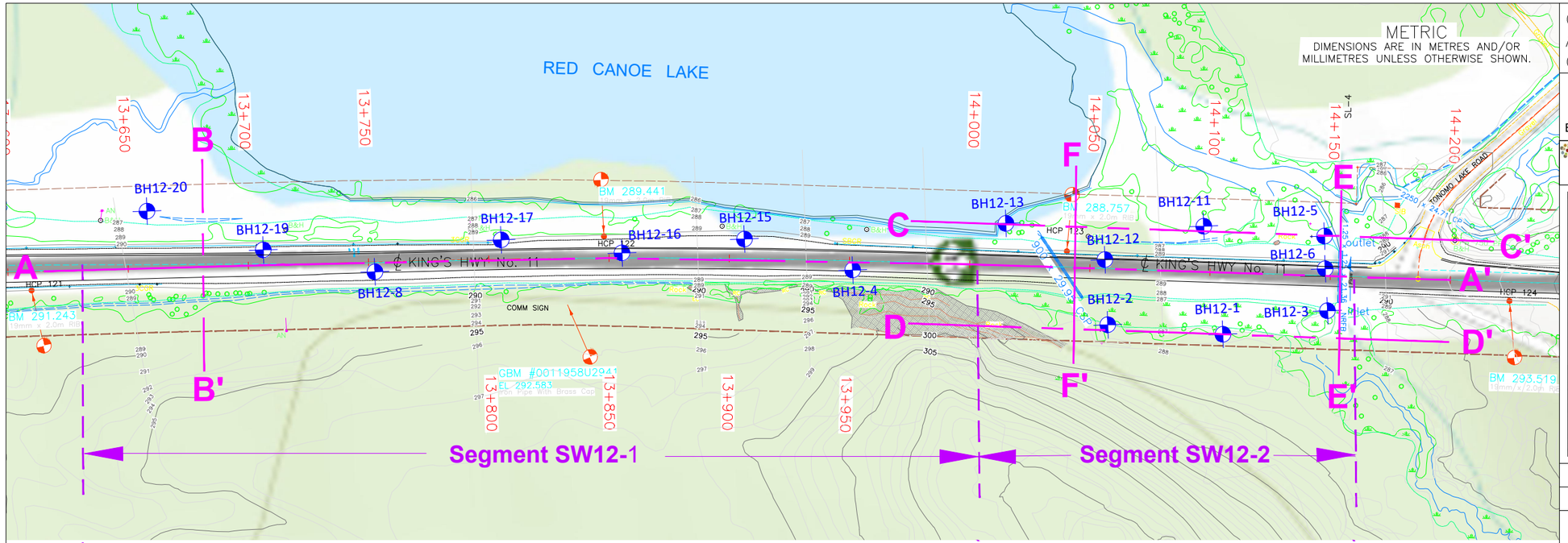


Photograph 11. Corrugated steel pipe culvert inlet and east side of embankment, facing west (May 7, 2024)



Photograph 12. Corrugated steel pipe culvert outlet and west side of embankment, facing east (May 7, 2024)

Appendix B – Drawings



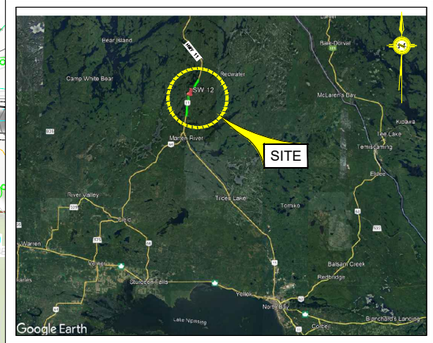
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ASSIG No.
GWP No. 5033-22-00

SHEET 1

Highway 11 from Sand Dam Road Northerly 13.8 Km to Ellesmere Road (SW12)
Latitude: 46.834602°; Longitude: -79.797110°

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)
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level in Piezometer (most recent) (W. L. STABILIZED)
- Piezometer

SOIL STRATA SYMBOLS

TOPSOIL	SAND	SILT
ASPHALT	CLAYEY SILT	ORGANIC SILT
FILL/ROCKFILL	SILTY CLAY	GLACIAL TILL
PEAT	SANDY SILT	BEDROCK
SILTY SAND	SILT AND SAND	SANDY GRAVEL

BOREHOLE COORDINATES/ NAD 83/ MTM ON-10

BH No.	ELEV.	NORTHING	EASTING
BH12-1	287.3	5188610.6	282183.2
BH12-2	287.5	5188562.9	282177.5
BH12-3	286.6	5188654.5	282175.0
BH12-4	289.2	5188457.8	282150.9
BH12-5	286.6	5188654.4	282144.0
BH12-6	290.9	5188654.2	282157.5
BH12-8	290.0	5188259.2	282144.3
BH12-11	288.4	5188604.3	282137.9
BH12-12	289.0	5188562.8	282150.4
BH12-13	286.4	5188522.2	282133.8
BH12-15	289.2	5188413.3	282136.3
BH12-16	289.6	5188362.2	282140.3
BH12-17	289.6	5188312.2	282133.0
BH12-19	290.2	5188213.2	282133.6
BH12-20	286.7	5188165.4	282115.6

NOTES

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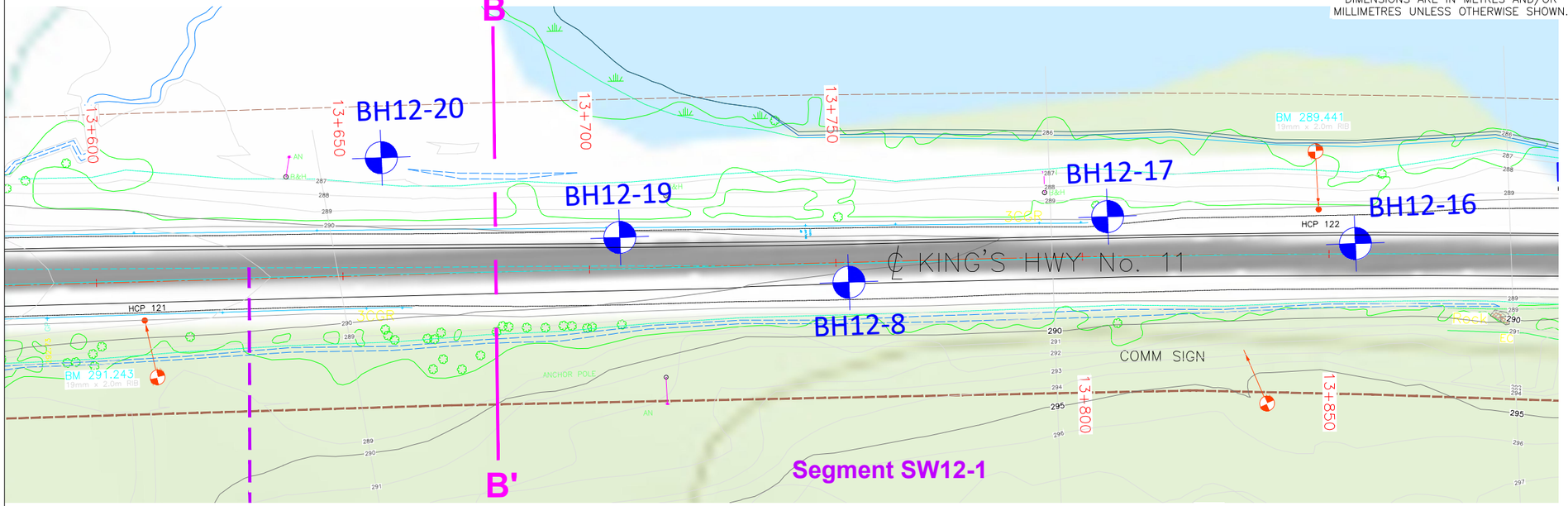
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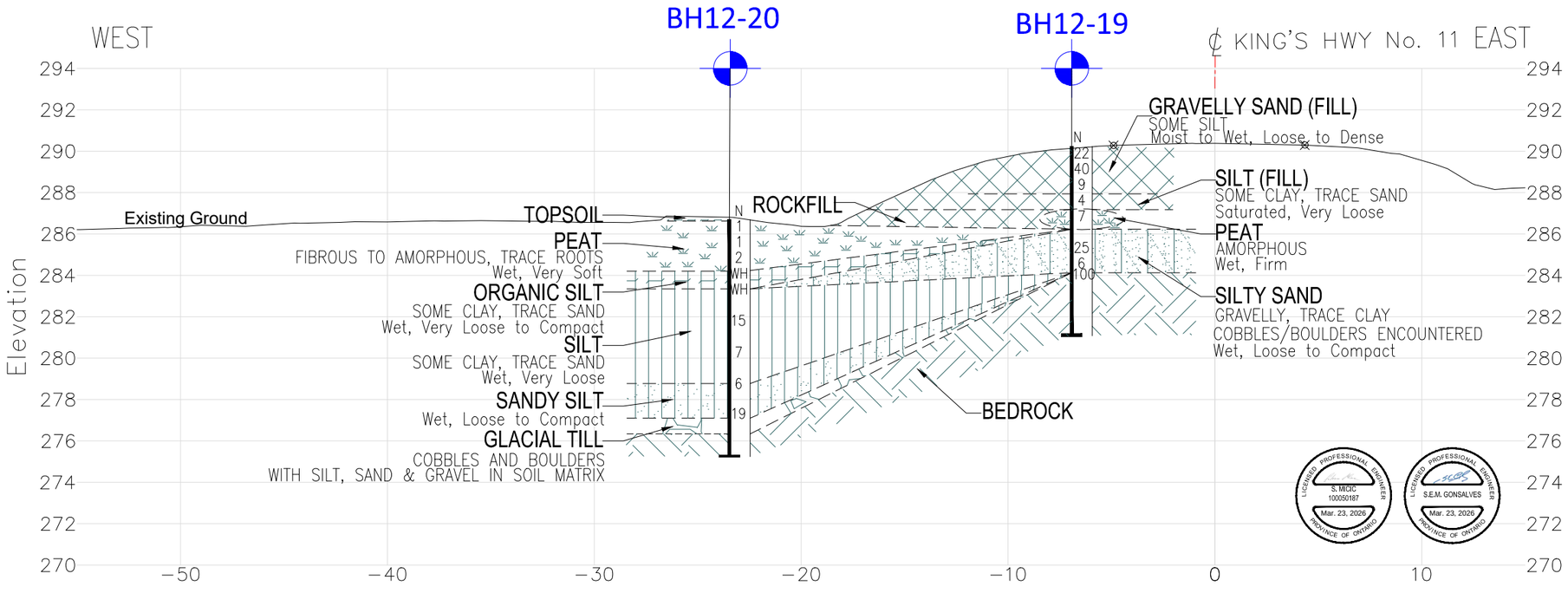
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PLAN

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SCALE



SECTION **B-B'**

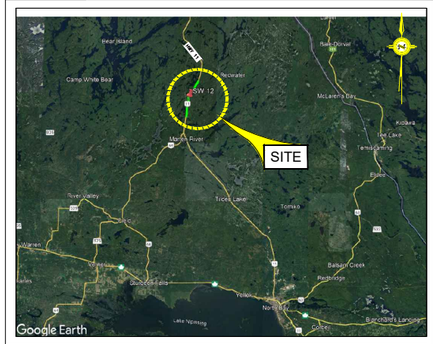
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CONT No.	5021-E-0038
ASSIG No.	
GWP No.	5033-22-00

Highway 11 from Sand Dam Road Northerly 13.8 Km to Ellesmere Road (SW12)
Latitude: 46.834602°; Longitude: -79.797110°
BOREHOLE LOCATION PLAN & SOIL STRATA

SHEET 2

exp. **EXP SERVICES INC.**



KEY PLAN
N.T.S.

LEGEND

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

SOIL STRATA SYMBOLS

TOPSOIL	SAND	SILT
ASPHALT	CLAYEY SILT	ORGANIC SILT
FILL/ROCKFILL	SILTY CLAY	GLACIAL TILL
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SILTY SAND	SILT AND SAND	SANDY GRAVEL

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BH12-17	289.6	5188312.2	282133.0
BH12-19	290.2	5188213.2	282133.6
BH12-20	286.7	5188165.4	282115.6

NOTES

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LICENSED PROFESSIONAL ENGINEER — S. MICIC — 100050187 — Mar. 23, 2026 — PROVINCE OF ONTARIO

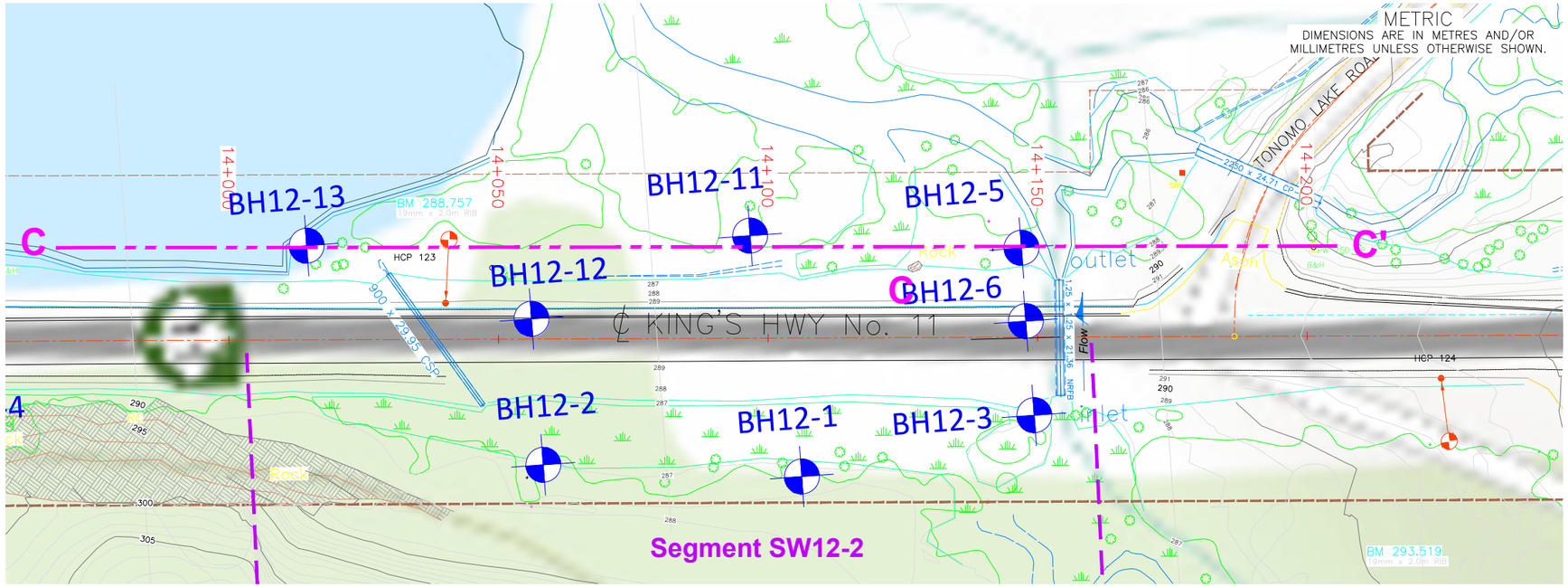
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REVISIONS

NO	DATE	BY	DESCRIPTION
			SUBMISSION FOR MTO REVIEW

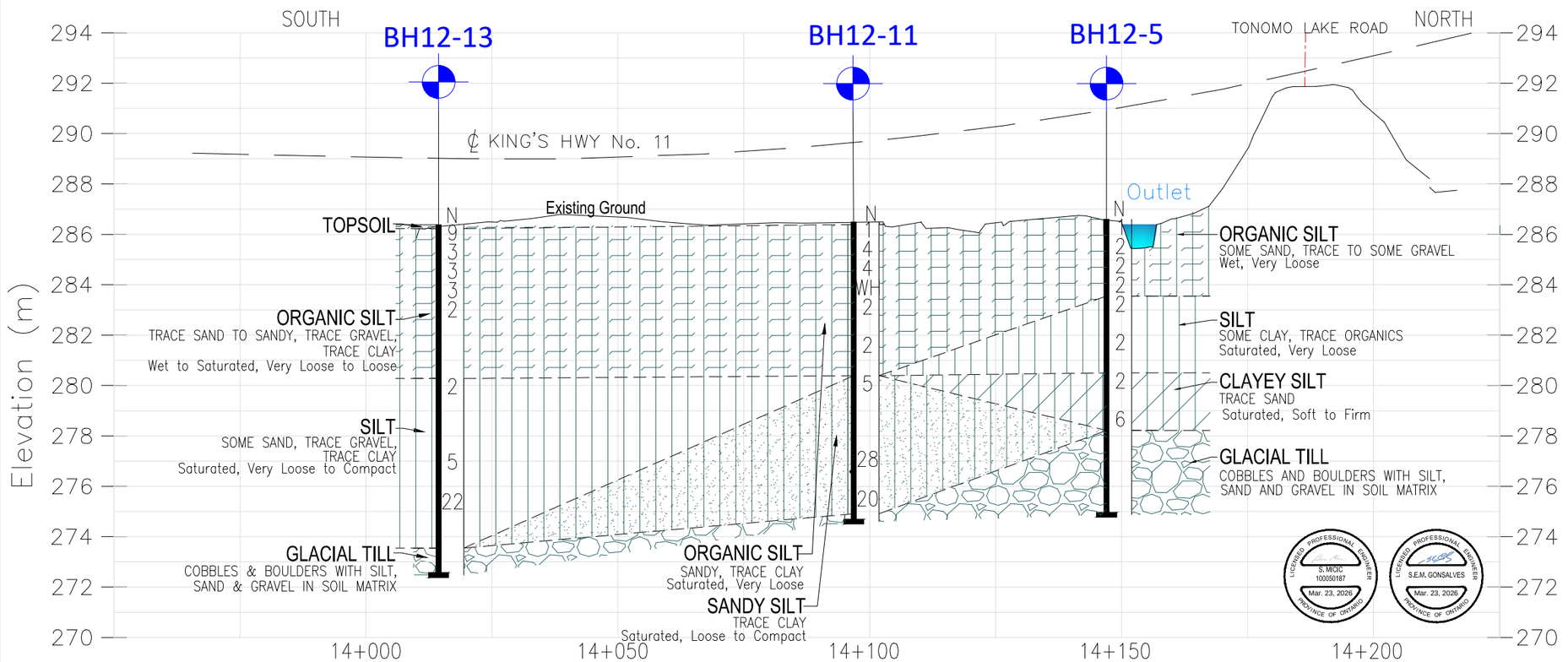
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PLAN

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VERT 0 1 6 m
SCALE



SECTION **C-C'**

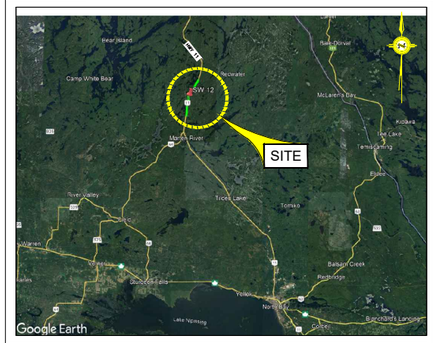
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BOREHOLE LOCATION PLAN & SOIL STRATA

SHEET 3

EXP SERVICES INC.



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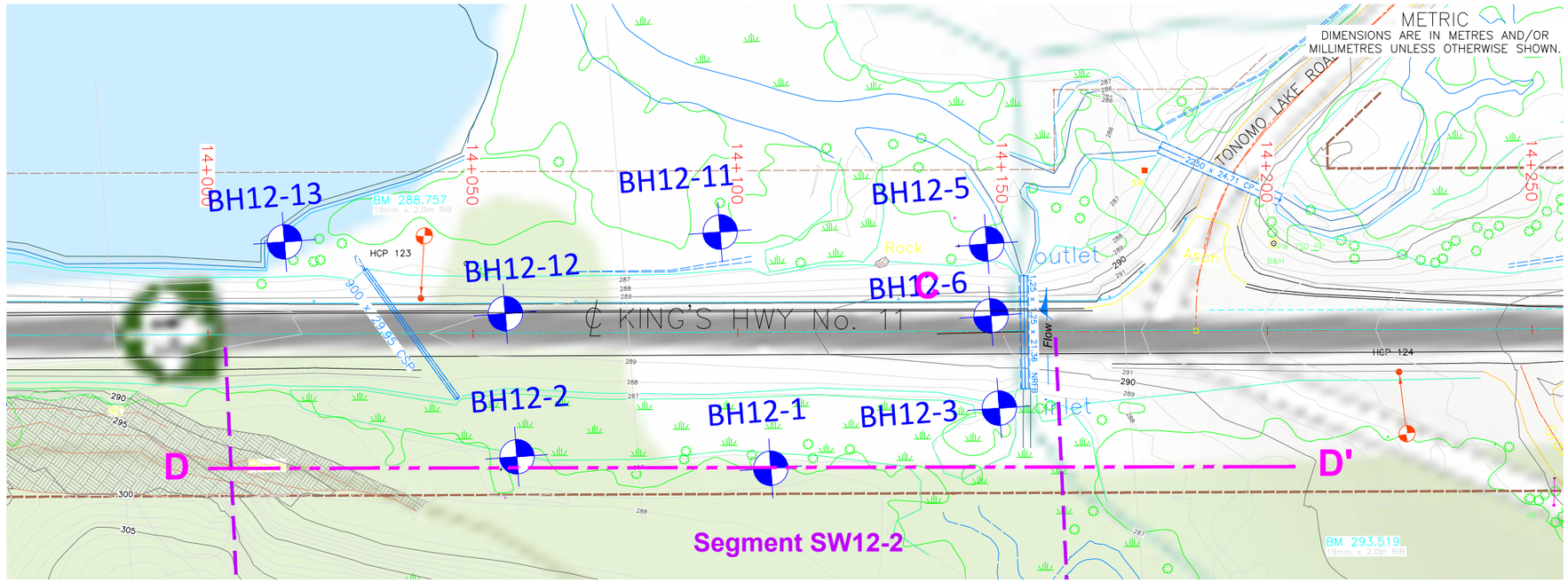
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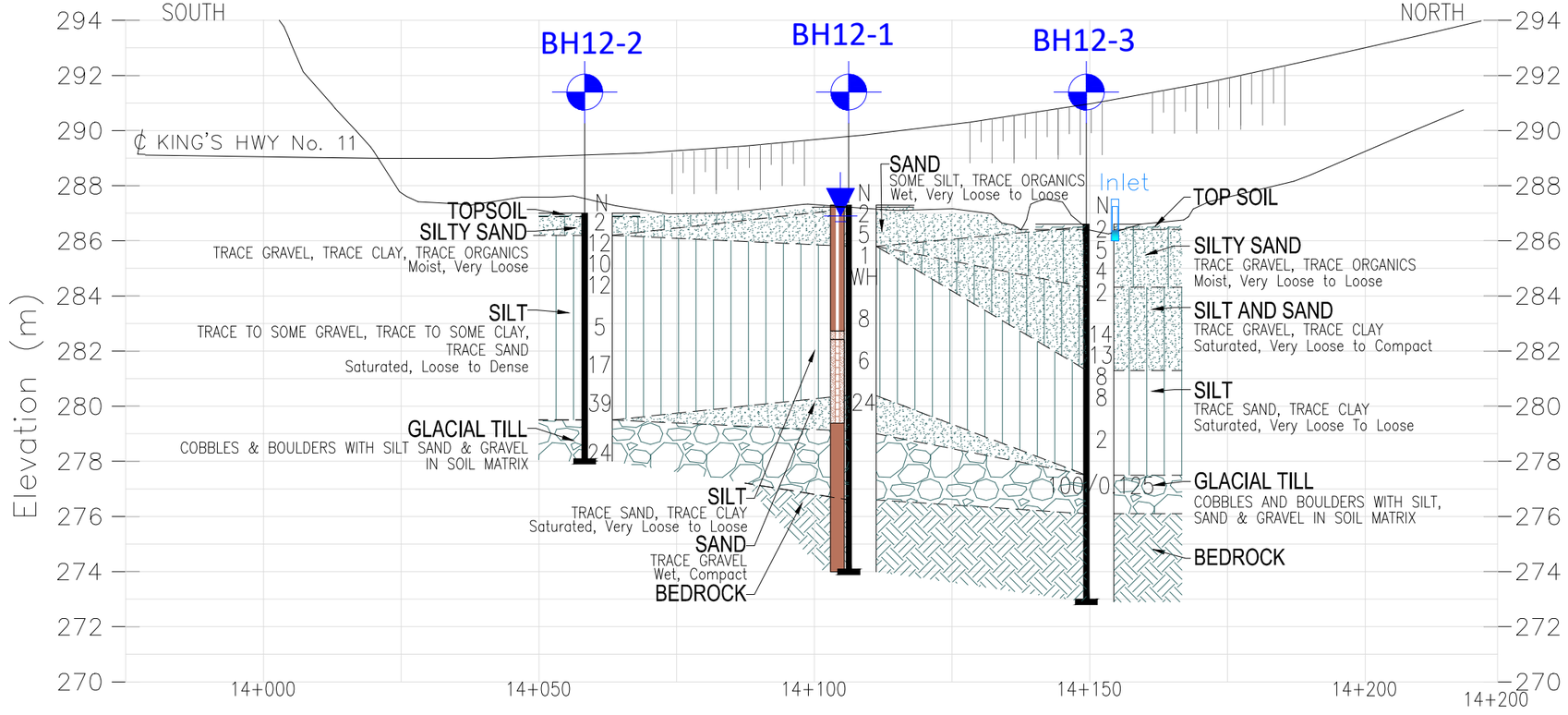
S.E.M. GONSALVES Mar. 23, 2026 PROVINCE OF ONTARIO — LICENSED PROFESSIONAL ENGINEER

REVISIONS			
			SUBMISSION FOR MTO REVIEW
NO	DATE	BY	DESCRIPTION

PROJECT No.	ADM-23010055-A0	GEOCRES No.	31L13-008
SUBM'D SH	CHKD. SM	DATE JAN. 22, 2025	SITE -
DRAWN SH	CHKD. TL	APPRD SG	DWG 03

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MODIFIED: 2025-01-10 10:31





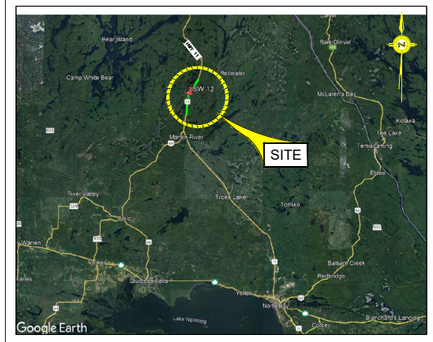
SECTION **D-D'**

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 (SW12)
Latitude: 46.834602°; Longitude: -79.797110°
BOREHOLE LOCATION PLAN & SOIL STRATA

SHEET 4

EXP SERVICES INC.



KEY PLAN
N.T.S.

LEGEND

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

SOIL STRATA SYMBOLS

TOPSOIL	SAND	SILT
ASPHALT	CLAYEY SILT	ORGANIC SILT
FILL/ROCKFILL	SILTY CLAY	GLACIAL TILL
PEAT	SANDY SILT	BEDROCK
SILTY SAND	SILT AND SAND	SANDY GRAVEL

BOREHOLE COORDINATES/ NAD 83/ MTM ON-10

BH No.	ELEV.	NORTHING	EASTING
BH12-1	287.3	5188610.6	282183.2
BH12-2	287.0	5188562.9	282177.5
BH12-3	286.6	5188654.5	282175.0
BH12-4	289.2	5188457.8	282150.9
BH12-5	286.6	5188654.4	282144.0
BH12-6	290.9	5188654.2	282157.5
BH12-8	290.0	5188259.2	282144.3
BH12-11	288.4	5188604.3	282137.9
BH12-12	289.0	5188562.8	282150.4
BH12-13	286.4	5188522.2	282133.8
BH12-15	289.2	5188413.3	282136.3
BH12-16	289.6	5188362.2	282140.3
BH12-17	289.6	5188312.2	282133.0
BH12-19	290.2	5188213.2	282133.6
BH12-20	286.7	5188165.4	282115.6

NOTES

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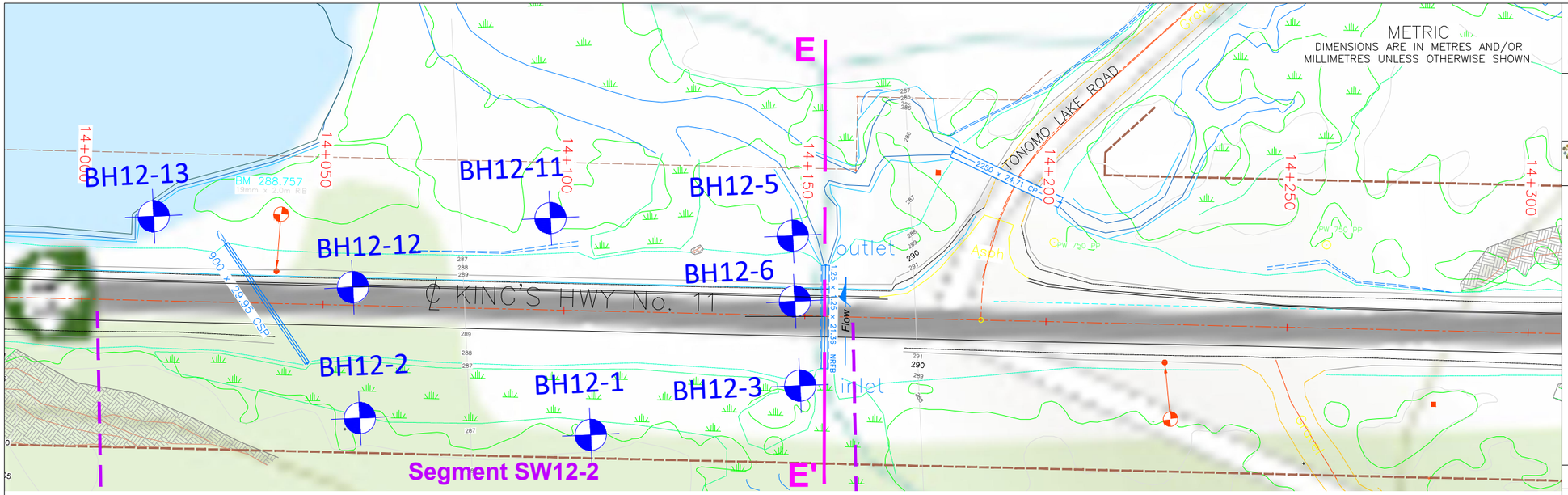
LICENSED PROFESSIONAL ENGINEER
S. MICIC
100050187
Mar. 23, 2026
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S.E.M. GONSALVES
Mar. 23, 2026
PROVINCE OF ONTARIO

REVISIONS	NO	DATE	BY	DESCRIPTION
				SUBMISSION FOR MTO REVIEW

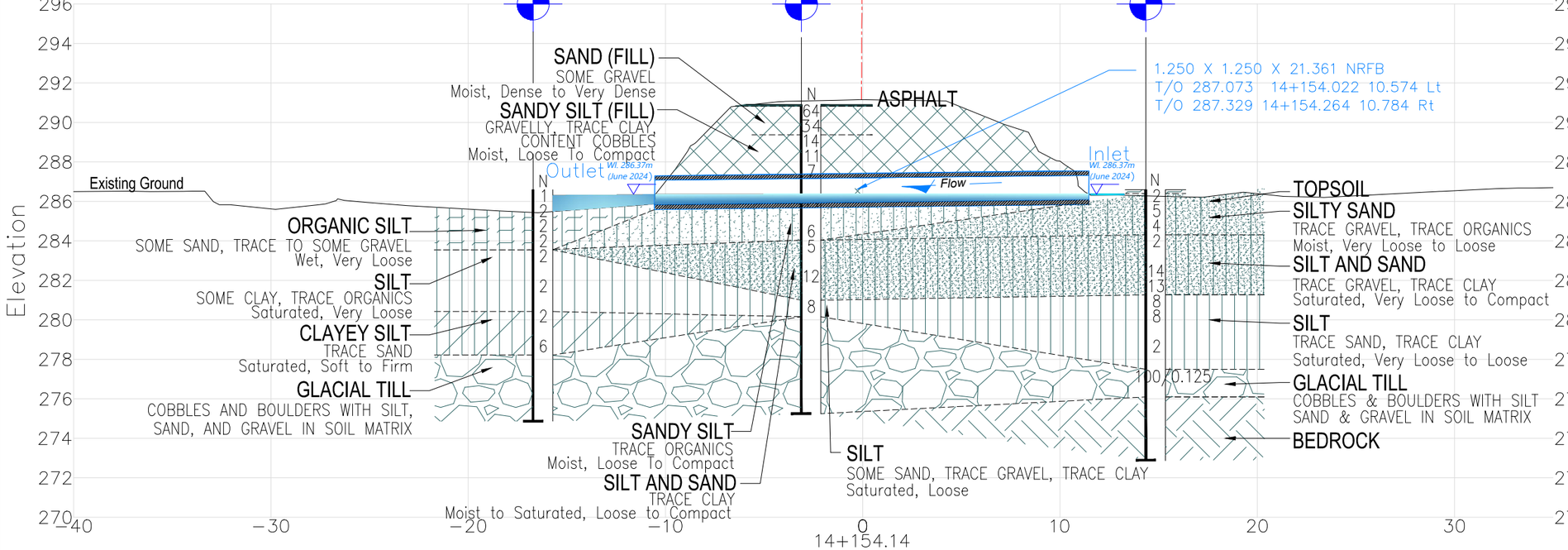
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SUBM'D	SH	CHKD.	SM	DATE JAN. 22, 2025	SITE -
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PLAN

PLAN 0 4 20 m
SEC 0 1 5 m
SCALE



SECTION **E-E'**

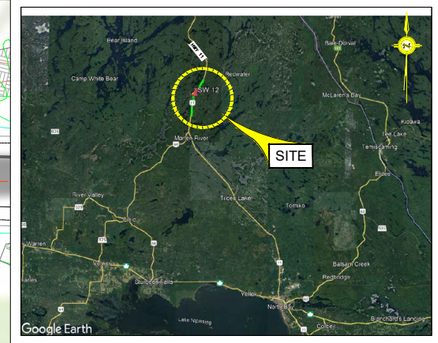
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DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.

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 (SW12)
Latitude: 46.834602°; Longitude: -79.797110°
BOREHOLE LOCATION PLAN & SOIL STRATA

SHEET 5

exp. **EXP SERVICES INC.**



KEY PLAN
N.T.S.

LEGEND

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

SOIL STRATA SYMBOLS

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ASPHALT	CLAYEY SILT	ORGANIC SILT
FILL/ROCKFILL	SILTY CLAY	GLACIAL TILL
PEAT	SANDY SILT	BEDROCK
SILTY SAND	SILT AND SAND	SANDY GRAVEL

BOREHOLE COORDINATES/ NAD 83/ MTM ON-10

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BH12-1	287.3	5188610.6	282183.2
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BH12-19	290.2	5188213.2	282133.6
BH12-20	286.7	5188165.4	282115.6

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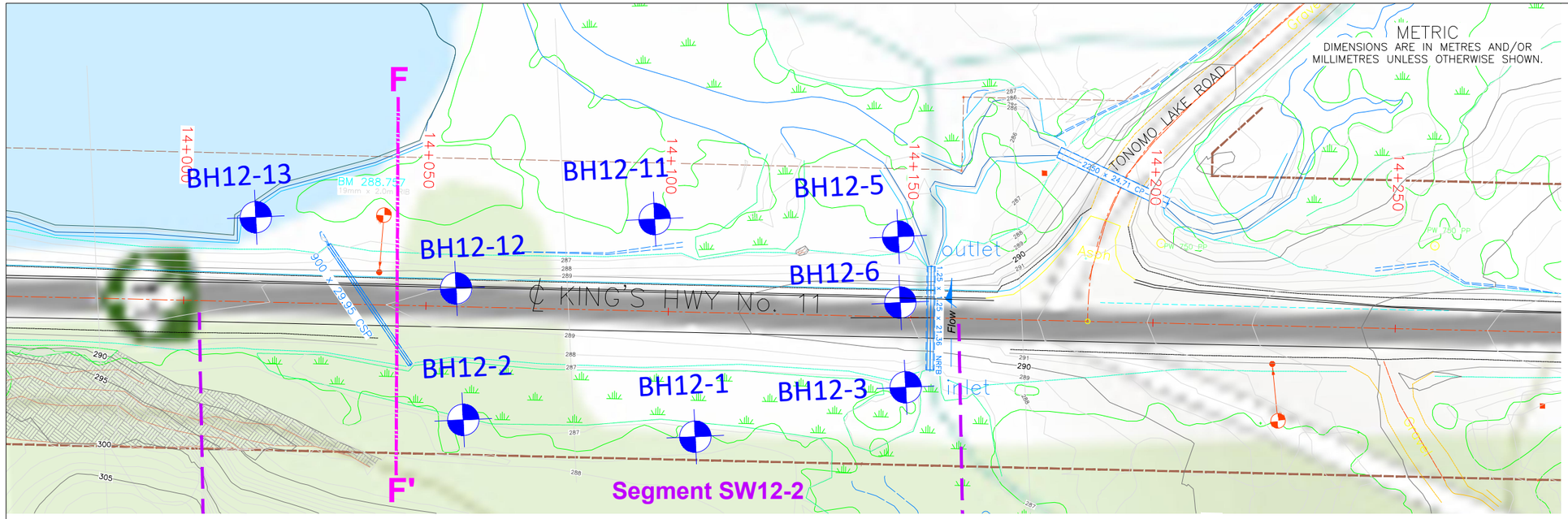
LICENSED PROFESSIONAL ENGINEER — S. MICIC 100050187 — Mar. 23, 2026 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — S.E.M. GONSALVES — Mar. 23, 2026 — PROVINCE OF ONTARIO

REVISIONS	NO	DATE	BY	DESCRIPTION
				SUBMISSION FOR MTO REVIEW

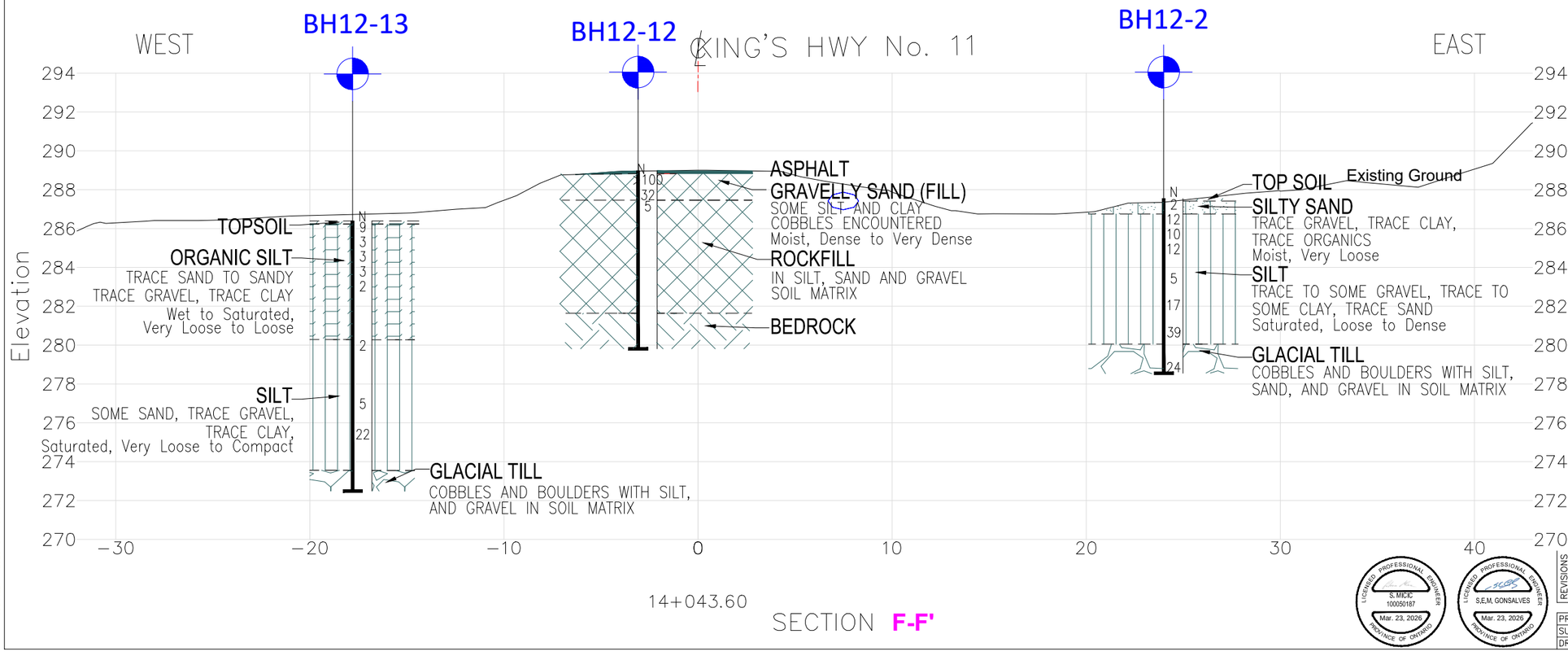
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SUBM'D SH	CHK'D. SM	DATE JAN. 22, 2025	SITE -
DRAWN SH	CHK'D. TL	APPR'D SG	DWG 05

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PLAN

PLAN 0 4 20 m
SEC 0 1 5 m
SCALE



14+043.60

SECTION **F-F'**

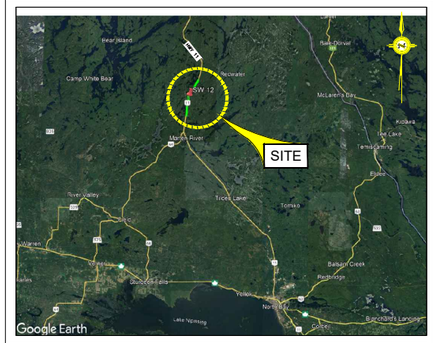
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CONT No. 5021-E-0038
ASSIG No.
GWP No. 5033-22-00

Highway 11 from Sand Dam Road Northerly 13.8 Km to Ellesmere Road (SW12)
Latitude: 46.834602°; Longitude: -79.797110°
BOREHOLE LOCATION PLAN & SOIL STRATA

SHEET 6

exp. **EXP SERVICES INC.**



KEY PLAN
N.T.S.

LEGEND

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BOREHOLE COORDINATES/ NAD 83/ MTM ON-10

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LICENCED PROFESSIONAL ENGINEER S. MICIC 100050187 Mar. 23, 2026 PROVINCE OF ONTARIO

LICENCED PROFESSIONAL ENGINEER S.E.M. GONSALVES Mar. 23, 2026 PROVINCE OF ONTARIO

REVISIONS

NO	DATE	BY	DESCRIPTION
			SUBMISSION FOR MTO REVIEW

PROJECT No.	ADM-23010055-A0	GEOCRES No.	31L13-008
SUBM'D SH	CHKD. SM	DATE JAN. 22, 2025	SITE:-
DRAWN SH	CHKD. TL	APPRD SG	DWG 06

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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:

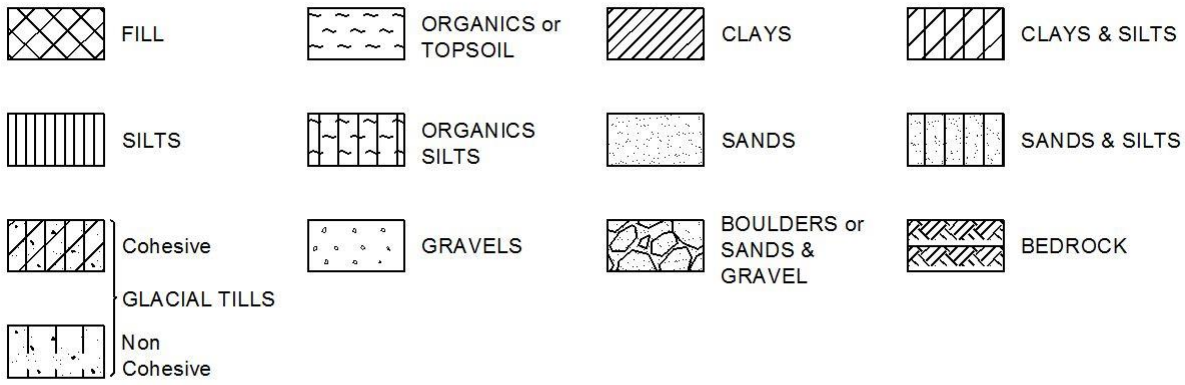
Table c: Consistency of Cohesive Soil

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'	–°	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	–°	Apparent angle of internal friction
τ_R	kPa	Residual shear strength
τ_r	kPa	Remoulded shear strength
S_t	1	Sensitivity = c_u/τ_r

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No BH12-1

1 OF 2

METRIC

W.P. ADM-23010055-A0 LOCATION 5188610.64N, 282183.182E, NAD83 MTM Zone 10 ORIGINATED BY AM

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

DATUM Geodetic DATE 2024.05.07 - 2024.05.08 LATITUDE 46.836644 LONGITUDE -79.7964979 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60 117)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
287.3	GROUND SURFACE										
287.2 / 0.1	**TOPSOIL,** ~75 mm thick										
	SAND, some silt, trace organics, grey, wet, very loose to loose		1	SS	2	▼	287				Organic Content =1.7%
			2	SS	5			○	○		
285.8							286				
1.5	**SILT,** trace sand, trace clay, grey, saturated, very loose to loose		3	SS	1				○		0 5 88 7 Non-plastic
			4	SS	WH		285		○		
									○		
							284				
			5	SS	8				○		
							283				
							282				
			6	SS	6				○		0 5 89 6
280.4							281				
6.9	**SAND,** trace gravel, grey, wet, compact		7	SS	24						
279.0							280				
8.3	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix			NQ			279				
276.6							278				
10.7	**BEDROCK**						277				
	Run 1: Start/End: 10.7 to 12.2 m Recovery: 87% RQD: 53%		RUN 1	NQ			276				
	Run 2: Start/End: 12.2 to 13.3 m Recovery: 86% RQD: 61%		RUN 2	NQ			275				
274.0							274				
13.3	BOREHOLE TERMINATED AT ~ 13.3 m DEPTH										

Notes:
1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.
2. WH - weight of hammer
3. Borehole backfilled upon completion.

Continued Next Page

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

RECORD OF BOREHOLE No BH12-1 2 OF 2 METRIC

W.P. ADM-23010055-A0 LOCATION 5188610.64N, 282183.182E, NAD83 MTM Zone 10 ORIGINATED BY AM

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

DATUM Geodetic DATE 2024.05.07 - 2024.05.08 LATITUDE 46.836644 LONGITUDE -79.7964979 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	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	w_P w w_L	γ kN/m³	GR SA SI CL
	4. Monitoring Well Readings DATE DEPTH(M) ELEV. May 15/24 0.5 286.8 June 18/24 0.5 286.8 July 31/24 0.4 286.9							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60		

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

RECORD OF BOREHOLE No BH12-2

1 OF 1 **METRIC**

W.P. ADM-23010055-A0 LOCATION 5188562.977N, 282177.504E, NAD83 MTM Zone 10 ORIGINATED BY AM

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

DATUM Geodetic DATE 2024.05.09 - 2024.05.09 LATITUDE 46.83621519 LONGITUDE -79.79657003 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (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
287.5	GROUND SURFACE										
287.4	**TOPSOIL,** ~125mm thick										
0.1	**SILTY SAND,** trace gravel, trace clay, trace organics, brown to grey, moist, very loose		1	SS	2		287				Organic Content =1.6%
286.7											
0.8	**SILT,** trace to some gravel, trace to some clay, trace sand, grey, saturated, loose to dense		2	SS	12						
			3	SS	10		286				11 2 72 15 Non-plastic
			4	SS	12		285				
			5	SS	5		284			20.3	1 5 93 1
			6	SS	17		283				
			7	SS	39		282				
280.0							281				
7.5	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix		8	SS	24		280				
278.5							279				
9.0	BOREHOLE TERMINATED AT ~ 9.0 m DEPTH Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole backfilled upon completion.										

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

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

RECORD OF BOREHOLE No BH12-3 1 OF 2 METRIC

W.P. ADM-23010055-A0 LOCATION 5188654.481N, 282175.001E, NAD83 MTM Zone 10 ORIGINATED BY AM

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

DATUM Geodetic DATE 2024.05.07 - 2024.05.07 LATITUDE 46.83703829 LONGITUDE -79.79660737 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 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
286.6	GROUND SURFACE										
286.4 / 0.0	**TOPSOIL,** ~190 mm thick										
0.2	**SILTY SAND,** trace gravel, trace organics, grey, moist, very loose to loose		1	SS	2		286				Organic Content =4.9%
			2	SS	5						
			3	SS	4		285			18.7	
284.3										17.5	
2.3	**SILT AND SAND,** trace gravel, trace clay, grey, saturated, very loose to compact		4	SS	2		284				0 53 43 4 Non-plastic
			5	SS	14		283				
			6	SS	13		282				6 41 53 0
281.3											
5.3	**SILT,** trace sand, trace clay, grey, saturated, very loose to loose		7	SS	8		281				0 3 88 9
			8	SS	8		280				
			9	SS	2		279				
277.5							278				
9.1	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix		10	SS	100/ 125mm		277				
276.1				NQ							
10.5	**BEDROCK** Run 1: Start/End: 10.5 to 12.0 m Recovery: 100% RQD: 91%		RUN 1	NQ			276				
	Run 2: Start/End: 12.0 to 13.7 m Recovery: 100% RQD: 82%		RUN 2	NQ			275				
272.9							274				
13.7	BOREHOLE TERMINATED AT ~ 13.7 m DEPTH						273				

Notes:
1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.

Continued Next Page

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

RECORD OF BOREHOLE No BH12-3 2 OF 2 METRIC

W.P. ADM-23010055-A0 LOCATION 5188654.481N, 282175.001E, NAD83 MTM Zone 10 ORIGINATED BY AM

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

DATUM Geodetic DATE 2024.05.07 - 2024.05.07 LATITUDE 46.83703829 LONGITUDE -79.79660737 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	2. Borehole backfilled upon completion.										

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

RECORD OF BOREHOLE No BH12-4

1 OF 1 **METRIC**

W.P. ADM-23010055-A0 LOCATION 5188457.783N, 282150.872E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.06 - 2024.05.06 LATITUDE 46.83526794 LONGITUDE -79.79691394 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.2	GROUND SURFACE										
289.0	**ASPHALT,** ~150 mm thick										
0.2	**SAND AND GRAVEL (FILL),** trace silt, brown to dark brown, moist to wet, compact to dense		1	SS	41		289		○		39 58 (3)
288.0			2	SS	28				○		
1.2	**ROCKFILL,** in silt, sand, and gravel soil matrix			NQ			288				
287.1											
2.1	**BEDROCK** Run 1: Start/End: 2.1 to 3.2 m Recovery: 100% RQD: 90%		RUN 1	NQ			287				
	Run 2: Start/End: 3.2 to 4.0 m Recovery: 100% RQD: 31%		RUN 2	NQ			286				
284.6	Run 3: Start/End: 4.0 to 4.6 m Recovery: 100% RQD: 21%		RUN 3	NQ			285				
4.6	BOREHOLE TERMINATED AT ~ 4.6 m DEPTH Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole backfilled upon completion.										

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

RECORD OF BOREHOLE No BH12-5

1 OF 1 **METRIC**

W.P. ADM-23010055-A0 LOCATION 5188654.381N, 282143.901E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE EXPLO 220 Geotechnical Drill Rig COMPILED BY AM

DATUM Geodetic DATE 2024.05.30 - 2024.06.03 LATITUDE 46.83703634 LONGITUDE -79.79701507 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (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
286.6	GROUND SURFACE										
0.0	**ORGANIC SILT,** some sand, trace to some gravel, dark brown to grey, wet, very loose		1	SS	1		286				Organic Content =11.6%
			2	SS	2						
			3	SS	2		285				
			4	SS	2		284				
283.6											
3.0	**SILT,** some clay, trace organics, grey, saturated, very loose		5	SS	2		283			16.4	Non-plastic 0 1 83 16
			6	SS	2		282				
280.5							281				
6.1	**CLAYEY SILT,** trace sand, grey, saturated, soft to firm		7	SS	2		280			17.7	0 3 74 23
			8	SS	6		279				
278.2											
8.4	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix			NQ			278				
				NQ			277				
				NQ			276				
274.9							275				
11.7	BOREHOLE TERMINATED AT ~ 11.7 m DEPTH Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole backfilled upon completion.										

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

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

RECORD OF BOREHOLE No BH12-6 1 OF 2 METRIC

W.P. ADM-23010055-A0 LOCATION 5188654.18N, 282157.507E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.13 - 2024.05.13 LATITUDE 46.83703499 LONGITUDE -79.7968367 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
290.9	GROUND SURFACE								
290.8 / 0.1	**ASPHALT,** ~75 mm thick								
	SAND (FILL), some gravel, grey, moist, dense to very dense		1	SS	64				
			2	SS	34				
289.4									
1.5	**SANDY SILT (FILL),** gravelly, trace clay, brown, moist, loose to compact		3	SS	14	22	22	49	7
			4	SS	11				
			5	SS	7				
	- cobbles at ~ 4.1 m depth								
286.3									
4.6	**SANDY SILT,** trace organics, brown, moist, loose to compact		6	SS	11				
			7	SS	6				
284.0									
6.9	**SAND AND SILT,** trace clay, grey, moist to saturated, loose to compact		8	SS	5	Non-plastic			
			9	SS	12	0	54	44	2
281.0									
9.9	**SILT,** some sand, trace gravel, trace clay, grey, saturated, loose		10	SS	8	2	10	81	7
280.2									
10.7	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix			NQ					
				NQ					
				NQ					
				NQ					

ELEVATION SCALE: 290, 289, 288, 287, 286, 285, 284, 283, 282, 281, 280, 279, 278, 277, 276

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

GROUND WATER CONDITIONS

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

Continued Next Page

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

RECORD OF BOREHOLE No BH12-6 2 OF 2 METRIC

W.P. ADM-23010055-A0 LOCATION 5188654.18N, 282157.507E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.13 - 2024.05.13 LATITUDE 46.83703499 LONGITUDE -79.7968367 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (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
275.3	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix *(continued)*			NQ							
15.6	BOREHOLE TERMINATED AT ~ 15.6 m DEPTH Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole backfilled upon completion.										

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

RECORD OF BOREHOLE No BH12-8 1 OF 1 METRIC

W.P. ADM-23010055-A0 LOCATION 5188259.248N, 282144.342E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.06 - 2024.05.06 LATITUDE 46.83348166 LONGITUDE -79.79698971 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 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
290.0	GROUND SURFACE										
289.8 / 0.2	**ASPHALT,** ~ 150 mm thick										
	GRAVELLY SAND (FILL), trace silt and clay, brown, moist to wet, compact to dense		1	SS	26				○		34 56 (10)
288.8			2	SS	31		289		○		
1.2	**ROCKFILL,** in silt, sand, and gravel soil matrix			NQ							
			3	SS	14		288				
			4	SS	20		287				
285.6			5	SS	10		286				
4.4	**BEDROCK,** Run 1: Start/End: 4.4 to 5.4 m Recovery: 100% RQD: 75%		RUN 1	NQ			285				
	Run 2: Start/End: 5.4 to 6.2 m Recovery: 38% RQD: 42%		RUN 2	NQ			284				
	Run 3: Start/End: 6.2 to 7.7 m Recovery: 100% RQD: 97%		RUN 3	NQ			283				
282.3											
7.7	BOREHOLE TERMINATED AT ~ 7.7 m DEPTH Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole backfilled upon completion.										

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

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

RECORD OF BOREHOLE No BH12-11 1 OF 1 METRIC

W.P. ADM-23010055-A0 LOCATION 5188604.348N, 282137.955E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE EXPLO 220 Geotechnical Drill Rig COMPILED BY AM

DATUM Geodetic DATE 2024.06.05 - 2024.06.06 LATITUDE 46.836586 LONGITUDE -79.7970906 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (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
288.4	GROUND SURFACE										
288.3 / 0.1	**TOPSOIL,** ~100 mm thick										
	ORGANIC SILT, sandy, trace clay, brown to black, saturated, very loose		1	SS	1		288		229		Organic Content =14.4%
	- clayey silt layer at ~ 1.0 m depth		2	SS	4						Organic Content =3.6%
			3	SS	4		287				0 28 69 3 Organic Content =7.3%
			4	SS	WH		286				Organic Content =7.7%
			5	SS	2		285		103		Organic Content =8.8%
			6	SS	2		284		81		Organic Content =11.4%
282.3 / 6.1	**SANDY SILT,** trace clay, grey, saturated, loose to compact		7	SS	5		283 / 282				0 20 73 7 Non-plastic
			8	SS	28		281 / 280 / 279				
			9	SS	20		278 / 277				
276.8 / 11.6	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix			NQ							
276.5 / 11.9	BOREHOLE TERMINATED AT ~ 11.9 m DEPTH										

Notes:
1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.
2. WH - weight of hammer
3. Borehole backfilled upon completion.

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

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

RECORD OF BOREHOLE No BH12-12 1 OF 1 METRIC

W.P. ADM-23010055-A0 LOCATION 5188562.77N, 282150.38E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.13 - 2024.05.13 LATITUDE 46.836212 LONGITUDE -79.7969255 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.0	GROUND SURFACE										
288.8	**ASPHALT,** ~ 150 mm thick										
0.2	**GRAVELLY SAND (FILL),** some silt and clay, cobble encountered, brown, moist, dense to very dense		1	SS	100/130mm				○		
			2	SS	32		288		○		30 46 (24)
287.5											
1.5	**ROCKFILL,** in silt, sand, and gravel soil matrix		3	SS	5		287				
				NQ			286				
				NQ			285				
				NQ			284				
281.7							283				
7.3	**BEDROCK,** Run 1: Start/End: 7.3 to 8.3 m Recovery: 100% RQD: 83%		RUN 1	NQ			282				
	Run 2: Start/End: 8.3 to 9.2 m Recovery: 83% RQD: 55%		RUN 2	NQ			281				
279.8							280				
9.2	BOREHOLE TERMINATED AT ~ 9.2 m DEPTH										

Notes:
1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.
2. Borehole backfilled upon completion.

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

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

RECORD OF BOREHOLE No BH12-13 1 OF 2 METRIC

W.P. ADM-23010055-A0 LOCATION 5188522.17N, 282133.791E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE EXPLO 220 Geotechnical Drill Rig COMPILED BY AM

DATUM Geodetic DATE 2024.06.18 - 2024.06.20 LATITUDE 46.835846 LONGITUDE -79.797141 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 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
286.4	GROUND SURFACE										
286.2	**TOPSOIL,** ~150 mm thick										
0.2	**ORGANIC SILT,** trace sand to sandy, trace gravel, trace clay, dark brown to black, wet to saturated, very loose to loose		1	SS	9		286				
			2	SS	3				243		Organic Content =6.7%
			3	SS	3		285		113		Organic Content =10.7%
			4	SS	3		284				7 32 58 3 Non-plastic Organic Content =10.8%
			5	SS	2		283				5 23 67 5 Non-plastic Organic Content =9.2%
280.3							282				
6.1	**SILT,** some sand, trace gravel, trace clay, grey, saturated, very loose to compact		6	SS	2		281				
							280				5 10 82 3 Non-plastic
			7	SS	5		279				
							278				
			8	SS	22		277				
273.6							276				
12.8	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix			NQ			275				
272.5							274				
13.9	BOREHOLE TERMINATED AT ~ 13.9 m DEPTH						273				
	Notes: 1. Groundwater level not measured in open hole due to water being										

Continued Next Page

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

RECORD OF BOREHOLE No BH12-13 2 OF 2 METRIC

W.P. ADM-23010055-A0 LOCATION 5188522.17N, 282133.791E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE EXPLO 220 Geotechnical Drill Rig COMPILED BY AM

DATUM Geodetic DATE 2024.06.18 - 2024.06.20 LATITUDE 46.835846 LONGITUDE -79.797141 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 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	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	introduced in drilling/coring process. 2. Borehole backfilled upon completion.										

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

RECORD OF BOREHOLE No BH12-15 1 OF 1 METRIC

W.P. ADM-23010055-A0 LOCATION 5188413.28N, 282136.321E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.07 - 2024.05.07 LATITUDE 46.834867 LONGITUDE -79.7971024 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.2	GROUND SURFACE										
0.0	**GRAVELLY SAND (FILL),** trace silt and clay, brown, moist to wet, compact to dense		1	SS	30		289		○		32 65 (3)
			2	SS	16		288		○		
287.4			3	SS	100/80mm						
1.8	**ROCKFILL,** in silt, sand, and gravel soil matrix			NQ			287				
285.5				NQ			286				
3.7	**BEDROCK** Run 1: Start/End: 3.7 to 4.7 m Recovery: 100% RQD: 35.8%		RUN 1	NQ			285				
	Run 2: Start/End: 4.7 to 6.0 m Recovery: 100% RQD: 49%		RUN 2	NQ			284				
283.2											
6.0	BOREHOLE TERMINATED AT ~ 6.00 m DEPTH Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole backfilled upon completion.										

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

RECORD OF BOREHOLE No BH12-16 1 OF 1 METRIC

W.P. ADM-23010055-A0 LOCATION 5188362.173N, 282140.259E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.07 - 2024.05.07 LATITUDE 46.8344074 LONGITUDE -79.7970483 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.6	GROUND SURFACE										
289.4 / 0.2	**ASPHALT,** ~ 150 mm thick										
	SAND AND GRAVEL (FILL), some silt, grey, moist to wet, compact to dense		1	SS	39		289		○		
			2	SS	21				○		
287.9 / 1.7	**SILT AND GRAVEL (FILL),** trace sand, trace clay, brown, compact		3	SS	13		288		○		37 5 55 3
287.1 / 2.5	**SILT,** trace sand, trace clay, brown, saturated, compact		4	SS	12		287		○		
			5	SS	15		285		○		0 1 94 5
283.9 / 5.7	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix		RUN 1	NQ			284				
283.6 / 6.0	**BEDROCK,** Run 1: Start/End: 6.0 to 6.3 m Recovery: 100% RQD: 100%		RUN 2	NQ			283				
281.9 / 7.7	Run 2: Start/End: 6.3 to 7.7 m Recovery: 100% RQD: 100%						282				
	BOREHOLE TERMINATED AT ~ 7.7 m DEPTH										

Notes:
1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.
2. Borehole backfilled upon completion.

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

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

RECORD OF BOREHOLE No BH12-17 1 OF 1 METRIC

W.P. ADM-23010055-A0 LOCATION 5188312.163N, 282132.976E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.07 - 2024.05.07 LATITUDE 46.8339573 LONGITUDE -79.79714133 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.6	GROUND SURFACE										
0.0 / 288.8	**SAND AND GRAVEL (FILL),** some silt, brown, moist, compact.		1	SS	13		289		○		
0.8 / 288.1	**SAND (FILL),** some silt, brown, wet, compact.		2	SS	19				○		
1.5 / 287.3	**SILT (FILL),** some gravel, contains cobbles, grey, wet, compact		3	SS	10		288		○		
2.3 / 286.5	**SILT,** trace sand, trace clay, brown, wet, loose		4	SS	8		287		○		0 2 91 7 Non-plastic
3.1 / 285.6	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix			NQ			286				
4.0 / 281.9	**BEDROCK,** Run 1: Start/End: 4.0 to 4.6 m Recovery: 96% RQD: 46% Run 2: Start/End: 4.6 to 6.1 m Recovery: 72% RQD: 30% Run 3: Start/End: 6.1 to 7.7 m Recovery: 100% RQD: 93%		RUN 1 RUN 2 RUN 3	NQ NQ NQ			285 284 283				
7.7	BOREHOLE TERMINATED AT ~ 7.7 m DEPTH Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole backfilled upon completion.						282				

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

RECORD OF BOREHOLE No BH12-19 1 OF 1 METRIC

W.P. ADM-23010055-A0 LOCATION 5188213.156N, 282133.56E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY AM

DATUM Geodetic DATE 2024.05.13 - 2024.05.13 LATITUDE 46.83306664 LONGITUDE -79.79712876 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "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 × LAB VANE 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
290.2	GROUND SURFACE										
0.0	**GRAVELLY SAND (FILL),** some silt, grey to brown, moist to wet, loose to dense		1	SS	22		290		○		
			2	SS	40		289		○		
			3	SS	9				○		
287.9							288				
2.3	**SILT (FILL),** some clay, trace sand, grey, saturated, very loose		4	SS	4				○		0 2 87 11
287.2											
3.0	**PEAT,** amorphous, dark brown, wet, firm		5	SS	7		287			141 ○	Organic Content =41.4%
286.2											
4.0	**SILTY SAND,** gravelly, trace clay, cobbles/boulders encountered, grey, wet, loose to compact						286				
			6	SS	25						
			7	SS	6		285		○		21 41 34 4
284.1											
6.1	**BEDROCK** Run 1: Start/End: 6.1 to 7.7 m Recovery: 100% RQD: 100% Run 2: Start/End: 7.7 to 9.1m Recovery:100% RQD: 88%		RUN 1	NQ			284				
							283				
			RUN 2	NQ			282				
281.1											
9.1	BOREHOLE TERMINATED AT ~9.1 m DEPTH Notes: 1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process. 2. Borehole backfilled upon completion.										

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

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

RECORD OF BOREHOLE No BH12-20 1 OF 1 METRIC

W.P. ADM-23010055-A0 LOCATION 5188165.425N, 282115.647E, NAD83 MTM Zone 10 ORIGINATED BY BJ

DIST NER HWY 11 BOREHOLE TYPE EXPLO 220 Geotechnical Drill Rig COMPILED BY AM

DATUM Geodetic DATE 2024.07.29 - 2024.07.30 LATITUDE 46.83263843 LONGITUDE -79.79736006 CHECKED BY SM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.7	GROUND SURFACE										
286.6 / 0.1	**TOPSOIL,** ~75mm thick										
	PEAT, fibrous to amorphous, trace roots, dark brown to dark grey, wet, very soft		1	SS	1		286				
			2	SS	1				226		
			3	SS	2		285		236		
284.2	- amorphous peat mixed with clayey silt & sand at a depth of 2.3 m								83		Organic Content =11.8%
2.5	**ORGANIC SILT,** some clay, trace sand, dark brown, wet, very loose		4	SS	WH		284				0 3 96 1
283.3			5	SS	WH						Organic Content =5.5% Non-plastic
3.4	**SILT,** some clay, trace sand, dark brown, wet, very loose to compact										Organic Content =5.3% 0 1 87 12
			6	SS	15		282				
			7	SS	7		281				0 1 88 11 Non-plastic
278.8			8	SS	6		279				
7.9	**SANDY SILT,** light grey to light brown, wet, loose to compact										
277.1	- spoon refusal; suspected cobbles/ boulders encountered, no recovery		9	SS	19		278				
9.6	**GLACIAL TILL,** cobbles and boulders with silt, sand, and gravel in soil matrix			NQ			277				
276.5											
10.2	**BEDROCK,** Run 1: Start/End: 10.2 to 11.4 m Recovery: 90% RQD: 93%		RUN1	NQ			276				
275.3											
11.4	BOREHOLE TERMINATED AT ~ 11.4 m DEPTH										

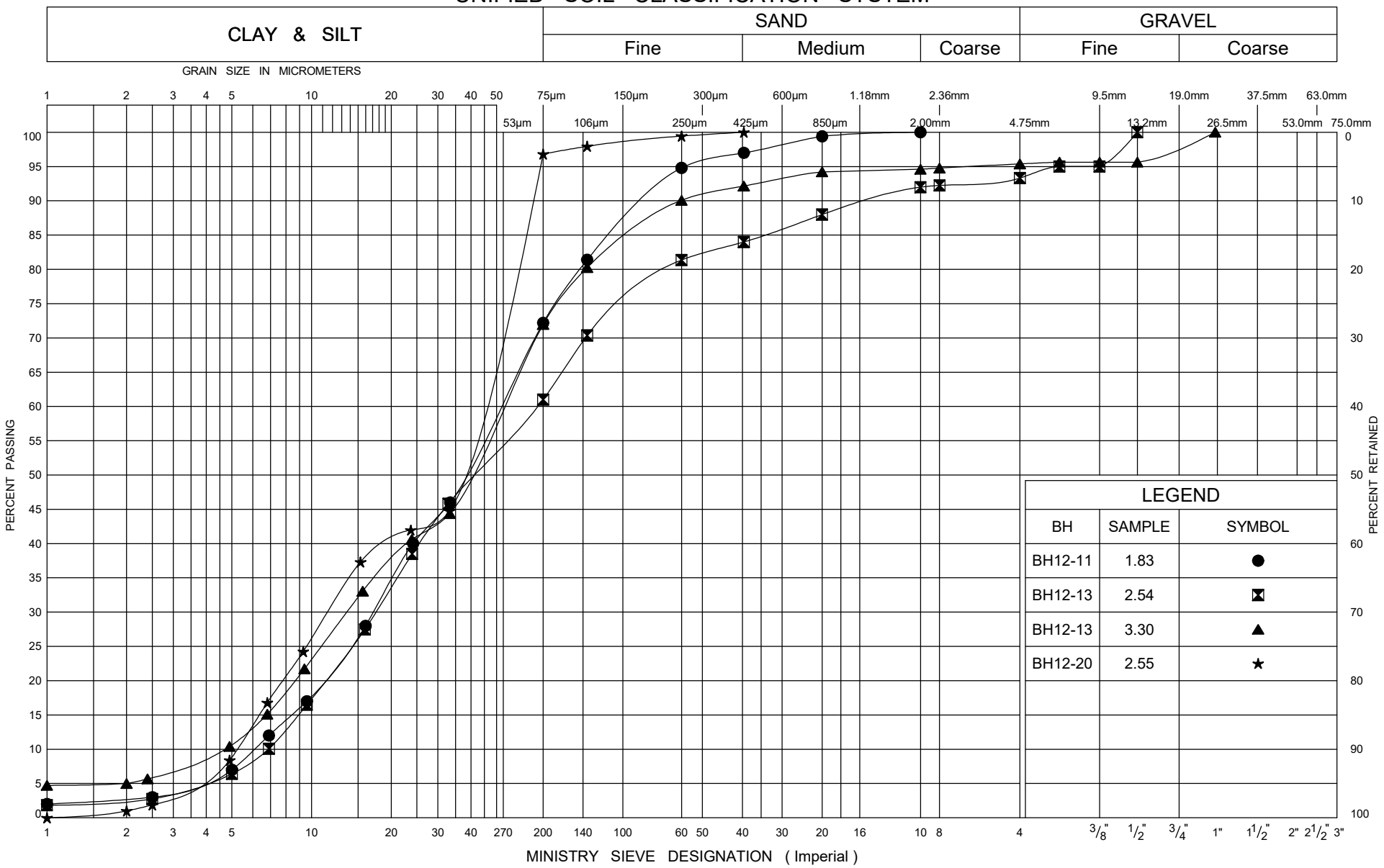
Notes:
1. Groundwater level not measured in open hole due to water being introduced in drilling/coring process.
2. WH - weight of hammer
3. Borehole backfilled upon completion.

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

ONTARIO MTO HWY 11-SW12-AMIR -4.GPJ ONTARIO MTO.GDT 1/22/25

Appendix D –
Laboratory Data

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Organic Silt

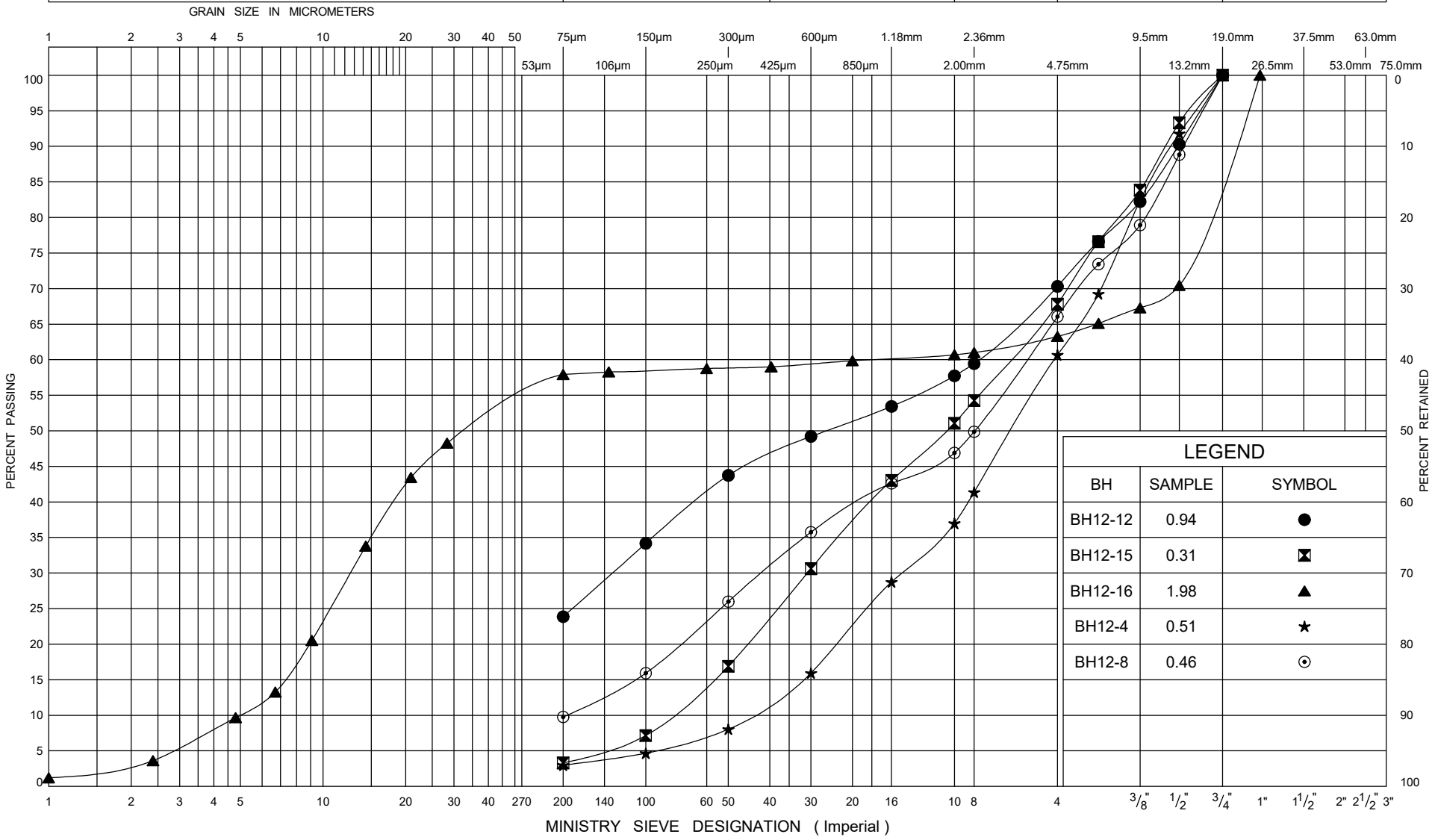
FIG No 1

GWP 5033-22-00

Highway 11 2+1, SW12

ONTARIO MOT GRAIN SIZE HWY 11-SW12-AMIR -4.GPJ ONTARIO MOT.GDT 1/21/25

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Sand and Gravel/Gravelly Sand (Fill)

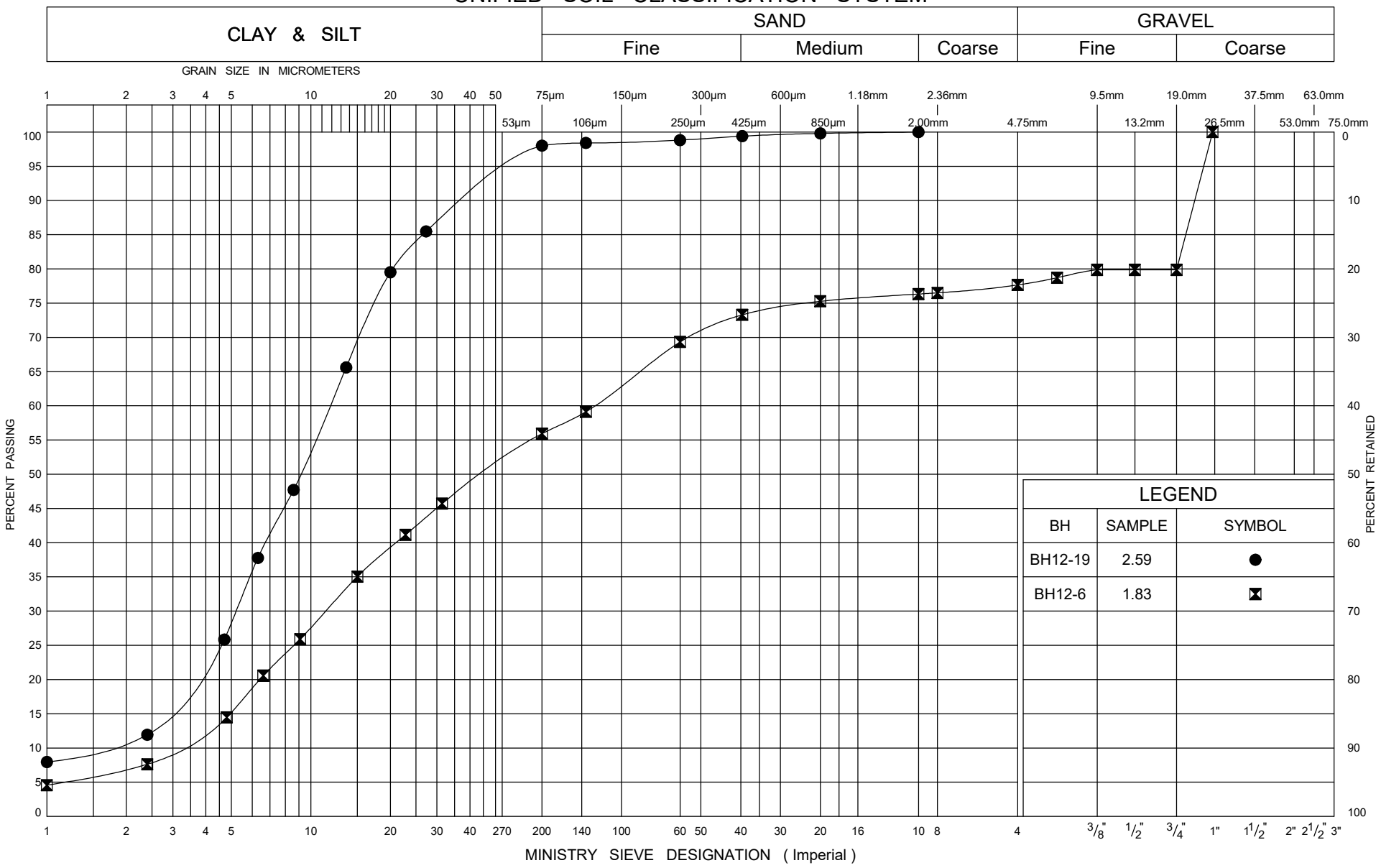
FIG No 2

GWP 5033-22-00

Highway 11 2+1, SW12

ONTARIO MOT GRAIN SIZE HWY 11-SW12-AMIR -4.GPJ ONTARIO MOT.GDT 1/21/25

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silt/Sandy Silt (Fill)

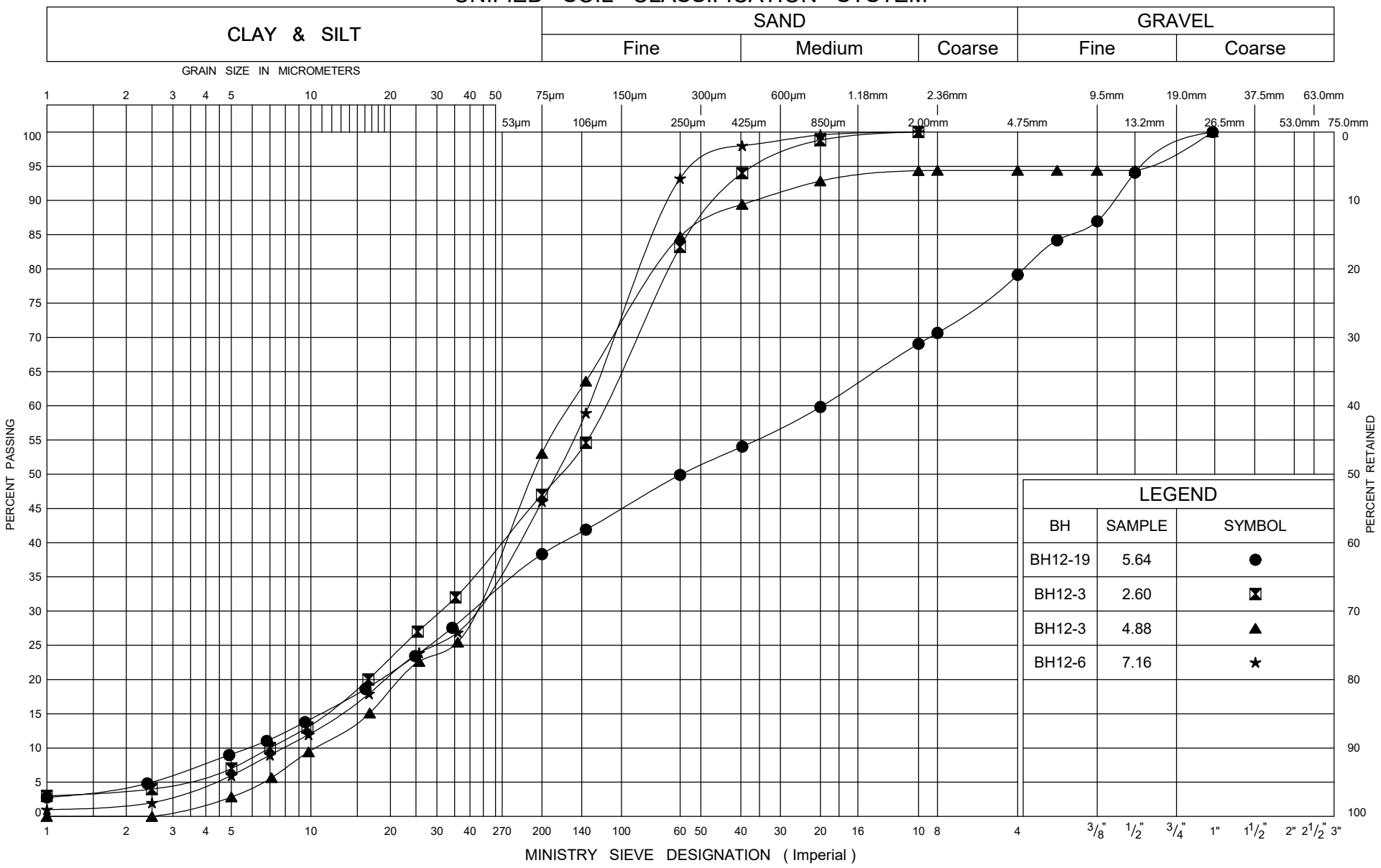
FIG No 3

GWP 5033-22-00

Highway 11 2+1, SW12

ONTARIO MOT GRAIN SIZE HWY 11-SW12-AMIR -4.GPJ ONTARIO MOT.GDT 1/21/25

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silt and Sand/Silty Sand

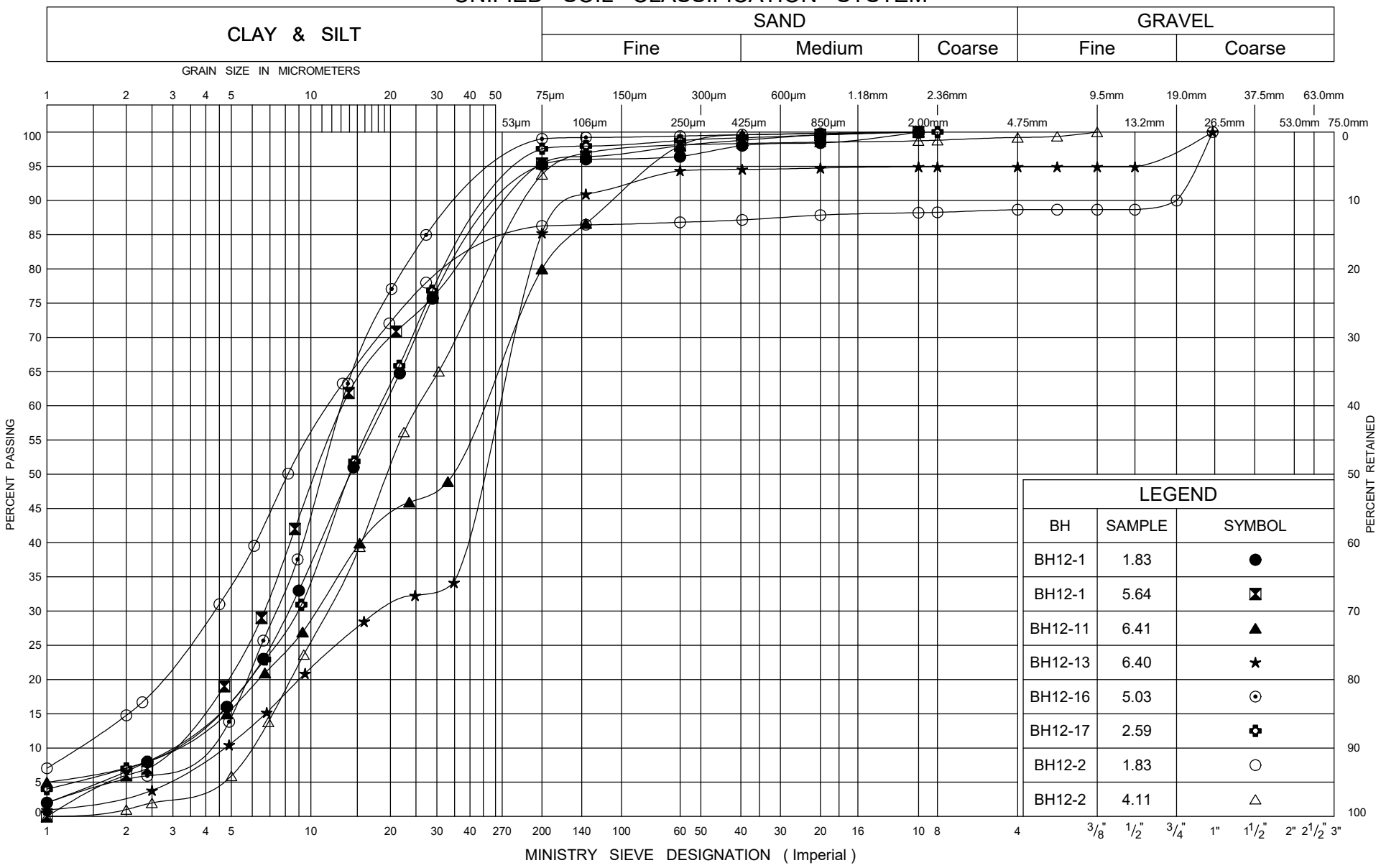
FIG No 4

GWP 5033-22-00

Highway 11 2+1, SW12

ONTARIO MOT GRAIN SIZE HWY 11-SW12-AMIR -4.GPJ ONTARIO MOT.GDT 1/21/25

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silt/Sandy Silt

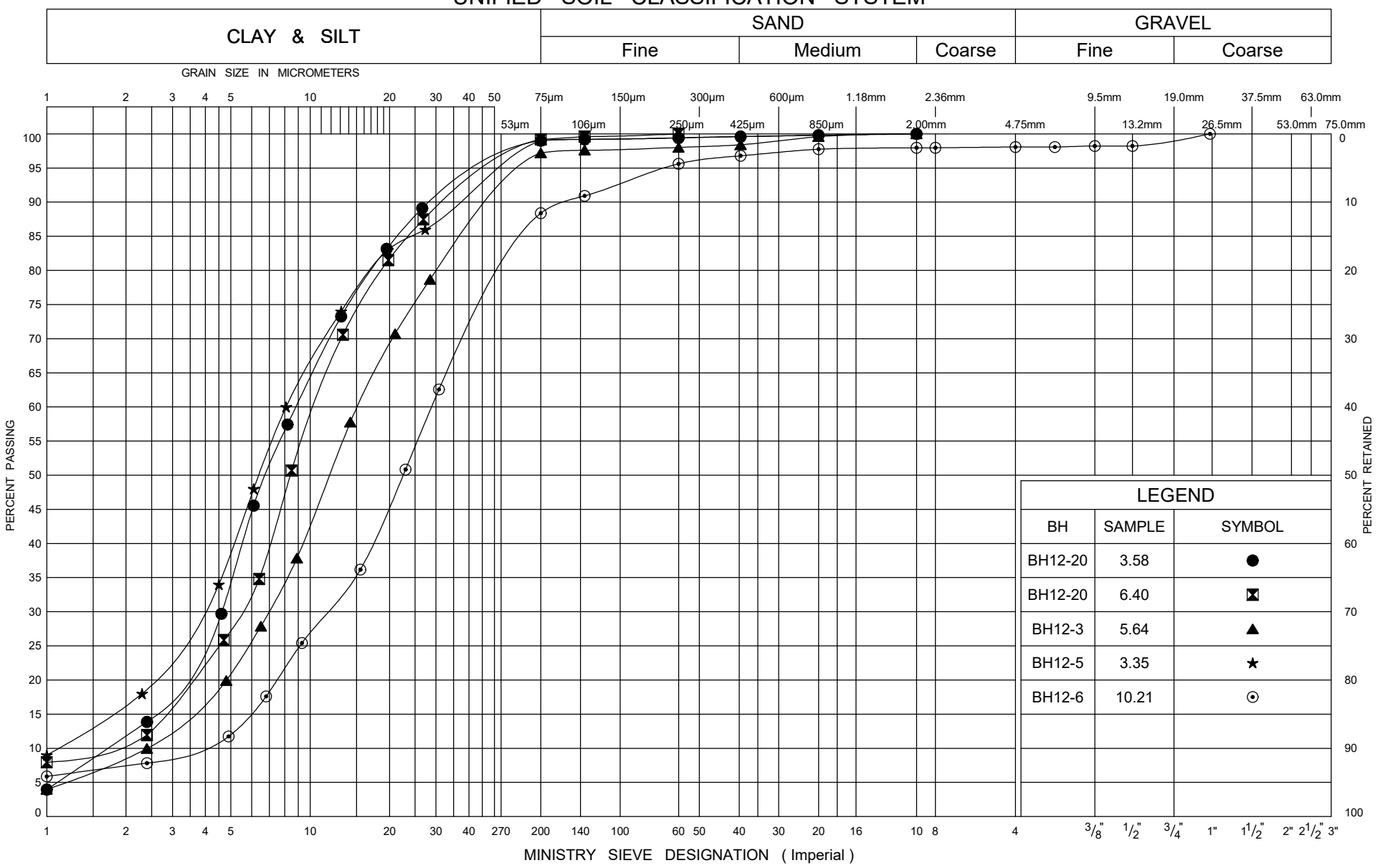
FIG No 5

GWP 5033-22-00

Highway 11 2+1, SW12

ONTARIO MOT GRAIN SIZE HWY 11-SW12-AMIR -4.GPJ ONTARIO MOT.GDT 1/21/25

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silt/Sandy Silt

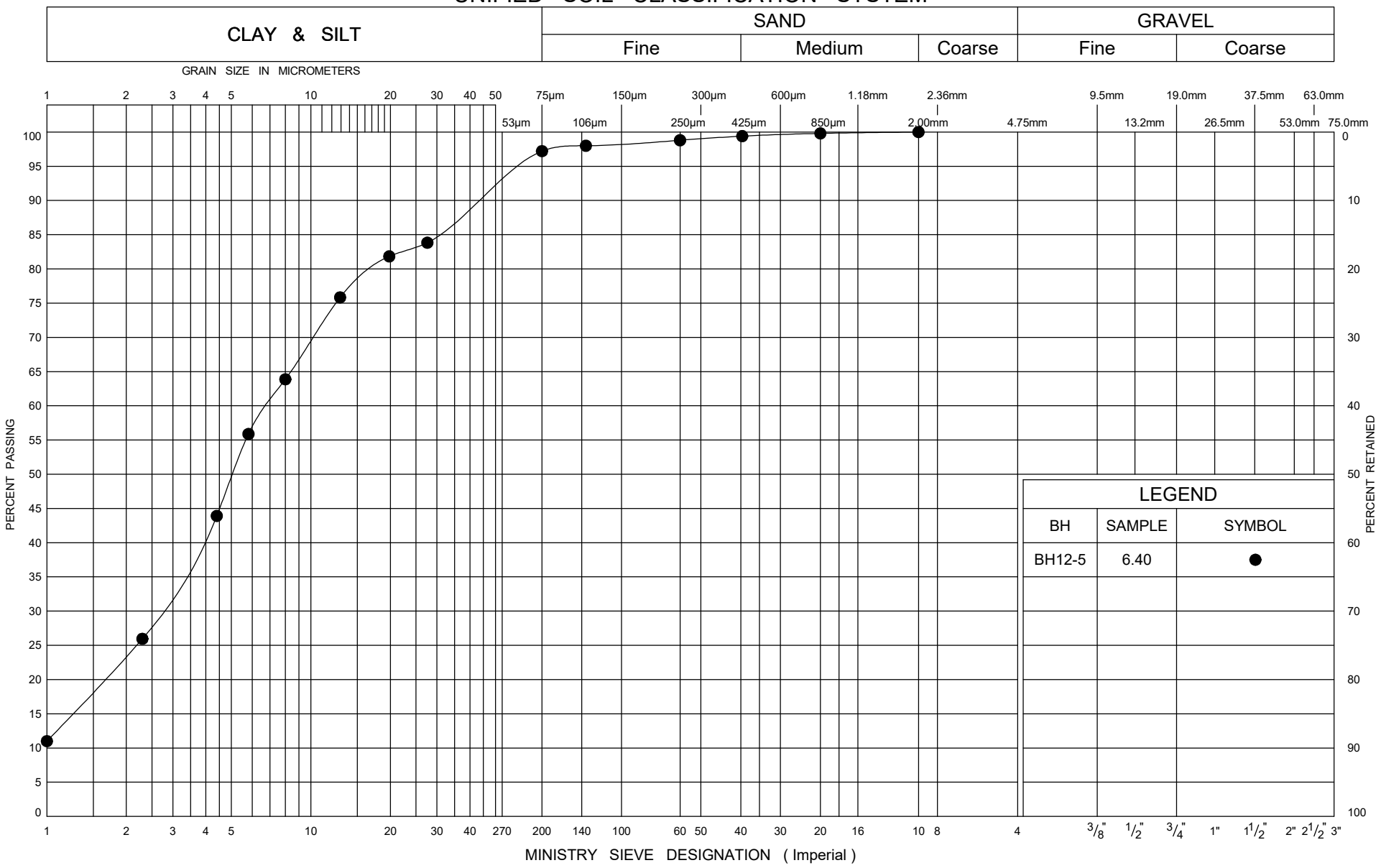
FIG No 6

GWP 5033-22-00

Highway 11 2+1, SW12

ONTARIO MOT GRAIN SIZE HWY 11-SW12-AMIR -4.GPJ ONTARIO MOT.GDT 1/21/25

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIG No 7

GWP 5033-22-00

Highway 11 2+1, SW12

ONTARIO MOT GRAIN SIZE HWY 11-SW12-AMIR -4.GPJ ONTARIO MOT.GDT 1/21/25

Your Project #: ADM-23010055-A0
Site Location: HWY11:2+1, SW12
Your C.O.C. #: N/A

Attention: Elvis Lu

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

Report Date: 2024/05/29
Report #: R8169404
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C4F4764
Received: 2024/05/21, 15:39

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	1	2024/05/29	2024/05/29	CAM SOP-00463	MOE E3013 m
Conductivity	1	2024/05/27	2024/05/27	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2024/05/29	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2024/05/28	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2024/05/25	2024/05/25	CAM SOP-00413	EPA 9045 D m
Redox Potential (3)	1	2024/05/27	2024/05/27	CAM SOP-00421	SM 24 2580 B
Resistivity of Soil	1	2024/05/24	2024/05/27	CAM SOP-00414	SM 24 2510 m
Sulphate (20:1 Extract)	1	2024/05/29	2024/05/29	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, EPA, APHA or the Quebec Ministry of Environment.

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.

Your Project #: ADM-23010055-A0
Site Location: HWY11:2+1, SW12
Your C.O.C. #: N/A

Attention: Elvis Lu

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

Report Date: 2024/05/29
Report #: R8169404
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C4F4764

Received: 2024/05/21, 15:39

(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
29 May 2024 21:27:33

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.
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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

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

Bureau Veritas Job #: C4F4764
Report Date: 2024/05/29

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: HWY11:2+1, SW12
Sampler Initials: EL

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		ZGB196			ZGB196		
Sampling Date		2024/05/13 12:00			2024/05/13 12:00		
COC Number		N/A			N/A		
	UNITS	**BH 12 -6, SS8**	**RDL**	**QC Batch**	**BH 12 -6, SS8 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters							
Resistivity	ohm-cm	2200		9412348			
CONVENTIONALS							
Redox Potential	mV	440	N/A	9415358	470	N/A	9415358
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	170	20	9420648			
Conductivity	umho/cm	452	2	9415204	451	2	9415204
Available (CaCl2) pH	pH	7.40		9413982			
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	9420675			
Sulphide	mg/kg	<0.5 (1)	0.5	9419502			

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

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

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

Bureau Veritas Job #: C4F4764
Report Date: 2024/05/29

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: HWY11:2+1, SW12
Sampler Initials: EL

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		ZGB196		
Sampling Date		2024/05/13 12:00		
COC Number		N/A		
	UNITS	**BH 12 -6, SS8**	**RDL**	**QC Batch**
Physical Testing				
Moisture-Subcontracted	%	22	0.30	9422476

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

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

Bureau Veritas Job #: C4F4764
Report Date: 2024/05/29

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: HWY11:2+1, SW12
Sampler Initials: EL

TEST SUMMARY

Bureau Veritas ID: ZGB196
Sample ID: BH 12 -6, SS8
Matrix: Soil

Collected: 2024/05/13
Shipped:
Received: 2024/05/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9420648	2024/05/29	2024/05/29	Massarat Jan
Conductivity	AT	9415204	2024/05/27	2024/05/27	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9422476	N/A	2024/05/29	Basilla Ashrafi
Sulphide in Soil	SPEC	9419502	N/A	2024/05/28	Ly Vu
pH CaCl2 EXTRACT	AT	9413982	2024/05/25	2024/05/25	Kien Tran
Redox Potential	COND	9415358	2024/05/27	2024/05/27	Gurparteek KAUR
Resistivity of Soil		9412348	2024/05/27	2024/05/27	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9420675	2024/05/29	2024/05/29	Massarat Jan

Bureau Veritas ID: ZGB196 Dup
Sample ID: BH 12 -6, SS8
Matrix: Soil

Collected: 2024/05/13
Shipped:
Received: 2024/05/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	9415204	2024/05/27	2024/05/27	Gurparteek KAUR
Redox Potential	COND	9415358	2024/05/27	2024/05/27	Gurparteek KAUR

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

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

GENERAL COMMENTS

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

Package 1	8.3°C

Results relate only to the items tested.

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

Bureau Veritas Job #: C4F4764
Report Date: 2024/05/29

QUALITY ASSURANCE REPORT

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: HWY11:2+1, SW12
Sampler Initials: EL

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9413982	Available (CaCl2) pH	2024/05/25			100	97 - 103			0.071	N/A
9415204	Conductivity	2024/05/27			104	90 - 110	<2	umho/cm	0.23	10
9415358	Redox Potential	2024/05/27			102	95 - 105			6.6	35
9419502	Sulphide	2024/05/28	101	75 - 125	89	75 - 125	<0.5	mg/kg	31 (1)	30
9420648	Soluble (20:1) Chloride (Cl-)	2024/05/29	102	70 - 130	101	70 - 130	<20	ug/g	NC	35
9420675	Soluble (20:1) Sulphate (SO4)	2024/05/29	NC	70 - 130	94	70 - 130	<20	ug/g	21	35
9422476	Moisture-Subcontracted	2024/05/29					<0.30	%	1.2	20

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)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

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

Bureau Veritas Job #: C4F4764
Report Date: 2024/05/29

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: HWY11:2+1, SW12
Sampler Initials: EL

VALIDATION SIGNATURE PAGE

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

Cristina Carriere, Senior Scientific Specialist

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

Bureau Veritas Proprietary Software
Logiciel Propriétaire de Bureau Veritas

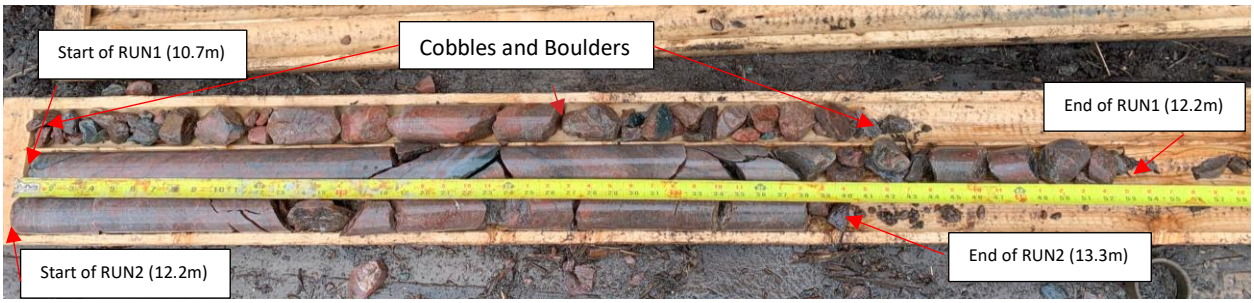
Automated Statchk

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.

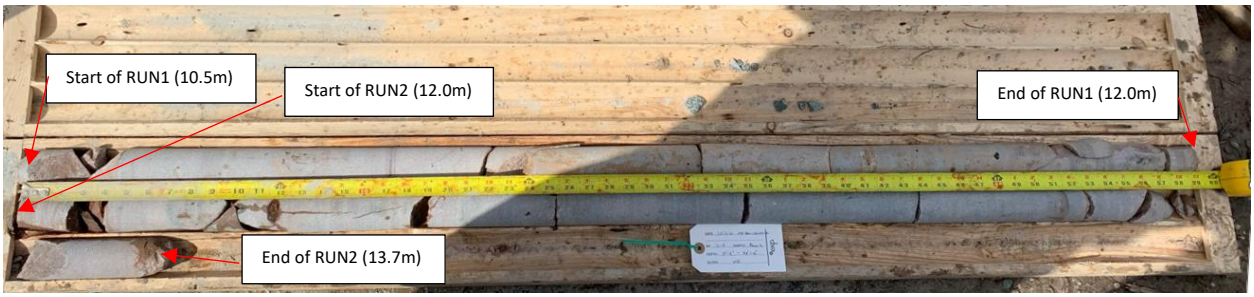
Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

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

Appendix E –
Bedrock Core Photographs



Photograph E1. Rock cores from BH12-1. Middle: Run 1, Bottom: Run 2.



Photograph E2. Rock cores from BH12-3. Top: Run 1, Middle/Bottom: Run 2.



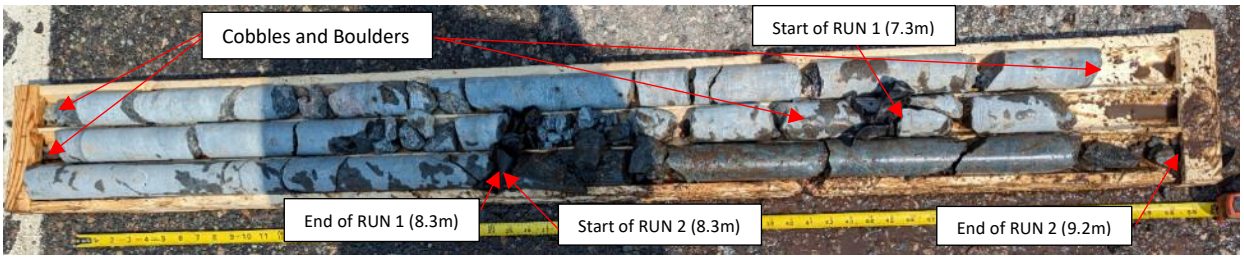
Photograph E3. Rock cores from BH12-4. Middle: Run 1, Bottom: Run 2.



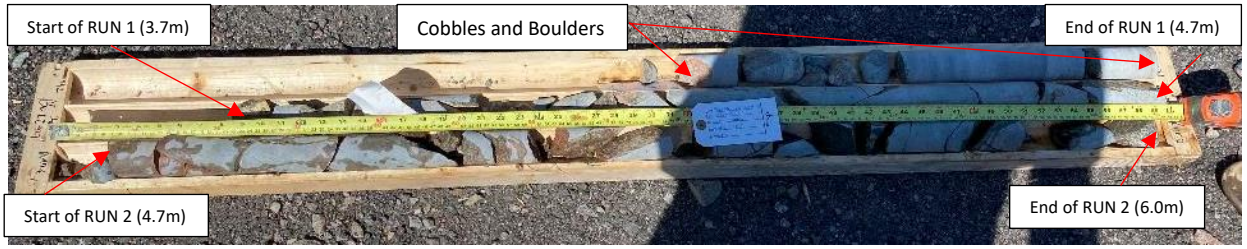
Photograph E4. Rock cores from BH12-4. Top: Run 3.



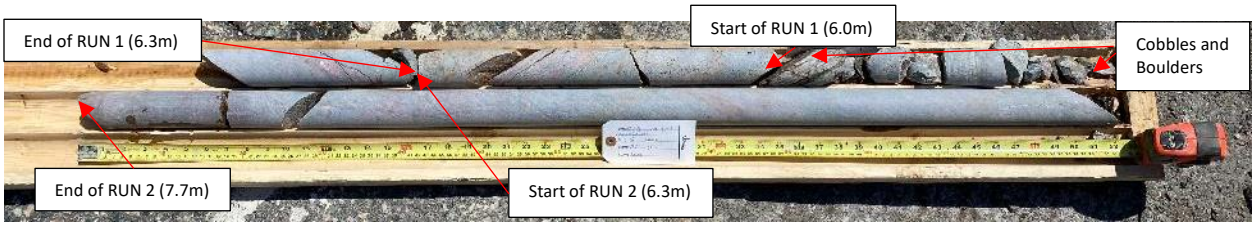
Photograph E5. Rock cores from BH12-8. Top: Run 3, Middle: Run 2, Bottom: Run 1.



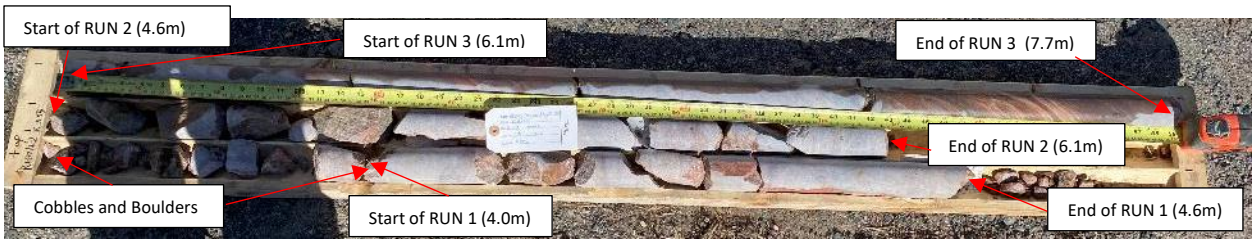
Photograph E6. Rock cores from BH12-12. Middle: Run 1, Bottom: Run 1&2.



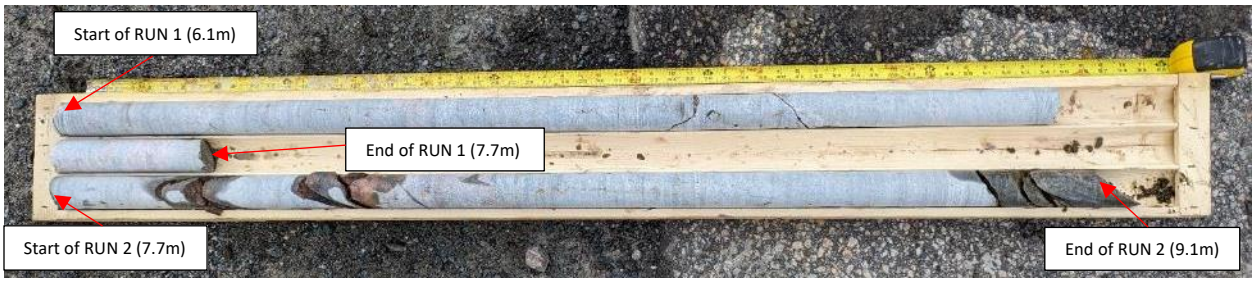
Photograph E7. Rock cores from BH12-15. Middle: Run 1, Bottom: Run 2.



Photograph E8. Rock cores from BH12-16. Top: Run 1/Run2, Bottom: Run 2.



Photograph E9. Rock cores from BH12-17. Top: Run 3, Middle: Run 2, Bottom: Run 1.



Photograph E10. Rock cores from BH12-19. Top: Run 1, Middle: Run 1, Bottom: Run 2.



Photograph E11. Rock cores from BH1-7. Top: Run 1.

Appendix F –
Slope Stability Analyses

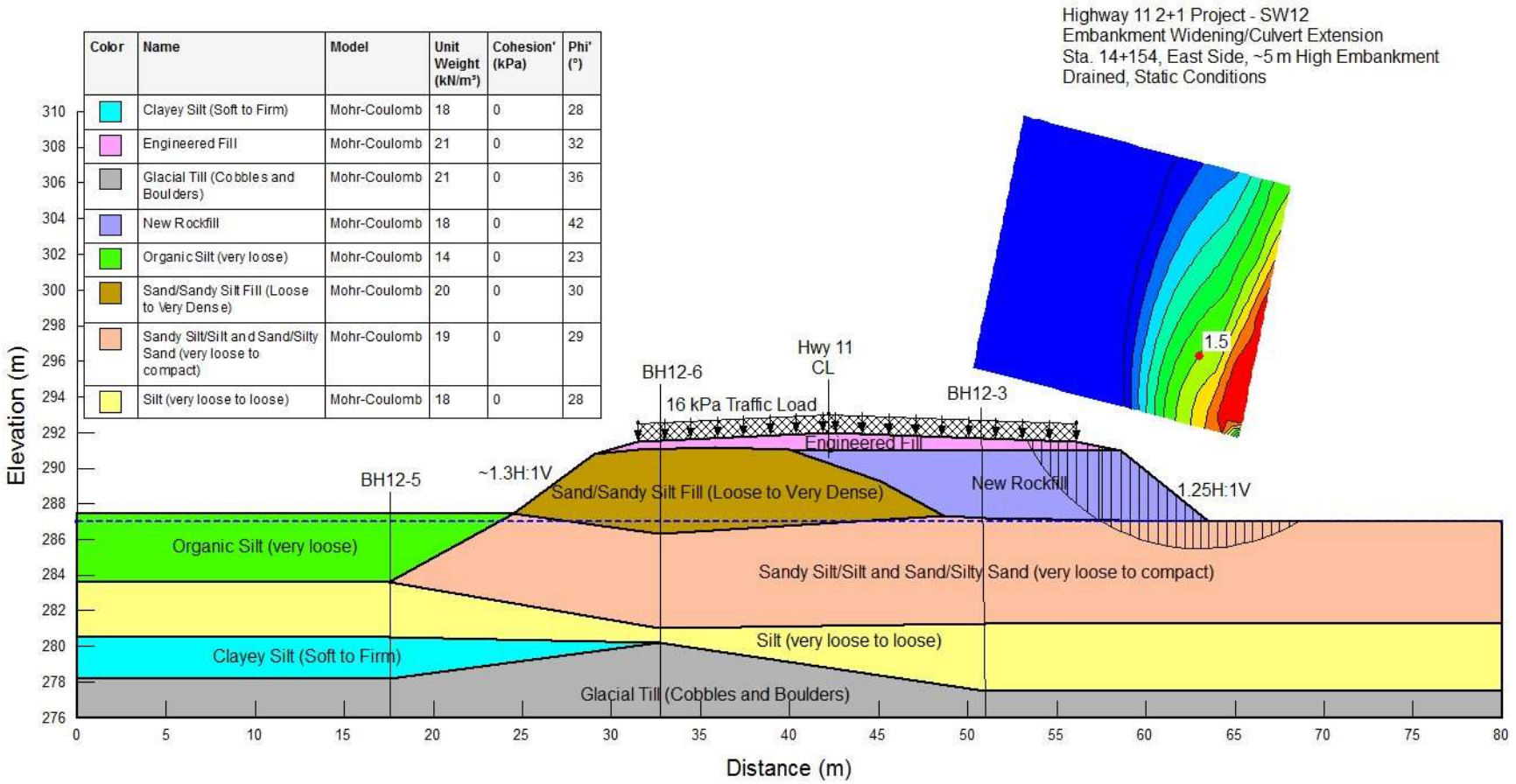


Figure F1: Slope stability analysis for embankment widening/culvert extension at Sta. 14+154, east side (~5 m high) – Rockfill (1.25H:1V) – drained, static condition

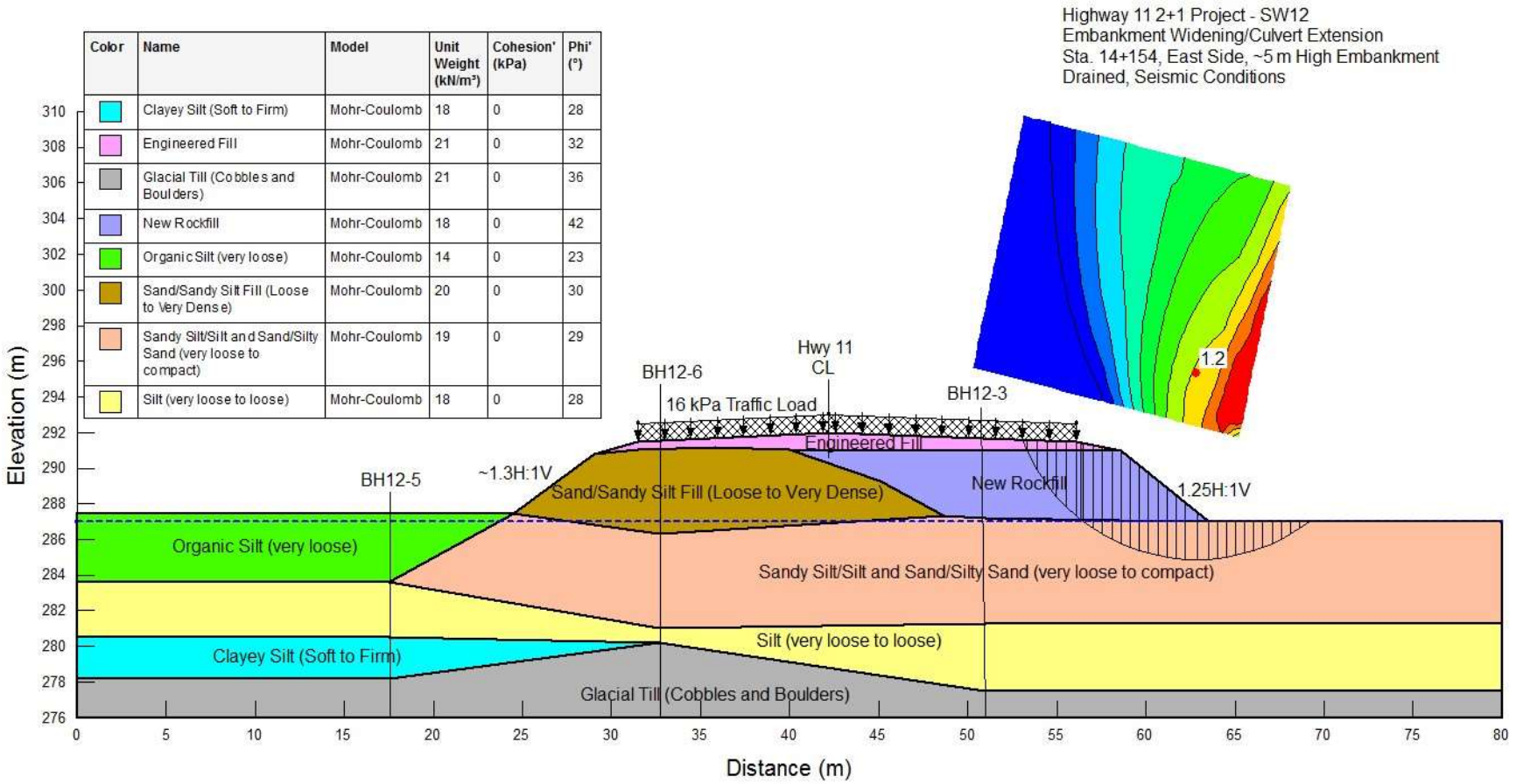
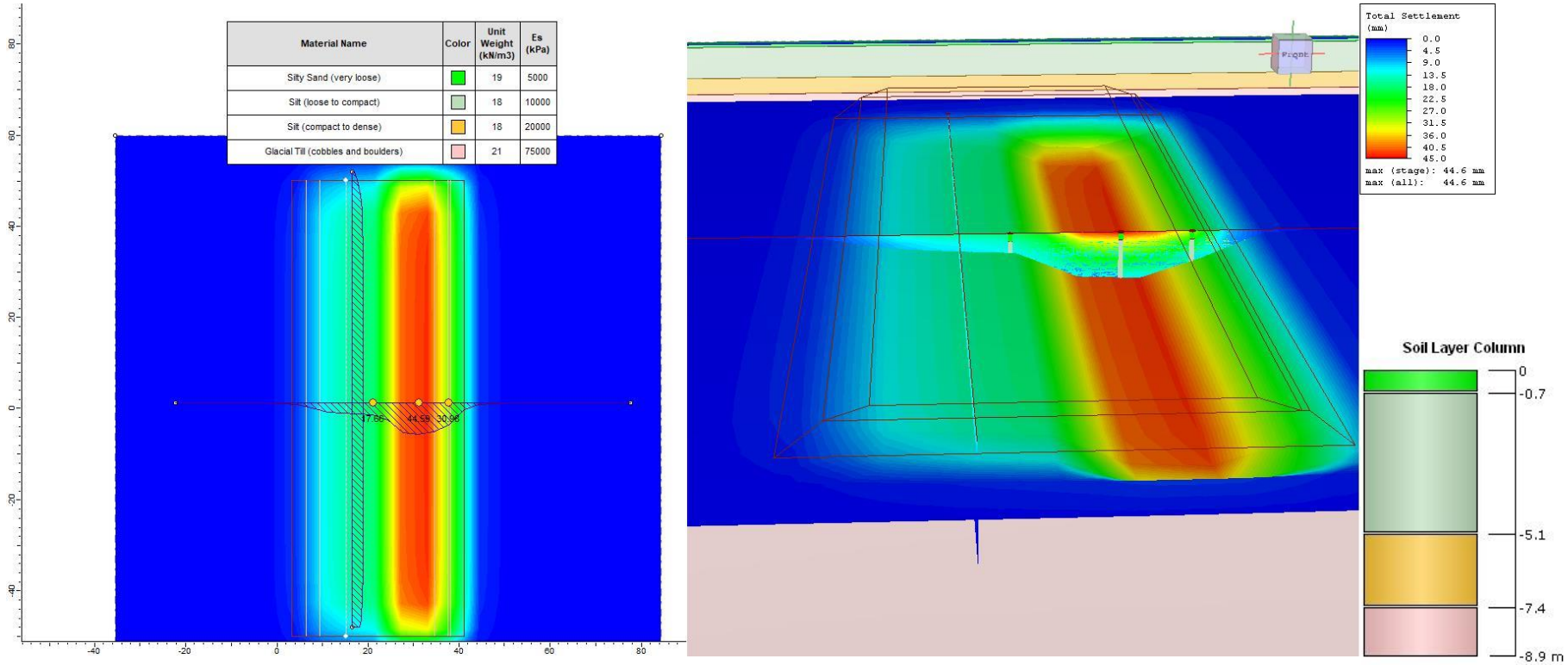
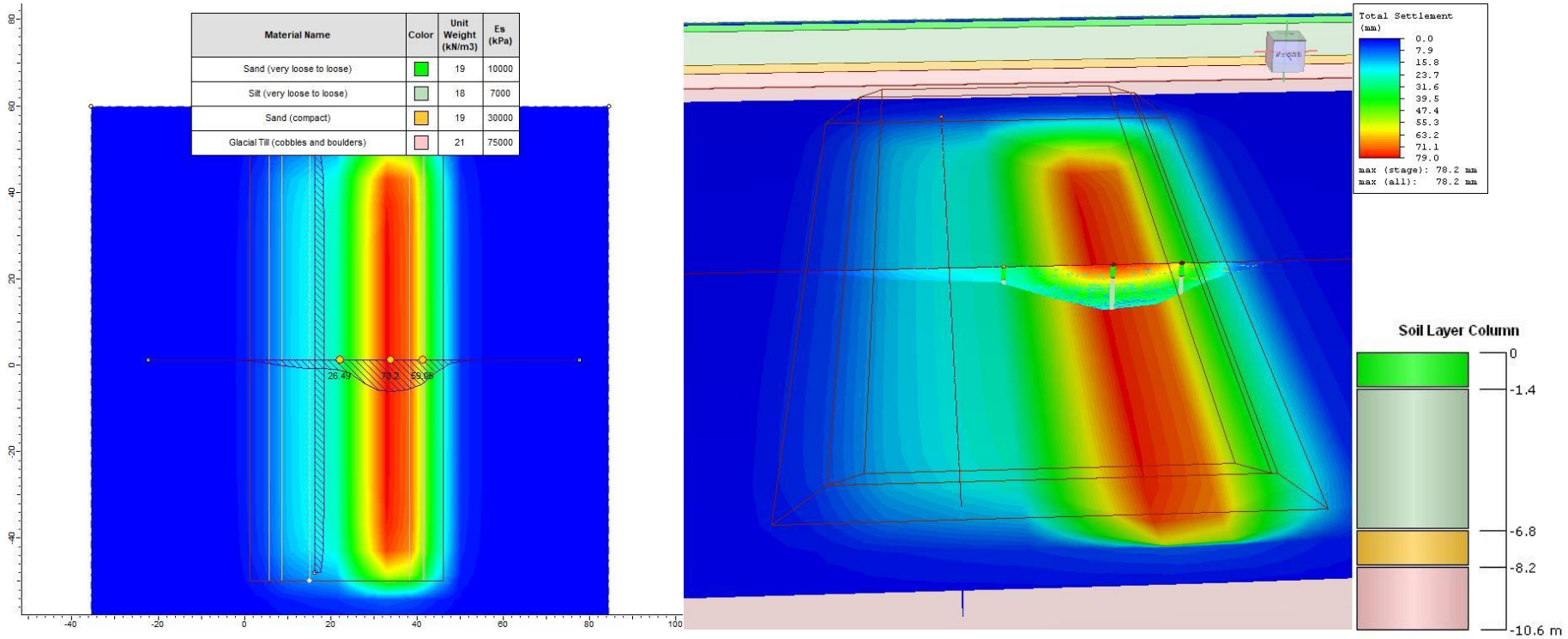


Figure F2: Slope stability analysis for embankment widening/culvert extension at Sta. 14+154, east side (~5 m high) – Rockfill (1.25H:1V) – drained, seismic condition

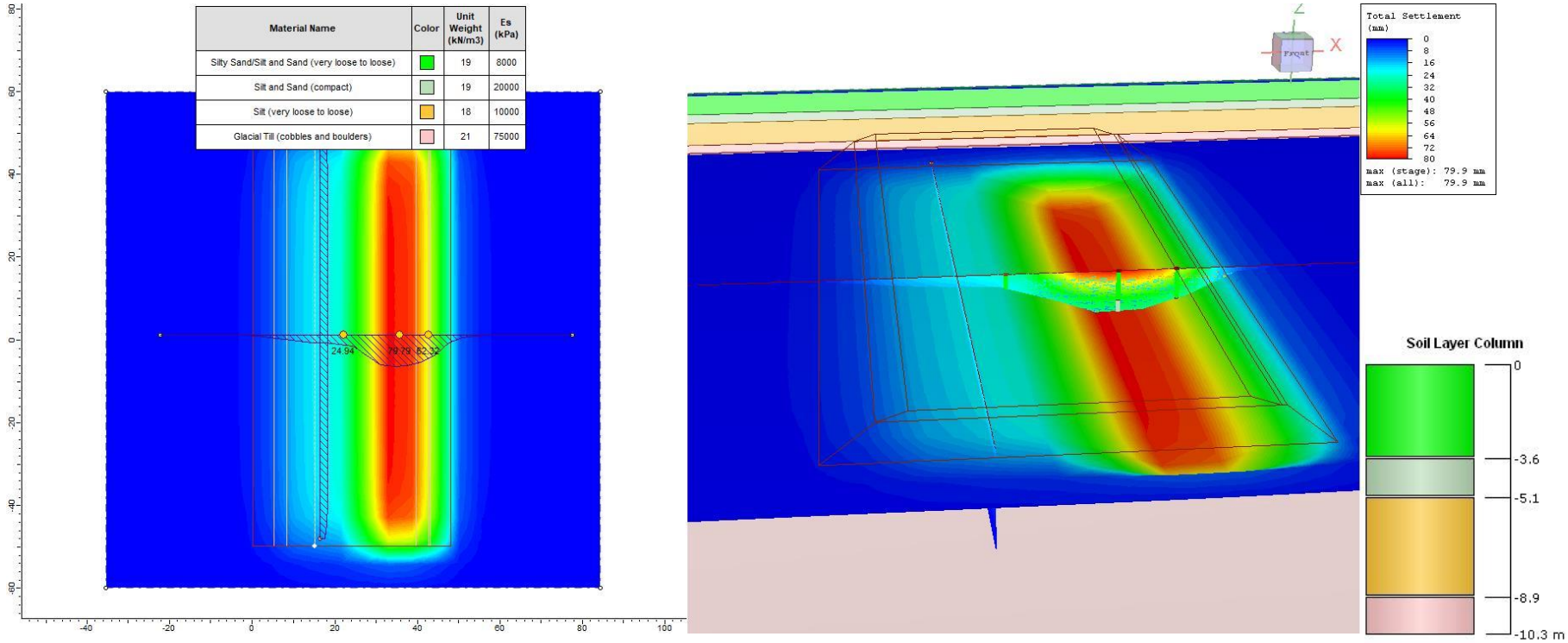
Appendix G –
Settlement Analyses



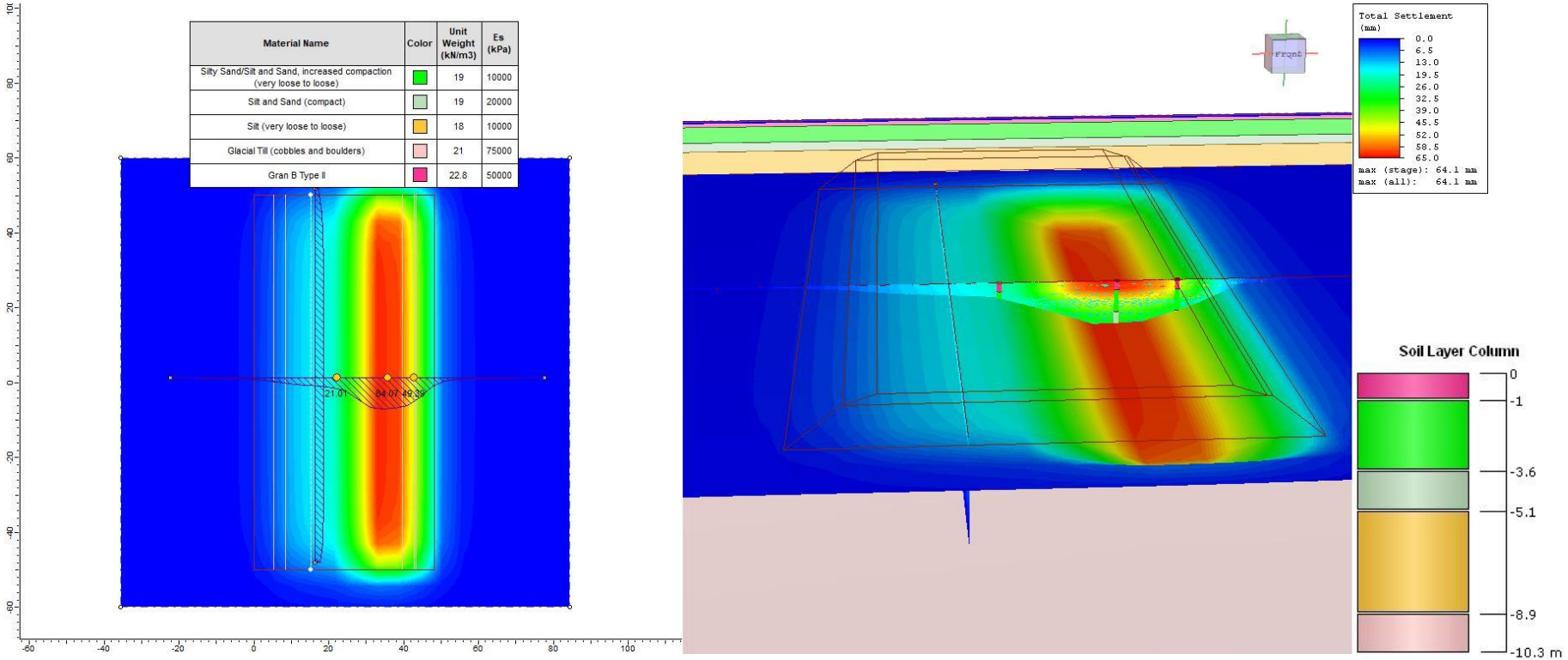
exp.	*Project:* Hwy 11: 2 + 1 – SW12	
	Analysis Description: **Model 1:** Embankment Widening with Rockfill at Station 14+070 (East side) – **Total Settlement**	
	*Figure No: G*1	*Company: EXP Services Inc.*
	Date: November 7, 2025	*File Name:* Hwy 11: 2+1 – SW12, Settlement Analysis 1



exp.	*Project:* Hwy 11: 2 + 1 – SW12	
	Analysis Description: **Model 2:** Embankment Widening with Rockfill at Station 14+110 (East side) – **Total Settlement**	
	*Figure No: G*2	*Company: EXP Services Inc.*
	Date: November 7, 2025	*File Name:* Hwy 11: 2+1 – SW12, Settlement Analysis 2



exp.	*Project:* Hwy 11: 2 + 1 – SW12	
	Analysis Description: **Model 3A:** Embankment Widening with Rockfill at Station 14+150 (East side) – **Total**	
	*Figure No: G*3	*Company: EXP Services Inc.*
	Date: November 7, 2025	*File Name:* Hwy 11: 2+1 – SW12, Settlement Analysis 3



exp.	*Project:* Hwy 11: 2 + 1 – SW12	
	Analysis Description: **Model 3B:** Embankment Widening with Rockfill at Station 14+150 (East side), Sub-Excavation of 1 m and Replacement with Compacted Granular B Type II – **Total Settlement**	
	Figure No: G4	*Company: EXP Services Inc.*
	Date: November 7, 2025	*File Name:* Hwy 11: 2+1 – SW12, Settlement Analysis 4

Appendix H –
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 (°)	46.837
Longitude (°)	-79.797

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

$S_a(0.2, X_D)$	$S_a(0.5, X_D)$	$S_a(1.0, X_D)$	$S_a(2.0, X_D)$	$S_a(5.0, X_D)$	$S_a(10.0, X_D)$	$PGA(X_D)$	$PGV(X_D)$
0.42	0.363	0.21	0.0983	0.026	0.00806	0.257	0.241

The log-log interpolated 2%/50 year $S_a(4.0, X_D)$ value is : **0.0359**

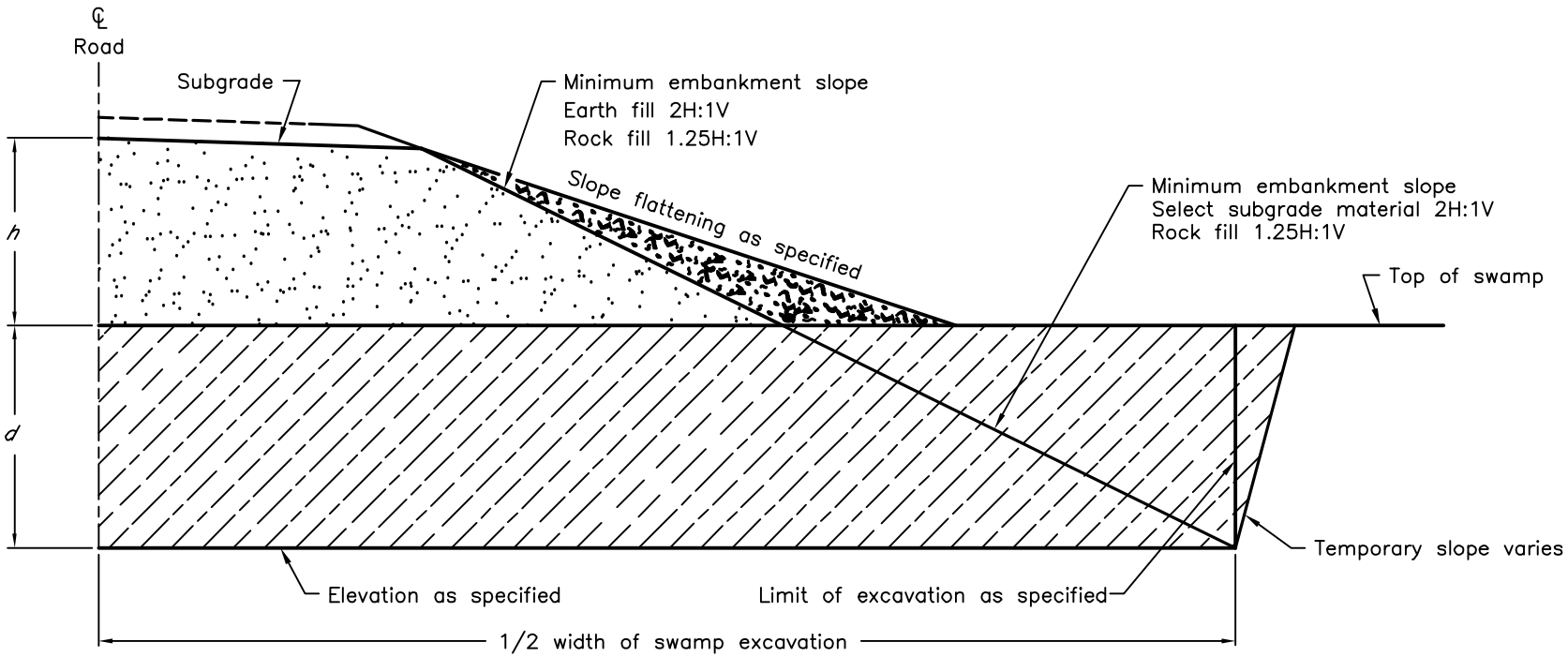
▶ Tables for 5% and 10% in 50 year values

Download CSV

← Go back to the seismic hazard calculator form

Date modified: 2021-04-06

Appendix I – OPSDs



LEGEND:

Embankment materials as specified

Excavated swamp material

Excavate and backfill as specified

h – Height of fill

d – Depth of sub–excavation

NOTE:

A Height of fill is the vertical difference between subgrade and top of swamp measured at new road centreline.

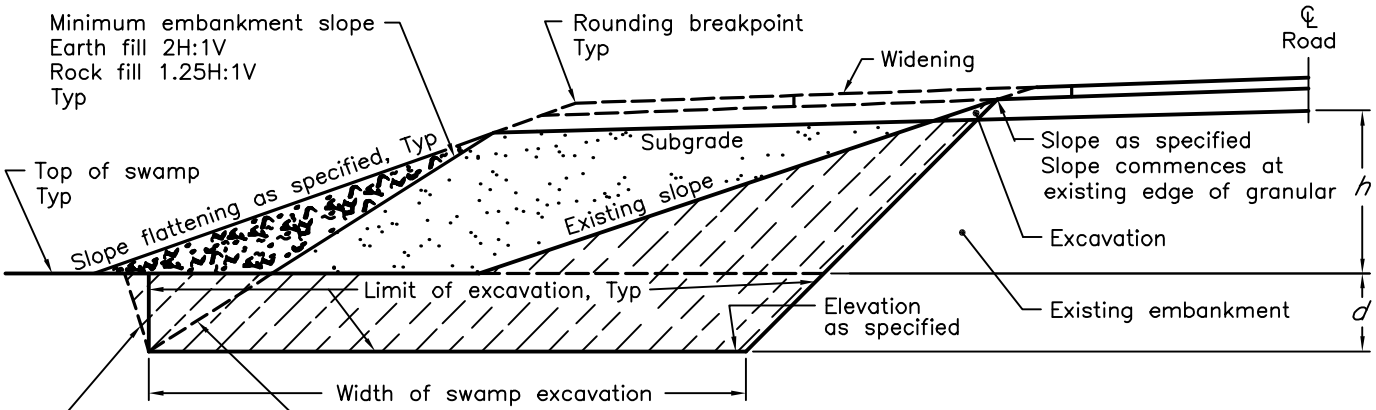
ONTARIO PROVINCIAL STANDARD DRAWING

EMBANKMENTS OVER SWAMP

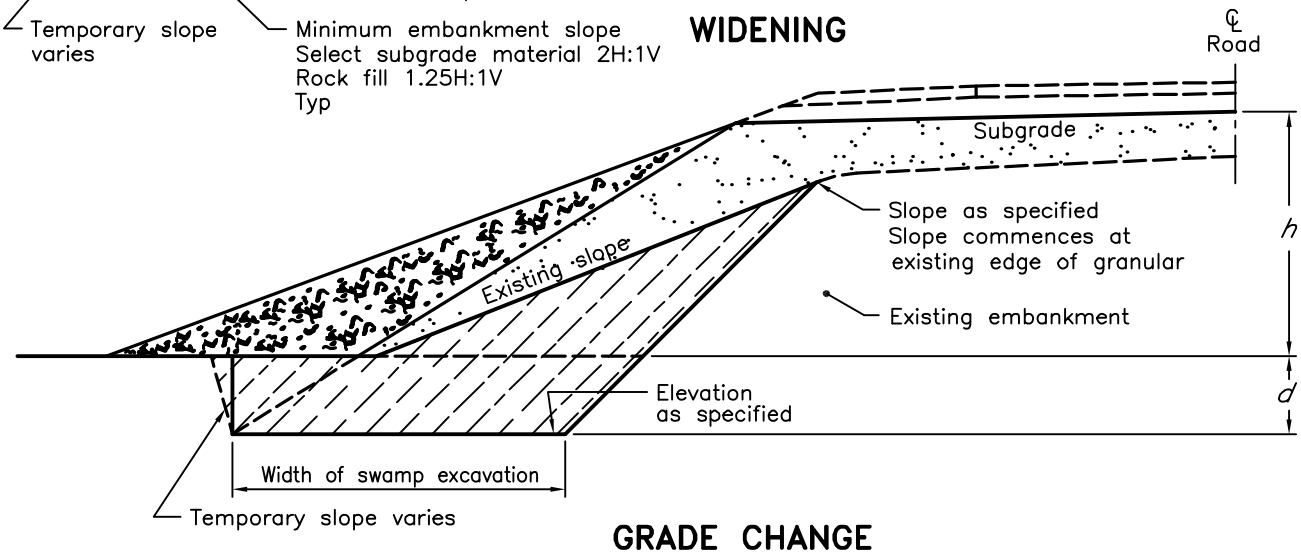
NEW CONSTRUCTION

Nov 2017 | Rev 4

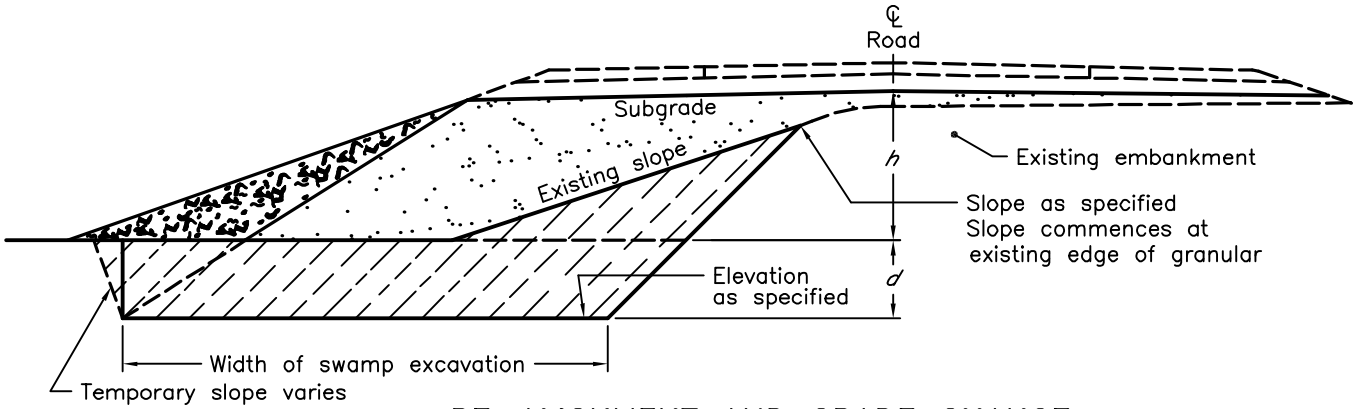
OPSD 203.010



WIDENING



GRADE CHANGE



RE–ALIGNMENT AND GRADE CHANGE

LEGEND:

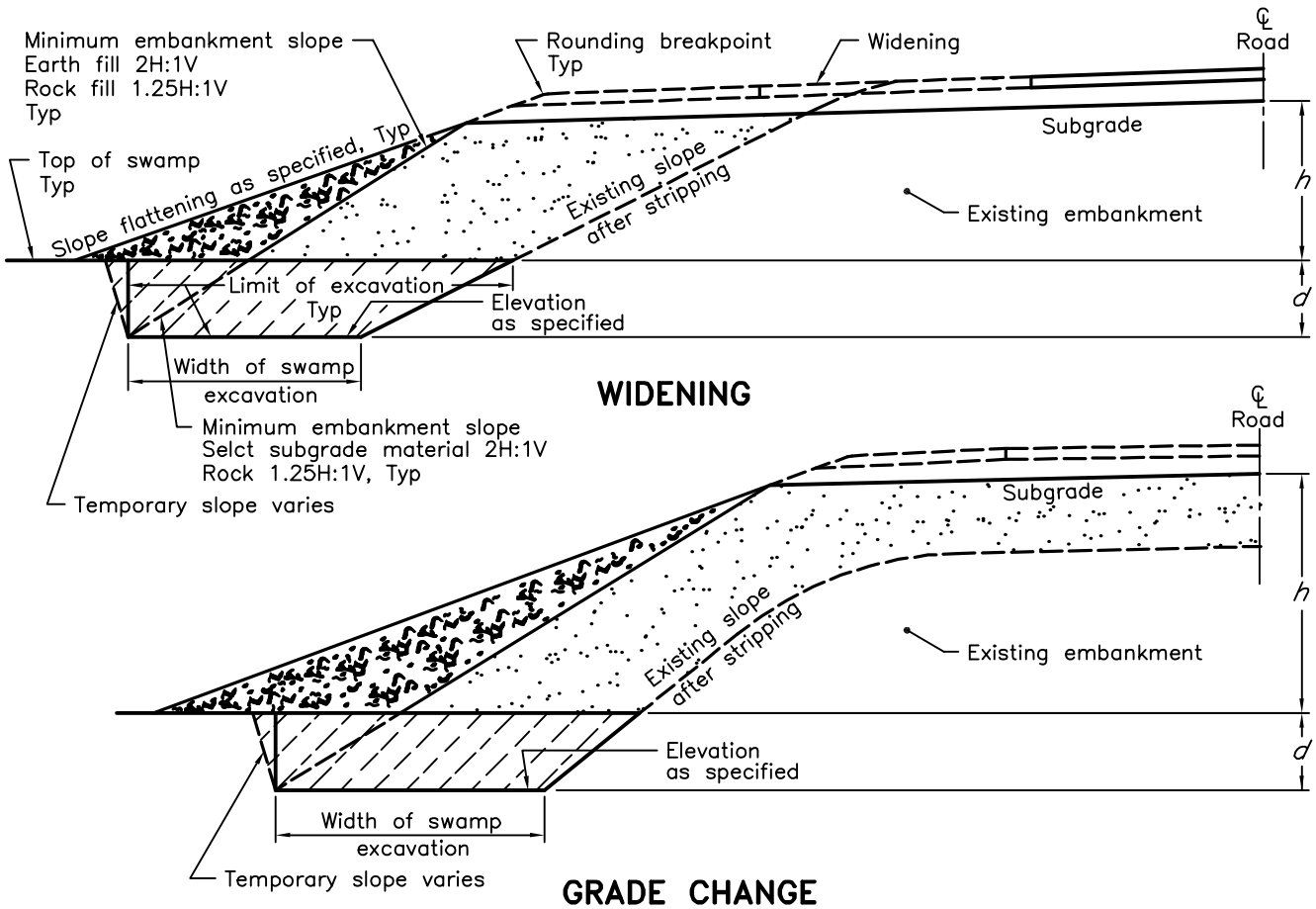
- *h* – Height of fill
- *d* – Depth of sub–excavation
- Embankment materials as specified
- Excavated swamp material
- Excavate and backfill as specified

NOTES:

A Height of fill is the vertical difference between subgrade and top of swamp measured at new road centreline.

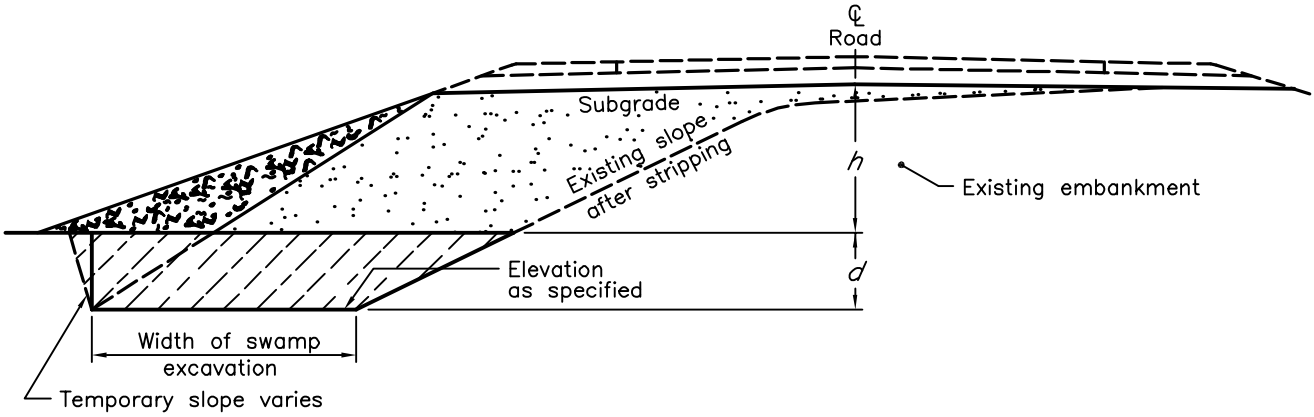
B Widening of existing earth embankments shall be benched according to OPSD 208.010.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2017	Rev	4
EMBANKMENTS OVER SWAMP EXISTING SLOPE EXCAVATED			
			OPSD 203.020



WIDENING

GRADE CHANGE



RE–ALIGNMENT AND GRADE CHANGE

NOTES:

A Topsoil shall be stripped from existing slopes.

B Height of fill is the vertical difference between subgrade and top of swamp measured at new road centreline.

C Widening of existing earth embankments shall be benched according to OPSD 208.010.

LEGEND:

h – Height of fill

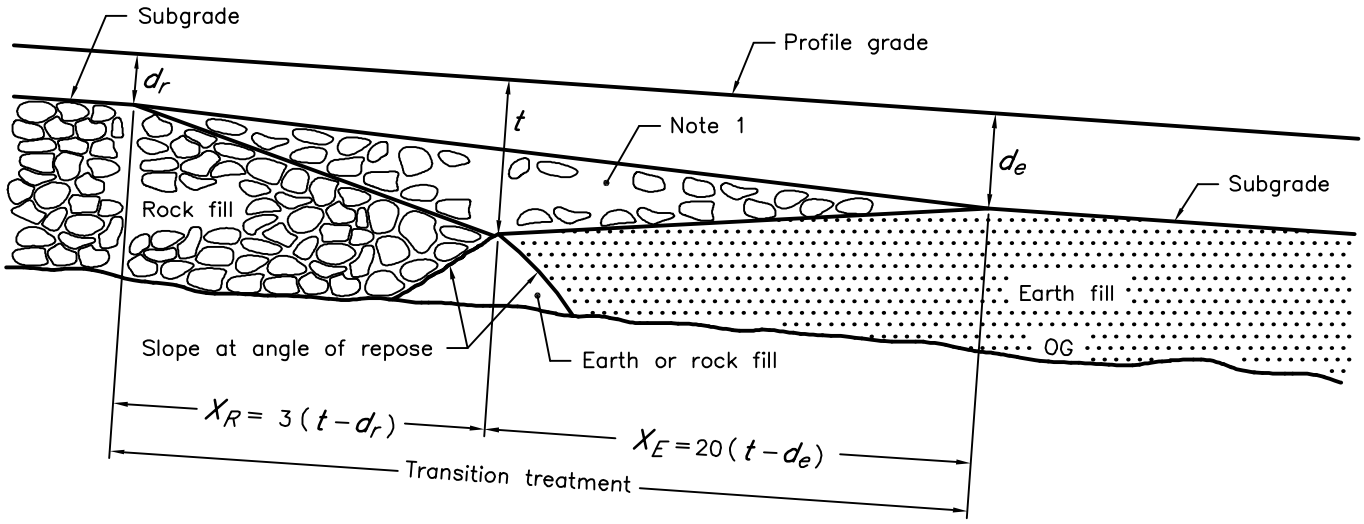
d – Depth of sub–excavation

Embankment materials as specified

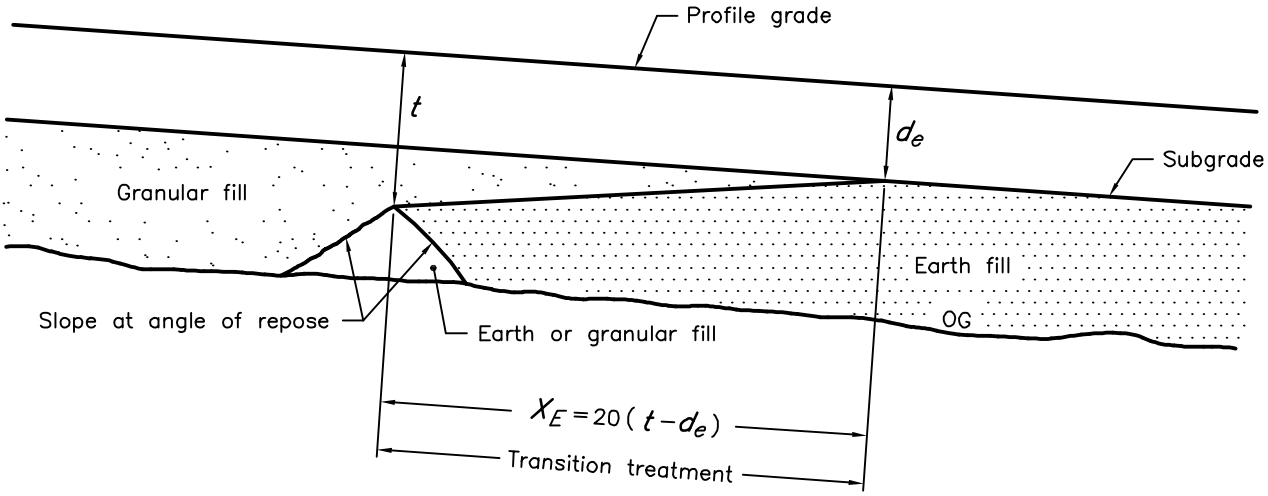
Excavated swamp material

Excavate and backfill as specified

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2017	Rev	4
# EMBANKMENTS OVER SWAMP EXISTING SLOPES MAINTAINED			
			OPSD 203.030



EARTH FILL TO ROCK FILL



EARTH FILL TO GRANULAR FILL

NOTES:

1 Rock or granular fill.

A Embankment slopes to transition uniformly over distance X_R and X_E.

B Profile grade and subgrade lines apply across the transverse section.

LEGEND:

d_e – Depth of granular base and subbase over earth

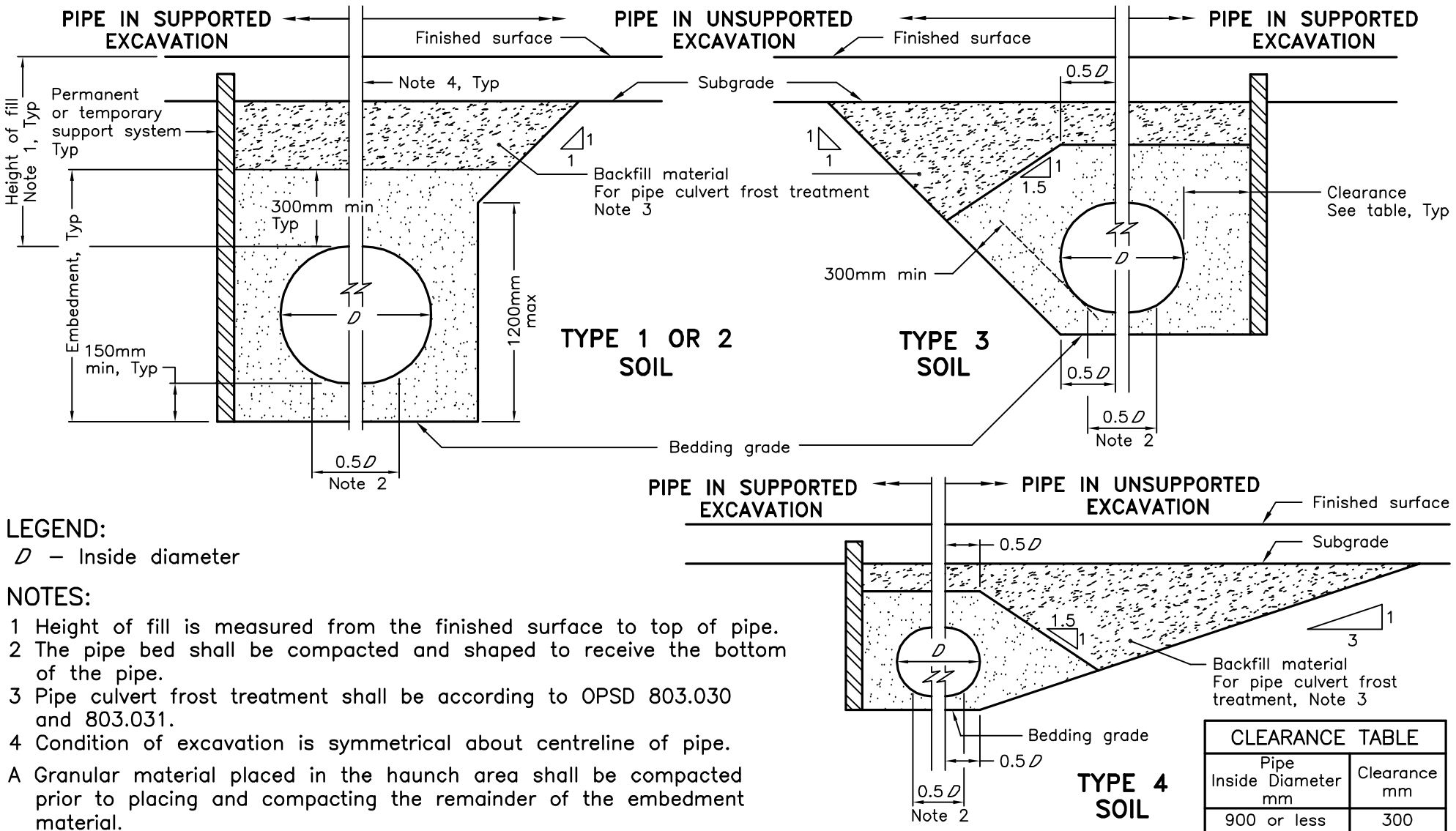
d_r – Depth of granular base and subbase over rock fill

t – Transition treatment depth, as specified

X_E – Length of transition for earth fill, 15m maximum

X_R – Length of transition in rock fill

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2016	Rev 3
TRANSITION TREATMENT EARTH FILL TO ROCK FILL AND EARTH FILL TO GRANULAR FILL		OPSD 205.040



LEGEND:

D – Inside diameter

NOTES:

1 Height of fill is measured from the finished surface to top of pipe.
2 The pipe bed shall be compacted and shaped to receive the bottom of the pipe.
3 Pipe culvert frost treatment shall be according to OPSD 803.030 and 803.031.
4 Condition of excavation is symmetrical about centreline of pipe.

A Granular material placed in the haunch area shall be compacted prior to placing and compacting the remainder of the embedment material.

B Soil types as defined in the Occupational Health and Safety Act and Regulations for Construction Projects.

C All dimensions are in metres unless otherwise shown.

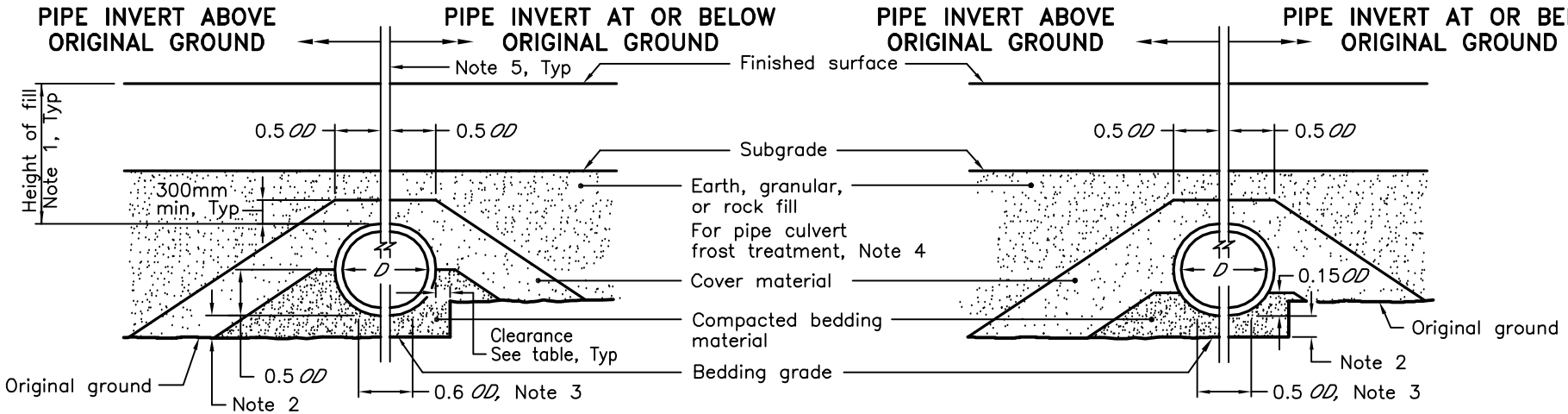
CLEARANCE TABLE	
Pipe Inside Diameter mm	Clearance mm
900 or less	300
Over 900	500

ONTARIO PROVINCIAL STANDARD DRAWING

Nov 2014 | Rev 3

FLEXIBLE PIPE EMBEDMENT AND BACKFILL EARTH EXCAVATION

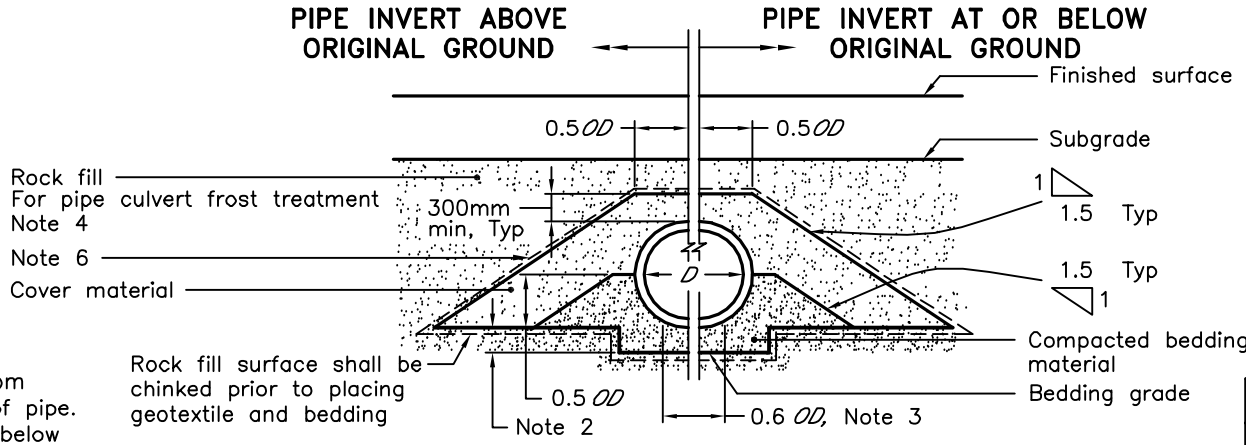
OPSD 802.010



CLASS B BEDDING

EARTH AND ROCK EXCAVATION

CLASS C BEDDING



PIPE BEDDING AND COVER WITH ROCK FILL UNDER AND OVER THE PIPE

NOTES:

1 Height of fill is measured from the finished surface to top of pipe.
2 The minimum bedding depth below the pipe shall be 0.15*D*, except on a rock foundation where the minimum bedding depth shall be 0.25*D*. In no case shall the minimum dimension be less than 150mm or greater than 300mm.
3 The pipe bed shall be compacted and shaped to receive the bottom of the pipe.
4 Pipe culvert frost treatment shall be according to OPSD 803.030 and 803.031.
5 Condition of excavation is symmetrical about centreline of pipe.
6 Bedding and cover material shall be wrapped in non–woven geotextile when specified.

A All dimensions are in metres unless otherwise shown.

LEGEND:

D – Inside diameter
OD – Outside diameter

CLEARANCE TABLE	
Pipe Inside Diameter mm	Clearance mm
900 or less	300
Over 900	500

ONTARIO PROVINCIAL STANDARD DRAWING

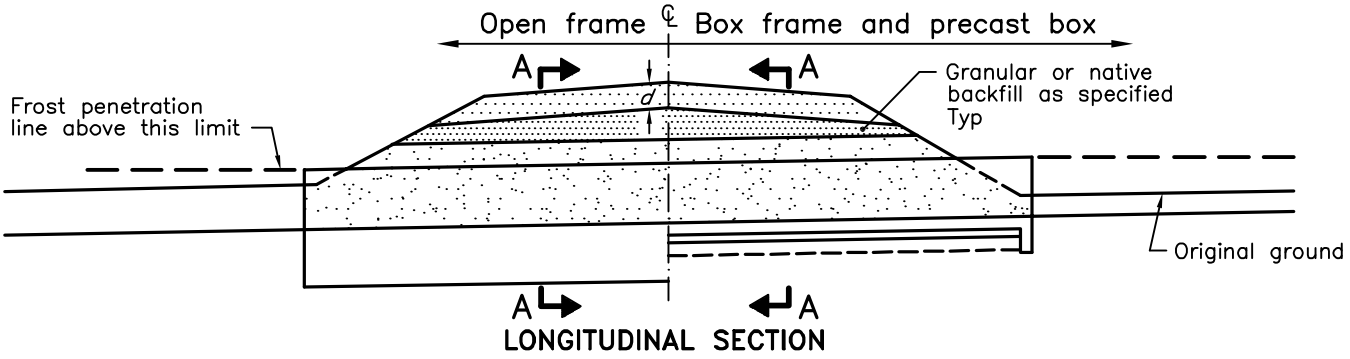
RIGID PIPE BEDDING AND COVER IN EMBANKMENT ORIGINAL GROUND: EARTH OR ROCK

Nov 2015 | Rev 3

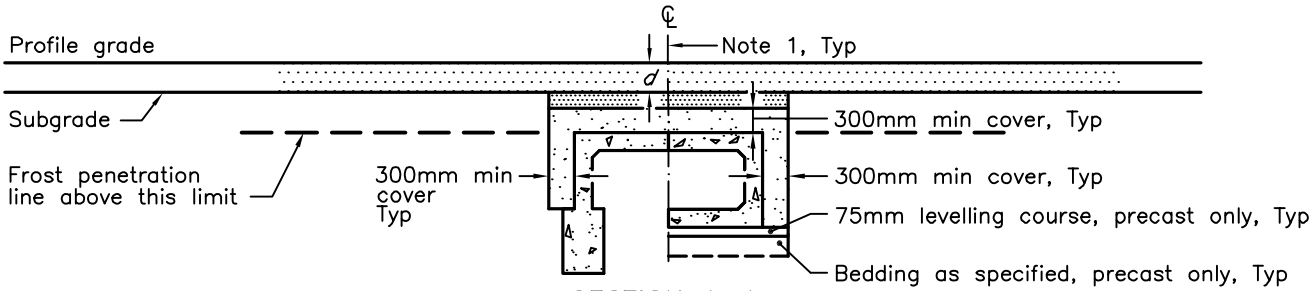
ONTARIO STANDARD MUNICIPAL – PROVINCIAL

OPSD 802.034

FROST PENETRATION LINE AT OR ABOVE TOP OF CULVERT

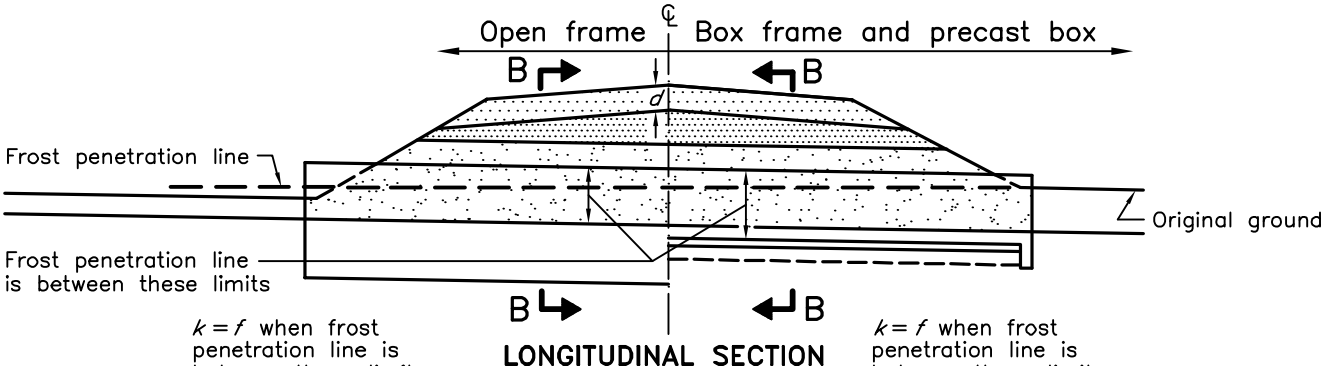


LONGITUDINAL SECTION

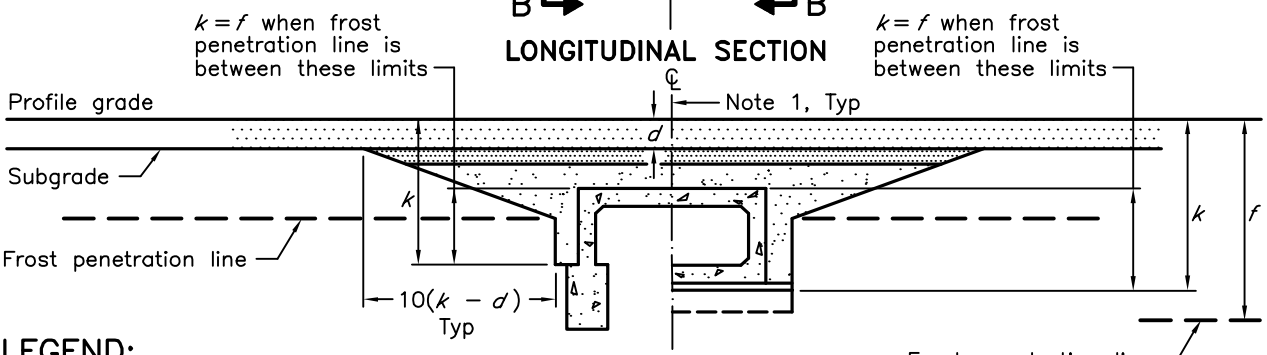


SECTION A–A

FROST PENETRATION LINE BELOW TOP OF CULVERT



LONGITUDINAL SECTION



SECTION B–B

LEGEND:

d = depth of roadbed granular
k = depth of frost treatment below profile grade
f = depth of frost penetration below profile grade

NOTES:

1 Condition of frost treatment symmetrical about centreline of culvert.

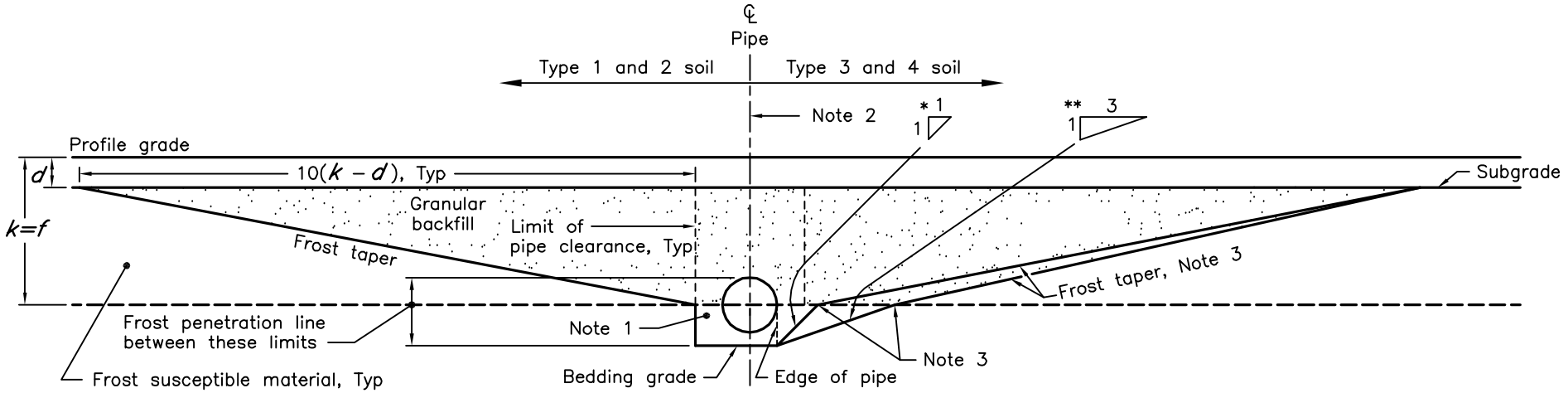
A Bedding, levelling, and cover material shall be granular as specified.

B The depth of roadbed granular shall be 600mm minimum.

C The maximum depth of frost treatment shall be bottom of box frame or top of footing.

D All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2015	Rev	3
BACKFILL AND COVER FOR CONCRETE CULVERTS WITH SPANS LESS THAN OR EQUAL TO 3.0M			
			OPSD 803.010



FROST TREATMENT
RIGID AND FLEXIBLE PIPE

NOTES:

1 Pipe embedment or bedding, cover, and backfill shall be according to:
   a) Flexible OPSD 802.010, 802.013, 802.014, 802.020, 802.023, and 802.024.
   b) Rigid – OPSD 802.030, 802.031, 802.032, 802.033, 802.034, 802.050, 802.051, 802.052, 802.053, and 802.054.

2 Condition of frost treatment symmetrical about centreline of pipe.

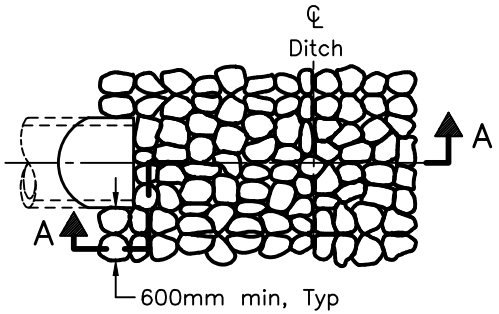
3 Frost tapers shall start at the intersection of the 1H:1V or 3H:1V slope and the frost penetration line.

A Soil types as defined in the Occupational Health and Safety Act and Regulations for Construction Projects.

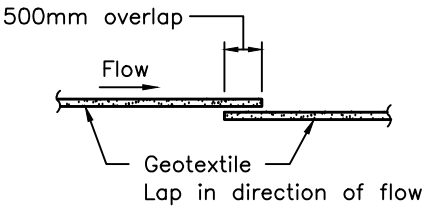
LEGEND:

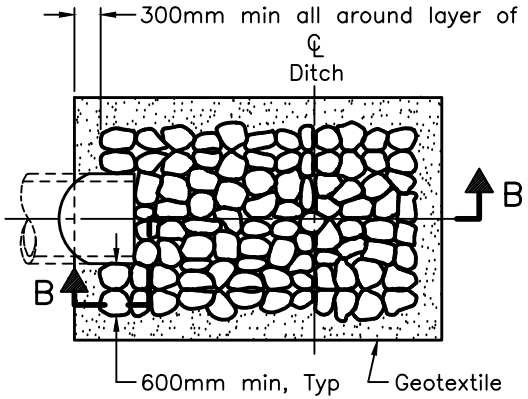
d – depth of roadbed granular
k – depth of frost treatment below profile grade
f – depth of frost penetration below profile grade
* – Type 3 soil
** – Type 4 soil

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2015	Rev	4
FROST TREATMENT – PIPE CULVERTS FROST PENETRATION LINE BETWEEN TOP OF PIPE AND BEDDING GRADE			
	OPSD 803.031		

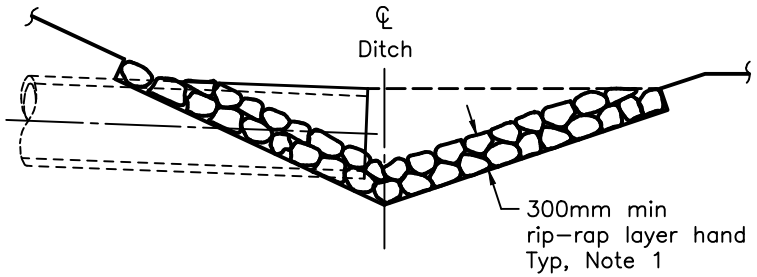


PLAN
CUT OR FILL

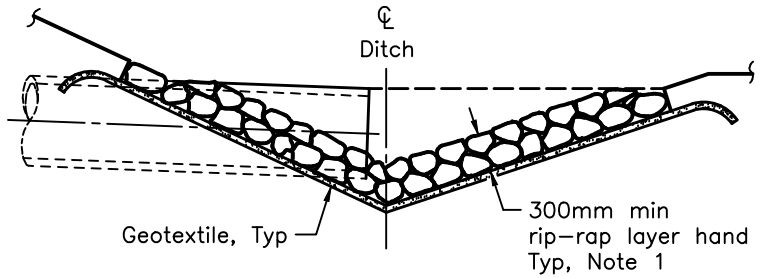




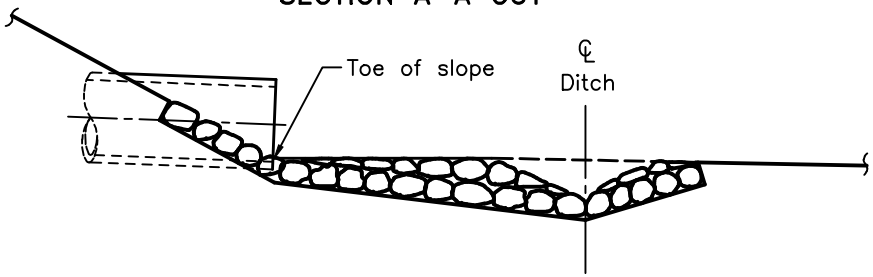
PLAN
CUT OR FILL



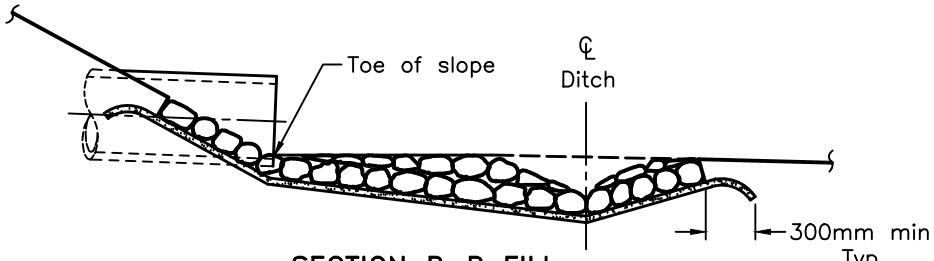
SECTION A–A CUT



SECTION B–B CUT



SECTION A–A FILL



SECTION B–B FILL

TYPE A – WITHOUT GEOTEXTILE

TYPE B – WITH GEOTEXTILE

NOTES:

1 The thickness of the rip–rap layer shall be at least 1.5 times the rip–rap mean diameter.

A All dimensions are in millimetres unless otherwise shown.

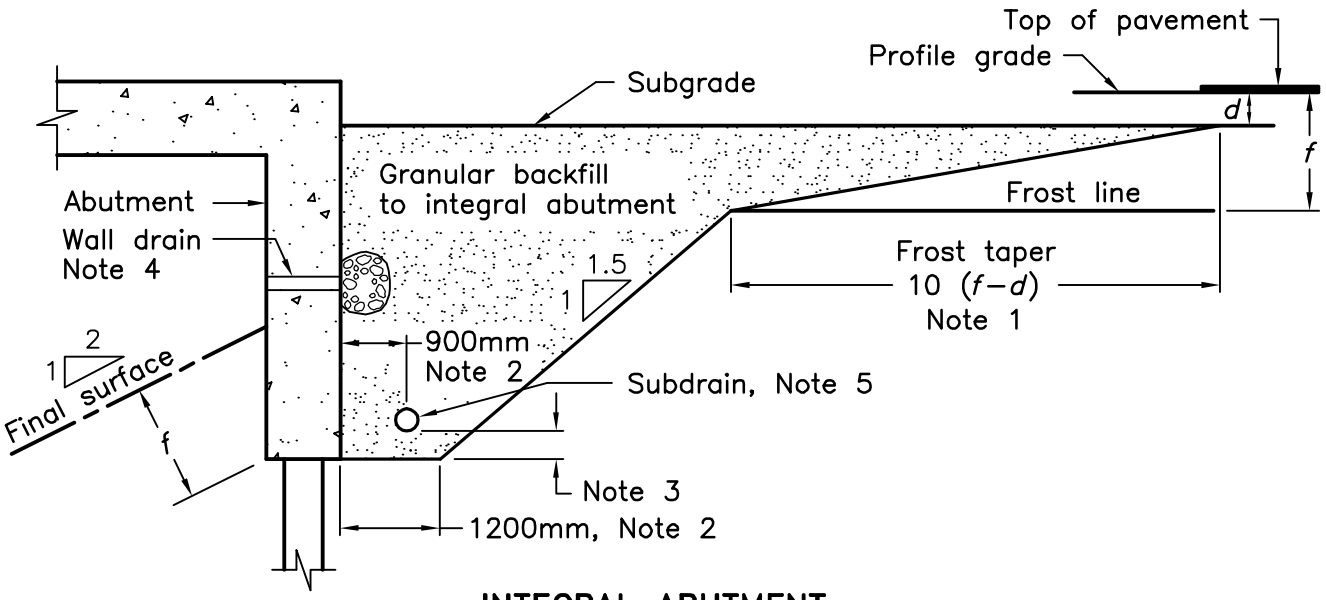
ONTARIO PROVINCIAL STANDARD DRAWING

GENERAL RIP–RAP LAYOUT FOR SEWER AND CULVERT OUTLETS

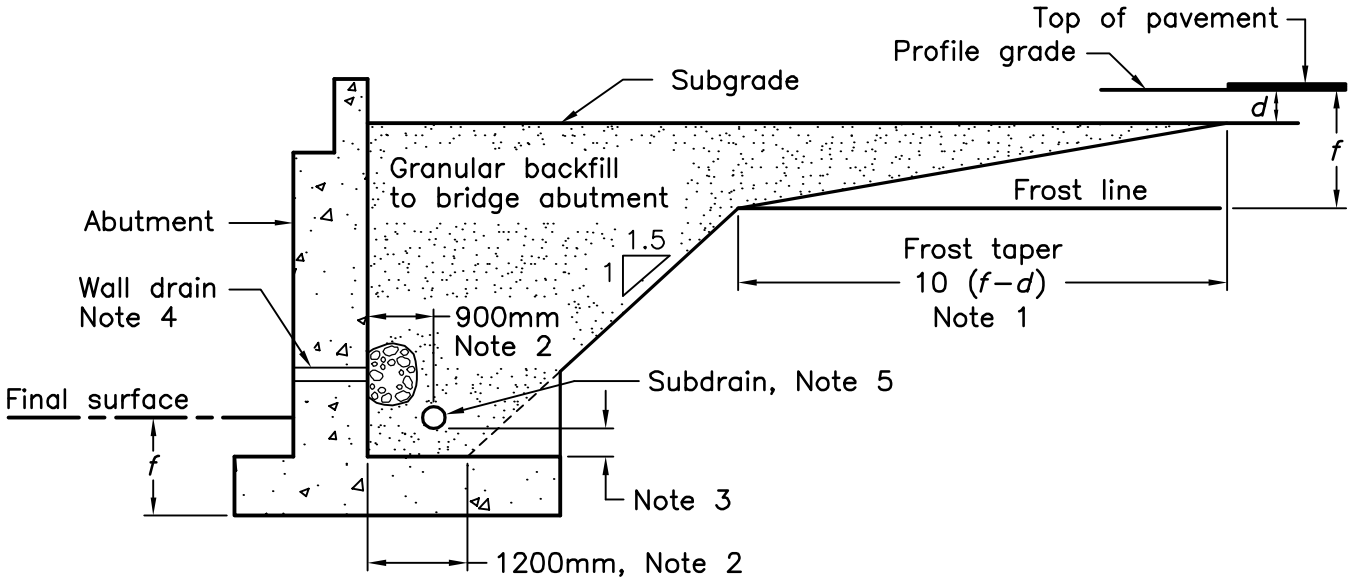
Nov 2018 | Rev 3

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OPSD 810.010



INTEGRAL ABUTMENT



ABUTMENT

NOTES:

1 d = depth of combined base and subbase courses
f = frost penetration depth as specified

2 Dimensions perpendicular to back face of abutment.

3 Height to be consistent with positive drainage of subdrain as specified.

4 Where specified, wall drains shall be installed according to OPSD 3190.100.

5 150mm dia perforated pipe subdrain wrapped with geotextile.

A Lateral limits of granular backfill to bridge abutment to be inside face to inside face of retaining wall or wingwall. Frost taper shall extend the full width of the backfill unless interrupted by the retaining wall or wingwall.

B Sections shown are parallel to centreline of roadway.

C Subdrain shall be installed with a 2% gradient behind wall.

D All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2010	Rev	1
WALLS **ABUTMENT, BACKFILL** **MINIMUM GRANULAR REQUIREMENT**			
	OPSD 3101.150		

Appendix J –
NSSPs

EXCAVATION OF PEAT/ORGANIC DEPOSITS AT THE TOE OF HWY 11 EMBANKMENT AND BACKFILLING WITH ROCK FILL

Non-Standard Special Provision

Scope of Work

Excavation of top layers of peat/organic material within the footprint of new embankment fill for widening of Hwy 11, and backfill of excavation with rock fill.

Construction

The top peat/organic material shall be excavated along the whole footprint of the new embankment fill for widening. The excavation shall be in accordance with OPSD 203.020 and/or OPSD 203.030 following the slope of the existing rock fill embankment, and then, backfilled with rock fill immediately after excavation. Do not keep the excavation opened under any circumstances.

These simultaneous excavation and backfilling operations shall be done from outside to inside in sections parallel to the existing highway as shown below. The sections shall be approximately 3 m to 5 m wide.

