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Submitted: November 28, 2017



Foundation Investigation
Report

Agreement No. 5016-E-0016

GWP 411-00-00

GEOCRES No. 410-34

Embankment Widening

Stn. 19+770 to 10+040

**Highway 129, Birch and Langlois
Townships, District of Sudbury**

Prepared For:

Ministry of Transportation

Northeast Region

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The Ministry of Transportation

Foundation Investigation Report
Assignment No. 5016-E-0016
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Embankment Widening, Stn. 19+770 to 10+040
Highway 129, Birch and Langlois Townships, District of Sudbury

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1 Foundation Investigation Report

1.1 Introduction

This Foundation Investigation Report (FIR) presents the results of a geotechnical investigation completed by **exp** Services Inc. (**exp**) for the widening of an existing embankment on Highway 129 from Stn. 19+770 (Birch Township) to Stn. 10+040 (Langlois Township), District of Sudbury, Ministry of Transportation (MTO) Northeastern Region. This work was undertaken under Agreement No. 5016-E-0016, GWP 411-00-00. The terms of reference (TOR) were presented in the MTO Request for Quotation Document dated August 22, 2016.

The purpose of the investigation is to evaluate the subsurface conditions along the proposed embankment widening in order to provide geotechnical information to facilitate the design and construction of the widening. The site specific geotechnical investigation consisted of borings, soil sampling, borehole logging, and field and laboratory testing.

The proposed widening will be approximately 3 to 5 m in width and will occur on the east side of the embankment in accordance with the Start-Up Meeting minutes for this project dated Nov. 15, 2016.

This FIR 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.

1.1.1 Proposed Culvert Replacement at Station 19+829

A foundation investigation was completed by **exp** for the replacement of an existing 1.2 m diameter corrugated steel pipe (CSP) culvert within the embankment at Stn. 19+829 (Birch Township). The FIR for the culvert replacement has been addressed by **exp** under a separate report. For this investigation, a total of three (3) boreholes were advanced. Two (2) of the boreholes, BH-1 and BH-2, have also been utilized for this embankment widening investigation as they were advanced through the existing embankment and near the toe of the embankment at the culvert outlet on the east side of the embankment.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The foundation investigation was carried out on Highway 129 near the proposed embankment widening from Station 19+770 within Birch Township, to Station 10+040 within Langlois Township. The total length of proposed embankment widening is approximately 250 m. The site is located along Highway 129, approximately 45.0 km south of the South Junction of Highway 101. The location of the embankment and a cross section of the existing alignment are shown on Dwg. No. 1 in Appendix A.

At this site, Highway 129 is an asphalt paved, two lane, north/south roadway having approximately 1.0 m wide granular and partially paved shoulders with cable guide rails on both sides of the roadway. The highway embankment at the investigated location is approximately 2.0 to 9.5 m high on both sides of the roadway, having side slopes of approximately 1.5H:1V from the top to toe of each embankment. Photographs of the site are included in Appendix B.

The general site conditions were assessed on November 16, 2016. The side slopes of the highway embankment are covered with grass and light vegetation, as well as large boulder rip-rap for slope protection. The toe of the embankment is forested with large coniferous and deciduous trees. Guardrails at the top of the embankment and trees near the embankment toe all appeared to generally be standing vertically, suggesting there is not likely any stability issues with the current embankment. A small creek is located near the toe of the embankment around Stn. 19+830, flowing from west to east through an existing 1.2 m diameter corrugated steel pipe (CSP) culvert within the embankment at Stn. 19+829. The highway travels through a large bedrock

cut south of the embankment (south of Stn. 19+725), however, bedrock outcrops were not visible at the embankment widening location. The surface of Highway 129 along the embankment was in fair shape, with moderate wheel track rutting and moderate transverse, longitudinal, and map cracking. A large asphalt patch is present across both lanes from approximately Stn. 19+925 to Stn. 19+955. The observed cracking extends within the patch, suggesting it has been there for some time.

1.2.2 Geological Setting

In accordance with Ontario Geological Survey Northern Ontario Engineering Geology Terrain Study 86, the dominant landform at the site is ground moraine consisting mainly of till. Local relief is generally moderate (15 to 60 m) and the terrain is generally undulating to rolling. Overall drainage is good (dry). Within Birch Township, rock knobs generally occur within the ground moraine.

Ministry of Northern Development and Mines (MNDM) Map 2543, Bedrock Geology of Ontario East-Central Sheet indicates the bedrock at the site consists of tonalite to granodiorite, foliated to gneissic, with minor supracrustal inclusions.

1.3 Investigation Procedures

1.3.1 Site Investigation and Field Testing

The field investigation was performed on January 15 to 31, 2016 and May 3 to 4, 2017. The field program consisted of the advancement of four (4) sampled boreholes (BH-E1 to BH-E4) advanced at accessible location along the existing toe. In addition, two (2) additional boreholes (BH-1 and BH-2) were advanced as part of the culvert replacement at Stn. 19+829. Borehole BH-1 was located within the travelled southbound lane through the embankment and BH-2 was advanced near the embankment toe at the culvert outlet. The borehole locations are shown on Dwg. No. 1 in Appendix A.

Borehole BH-1 was advanced using a truck mounted CME-55 drill rig equipped with hollow stem augers, NW casing, and standard soil sampling equipment. Due to access restrictions, Boreholes BH-2 and BH-E1 to BH-E4 were advanced with portable tripod mounted equipment with a cathead and Hilti D200 drill. The drilling equipment was operated by a specialist drilling contractor, Landcore Drilling. Borehole BH-1 was advanced to 14.3 m depth from the existing top of roadway elevation. Borehole BH-2 was terminated at 6.7 m depth. Boreholes BH-E1 to E-4 were advanced to equipment refusal on suspected boulders at depths ranging from 2.4 to 5.8 m.

The borehole locations (referenced to MTM NAD83 coordinate system, Zone 13) and their ground surface elevations were surveyed by **exp** personnel following drilling using hand-held GPS equipment. The geodetic borehole and water elevations were surveyed using a Temporary Benchmark (TBM) established on the roadway centreline at Stn. 19+825. The TBM was assigned an elevation of 464.7 m based on a survey of the site provided to **exp** by the MTO. The borehole and TBM locations are shown on Dwg. No. 1 in Appendix A.

Soil samples were obtained using a 51 mm outside diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586) at selected intervals as shown on the attached borehole logs in Appendix C. The original field (uncorrected) SPT "N" values were recorded on the borehole logs and used to provide an assessment of the in-situ compactness condition of encountered cohesionless soils.

Upon completion of the boreholes, groundwater measurements were carried out within the boreholes in accordance with MTO guidelines. The measured groundwater levels after completion were recorded on the borehole logs as shown in Appendix C. The boreholes were decommissioned using bentonite in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the Ontario Water Resources Act).



The fieldwork was supervised by members of **exp's** engineering staff who directed the drilling and sampling operations, logged borehole data in accordance with the MTO Soil Classification System, and retrieved soil samples for subsequent laboratory testing and identification.

All of the recovered soil samples were placed in labelled moisture-proof bags and returned to **exp's** Sudbury Laboratory for additional visual, textural, olfactory examination and selective testing.

1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included determination of natural moisture content on all samples and particle size distribution for approximately 25% of the collected soil samples. All of the laboratory tests were carried out in accordance with MTO and/or ASTM Standards as appropriate.

The laboratory test results are summarized on the attached Record of Borehole Sheets in Appendix C. The results of the particle size analyses are presented graphically in Appendix D.

1.4 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the Record of Borehole Sheets in Appendix C. Laboratory test results are provided in Appendix D. The "Explanation of Terms Used in Report" preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

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

In general, the subsurface conditions encountered within the embankment (BH-1) consist of asphalt overlying fill materials, native silt, and till materials. At the toe of the embankment slope (BH-2 and BH-E1 to E4), the subsurface conditions encountered consist of a thin layer of peat or topsoil overlying native silt and sand, silt, and till materials. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

1.4.1 Asphalt

Asphalt was encountered at the surface of Borehole BH-1 and was approximately 50 mm thick. Asphalt thicknesses may further vary beyond the borehole location.

1.4.2 Fill Materials

Fill materials were encountered below the asphalt at Borehole BH-1 and extended to approximately 7.6 m depth. Directly below the asphalt was an approximately 1.0 m thick layer of moist gravel and sand fill with cobbles and trace silt. Below the gravel and sand fill was very dense rock fill, consisting of cobbles and boulders that extended to 6.9 m depth. The cobbles and boulders ranged in diameter from approximately 0.1 to 0.7 m. A wet, sandy gravel seam was encountered within the rock fill at approximately 5.3 m depth. Underlying the rock fill was an approximately 0.7 m thick layer of silty sand fill with some gravel. The silty sand fill was frozen at the time of the investigation. One SPT was performed within the silty sand fill, resulting in an uncorrected "N" value of 102 blows per 300 mm, classifying the silty sand fill as very dense in compactness condition.



Laboratory testing performed on selected samples consisted of three (3) moisture content tests and one (1) grain size analysis. The grain size analysis was performed on the upper gravel and sand fill. The test results are as follows:

Moisture Content:

- 2 to 20 %

Grain Size Distribution:

- 52 % gravel
- 42 % sand
- 6 % fines

The results of the moisture content and grain size distribution tests are provided on the Record of Borehole Sheet for BH-1 in Appendix C. The result of the grain size distribution test is also provided on Figure 1 in Appendix D.

1.4.3 Topsoil and Peat

Topsoil was encountered at the surface of Boreholes BH-E1 to BH-E4 and was approximately 50 to 150 mm thick. Peat was encountered at the surface of Borehole BH-2 and was approximately 200 mm thick.

Topsoil and peat thicknesses may further vary beyond the borehole locations.

Laboratory testing performed on samples of the peat and topsoil consisted of two (2) moisture content tests. The test results are as follows:

Moisture Content:

- 45 to 80%

The results of the moisture content tests are provided on the Record of Borehole Sheets in Appendix C.

1.4.4 Silt

Underlying the fill material at Borehole BH-1 and the topsoil at BH-E4 was an approximately 0.7 m thick layer of native silt. The silt was grey and brown in colour, and contained some sand and trace organics. Uncorrected SPT "N" values within the silt ranged from 7 to 24 blows per 300 mm, classifying the silt as loose to compact in compactness condition.

Laboratory testing performed on samples of the silt consisted of two (2) moisture content tests. The test results are as follows:

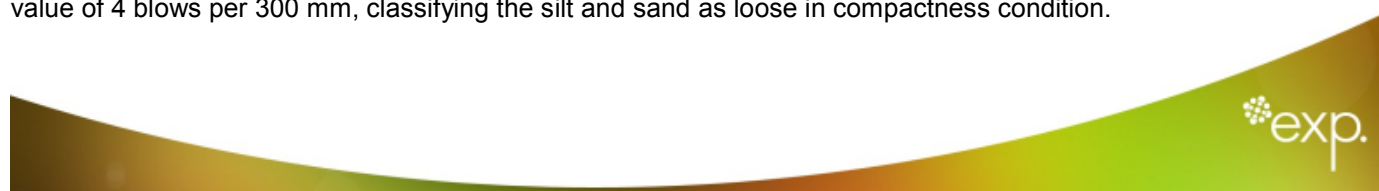
Moisture Content:

- 25 to 36%

The results of the moisture content tests are provided on the Record of Borehole Sheets in Appendix C.

1.4.5 Silt and Sand

Underlying the topsoil at Borehole BH-E2 was an approximately 0.7 m thick layer of native silt and sand. The silt and sand was brown in colour and moist. One SPT performed within the silt and sand resulted in an uncorrected "N" value of 4 blows per 300 mm, classifying the silt and sand as loose in compactness condition.



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

Moisture Content:

- 29%

The result of the moisture content test is provided on the Record of Borehole Sheet for BH-E2 in Appendix C.

1.4.6 Till

Underlying the silt at Boreholes BH-1 and BH-E4, the silt and sand at BH-E2, and the topsoil/peat at BH-2, BH-E1, and BH-E3 was native till that extended to the termination depth/refusal depth of each borehole. The encountered till was highly variable in composition consisting of silty sand, sandy gravel, sand, silt and gravel, gravelly sandy silt, sand and silt/silt and sand, and silty gravel. The till generally contained trace clay and cobbles/boulders throughout and was brown to grey in colour, and moist to wet. Generally, uncorrected SPT "N" values within the till ranged from 13 to 110 blows per 300 mm, classifying the till as compact to very dense in compactness condition. The upper 0.3 m of the till at Boreholes BH-2 and BH-E3 was generally loose in compactness condition.

Laboratory testing performed on selected samples consisted of thirty (30) moisture content tests and eight (8) grain size analyses. The test results are as follows:

Moisture Content:

- 6 to 40 %

Grain Size Distribution:

- 9 to 66 % gravel
- 8 to 78 % sand
- 9 to 54 % silt
- 0 to 2 % clay

The results of the moisture content and grain size distribution tests are provided on the Record of Borehole Sheets in Appendix C. The results of the grain size distribution tests are also provided on Figures 2 and 3 in Appendix D.

1.5 Groundwater and Surface Water Conditions

Groundwater was observed in Borehole BH-1 at approximately 7.3 m depth, Elev. 457.3 m. Note, however, that this water elevation is not likely accurate as water was pumped into the borehole for the washboring techniques utilized. Washboring techniques were also used at BH-2 and BH-E1 to BH-E4 with the portable equipment utilized, and as such, no groundwater measurements were made in these boreholes. Therefore, accurate groundwater measurements could not be obtained in the boreholes upon completion.

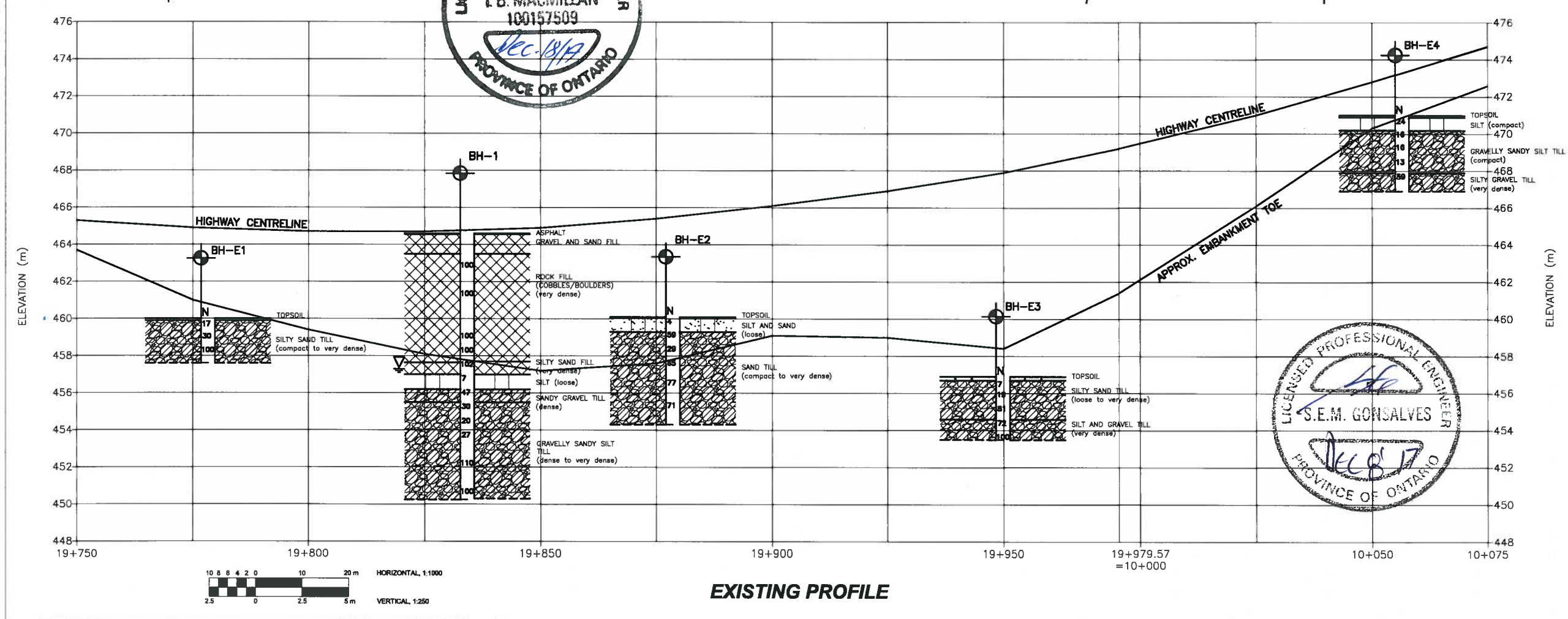
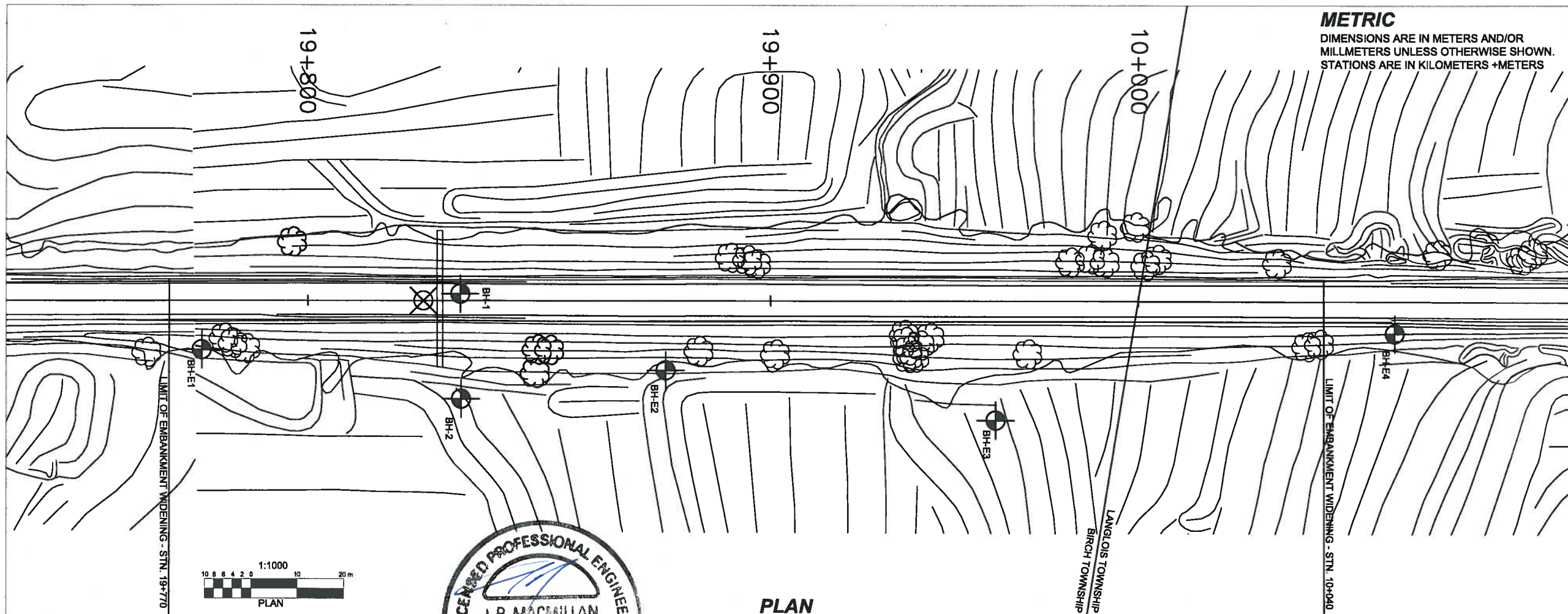
Samples within Borehole BH-1 were generally frozen to wet below 6.9 m depth, Elev. 457.7 m. In addition, samples at BH-2 were generally wet from surface, Elev. 457.1. These boreholes were advanced near an existing creek and culvert. The water level in the creek was measured on June 26, 2017 and it was at approximately Elev. 456.6 m at the culvert outlet. This is generally at a similar level as the wet samples encountered within the boreholes, which suggests the groundwater level is around Elev. 457.0 near these boreholes. Observations in the remaining boreholes do not provide indication of the groundwater levels as samples were generally moist.

Groundwater would be expected to reflect levels in the creek and to fluctuate seasonally. 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.



Appendix A – Drawings





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

Agreement No. 5016-E-0016
GWP 411-00-00
GEOCRE No. 410-34

EMBANKMENT WIDENING, STN. 19+770 to 10+040
HIGHWAY 129, BIRCH AND LANGLOIS TOWNSHIPS
DISTRICT OF SUDBURY

BOREHOLE LOCATION PLAN AND SOIL STRATA

exp Services Inc.



- LEGEND**
- BOREHOLE LOCATION
 - STANDARD PENETRATION TEST (BLOWS/300mm)
 - TEMPORARY BENCHMARK (EL. 464.7 m)
 - ESTIMATED WATER LEVEL IN BOREHOLE

BOREHOLE NO.	APPROX. ELEV. (m)	MTM COORDINATES	
		NORTHING	EASTING
BH-E1	460.0	5255201.9	364885.8
BH-E2	460.1	5252601.4	364852.9
BH-E3	456.9	5252673.5	364851.2
BH-E4	471.0	5252558.9	364866.6
BH-1	464.6	5252554.9	364844.3
BH-2	457.1	5252558.9	364866.6

NOTES

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

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

SOIL STRATA SYMBOLS	
ASPHALT	SILT
FILL	SILT AND SAND
TOPSOIL/PEAT	TILL

REVISIONS		
DATE	BY	DESCRIPTION
2017.10.25	IM	SUBMISSION FOR MTO REVIEW
2017.11.28	IM	FINAL REPORT SUBMISSION
SCALE: AS NOTED		PROJECT NO.: SUD-00014543-AG
SUBMD: IM	CHECKED: AS	DATE: 2017.10.25
DRAWN: IM	CHECKED: SG	APPROVED: SG DWG. 1

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

Agreement No. 5016-E-0016
GWP 411-00-00
GEOCRES No. 410-34

EMBANKMENT WIDENING, STN. 19+770 to 10+040
HIGHWAY 129, BIRCH AND LANGLOIS TOWNSHIPS
DISTRICT OF SUDBURY

BOREHOLE LOCATION PLAN AND SOIL
STRATA



exp Services Inc.

KEY PLAN - NTS



LEGEND

- BOREHOLE LOCATION
- STANDARD PENETRATION TEST (BLOWS/300mm)
- TEMPORARY BENCHMARK (EL. 484.7 m)
- ESTIMATED WATER LEVEL IN BOREHOLE

BOREHOLE COORDINATES

BOREHOLE NO.	APPROX. ELEV. (m)	MTM COORDINATES	
		NORTHING	EASTING
BH-E1	480.0	5255201.9	364865.8
BH-E2	480.1	5252801.4	364852.9
BH-E3	456.9	5252873.5	364851.2
BH-E4	471.0	5252558.9	364866.6
BH-1	464.6	5252554.9	364844.3
BH-2	457.1	5252558.9	364866.6

NOTES

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SOIL STRATA SYMBOLS

- ASPHALT
- FILL
- TOPSOIL/PEAT
- SILT
- SILT AND SAND
- TILL

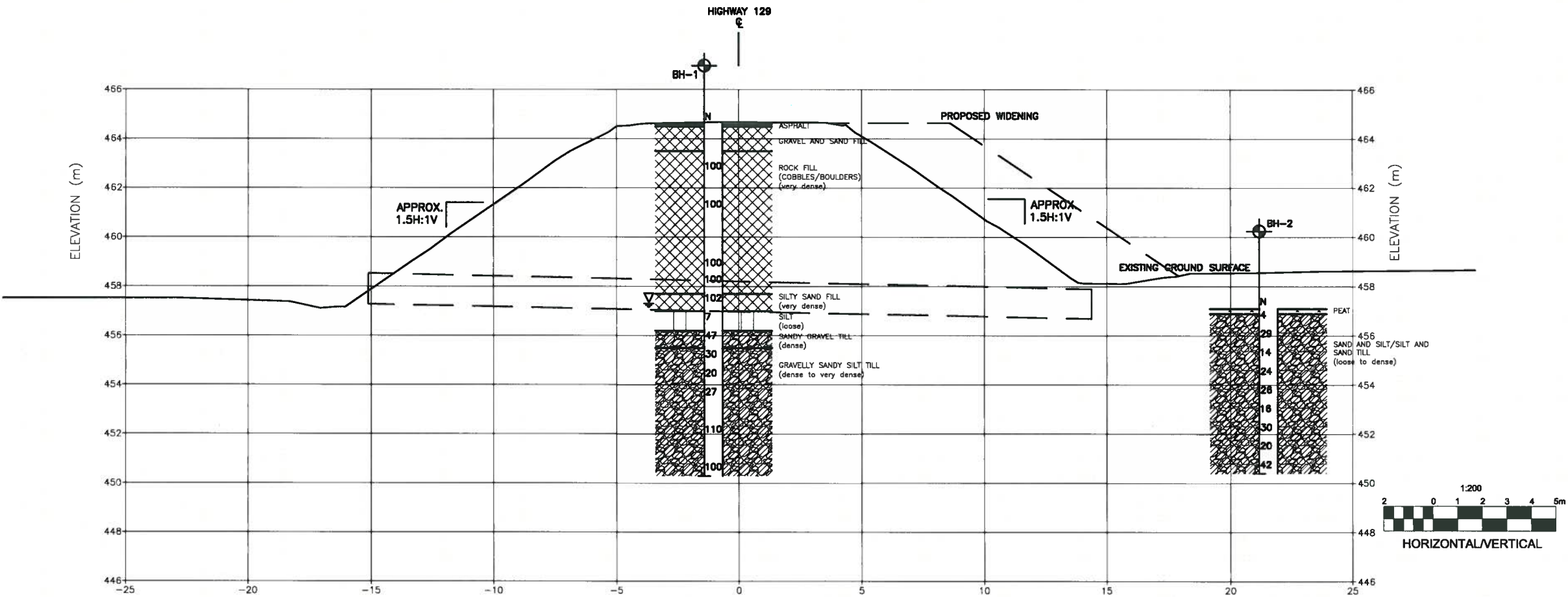
REVISIONS

DATE	BY	DESCRIPTION
2017.10.25	IM	SUBMISSION FOR MTO REVIEW
2017.11.28	IM	FINAL REPORT SUBMISSION

SCALE: AS NOTED PROJECT NO.: SUD-00014543-AG

SUBM'D: IM CHECKED: AS DATE: 2017.10.25

DRAWN: IM CHECKED: SG APPROVED: SG DWG. 2



CROSS SECTION AT STN. 19+825



Appendix B – Photographs



Photograph No. 1 – Highway 129 at Proposed Embankment Widening (Facing Up Chainage)



Photograph No. 2 – Highway 129 at Start of Embankment Widening, Stn. 19+770 (Facing Up Chainage)



Photograph No. 3 – East Embankment from Start of Widening, Stn. 19+770 (Facing Up Chainage)



Photograph No. 4 – West Embankment from Start of Widening, Stn. 19+770 (Facing Up Chainage)



Photograph No. 5 – East Embankment from approximately Stn. 19+830 (Facing Up Chainage)



Photograph No. 6 – East Embankment from approximately Stn. 19+900 (Facing Up Chainage)



Photograph No. 7 – East Embankment from approximately Stn. 19+925 (Facing Up Chainage)



Photograph No. 8 – East Embankment from approximately Stn. 19+950 (Facing Up Chainage)



Photograph No. 9 – East Embankment from approximately Stn. 10+000 (Facing Up Chainage)



Photograph No. 10 – East Embankment at End of Embankment Widening, Stn. 10+040 (Facing Up Chainage)



Photograph No. 11 – Existing Creek at Culvert 19+829 Outlet (Facing East)



Photograph No. 12 – Existing Creek at Culvert 19+829 Outlet (Facing East)

Appendix C – Borehole Logs



Explanation of Terms Used on Borehole Records

SOIL DESCRIPTION

Terminology describing common soil genesis:

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

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

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

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

Terminology describing soil structure:

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

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

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

Fissured: material breaks along plane of fracture.

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

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

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

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

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

Homogeneous: same color and appearance throughout.

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

Uniformly Graded: predominantly on grain size.

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

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

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

Table a: Percent or Proportion of Soil, Pp

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

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

Table b: Apparent Density of Cohesionless Soil

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

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

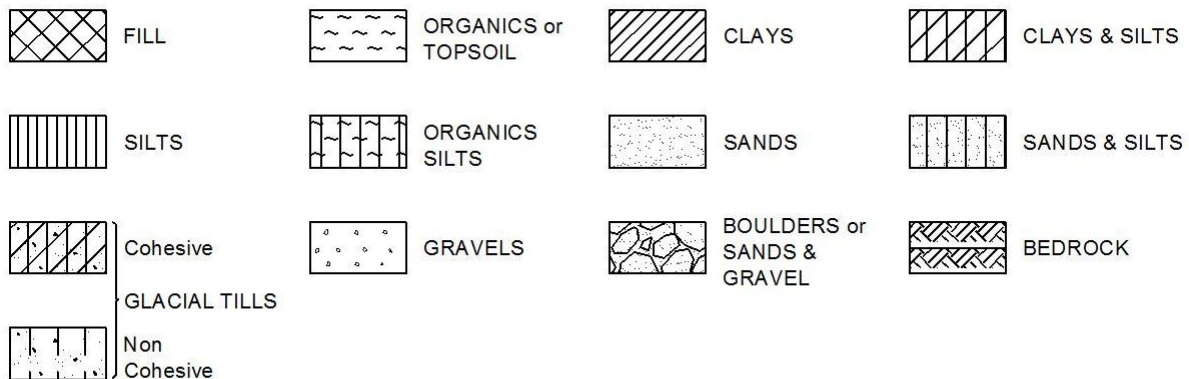
Table c: Consistency of Cohesive Soil

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

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

STRATA PLOT

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



WATER LEVEL MEASUREMENT



Open Borehole or Test Pit



Monitoring Well, Piezometer or Standpipe

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL


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

RECORD OF BOREHOLE No BH-E1

1 OF 1

METRIC

W.P. 411-00-00,5016-E-0016 LOCATION Stn. 19+777, MTM-13, 5252501.85N, 364865.79E, Embankment Widening ORIGINATED BY ST
DIST Sudbury HWY 129 BOREHOLE TYPE Portable Tripod With Cathead and Hilti D200 Drill COMPILED BY IM
DATUM Geodetic DATE 2017.01.26 - 2017.01.26 LATITUDE 47.409022 LONGITUDE -83.204067 CHECKED BY IM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
460.0	Ground Surface																
458.0	TOPSOIL (~ 76 mm thick) TILL , silty sand, some to and gravel, trace clay, brown, moist, compact.		1	SS	17											11 58 29 2	
			2	SS	30		459										
	very dense below ~ 1.5 m depth. with cobbles/boulders below ~ 1.8 m depth. Cored using NW casing. Casing seized at ~ 2.4 m depth.		3	SS	100		458										
457.6																	
2.4	END OF BOREHOLE Borehole terminated at ~ 2.4 m depth due to refusal on suspected boulders. NOTES: 1. This drawing to be read with the subject report and project numbers as presented above. 2. Multiple attempts made to advance borehole beyond refusal depth. 3. Borehole dry upon completion.																

RECORD OF BOREHOLE No BH-E2

1 OF 1

METRIC

W.P. 411-00-00,5016-E-0016 LOCATION Stn. 19+877, MTM-13, 5252601.44N, 364852.92E, Embankment Widening ORIGINATED BY ST
 DIST Sudbury HWY 129 BOREHOLE TYPE Portable Tripod With Cathead and Hilti D200 Drill COMPILED BY IM
 DATUM Geodetic DATE 2017.01.27 - 2017.01.27 LATITUDE 47.409919 LONGITUDE -83.204224 CHECKED BY IM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE								
								● QUICK TRIAXIAL × LAB VANE								
460.1	Ground Surface						20	40	60	80	100					
460.0	TOPSOIL (~ 50 mm thick)		1	SS	4											
459.3	SILT AND SAND , brown, moist, loose.															
0.8	TILL , sand, some silt, trace to some gravel, trace clay, brown, moist, very dense to compact.		2	SS	59											
			3	SS	29											
			4	SS	65											
			5	SS	77											
	with cobbles/boulders below ~ 3.1 m depth. Cored using NW casing. Casing seized at ~ 5.8 m depth.															
454.3	END OF BOREHOLE Borehole terminated at ~ 5.8 m depth due to refusal on suspected boulders.															
5.8	NOTES: 1. This drawing to be read with the subject report and project numbers as presented above. 2. Multiple attempts made to advance borehole beyond refusal depth. 3. Borehole dry upon completion.															

ONTARIO MTO SUD-00014543-AG - HWY. 129 - EMBANKMENT WIDENING.GPJ ONTARIO MTO.GDT 11/13/17

RECORD OF BOREHOLE No BH-E3

1 OF 1

METRIC

W.P. 411-00-00,5016-E-0016 LOCATION Stn. 19+949, MTM-13, 5252673.47N, 364851.20E, Embankment Widening ORIGINATED BY ST
DIST Sudbury HWY 129 BOREHOLE TYPE Portable Tripod With Cathead and Hilti D200 Drill COMPILED BY IM
DATUM Geodetic DATE 2017.01.30 - 2017.01.30 LATITUDE 47.410567 LONGITUDE -83.204237 CHECKED BY IM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE									
456.9	Ground Surface																	
456.8	TOPSOIL (~ 150 mm thick)																	
0.2	TILL , silty sand, some gravel, brown, wet, loose to very dense.		1	SS	7													
			2	SS	19													
			3	SS	81													
454.6																		
2.3	TILL , silt and gravel, trace sand, brown, wet, very dense.		4	SS	72										40 8 52 0			
			5	SS	100													
453.6	with cobbles/boulders below ~ 3.2 m depth. Cored using NW casing. Casing seized at ~ 3.4 m depth.																	
3.4	END OF BOREHOLE Borehole terminated at ~ 3.4 m depth due to refusal on suspected boulders. NOTES: 1. This drawing to be read with the subject report and project numbers as presented above. 2. Multiple attempts made to advance borehole beyond refusal depth. 3. Groundwater was not measured within borehole as water was pumped into hole due to washboring/coring techniques utilized.																	

RECORD OF BOREHOLE No BH-E4

1 OF 1

METRIC

W.P. 411-00-00,5016-E-0016 LOCATION Stn. 10+055, MTM-13, 5252755.18N, 364817.99E, Embankment Widening ORIGINATED BY ST
DIST Sudbury HWY 129 BOREHOLE TYPE Portable Tripod With Cathead and Hilti D200 Drill COMPILED BY IM
DATUM Geodetic DATE 2017.01.31 - 2017.01.31 LATITUDE 47.411305 LONGITUDE -83.204666 CHECKED BY IM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE														
471.0	Ground Surface							20	40	60	80	100										
470.9	TOPSOIL (~ 76 mm thick) SILT , some sand, brown, moist, compact.		1	SS	24																	
470.2	TILL , gravelly sandy silt, brown, moist, compact.		2	SS	16		470										24 23 54 0					
0.8	some roots below ~ 1.5 depth.		3	SS	16		469															
			4	SS	13		468															
467.9	TILL , silty gravel, trace sand, brown, moist, very dense.		5	SS	59		467															
3.1	with cobbles/boulders ~ 3.8 m depth. Cored using NW casing. Casing seized at ~ 4.1 m depth.																					
466.9	END OF BOREHOLE Borehole terminated at ~ 4.1 m depth due to refusal on suspected boulders.																					
4.1	NOTES: 1. This drawing to be read with the subject report and project numbers as presented above. 2. Multiple attempts made to advance borehole beyond refusal depth. 3. Groundwater was not measured within borehole as water was pumped into hole due to washboring/coring techniques utilized.																					

RECORD OF BOREHOLE No BH-1

1 OF 1

METRIC

W.P. 411-00-00,5016-E-0016 LOCATION Stn. 19+833, MTM-13, 5252554.88N, 364844.34E, Non-Structural Culvert at Stn. 19+829 ORIGINATED BY ST
DIST Sudbury HWY 129 BOREHOLE TYPE Continuous Flight HSA and Washboring with NW Casing COMPILED BY IM
DATUM Geodetic DATE 2017.05.03 - 2017.05.04 LATITUDE 47.409501 LONGITUDE -83.204344 CHECKED BY IM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE								
						● QUICK TRIAXIAL	×	LAB VANE										
464.6	Pavement Surface							20	40	60	80	100				GR SA SI CL		
464.6	ASPHALT (~ 50 mm thick)		1	AS			464									52 42 (6)		
463.6	FILL, gravel and sand, trace silt, with cobbles, brown, moist.																	
463.6	ROCK FILL (COBBLES/BOULDERS), coring procedures utilized to penetrate cobbles/boulders. Cobbles/boulders range in size from 0.1 to 0.7 m diameter.		2	SS	100		463											
							462											
			3	SS	100		461											
							460											
	sandy gravel seam, some silt, brown at ~ 5.3 m depth.		4	SS	100		459											
			5	SS	100		458											
457.8	FILL, silty sand, some gravel, brown, frozen, very dense.		6	SS	102		457											
457.0	SILT, some sand, trace organics, grey, wet, loose.		7	SS	7		456											
456.2	TILL, sandy gravel, trace silt, brown, wet, dense.		8	SS	47		455									66 26 (9)		
455.5	TILL, gravelly, sandy silt, grey, wet, dense.		9	SS	30		454											
	compact below ~ 9.9 m depth.		10	SS	20		453									33 33 34 0		
			11	SS	27		452											
	very dense below ~ 12.2 m depth.		12	SS	110		451											
			13	SS	100													
450.3	END OF BOREHOLE Borehole terminated at ~ 14.3 m depth.																	
14.3	NOTES: 1. This drawing to be read with the subject report and project numbers as presented above. 2. Groundwater condition noted may not be accurate as water was pumped into hole due to washboring techniques utilized.																	

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

ONTARIO MTO SUD-00014543-AG - HWY. 129 - CL CULVERT 19+829.GPJ ONTARIO MTO.GDT 11/17/17

RECORD OF BOREHOLE No BH-2

1 OF 1

METRIC

W.P. 411-00-00,5016-E-0016 LOCATION Stn. 19+838, MTM-13, 5252558.89N, 364866.56E, Non-Structural Culvert at Stn. 19+829 ORIGINATED BY ST
DIST Sudbury HWY 129 BOREHOLE TYPE Portable Tripod With Cathead and Hilti D200 Drill COMPILED BY IM
DATUM Geodetic DATE 2017.01.15 - 2017.01.15 LATITUDE 47.409535 LONGITUDE -83.204049 CHECKED BY IM

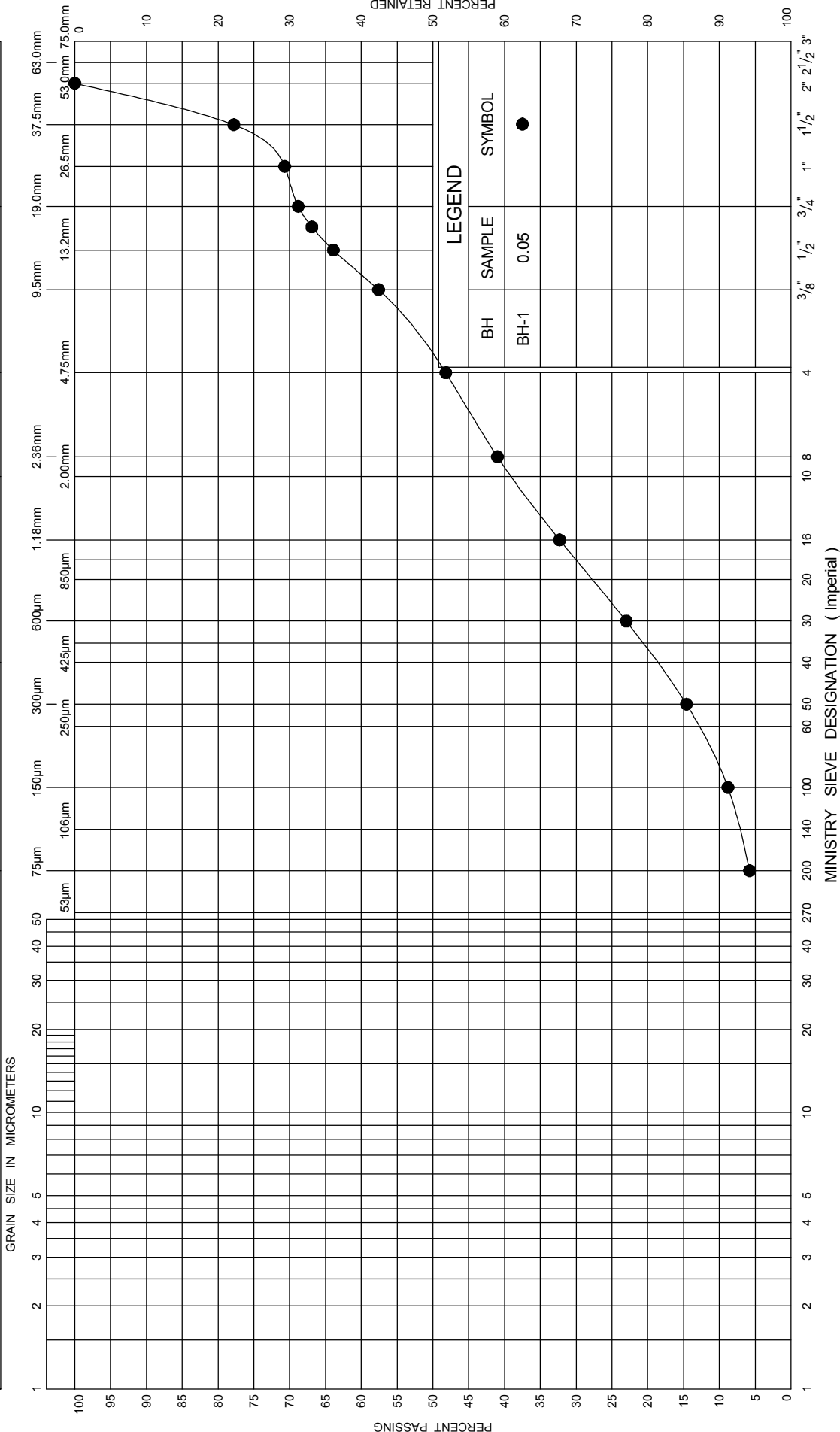
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× LAB VANE		
457.1	Ground Surface						20	40	60	80	100	20	40	60				
457.0	PEAT, black, wet.		1	SS	4													
0.2	TILL, sand and silt to silt and sand, brown, wet, loose.																	
	some gravel, trace clay, compact to dense below ~ 0.8 m depth.		2	SS	29													
	brown to grey below ~ 1.5 m depth.		3	SS	14											15 47 37 2		
			4	SS	24													
	grey below ~ 3.1 m depth.		5	SS	26													
			6	SS	16											12 37 51 1		
			7	SS	30													
			8	SS	20													
			9	SS	42													
450.4	END OF BOREHOLE Borehole terminated at ~ 6.7 m depth.																	
6.7	NOTES: 1. This drawing to be read with the subject report and project numbers as presented above. 2. Groundwater level not measured within borehole as water was pumped into hole due to washboring technique utilized.																	

Appendix D – Laboratory Test Results

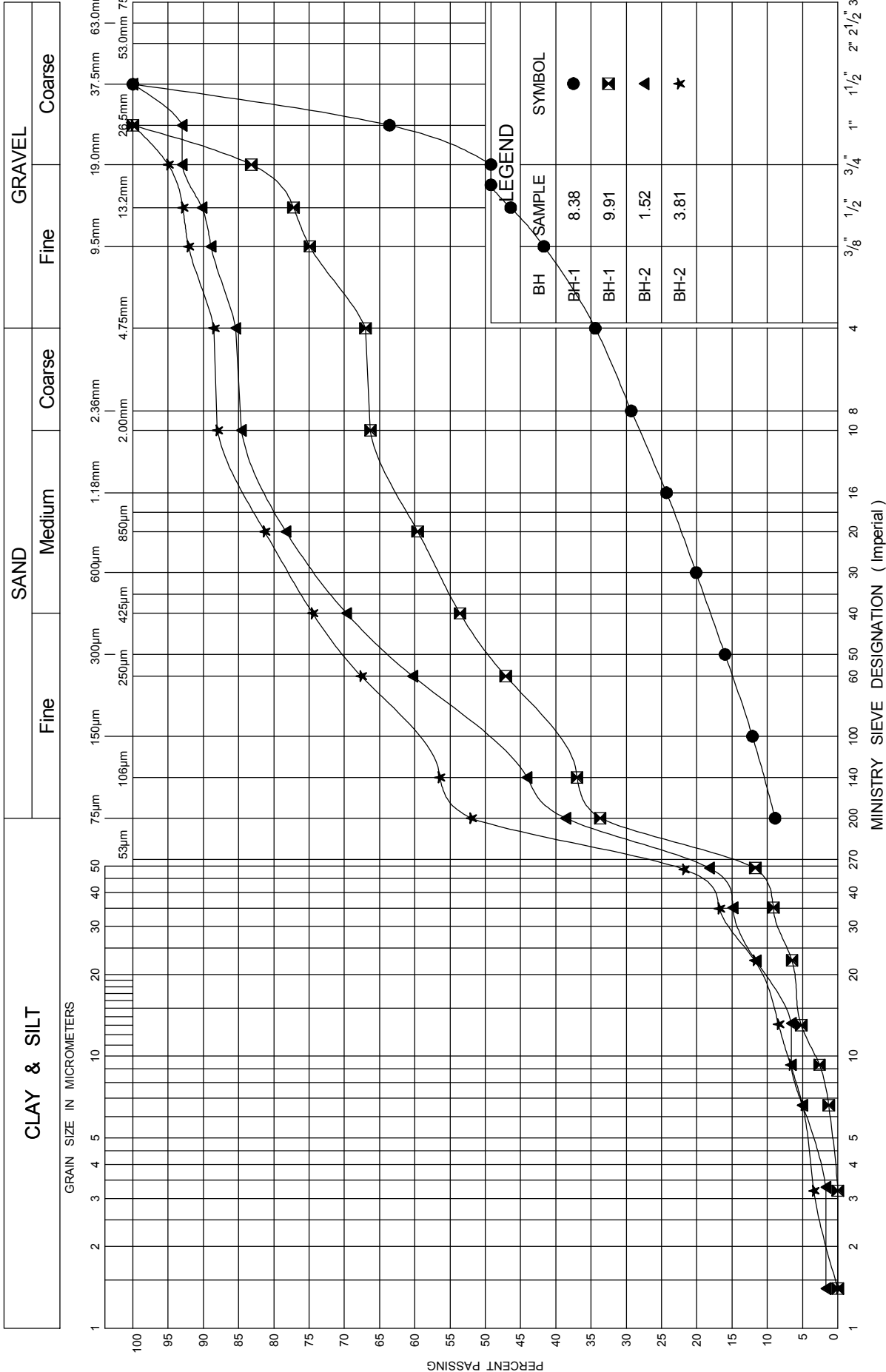


UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine		Medium	Fine	Coarse



UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT			SAND			GRAVEL		
Fine			Medium			Fine		
			Coarse					

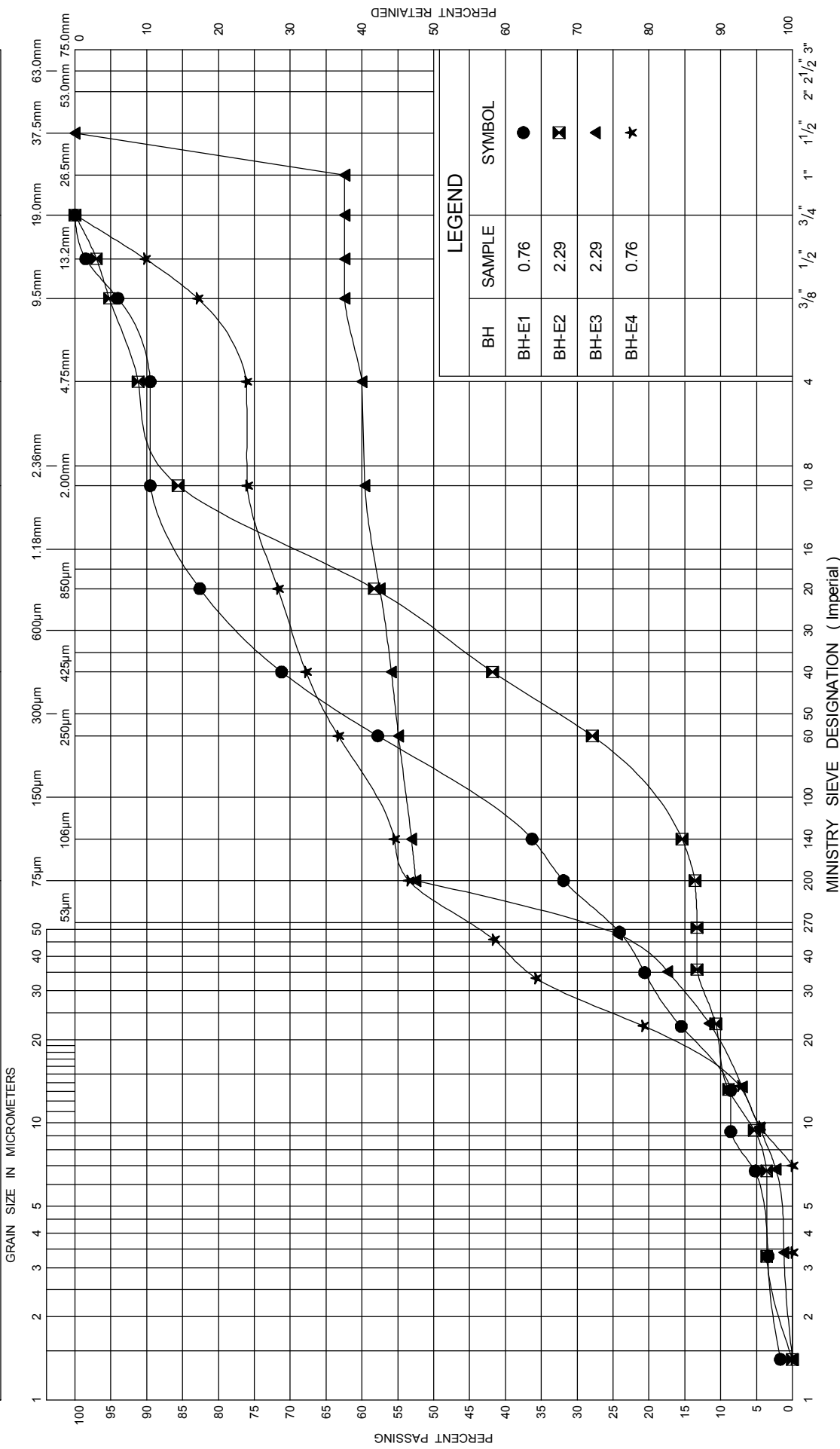


FIG No 3

GRAIN SIZE DISTRIBUTION

W P 411-00-00,5016-E-0016

Embankment Widening