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Foundation Investigation
and Design 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:

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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:

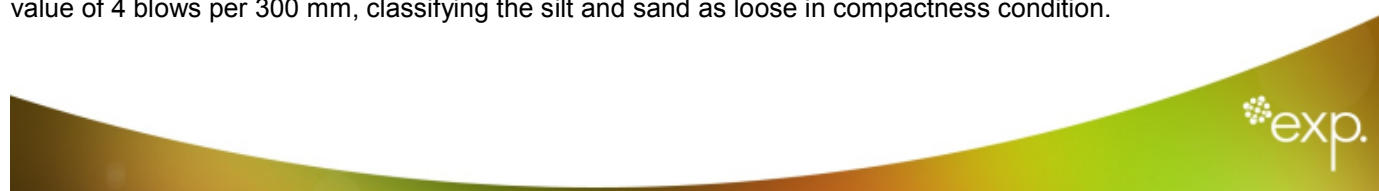
Moisture Content:

- 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.

2 Engineering Discussion and Recommendations

2.1 General

This section of the report provides geotechnical design recommendations for the widening of an existing embankment located on Highway 129 from Station 19+770, within Birch Township, to Station 10+040, within Langlois Township, District of Sudbury, Ministry of Transportation (MTO) Northeastern Region. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation at the site and presented in Part 1 - Foundation Investigation Report. The interpretations and recommendations provided are intended solely to permit designers to assess foundation alternatives and design for the embankment widening. Comments on construction are only provided to highlight issues that could affect the design. Contractors bidding on the works should make their own assessments of the factual data and how it might affect construction means and methods, scheduling, etc.

Based on the TOR provided by the MTO and Start-Up Meeting for this project, the existing embankment will be widened approximately 3 to 5 m on the eastern side. It is understood that there will be no grade change along the top of the embankment. Plan and profile information utilized in this report is based on a topographic survey of the site completed by others and provided to **exp** by the MTO.

2.1.1 Proposed Culvert Replacement at Station 19+829

In addition to the embankment widening, it is understood that an existing 1.2 m diameter corrugated steel pipe (CSP) culvert within the embankment at Stn. 19+829 (Birch Township) will also be replaced. The Foundation Investigation and Design Report for the culvert replacement has been addressed by **exp** under a separate report.

Although this FIDR provides recommendations for the embankment widening, independent of the culvert replacement, if the culvert replacement is to occur, it is recommended that the design and construction of the embankment widening consider the culvert replacement recommendations and construction options as well, as it would likely be more economical and easier to construct both in conjunction with one another.

2.2 Expected Ground Conditions

The following ground conditions within the existing embankment and along the proposed widening alignment are evident from the current investigation:

- Highway 129 is an asphalt paved, two lane, north/south roadway having approximately 1.0 m wide granular and partially paved shoulders, as well as cable guide rails on both sides of the roadway at the existing embankment location. 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. The current elevation of the crest of the roadway ranges from approximately 464.7 to 472.1 m.
- Based on Borehole BH-1, the highway embankment consists of very dense fill materials generally consisting of rock fill with cobbles and boulders ranging in diameter from approximately 0.1 to 0.7 m. Underlying the embankment was a thin layer (< 1.0 m thick) of loose silt with trace organics, followed by native compact to very dense till which extended to greater than 14.3 m depth (Elev. 450.3 m, Borehole BH-1 termination depth). It is assumed that the encountered embankment fill materials extend throughout the embankment beyond the location of Borehole BH-1.



- Near the outlet of the existing culvert at Stn. 19+829, a thin layer of peat was encountered overlying native till that was loose in the upper 0.3 m becoming compact to dense and extending to greater than 6.7 m depth (Elev. 450.4 m, borehole termination depth). Along the remainder of the embankment toe, a relatively thin layer of topsoil was encountered overlying compact to dense till that extended to the borehole refusal depths. In some locations, up to approximately 0.8 m of loose native soils were encountered immediately below the topsoil.
- The water level within the Creek measured on June 26, 2017 was at approximately Elev. 456.6 m at the outlet. Wet samples within Borehole BH-1 and BH-2 were found below Elev. 457.0 m to 458.0 m. As such, an inferred groundwater elevation of Elev. 457.0 m is anticipated near the creek. However, the groundwater elevation will likely fluctuate seasonally. Groundwater was not encountered along the remainder of the embankment toe, however, this may have been influenced by the wash boring techniques utilized. For analysis purposes, it is assumed that the groundwater elevation is generally consistent near Elev. 457.0 m throughout the embankment.

2.3 Engineering Analysis

The potential impacts of additional fill placement near the toe of the existing embankment for the widening works were investigated. The following assumptions were made for the proposed embankment widening based on results of the field investigation and typical design practices:

- All topsoil, peat, and other deleterious materials will be removed prior to constructing the embankment widening. In addition, all loose native soils will be removed prior to construction.
- The embankment will be constructed using rock fill similar to the fills encountered within the existing embankment.
- Embankment widening will be constructed with side slopes similar to existing at 1.5H:1V.
- As the maximum embankment height is approximately 9.5 m, a mid-height berm will not be required for the rock fill.

Based on the boreholes advanced at the site, the soil conditions where the embankment will be widened generally consist of compact to very dense native cohesionless till materials. This has been assumed in the following analyses.

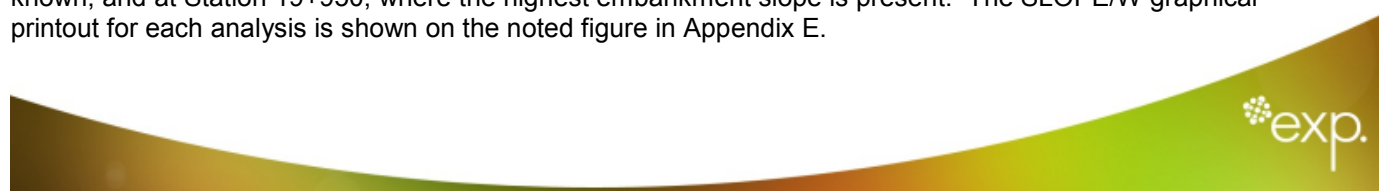
2.3.1 Stability Analysis

Slope stability analyses were performed to assess the global stability of the existing embankment configuration and to check that a minimum Factor of Safety of 1.3 will be achieved for the temporary conditions for proposed construction configurations. The static 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 modelling the embankment slopes and for computation.

Stability assessments of the existing slopes under static conditions were performed on various cross-sections perpendicular to the highway at the culvert location. The cross-sections of the existing embankment were established based on the topographic information provided by the MTO. The stratigraphy and groundwater conditions at the site were developed based on the results of the geotechnical investigation.

Based on the borehole information, the embankment fills and subsoils generally consist of cohesionless soil deposits. As such, an effective stress analysis for long term stability assessment was performed.

Stability analyses were performed near the location of Borehole BH-1 where existing embankment information is known, and at Station 19+950, where the highest embankment slope is present. The SLOPE/W graphical printout for each analysis is shown on the noted figure in Appendix E.



- Figure E-1 – Existing Embankment Stability – Station 19+825
- Figure E-2 – Existing Embankment Stability – Station 19+950
- Figure E-3 – Proposed Widened Embankment Stability – Station 19+825
- Figure E-4 – Proposed Widened Embankment Stability – Station 19+950

Tabulated below in Table 2-1 are the soil parameters used for the slope stability analyses. The soil parameters were generally estimated based on the results of the field and laboratory investigation and our past experience with similar soils.

Table 2-1: Soil Properties Used in Slope Stability Analysis

Soil Type	Long Term Conditions		
	ϕ'	c' (kPa)	γ (kN/m ³)
Existing Fill Materials (various, very dense)	32°	0	22
New Rock Fill (compact to dense)	40°	0	23
Peat	17°	2	12
Silt, Silt and Sand (loose)	28°	0	18
Till (various, compact to very dense)	35°	0	21

The results of the slope stability analyses performed are shown on Table 2-2 below. A minimum Factor of Safety (FS) of 1.3 is required to indicate that the embankment is stable. As shown on Table 2-2, the existing embankment is considered stable with Factors of Safety exceeding 1.3 (Figs. E-1 and E-2). For the proposed widened embankments the FS is greater than 1.3, which indicates that the embankments would be stable for long term conditions.



Table 2-2: Summary of Slope Stability Analysis Results

Figure No.	Analysis	Factor of Safety
E-1	Existing Embankment Stability – Station 19+825	1.411
E-2	Existing Embankment Stability – Station 19+950	1.526
E-3	Proposed Widened Embankment Stability – Station 19+825	1.445
E-4	Proposed Widened Embankment Stability – Station 19+950	1.413

2.3.2 Embankment Settlement

As the in-situ native soils are generally compact to dense cohesionless till soils, a significant portion of settlement is expected to be immediate and complete by the end of construction. Post construction settlements of the rock fill embankment are expected to be minimal (< 25 mm), provided the recommendations within this report are followed and the rock fill is placed and compacted in lifts in accordance with OPSS.PROV 206 and is not end-dumped.

2.4 Embankment Construction

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, organics, and softened or loosened soils should be stripped from below the proposed widening footprint. Note that the thickness of topsoil, organics, and loose soils were investigated at the borehole locations only, and may vary at other locations beyond the boreholes. The subgrade should be inspected following stripping to ensure all topsoil, organics, and softened or loosened soils are fully removed.

All subgrade soils should be proofrolled prior to fill placement. The embankment construction should be carried out in accordance with OPSS.PROV 206. Widening over organic deposits should follow OPSD 203.030 (included in Appendix F) with all organic materials excavated down to the in-situ compact to very dense native till soils.

Proposed embankment fill is to consist of rock fill similar to the existing embankment.

If the final rock fill embankment height exceeds 10 m, a mid-height berm consisting of a 2 m wide bench should be incorporated along the length of the rock fill embankment.

The existing embankment slope must be cleared of all vegetation and must be properly compacted and benched in accordance with OPSD 208.010 (included in Appendix F) prior to placing the new fill materials. Rock fill material cut from the existing embankment for benching purposes can likely be reused in the widening construction.

Attention should be given to maintain continuity of drainage between the existing pavement structure materials and the new widened pavement structure materials.

When constructing the widening portion, material placement is to begin at the toe of the existing embankment, working up towards the centreline. Each lift should be placed and compacted along the full length of the embankment before each successive lift is placed. Fill materials are not to be end-dumped from the crest of the existing embankment.

2.4.1 Creek Diversion and Culvert Extension

The watercourse crossing through the existing culvert at Station 19+829 turns parallel to the toe of the embankment near the culvert outlet (refer to Photographs 11 and 12 in Appendix B). If the proposed embankment widening footprint approaches or extends over the existing creek, the creek will likely need to be permanently diverted to accommodate the widening. In addition, a culvert extension will also be required.

Any softened or loosened soils from the creek that will be below the embankment widening or culvert extension footprints will need to be excavated down to compact/dense native soils. Upfill shall consist of Granular "B" Type II (OPSS.PROV 1010) placed in maximum 200 mm thick lifts and compacted to 95% of the Standard Proctor Maximum Dry Density (SPMDD) in accordance with OPSS.PROV 501 before a subsequent layer is placed. A non-woven geotextile separator can be placed between the approved subgrade and the engineered fill pad to assist in material placement if required. The geotextile separator is to be a Class II non-woven material with an equivalent opening size of 75-150 µm.

2.5 Groundwater and Surface Water Control

Excavations are expected to extend below the observed groundwater level near the existing creek. To avoid disturbance of the founding subgrade and to allow for placement of fill in dry conditions, the groundwater must be lowered and controlled to a minimum of 0.5 m depth below any proposed excavation levels prior to excavation. The ingress of surface water must be controlled using a suitable system as well.

Appropriate permitting and approvals must be in place for this work (i.e. MOE, DFO, etc.) and work must be carried out in accordance with the approved schedules. In addition, to control water flow in the creek and for protection of the construction area, a cofferdam will likely be required for all replacement options. Dewatering requirements behind the cofferdam to keep the construction site dry will be impacted by water levels in the creek at the time of construction.

Dewatering requirements will be governed by the time of the year the construction is performed. Dewatering shall be carried out in accordance with OPSS 517 and OPSS 518. It is the responsibility of the Contractor to propose a suitable dewatering system based on the time of construction and creek/groundwater levels. The dewatering method is the responsibility of the Contractor and the Contractor should submit a proposal to the MTO for review and approval prior to construction. The method used should not undermine the existing road embankment or adjacent side slopes.

Erosion and sediment control during 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.

2.6 Unsupported Excavations

All excavations at this site must be conducted in accordance with the Occupational Health and Safety Act (OHSA) and Regulations for Construction (O. Reg. 213/91). All fills and native soils may be classified as a Type 3 soil above the groundwater table in conformance with the OHSA. The soils below the groundwater table may be classified as a Type 4 soil. Temporary excavation side slopes for Type 3 soil should not exceed 1H:1V in accordance with OHSA. Temporary excavation side slopes for Type 4 soils should not exceed 3H:1V where applicable. There is a potential for sloughing to occur if any trench remains open for an extended period of time (i.e. > 24 hours) or during a rainfall event. In addition, some localized surficial sloughing may be experienced in areas of perched groundwater seepage (i.e. within the embankment fill).



2.7 Obstructions

Compact to very dense till materials and rock fill consisting of cobbles and boulders were encountered during the investigation. These potential obstructions may impact excavations and construction. A non-standard special provision is provided in Appendix G, which may form the basis for advising the contractor on this issue.

3 Closure

The recommendations made in this report are in accordance with our present understanding of the project and are provided solely for the design 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 noted. Should any conditions at the site be encountered that differ from those reported at the test locations, we require that we be notified immediately in order to allow reassessment of our recommendations. It may then be necessary to perform additional investigation and analysis.

The number of test holes required to determine the localized underground conditions between test holes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual test hole results, so that 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 Ian MacMillan, P.Eng. It has been reviewed by Andy Schell, M.Sc.(Eng.), P.Eng., TaeChul Kim, M.E.Sc., P.Eng., and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Shane Tobias and Nicole Wyld.

Yours truly,

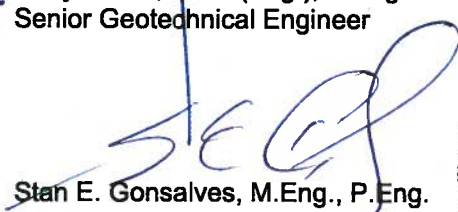
exp Services Inc.



Ian MacMillan, P.Eng.
Senior Geotechnical Engineer


P.Eng.: Andy Schell, M.Sc.(Eng.), P.Eng.
Senior Geotechnical Engineer


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


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



4 Limitations and Use of Report

Basis of Report

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur, which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of **exp** may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by **exp**. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and **exp**'s recommendations. Any reduction in the level of services recommended will result in **exp** providing qualified opinions regarding the adequacy of the work. **Exp** can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, 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 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 and design objectives and purpose as communicated by the Client. **Exp** has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to **exp**.



Standard of Care

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

Complete Report

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to **exp** by its client ("Client"), communications between **exp** and the Client, other reports, proposals or documents prepared by **exp** for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. **Exp** is not responsible for use by any party of portions of the Report.

Use of Report

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. No other party may use or rely upon the Report in whole or in part without the written consent of **exp**. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. **exp** is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

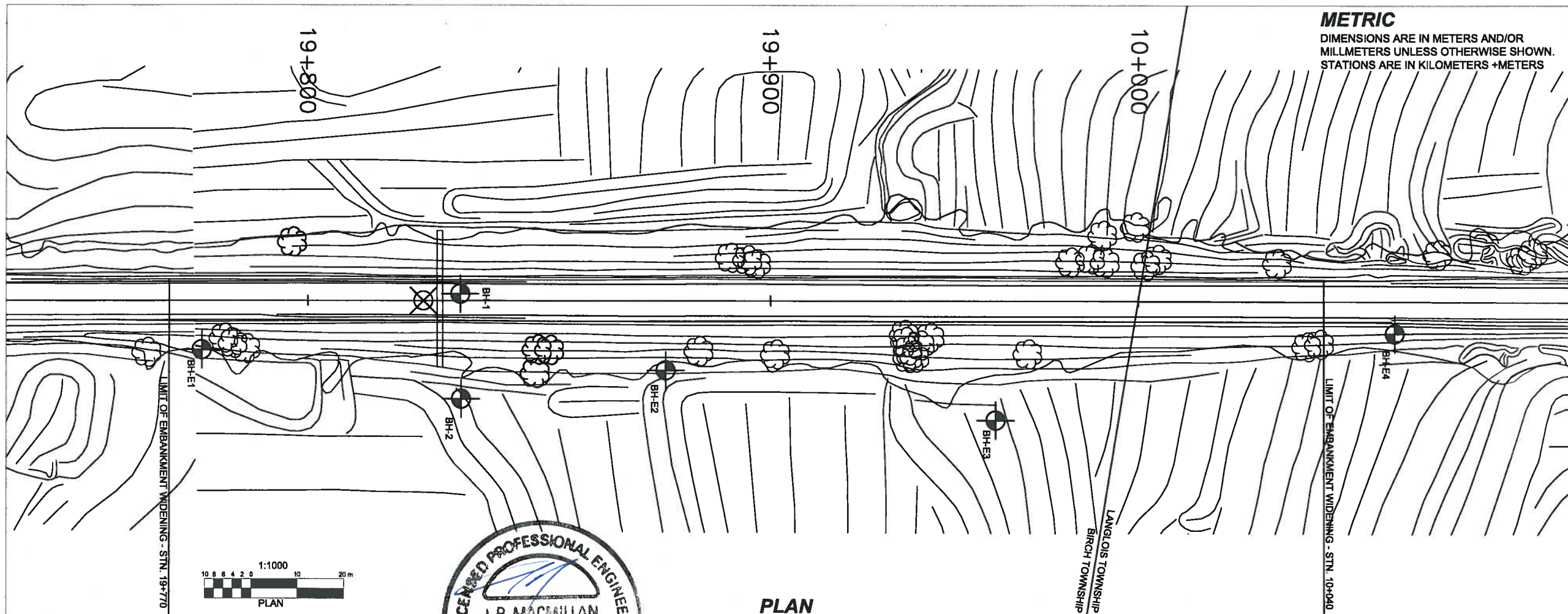
Report Format

Where **exp** has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by **exp** have utilized specific software and hardware systems. **Exp** makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are **exp**'s instruments of professional service and shall not be altered without the written consent of **exp**.

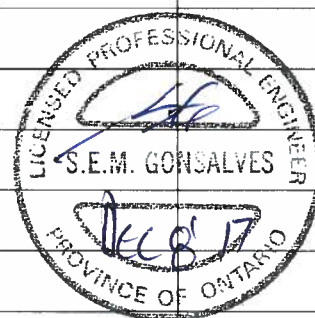
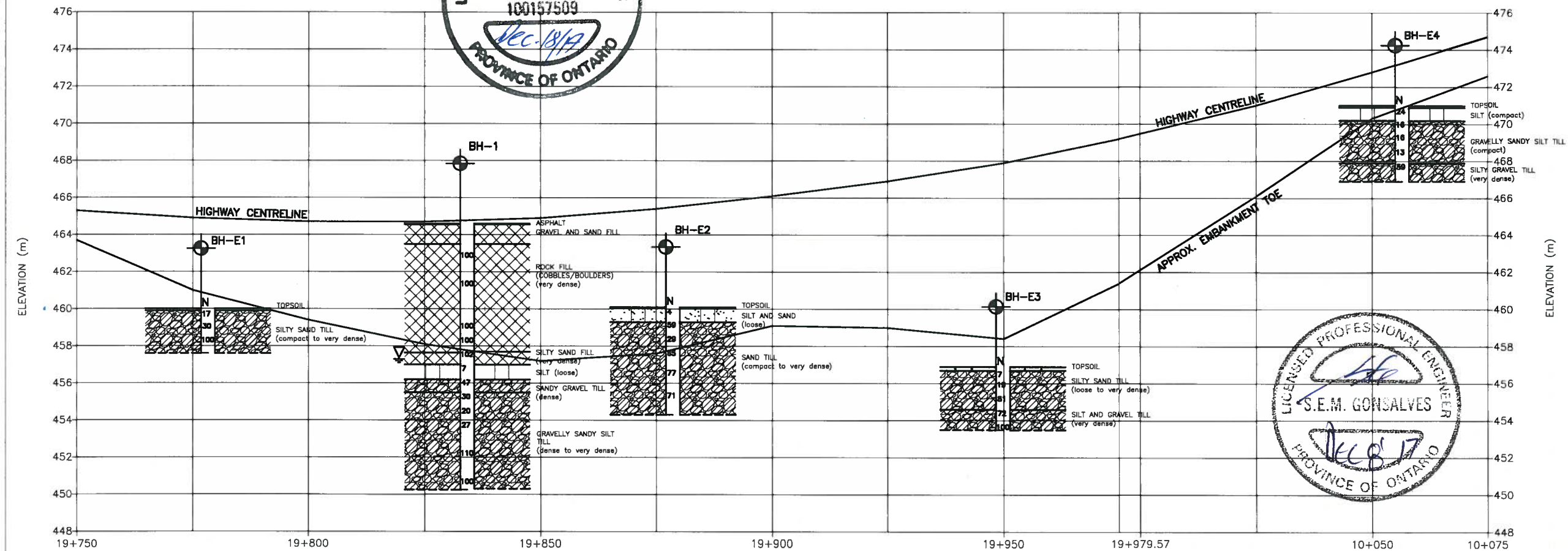


Appendix A – Drawings





PLAN



EXISTING PROFILE

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
GEOCRETS 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.

SHEET
1



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 OPG 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
DRAWN: IM	CHECKED: SG
DATE: 2017.10.25	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

N

STANDARD PENETRATION TEST (BLOWS/300mm)



TEMPORARY BENCHMARK (EL. 464.7 m)



ESTIMATED WATER LEVEL IN BOREHOLE

BOREHOLE COORDINATES

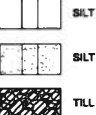
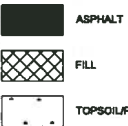
BOREHOLE NO.	APPROX. ELEV. (m)	MTM COORDINATES	
		NORTHING	EASTING
BH-E1	460.0	5255201.9	364865.8
BH-E2	460.1	5252601.4	364852.9
BH-E3	456.9	5252873.5	364851.2
BH-E4	471.0	5252558.9	364866.6
BH-1	464.6	5252554.9	364844.3
BH-2	457.1	5252558.9	364866.6

NOTES

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



REVISIONS

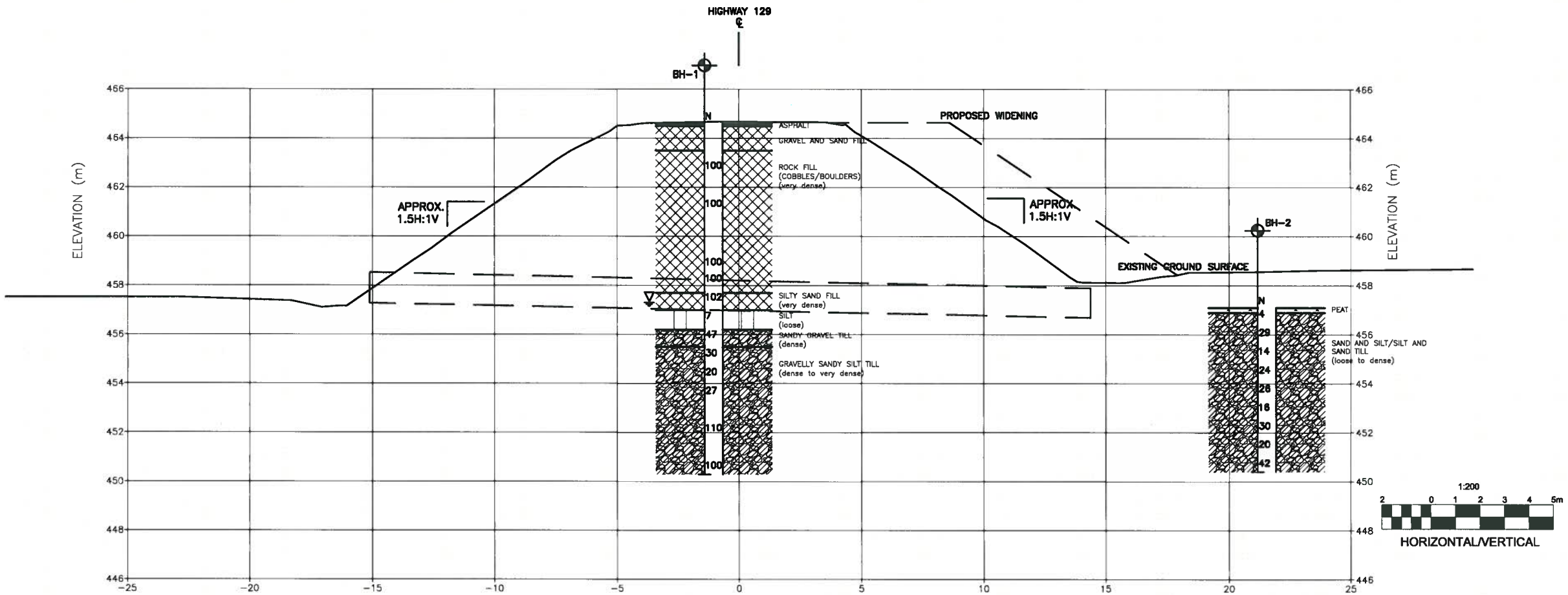
DATE	BY	DESCRIPTION
2017.10.25	IM	SUBMISSION FOR MTO REVIEW
2017.11.28	IM	FINAL REPORT SUBMISSION

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:

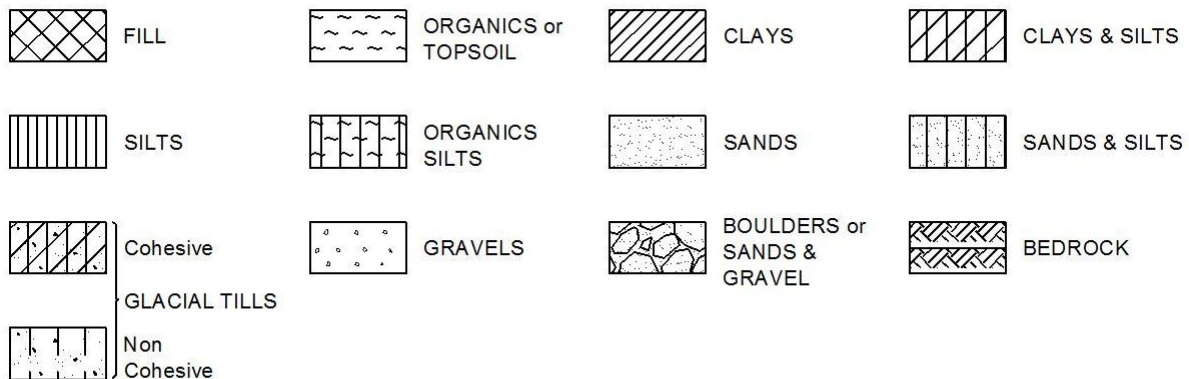
Table c: Consistency of Cohesive Soil

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'	—°	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 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									
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																	
460.0	Ground Surface						20	40	60	80	100						
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								○				
	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								○				
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									
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.																		
459.3	TILL , sand, some silt, trace to some gravel, trace clay, brown, moist, very dense to compact.		2	SS	59														
0.8	with cobbles/boulders below ~ 3.1 m depth. Cored using NW casing. Casing seized at ~ 5.8 m depth.		3	SS	29														
			4	SS	65														
			5	SS	77														
			6	SS	71														
454.3	END OF BOREHOLE Borehole terminated at ~ 5.8 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.																		
5.8																			

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								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								
456.9	Ground Surface						20	40	60	80	100					
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									
								20	40	60						80	100
464.6	Pavement Surface																
463.6	ASPHALT (~ 50 mm thick) FILL, gravel and sand, trace silt, with cobbles, brown, moist.		1	AS											52 42 (6)		
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.																
463.6		2	SS	100													
462.6																	
461.6		3	SS	100													
460.6																	
459.6	sandy gravel seam, some silt, brown at ~ 5.3 m depth.		4	SS	100												
458.6			5	SS	100												
457.8	FILL, silty sand, some gravel, brown, frozen, very dense.		6	SS	102												
457.0																	
457.0	SILT, some sand, trace organics, grey, wet, loose.		7	SS	7												
456.2																	
456.2	TILL, sandy gravel, trace silt, brown, wet, dense.		8	SS	47										66 26 (9)		
455.5																	
455.5	TILL, gravelly, sandy silt, grey, wet, dense.		9	SS	30												
454.5	compact below ~ 9.9 m depth.		10	SS	20										33 33 34 0		
454.5			11	SS	27												
453.5																	
452.5	very dense below ~ 12.2 m depth.		12	SS	110												
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+ 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

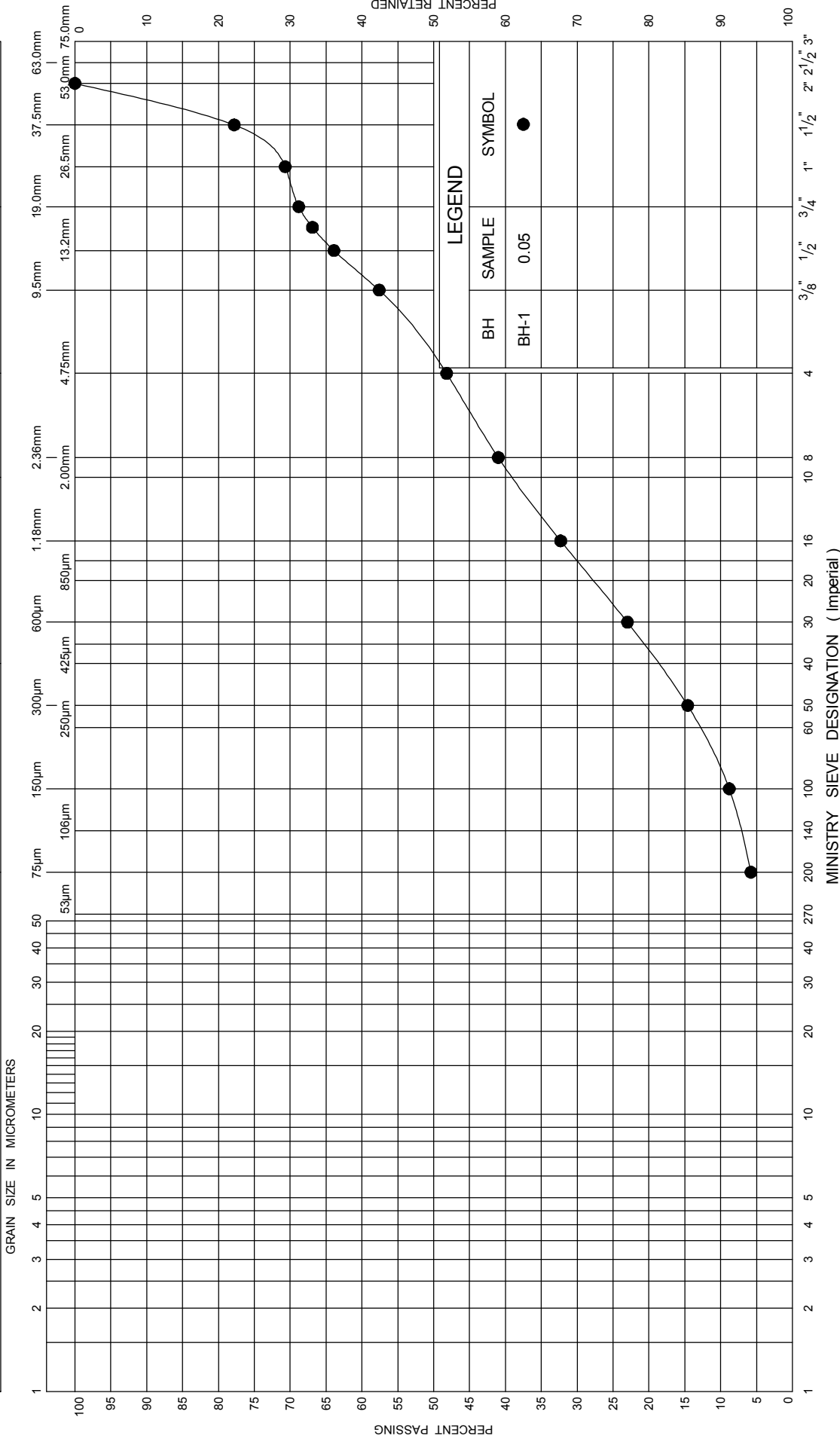
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			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		
Grain Size in Micrometers			Fine			Medium		
			Fine			Coarse		

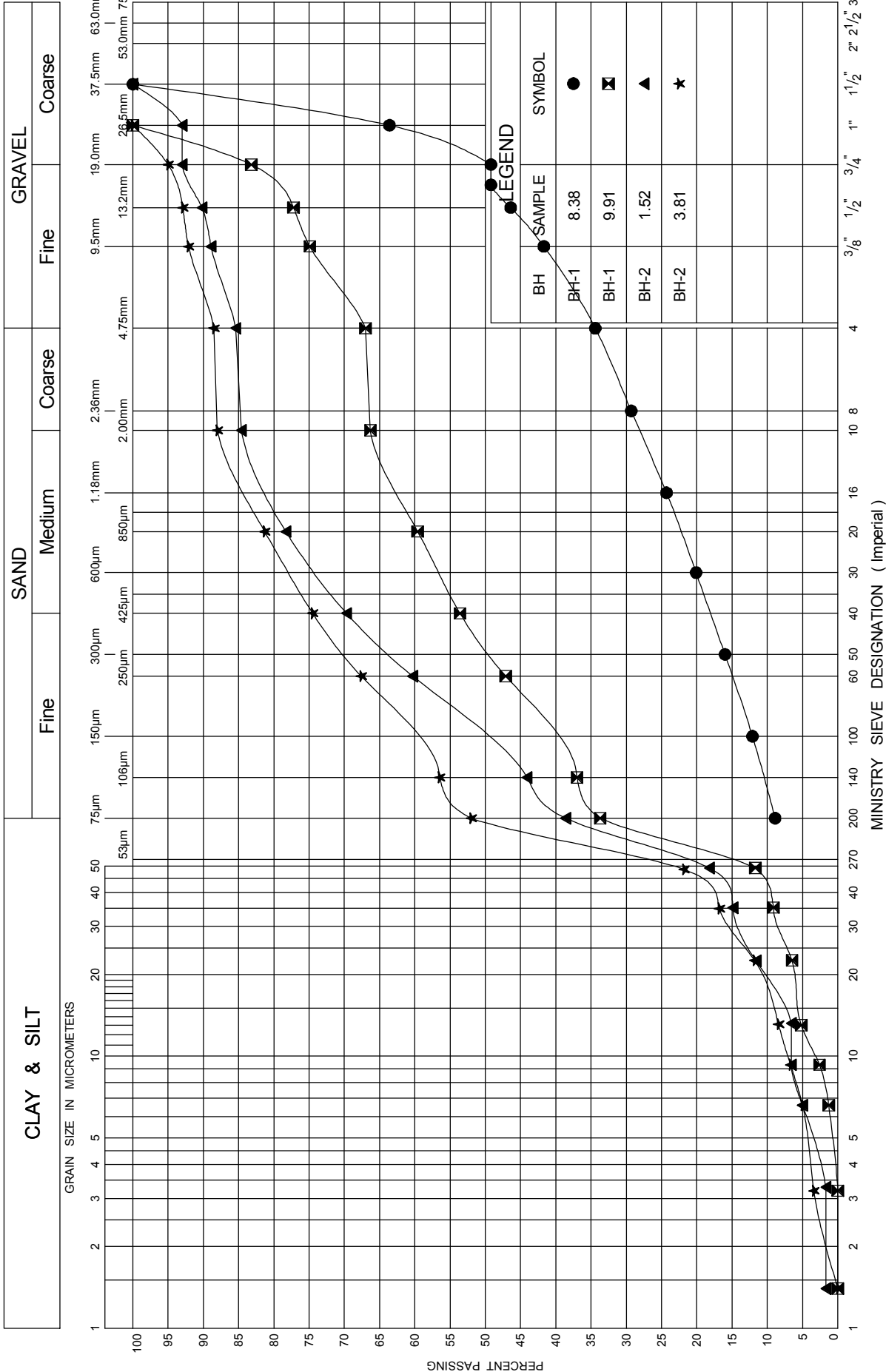


GRAIN SIZE DISTRIBUTION
GRAVEL AND SAND FILL

FIG No 1

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

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT			SAND			GRAVEL		
Fine			Medium			Fine		
Coarse			Coarse			Coarse		

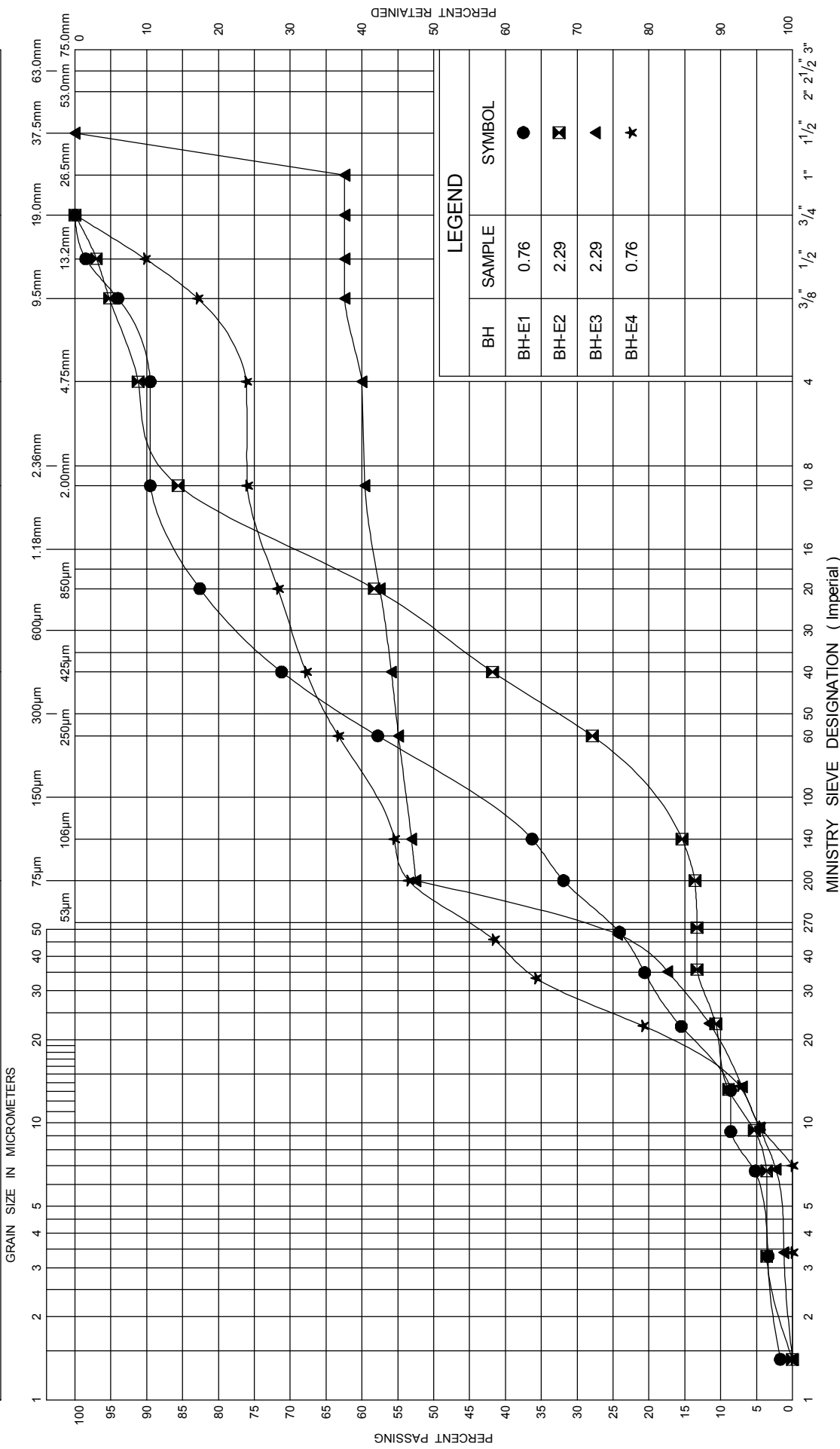


FIG No 3

GRAIN SIZE DISTRIBUTION

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

Embankment Widening

Appendix E – Slope Stability Analyses



FIGURE E-1 - Existing Embankment Stability - Strn. 19+825
Highway 129, Birch Township
Drained Conditions

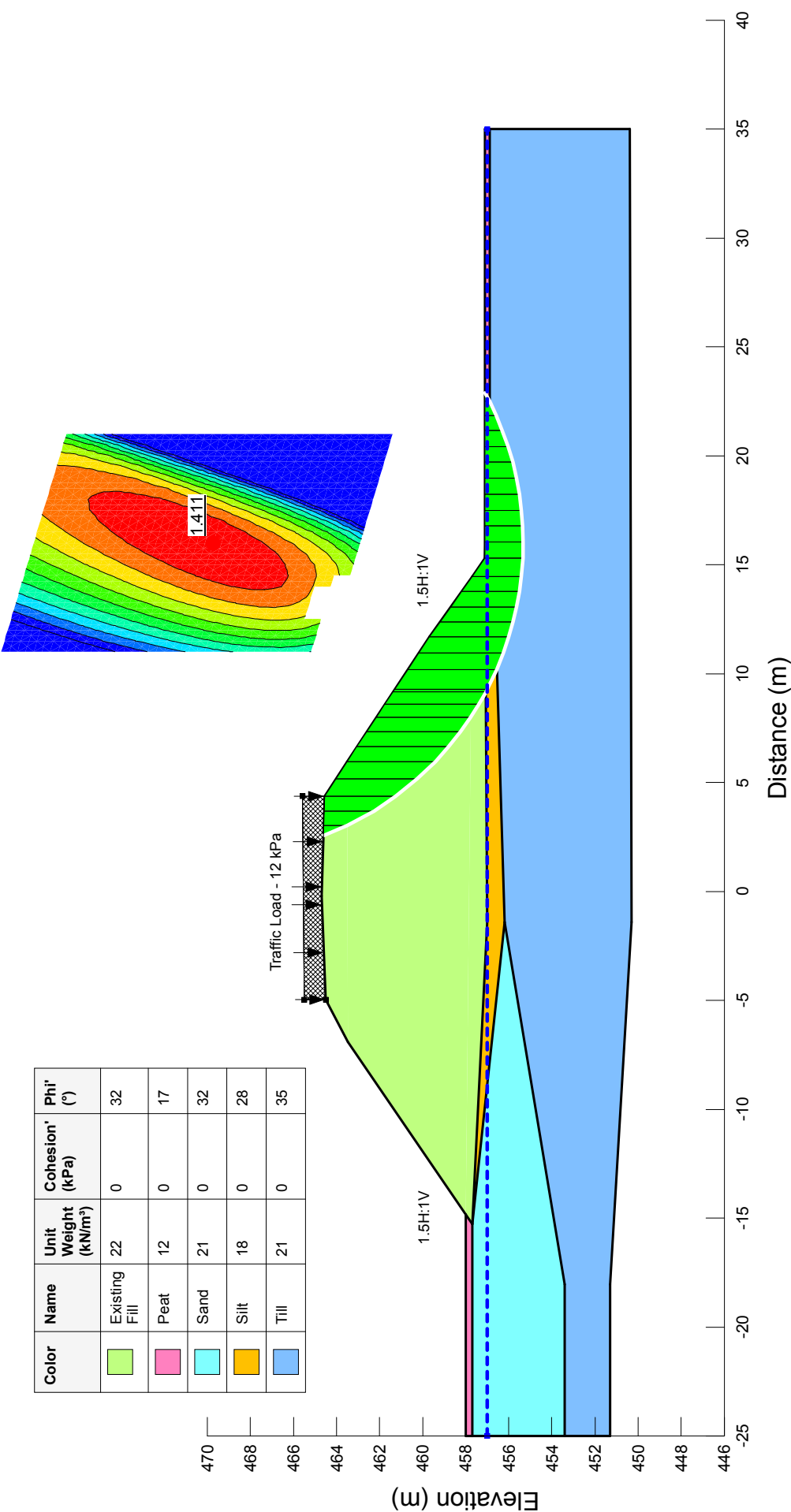


FIGURE E-2 - Existing Embankment Stability - Stn. 19+950
Highway 129, Birch Township
Drained Conditions

Color	Name	Unit Weight (kN/m³)	Cohesion* (kPa)	Phi* (°)
<div></div>	Existing Fill	22	0	32
<div></div>	Till	21	0	35
<div></div>	Topsoil	12	0	15

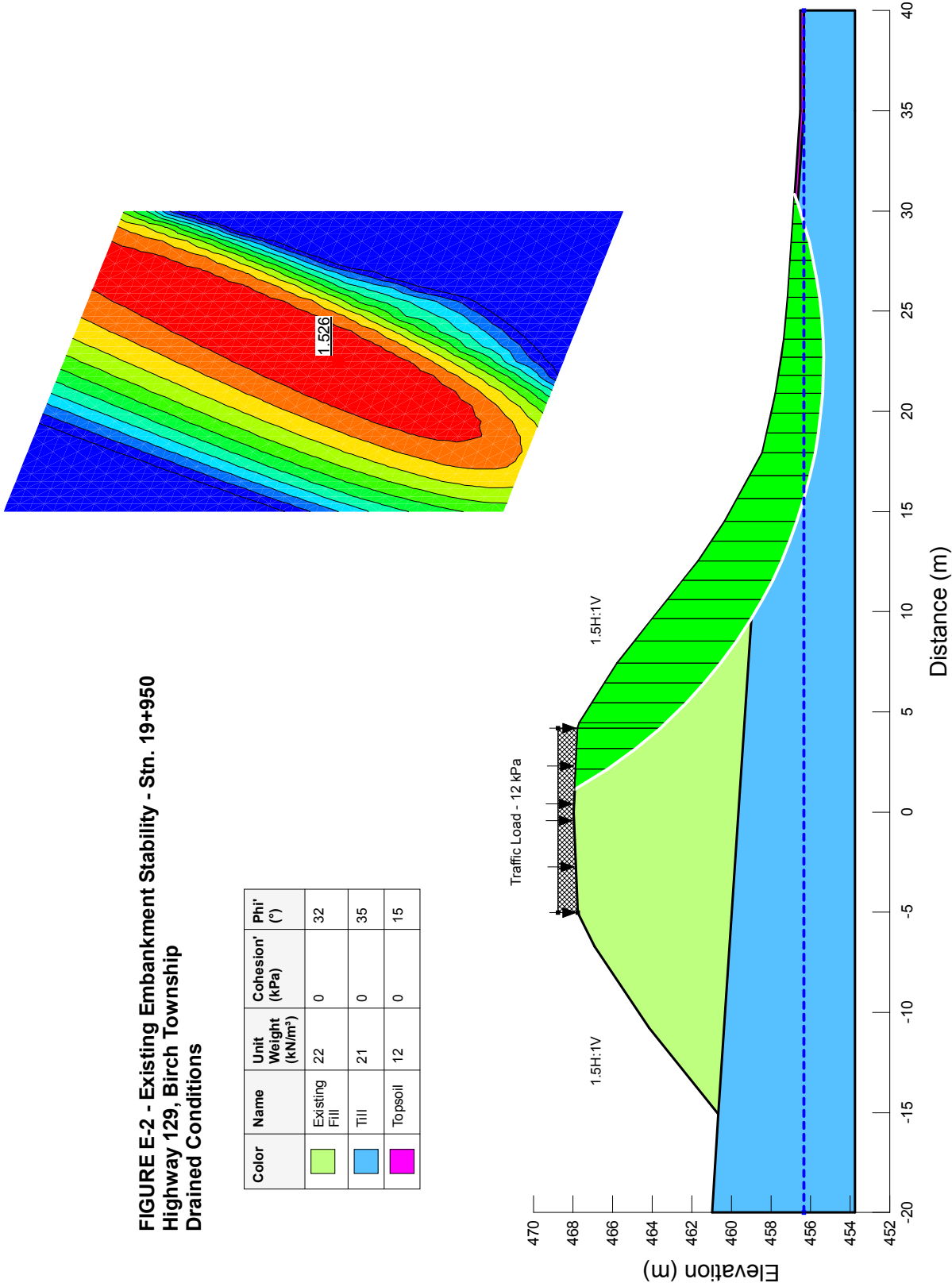


FIGURE E-3 - Proposed Widened Embankment Stability - Stn. 19+825
Highway 129, Birch Township
Drained Conditions

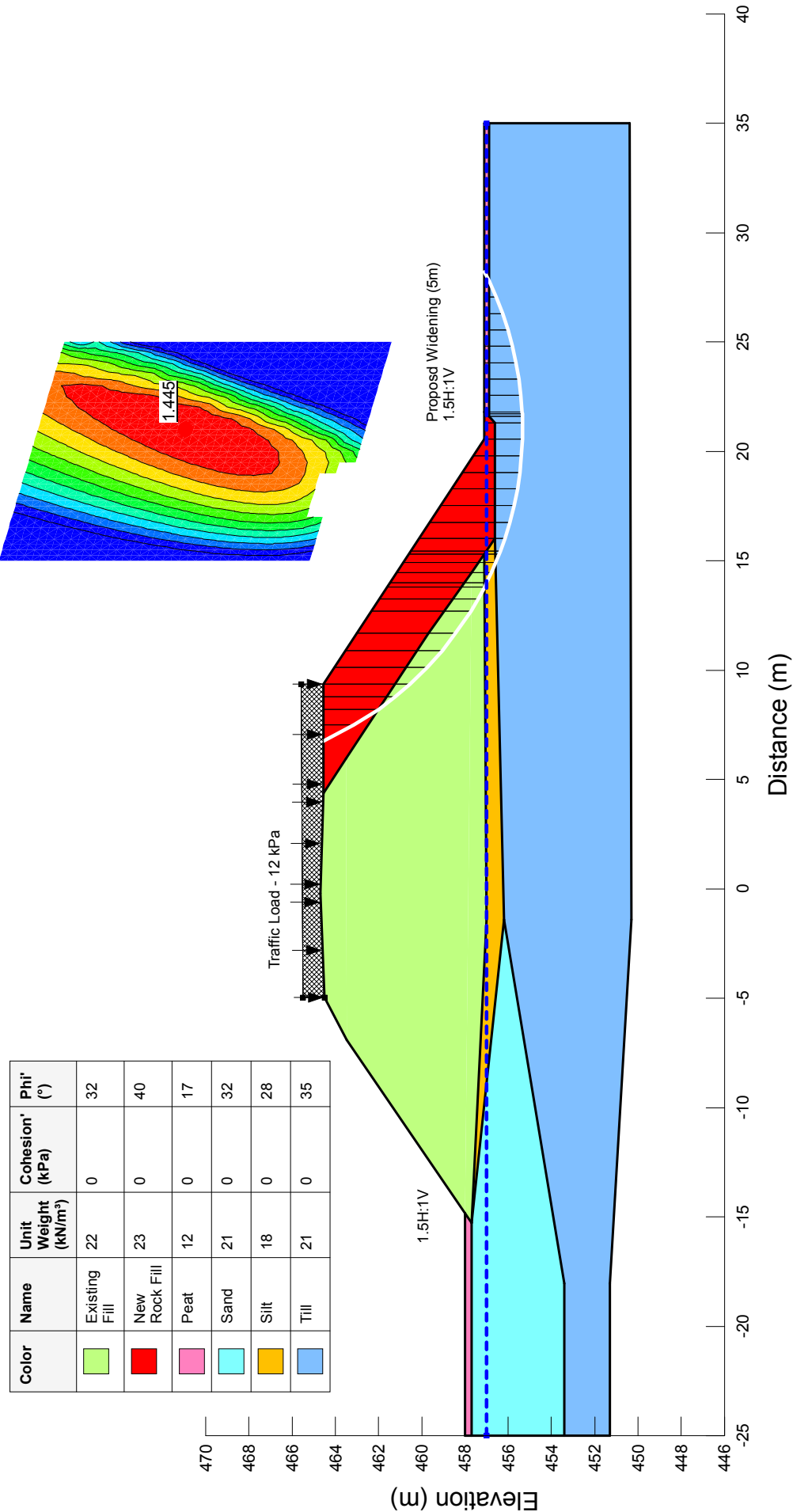
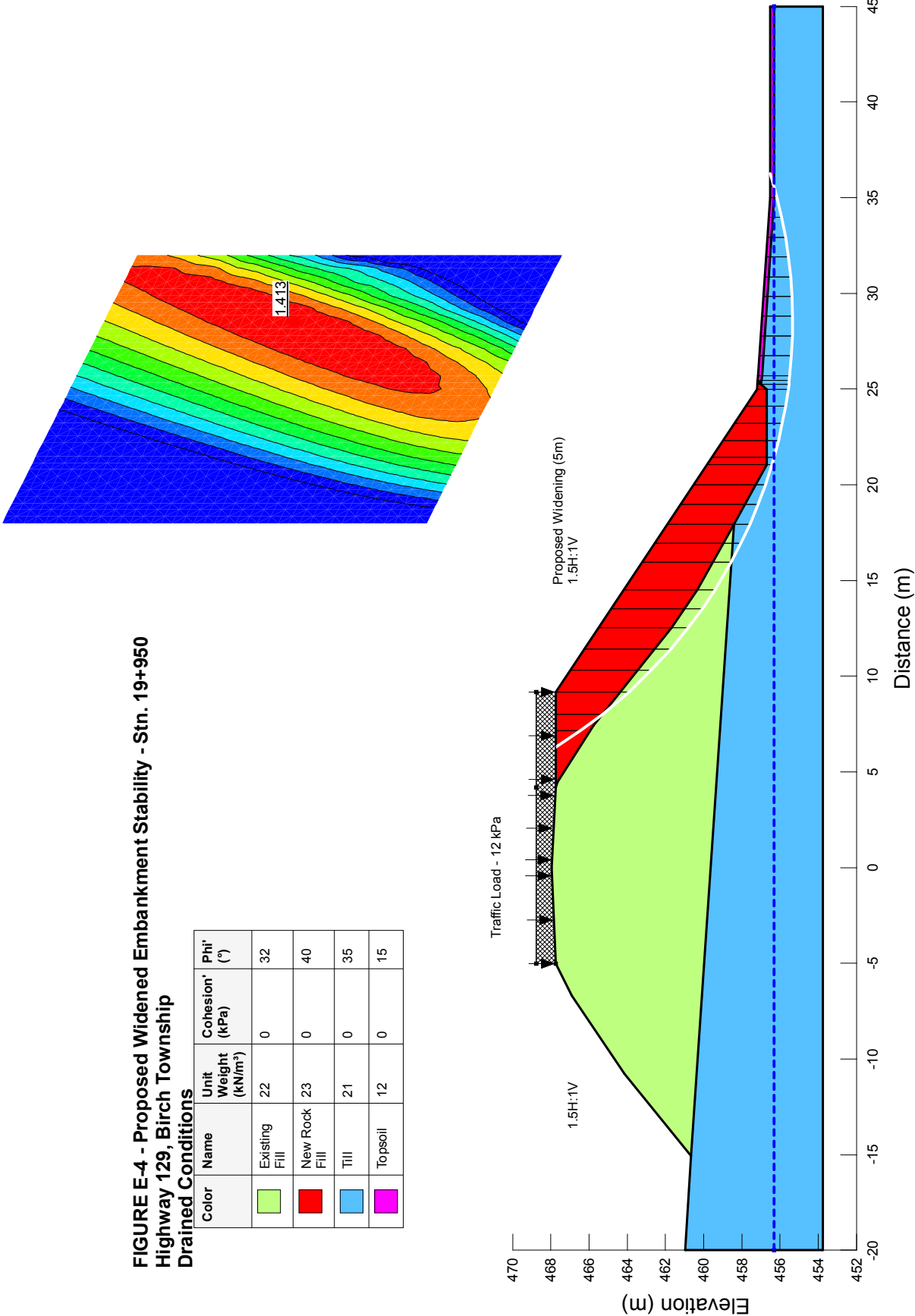


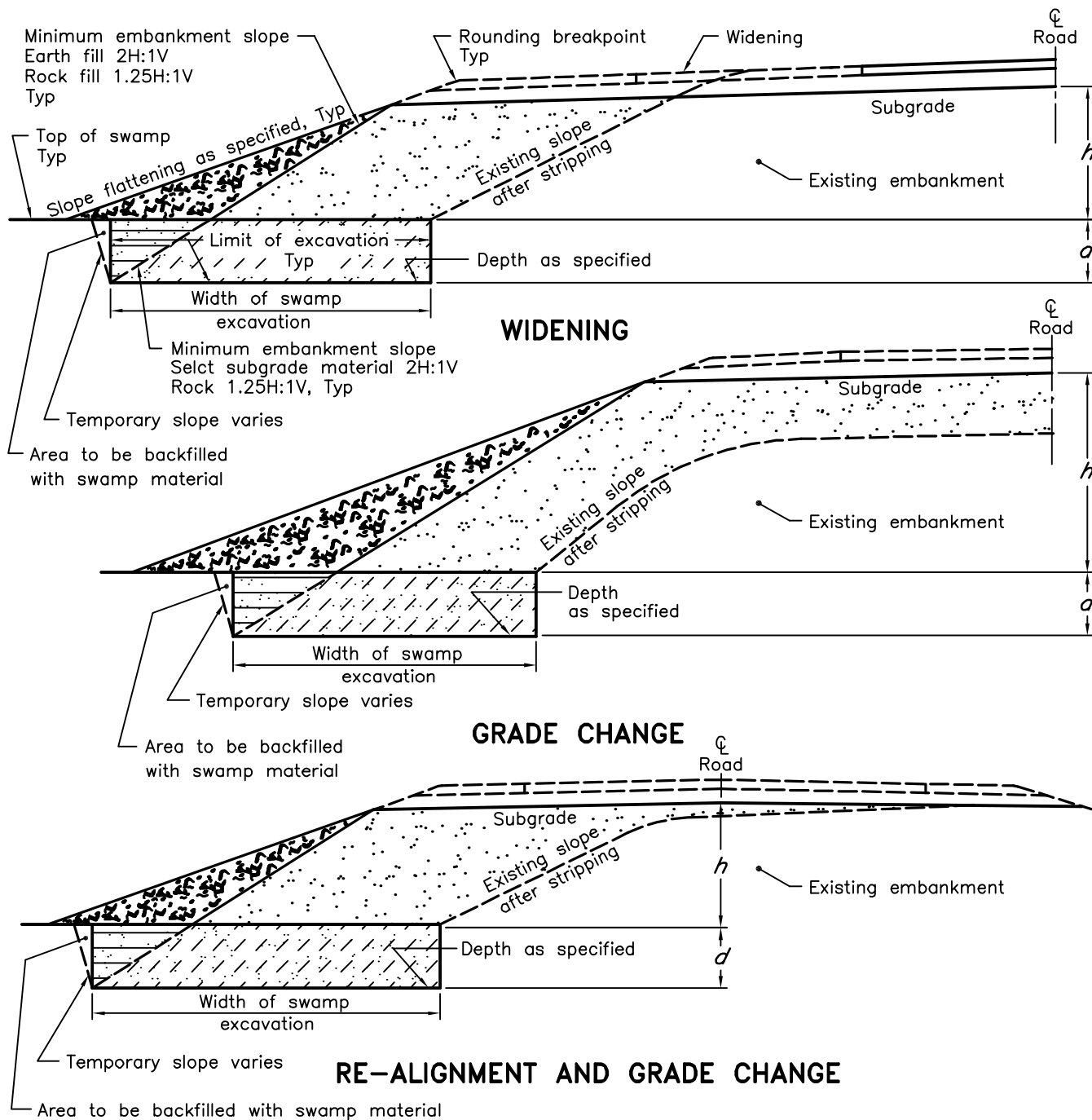
FIGURE E-4 - Proposed Widened Embankment Stability - Stn. 19+950
Highway 129, Birch Township
Drained Conditions

Color	Name	Unit Weight (kN/m³)	Cohesion* (kPa)	Phi* (°)
<div></div>	Existing Fill	22	0	32
<div></div>	New Rock Fill	23	0	40
<div></div>	Till	21	0	35
<div></div>	Topsoil	12	0	15



Appendix F – Ontario Provincial Standards Drawings (OPSD)





NOTES:

- A For this OPSD, $h \leq 4.5\text{m}$ and $d \leq 6.0\text{m}$.
- B Topsoil shall be stripped from existing slopes.
- C Height of fill is the vertical difference between subgrade and top of swamp measured at new road centreline.
- D 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
- Excavate and backfill with swamp material

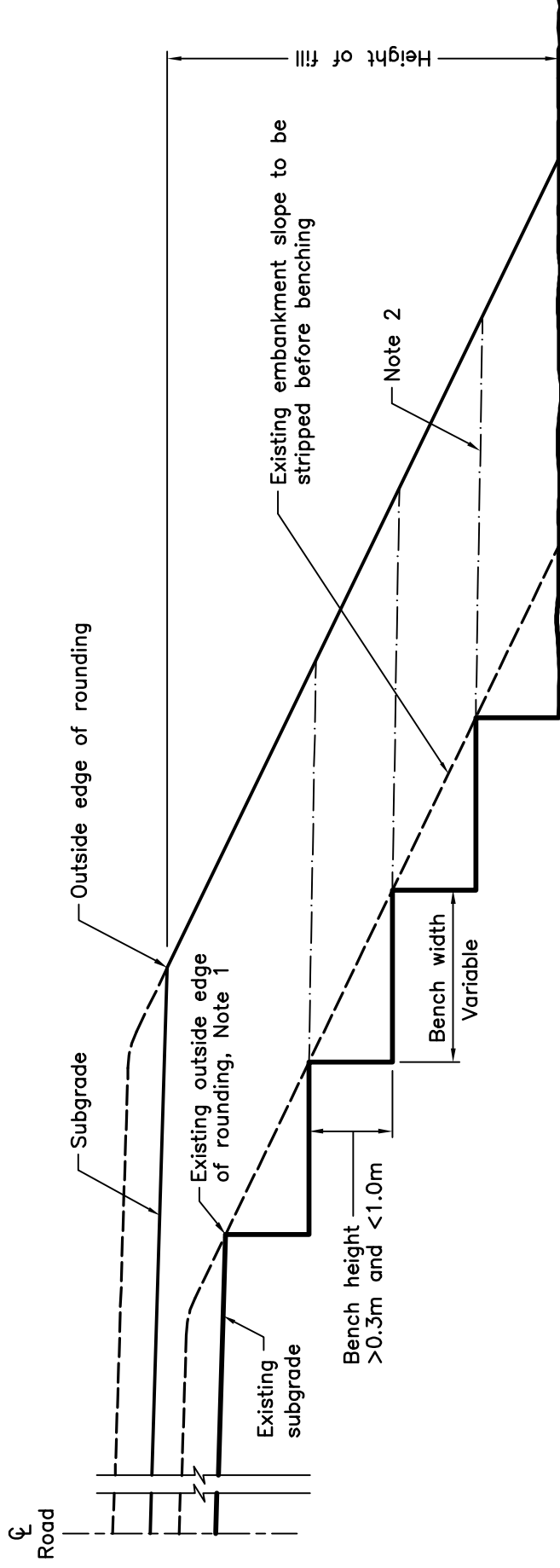
ONTARIO PROVINCIAL STANDARD DRAWING

Nov 2010 Rev 3

EMBANKMENTS OVER SWAMP
EXISTING SLOPES MAINTAINED



OPSD 203.030



NOTES:

- 1 When the subgrade is below the existing outside edge of rounding, benching shall be carried out below the point where the subgrade intersects the existing slope.
- 2 Benches shall be excavated one level at a time and the fill placed and compacted before the next bench is excavated.
- A Benchings is not required on existing slopes flatter than 3H:1V.
- B All dimensions are in metres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING

Nov 2013 Rev 3



BENCHING OF EARTH SLOPES

OPSD 208.010

Appendix G – Non-Standard Special Provisions (NSSP)



NSSP FOR COBBLES AND/OR BOULDERS OBSTRUCTIONS

Scope of Work

The Contractor should be aware that cobbles and/or boulders may be encountered during the installation of shoring elements and during excavations of the in-situ soils and embankment fill. Appropriate equipment and procedures will be required to penetrate/remove cobbles and/or boulders that may be encountered during installation of shoring and excavation,

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment, and materials for completion of the work.