Foundation Investigation and Design Report

Highway 17 – Neys Creek
Structural Culvert Replacement

Township of Coldwell
Station 16+441, Centerline, Lat: 48.770604, Long: -86.551926
District of Thunder Bay

W.P. 6022-E-0033
G.W.P. 6028-22-00

GEOCRES No. 42D-72

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Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ontario Ministry of Transportation Northwest Region (MTO) to provide foundation investigation and design services for the proposed culvert replacement on Highway 17, in the Township of Coldwell and district of Thunder Bay. This assignment includes borehole investigations and design recommendations in support of the proposed structural culvert replacement of Neys Creek Culvert (Site No. 48E-0139/C0).

The existing culvert is a set of wooden box culverts, each approximately 2.1 m x 1.8 m and 23.5 m long. The site is located approximately 27.4 km west of Highway 627 on Highway 17. The site coordinates are as follows:

- Neys Creek Culvert, Station 16+441, CL, Latitude: 48.770604, Longitude: -86.551926
- Overflow culvert, Station 16+430, CL, Latitude: 48.770647, Longitude: -86.552057
- BH 1, Station 16+445, 14.1 m Lt, Latitude: 48.77070922, Longitude: -86.55179527
- BH 2, Station 16+449, 2.9 m Lt, Latitude: 48.77060133, Longitude: -86.55180984
- BH 3, Station 16+422, 5.0 m Rt, Latitude: 48.77064779, Longitude: -86.55219050
- BH 4, Station 16+447, 3.8 m Rt, Latitude: 48.77055661, Longitude: -86.55187829

A Google Earth image illustrating the site location can be seen in Figure 1.1.

Borehole investigations were carried out to investigate subsurface conditions at Neys Creek Culvert. The investigation consisted of four boreholes. All initial borehole locations were determined through consultation with MTO, while final borehole locations were adjusted to suit field conditions. This report (Part A) describes the subsurface conditions encountered during the investigation.

The MTO Foundations Section has assigned Geocres No. 42D-72 to this site.

Figure 1.1: A Google Earth Image Illustrating the Site Location.

2 Site Description

The site is a two lane, two-way, undivided section of existing paved roadway along Highway 17. Neys Creek flows from the north side of Highway 17 to the road to south side of Highway 17. The existing culvert is perpendicular to Highway 17. Neys Creek Culvert has a span of approximately 23.4 m with a width of 4.8 m and a height of 1.8 m with 2 m of fill above the culvert. The timber culvert consists of two cells, with a failing median wall.

2.1 Surficial Geology

As defined by the Ontario Ministry of Natural Resources' Northern Ontario Engineering Geology Terrain Study (NOEGTS) 60, 1979, Map No. 5093 "Heron Bay", the site is defined as a glaciolacustrine plain. The site generally has low relief and is dry.

The NOEGTS indicates the general landforms of the glaciolacustrine plain having 3 m to 6 m of silty sand overlying a clay that is often varved, with alternating layers of silt and clay. Sand, silt and clay within the site are generally very susceptible to erosion. The area has a subordinate landform consisting of a sand outwash plain. The field investigation indicates the presence of silts and sands and sandy clay. A bedrock out crop and shallow bedrock was observed and encountered on the site. No evidence of varving within the clay was encountered.

3 Investigation Procedures

Prior to commencement of the field investigation, a field visit was conducted on April 26, 2023. During the field review, the pavement conditions and drill access were assessed.

A geotechnical site investigation was undertaken from May 2, 2023 to May 9, 2023. The field investigation consisted of advancing a total of four boreholes. The boreholes have been labelled Borehole No. 23-BH-001 to 004 but will henceforth be referenced in the report as Boreholes 1 to 4. Initial borehole locations were established through consultation with MTO, while final borehole locations were adjusted to suit field conditions. Borehole locations are illustrated on the Borehole Location and Soil Strata Drawings provided in Appendix C.

Boreholes were advanced to a minimum depth of 10 m below the invert of culvert or to refusal on bedrock using casing advancer. The refusal material was cored at Boreholes 1 and 2 to confirm the presence of bedrock.

The borehole locations were identified in the field by TBTE personnel and service clearances were completed prior to mobilizing the drill rig to site. The boreholes were advanced using a drill rig mounted on an all-terrain carrier equipped with casing advancer and apparatus used to carry out Standard Penetration Testing. During the drilling operations for the boreholes, soil samples were obtained by using the techniques of the Standard Penetration Test (SPT). SPTs are typically taken at a frequency of every 0.75 m for the first 3 m of the borehole, and every 1.5 m afterwards, to the termination depth of the borehole. Sample frequency may vary due to circumstances experienced in the field. One thin-walled tube sample was recovered within the sandy clay material.

Borehole locations were surveyed by TBTE and referenced to a round iron bar (R.I.B.) as shown on the Borehole Location and Soil Strata Drawing. A hand-held Garmin GPS device was used in the field to locate borehole locations. A summary of the borehole location data is provided in the table below, and on the enclosed Borehole Location and Soil Strata Drawings (Appendix C).

Table 3.1: Summary of Borehole Information.

Borehole Number	Co-ordinates	Surface Elevation (m)	Depth of Exploration (m)
1	Lat: 48.77070922 Lon: -86.55179527	221.2	4.5
2	Lat: 48.77060133 Lon: -86.55180984	223.2	11.4
3	Lat: 48.77064779 Lon: -86.55219050	223.9	15.0
4	Lat: 48.77055661 Lon: -86.55187829	223.6	15.4

A temporary standpipe piezometer was installed at Borehole 1 to a depth of 1.5 m.

All boreholes, have been backfilled and/or decommissioned with auger cuttings and bentonite in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the water well regulation under the Ontario Water Resources Act).

4 Laboratory Testing

Soil samples obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content determination, grain size analysis and Atterberg limits testing. Typically, 100% of the recovered soil samples are tested for natural moisture content, and 25% of the recovered soil samples are chosen for grain size analysis and/or Atterberg limits testing, as applicable. The following test methods/standards are followed for the above testing: LS 602, LS 701, ASTM C136, ASTM D4318, ASTM D2216. The results of this testing are shown on the borehole logs (Appendix A) and on the laboratory data reports (Appendix B).

Rock core samples were obtained at Boreholes 1 and 2. The rock core samples were subjected to Rock Quality Designation (RQD) determination, point-load testing, and detailed rock core logging. One point-load test is typically chosen per 1 m of recovered sample. Point-load testing follows ASTM D5731.

One soil sample was submitted to the ALS Canada Ltd. laboratory in Thunder Bay, Ontario which was subjected to corrosivity and conductivity testing. Results of this testing have been provided below and in Appendix B.

5 Subsurface Conditions

Details of the subsurface conditions are provided on the borehole logs in Appendix A and on the Borehole Location and Soil Strata drawings in Appendix C.

The generalized subsurface soils at this site consist of asphalt or fill at surface overlying sands and silts to the termination of the boreholes. A sandy clay layer was encountered within the sands and silts.

5.1 Asphalt/Topsoil

A layer of asphalt, approximately 80 mm to 100 mm thick, was encountered at the surface of Boreholes 2 and 4, and approximately 50 mm of topsoil was encountered at the surface of Borehole 1.

5.2 Fill

A silty sandy clay fill, a sand and gravel fill, and a silty sand fill was encountered at Borehole 1, Borehole 2, and Boreholes 3 and 4, respectively. Rock fill was noted within the fill at Boreholes 1 and 4, and boulders were noted within the fill at Boreholes 2 and 3. The fill extends to depths ranging from 1.2 m to 3.7 m (elevation 219.4 m to 220.6 m). The results of five grain size analyses completed on non-cohesive fills indicate it can consist of 7-52% gravel, 41-62% sand and 6-33% silt/clay sized particles. This material is in a compact to dense condition based on SPT N-values ranging from 11 to 31 blows per 0.3 m. Instances of N-values of 100+ blows per 0.3 m may have been influenced by the presence of cobbles and/or boulders, or rock fill.

5.2.1 Possible Fill

Possible fill consisting of silt and sand with trace organics and wood debris was identified underlying the fill at Borehole 4. This material is approximately 1.1 m thick and extended to a depth of 4.5 m (elevation 219.1 m). The results of one grain size analysis indicate this material can consist of 0% gravel, 43% sand and 57% silt/clay sized particles. The condition of this material is loose to compact with SPT N-values of 3 and 10 blows per 0.3 m.

5.3 Organics

200 mm of organics was encountered underlying the fill at Borehole 3 extending to a depth of 3.5 m (elevation 220.4 m).

5.4 Upper Sands and Silts

Sand with trace silt to silt with trace sand with trace to some gravel and trace organics was identified underlying the fill at Boreholes 2 and 3 and underlying the possible fill at Borehole 4.

This material ranges in thickness from 2.6 m to 3.7 m and extends to depths ranging from 7.1 m to 7.2 m (elevation 216.0 m to 216.7 m). This material is in a very loose to loose condition based on SPT N-values ranging from 3 to 7 blows per 0.3 m. The results of three grain size analyses indicate this material can consist of 0-11% gravel, 6-45% sand and 52-94% silt/clay sized particles.

5.5 Clay

Sand and clay to silty clay with trace to some sand was present below the upper sands and silts at Boreholes 2, 3, and 4. This material ranges from 1.2 m to 6.1 m thick and extends to depths ranging from 8.4 m to 13.2 m (elevation 210.4 m to 214.8 m). The results of four Atterberg Limits tests indicate this material ranges from silty clay to clay of medium plasticity with the natural moisture content at or above the liquid limit. The results of five grain size analysis indicate this material can consist of 0% gravel, 10-40% sand and 60-90% silt/clay sized particles. Field vane tests at selected depths varied from 73 to 90 kPa; however, it is expected that presence of sand and silt have inflated the test results. This material has a very soft to firm consistency based on SPT N-values ranging from 1 to 4 blows per 0.3 m.

5.6 Lower Sand

Silty sand with some gravel to sand and gravel with trace silt was encountered at Boreholes 3 and 4. Occasional cobbles were encountered within this material. This material was present beneath the clay and extends to the termination of these boreholes at depths ranging from 15.0 m to 15.4 m (elevations 208.2 m to 208.9 m). The results of one grain size analysis indicate this material can consist of 31% gravel, 54% sand and 15% silt/clay sized particles. The condition of this material is compact with SPT N-values of 13 and 15 blows per 0.3 m. Instances of N-values greater than 100 blows per 0.3 m may have been on bedrock or influenced by the presence of cobbles and/or boulders.

5.7 Refusal and Bedrock

Auger refusal was encountered at Borehole 3 at a depth of 15.0 m. SPT refusal (100+ blows per 0.3 m) was encountered at Borehole 4 at a depth of 15.4 m and may have been encountered on cobbles or boulders. Bedrock was cored and sampled at Boreholes 1 and 2 at depths/elevations summarized below.

Table 5.1: Bedrock Depths/Elevations.

Location	Bedrock Surface	
	Depth (m)	Elevation (m)
Borehole 1	1.2	220.0
Borehole 2	8.4	214.8

The bedrock consisted of medium to coarse grained granite. Further details on the bedrock can be found on the rock core logs in Appendix A.

5.7.1 Rock Quality Designation (RQD)

The RQD is a measure of the number of fractures and jointing in a rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths greater than 100 mm to the total length cored. The RQD index is used to provide a classification for the rock quality according to the limits provided by the Canadian Foundation Engineering Manual (CFEM) which are shown in the table below.

Table 5.2: Classification of Rock with Respect to RQD Value.

RQD Classification	RQD Value (%)	Number of Occurrences
Very Poor Quality	< 25	0
Poor Quality	25 to 50	0
Fair Quality	50 to 75	0
Good Quality	75 to 90	1
Excellent Quality	90 to 100	3

The bedrock encountered at this site ranges from good to excellent quality with the rock quality designation (RQD) ranging from 89 to 100%.

5.7.2 Point-Load Testing

To estimate the strength of the bedrock encountered at this site, multiple point-load tests were completed on the core samples. The point-load test results are provided in the table below.

Table 5.3: Estimated Uniaxial Compressive Strength of Bedrock Samples.

Borehole	Sample	Depth from Ground Surface (m)	Estimated Uniaxial Compressive Strength* (MPa)
1	RC #1	1.3	37.7
1	RC #2	2.8	227.8
1	RC #2	4.0	194.5
2	RC #1	8.6	183.8
2	RC #2	9.4	148.3
2	RC #2	11.1	254.1

* Estimated in accordance with ASTM D5731-16.

Based on the range of estimated uniaxial compressive strengths of 184 MPa to 293 MPa, the bedrock is generally classified as “very strong” to “extremely strong”, with one “medium strong” according to the CFEM 4th Edition.

5.8 Corrosivity and Conductivity Testing

One soil sample from the Upper Sands and Silts at approximate elevation 219.4 m was submitted for corrosivity and conductivity testing, results of which are summarized in the table below. Detailed results are provided in Appendix B.

Table 5.4: Analytical Testing Results.

Test	Unit	Result
Conductivity	mS/cm	1600
Moisture	%	32.9
Acidity/Basicity	pH	5.72
Redox Potential	mV	349
Resistivity	ohm-cm	620
Chloride	mg/kg	1000
Sulphide (as S)	mg/kg	0.65
Sulphate	mg/kg	<20

5.9 Groundwater

The groundwater levels were read nine hours after completion of drilling within the temporary standpipe piezometer installed to a depth of 1.5 m at Borehole 1. Observed groundwater levels have been provided below. Water level readings are not taken upon completion of drilling where water is introduced to the boreholes to facilitate the advancement of casing and rock coring. This supply of water will potentially elevate water levels and provide misleading information. Groundwater levels may vary from season to season and from the effects of heavy precipitation events.

Table 5.5: Observed Groundwater Levels.

Location	Surface Elevation (m)	Groundwater Level, Depth (m)
Borehole 1	221.2	221.0 (9 hrs after completion)
Borehole 4	223.9	220.6 (upon completion)

The water level in the creek was recorded at 220.29 m (upstream) and 220.25 m (downstream) in May of 2023, as provided.

6 Miscellaneous

Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The drill equipment for this investigation was operated by TBT Engineering. The field operations were supervised by Glen Hephner. Laboratory testing was supervised by Forch Valela, C.Tech. This report was prepared and reviewed by Dean Vale, P.Eng., Steven Anderson, P.Eng., and Steven Seller, P.Eng. (TBTE's designated principal contact identified for MTO Foundation Engineering projects).

Part B - FOUNDATION DESIGN RECOMMENDATIONS

7 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ontario Ministry of Transportation Northwest Region (MTO) to provide foundation investigation and design services for the proposed culvert replacement on Highway 17, in the Township of Coldwell, and district of Thunder Bay. The existing culvert is a set of wooden box culverts, each approximately 2.1 m x 1.8 m and 23.5 m long. The site is located approximately 27.4 km west of Highway 627 west of Marathon. This assignment includes borehole investigations and design recommendations in support of the proposed structural culvert replacement of Neys Creek Culvert (Site No. 48E-0139/C0).

The foundation investigations as described in Part A, were carried out to investigate subsurface conditions at this site. The investigation consisted of four boreholes, laboratory testing and geotechnical analysis. Part A of this report describes the subsurface conditions encountered during the investigation. The subsurface soils at this site typically consist of surface embankment fills, and sands and silts overlying a sandy clay to silty clay stratum. The clay stratum is underlain by silt, sand and gravel overlying bedrock.

The purpose of this section of the report (Part B) is to provide foundation design recommendations for various foundation configurations and geotechnical aspects of the proposed project. These are based on the conditions encountered at the borehole locations, TBTE's interpretation of the subsurface conditions at the site and analyses of bearing capacity, settlement and stability.

8 Structure Foundation Options

Multiple foundation systems have been considered for the proposed culvert replacement. The foundation systems considered are presented in the table below.

Table 8.1: Foundation Options.

Option		Advantages	Disadvantages	Comments
Closed Bottom Culvert	Steel or Concrete Culvert with Appropriate Bedding	- Typically, the least costly option. - Less excavation than footings. - Least construction time required. - May be designed/installed to accommodate large settlements.	- Requires diversion of the Neys Creek and complete excavation and rehabilitation of the water course. - Bedrock excavation may be required.	Preferred from Foundation Perspective.
Open Bottom Culvert	Footings on Native Sands and Silts or Rock Fill Pad	- Longer spans may be considered to minimize construction within the existing channel.	- Excavation below water level is required. - Disturbance of subgrade during construction. - Requires deep excavation to place footings at frost depth. - Rock excavation may be required. - May require diversion of the Neys Creek to accommodate work in the dry.	Not Recommended.
	Driven Piles	- Typically, high geotechnical capacities can be achieved. - Longer spans may be considered to minimize construction within the existing channel.	- Short piles along the north side. - Driven piles are expected to encounter cobbles/boulders. - Specialty contractor would be required. - End bearing piles within the lower sand provide lower capacity than those ends bearing on bedrock. May require additional piles to meet requirements. - May require diversion of the Neys Creek to accommodate work in the dry. - Potential downdrag loads will reduce the structural capacity of the piles.	Not Recommended.

9 Foundation Recommendations

All design recommendations presented in this report assume that an adequate level of construction monitoring during excavation and construction will be provided. An adequate level of construction monitoring is examination of all excavation surfaces prior to fill and/or concrete placement to ensure the integrity of the subgrade. Full-time monitoring, materials testing, and compaction testing should be provided.

Unless noted otherwise, foundation parameters provided herein are for static, vertically and concentrically loaded foundations in compression.

Soil properties established for the foundation materials to conduct bearing capacity analyses have been presented below in Table 9.1. The strength properties of the native materials have been estimated based on published correlations with index tests. Typical strength properties have been selected for granular materials.

Table 9.1: Soil Properties for Geotechnical Analyses.

Soil	Effective Shear Strength Properties			Unit Weight, γ (kN/m³)
	Angle of Internal Friction, ϕ' (degrees)	Cohesion Intercept, c' (kPa)	Undrained Shear Strength Cu (kPa)	
Pavement Structure	32	0	0	21
Compacted Granular B, Type I	32	0	0	21
Existing Fill	30	0	0	20
Native Sands and Silts	29	0	0	20
Sandy Clay	24	0	30*	19
Sands and Gravels	30	0	0	20

*Estimated Cu value based on a Cu/P_0 ratio of 0.27.

For the following sections, where applicable, the following parameters apply, as per the 2019 version of the Canadian Highway Bridge Design Code (CHBDC):

- A resistance factor of 0.5 for static bearing capacity of footings based on a typical site understanding has been applied.
- A resistance factor of 0.8 has been applied to SLS foundation resistances.
- Resistance factors of 0.65 (permanent conditions) and 0.75 (temporary conditions) for analyses of global stability of abutments based on a typical site understanding have been applied.
- A consequence factor of 1.0 for Ultimate Limit State (ULS) and Serviceability Limit State (SLS) resistances based on an assumed typical consequence level has been applied.

9.1 Closed Bottom Culverts

Either steel pipe/arch or concrete box culverts may be considered. It is understood the proposed box culvert will be 4.3 m or 5.6 m wide by 2.3 m high. The culvert shall be placed on bedding fill material and backfilled in accordance with the appropriate OPSD 802 series drawings. Possible applicable OPSD drawings include the most recent versions of 802.020, 802.024, 802.030, 802.031, 802.034, 802.050, 802.051, 802.052, 802.054, 803.010, 803.030 and 803.031. The designer should choose which is the most appropriate drawing for the actual culvert chosen.

Geotechnical resistances at ULS and SLS for closed bottom culverts founded on loose native sands and silts or on a compacted granular pad are provided below, and are subject to the following conditions:

- Footings should not be founded on bedrock and soil. Footings should only be founded on soil (includes compacted granular pad).

- A minimum depth of cover as indicated in the tables below must be provided.
- Foundations are to be placed on bedding material, as required by the appropriate OPSD, overlying loose native sands and silts. Any very loose soil encountered at the subgrade level shall be removed and replaced with compacted bedding material.
- Foundations are designed based on the assumption that they are vertically and concentrically loaded foundations in compression.
- For the ULS provided below, it has been assumed that the culvert will comprise of multiple 3 m long sections, each having the following outside dimensions: 4.3 m or 5.6 m wide, and 2.3 m height.
- The base of the culvert will be embedded 0.3 m below the creek bed at approximate elevation of 219.8 m.

Table 9.2: Geotechnical Resistances for a Closed Bottom Culvert on Native Soil.

Effective Footing Width (m)	Depth of Cover to Underside of Footing (m)	Gross Factored Geotechnical Resistance, ULS (kPa)	Net Factored Geotechnical Resistance, SLS (kPa) for 25 mm settlement	Net Factored Geotechnical Resistance, SLS (kPa) for 50 mm settlement
4.3	0.3	105	18	35
5.6	0.3	110	17	33

Table 9.3: Geotechnical Resistances for a Closed Bottom Culvert on Compacted Granular Pad.

Effective Footing Width (m)	Compacted Granular Pad Thickness (m)	Depth of Cover to Underside of Footing (m)	Gross Factored Geotechnical Resistance, ULS (kPa)	Net Factored Geotechnical Resistance, SLS (kPa) for 25 mm settlement	Net Factored Geotechnical Resistance, SLS (kPa) for 50 mm settlement
4.3	0.5	0.3	185	21	41
4.3	1.0	0.3	185	28	56
5.6	0.5	0.3	190	20	39
5.6	1.0	0.3	190	27	52

SLS values have been estimated for settlements of 25 mm and 50 mm based on foundation loading only from structural loads (i.e. only loads on top of the culvert).

9.2 Open Bottom Culverts

Recommendations for strip footings have been provided. To eliminate the effects of frost, footings must be placed below the depth of frost penetration. The depth of frost penetration extends from the top of creek low water level or backfill.

The excavations required for placement of a footing at the frost depth should be considered when planning for the locations of the footings, especially if construction within the existing channel/creek is not permitted.

Construction should take place in the "dry". Dewatering/depressurising may prove challenging and shall be conducted in a controlled manner.

9.2.1 Spread Footings on Loose Native Soil

Strip footings founded on loose native sands and silts have been analyzed. The vertical factored geotechnical resistances for footings of various sizes founded on loose native sands and silts are provided in the table below.

The foundation resistances and recommendations provided below are based on the following design/construction criteria:

- Footings should not be founded on bedrock and soil. Footings should only be founded on soil.
- The footing must have a minimum depth of cover (vertical distance between the creek bed and the underside of the footing) of 2.2 m to place the footing at/below the design frost depth.
- As part of the subgrade preparation, any deleterious, cohesive or very loose soils must be removed from below the proposed foundations to expose, as a minimum, loose native sands and silts.
- Assumed underside of footing elevation of 217.6 m.

SLS values have been estimated for settlements of 25 mm and 50 mm based on foundation loading only from structural loads.

Table 9.4: Geotechnical Resistances and Reactions for Strip Footings Founded on Loose Native Soil.

Effective Footing Width (m)	Depth of Cover to Underside of Footing (m)	Factored Geotechnical Resistance, ULS (kPa)	Factored Geotechnical Resistance for SLS (kPa) for 25 mm settlement	Factored Geotechnical Resistance for SLS (kPa) for 50 mm settlement
1.0	2.2	265	28	49
1.5	2.2	220	21	37
2.0	2.2	195	16	30

9.2.2 Resistance to Lateral Loads

Resistance to lateral forces for footings (sliding) shall be calculated in accordance with Section 6.10.5 of the CHBDC using the following unfactored parameters and appropriate resistance factors from Section 6.9.1 of the CHBDC:

- Between pre-cast concrete and granular pads:
  - Coefficient of friction of 0.50.
- Between cast-in-place concrete and granular pads:
  - Coefficient of friction of 0.55.
- Between cast-in-place concrete and native sand to sand some silt subgrade:
  - Coefficient of friction of 0.40.
- Between cast-in-place concrete and native sand and silt to silty sand subgrade:
  - Coefficient of friction of 0.30.

9.3 Geotechnical Model for Global Stability

Stability modeling was completed using Slope/W software and limit equilibrium analysis using the Morgenstern-Price method. Stability modelling was carried out for global stability of the foundations and the approach embankments. The slope stability models have been included in Appendix D.

The soil properties established for the embankment and foundation materials are presented above in Table 9.1. The strength properties of the native soils have been estimated based on published correlations with index tests. Typical strength properties have been selected for the various potential fill materials.

Stability analyses have been completed to investigate excavation slopes and to assess the global stability of the final configuration. The designs are based on providing a minimum calculated factor of safety (FoS) against global instability for slip surfaces extending into the foundation soils as stated in Section 9. The resistance factors have been referenced from the CHBDC, as stated in Section 9. A uniformly distributed traffic load of 12 kPa over the traversable lanes was applied for permanent configurations.

9.3.1 Excavation Slopes for Footing Construction

The following recommendations have been derived based on minimum requirements for excavation for footing construction:

- Excavation cut slopes shall be no steeper than 3H:1V.
- Groundwater must be lowered to 1.0 m below the cut surface for slopes no steeper than 3H:1V.
- The base of the excavation shall extend no deeper than 2.2 m below the adjacent creek invert.
- Temporary sheet pile walls must be driven to a depth of at least 1.4 m below the base of excavation for global stability requirements (may need to be driven deeper for other requirements).

A minimum factor of safety of 1.3 was achieved for effective stress and total stress analysis of excavation slopes (see Figure D.1 and D.2 in Appendix D).

9.3.2 Global Stability for Open Bottom Culverts

The following assumptions were made for the slope stability analyses of the permanent footings used for the open bottom culvert (slip surface extending into the foundation soils):

- Depth of footing of 2.2 m (design frost depth) below the creek bed.
- Excavation slopes as provided above.
- All new fill materials will be compacted.
- The base of the excavation must be at least 2 m in width.
- Maximum width of culvert is 6.2 m.

A minimum factor of safety of 1.5 was exceeded for effective stress analysis of an open bottom culvert (see Figure D.3 in Appendix D).

9.3.3 Global Stability for Embankment Slopes

The following recommendations have been derived based on minimum requirements for general embankment slopes adjacent to the proposed culvert:

- Embankment slopes shall be no steeper than 2H:1V.

A minimum factor of safety of 1.5 was exceeded for effective stress (see Figure D.4 in Appendix D).

10 Embankment Settlement

It is understood that the existing embankment will not be raised, and no appreciable settlements are expected. Culverts will not require camber.

11 Subgrade Preparation

All very loose soil, cohesive, deleterious and/or organic soils must be removed from beneath the proposed foundation footprint to expose, as a minimum, loose native sands and silts. Should zones of the aforementioned materials be encountered during excavation, they should be removed and replaced with compacted granular materials such as Granular A or Granular B, Type I as per OPSS.PROV 1010 Apr. 2013. Where the depth of organics exceeds stripping depths (300 mm), the organics shall be removed in accordance with OPSD 203.010 Nov. 2017. Foundation excavations and bearing surfaces should be protected from rain, freezing temperature, excessive drying or the ingress of groundwater before, during and after construction.

12 Temporary Roadway Protection

Temporary roadway protection can be employed for this culvert replacement and be integrated into staging operations. Systems including, but not limited to soldier pile with lagging or sheet pile walls can be considered. Due to the variation in bedrock elevations, piled systems may not work and rock sockets may be required. Additionally, the presence of cobbles and boulders may cause problems with driving piles. Temporary roadway protection systems should be designed and constructed in accordance with OPSS 539 November 2014 for a minimum Performance Level 2, by engineers with a minimum of five years of experience designing similar systems. Design should also consider the global stability of the chosen traffic protection system. Design of roadway protection systems is the responsibility of the contractor. Material properties for the existing soils are provided in Section 13 and may be utilized for the design of temporary roadway protection for horizontal backfill.

13 Staged Construction

Staging of the concrete box culvert utilizing culvert extensions, widening, and lane shift to maintain single lane traffic may prove difficult at this location due the creek alignment, presence of existing utilities, bedrock outcrops and property limits. The use of a temporary bridge may prove challenging given the shallow depth of cover over the existing culvert.

Construction staging should consider the use of temporary traffic protection measures.

14 Backfill and Lateral Earth Pressures

The existing site materials are generally not suitable for use as structural backfill. Structural backfill should consist of Granular B, Type I, or Type II. Granular A may be specified as structural backfill in specific zones. Backfill materials shall be supplied, placed and compacted in accordance with OPSS.PROV 1010 Apr. 2013, OPSS.PROV 206 Nov. 2014, OPSS 902 Nov. 2010 and OPSS.PROV 501 Nov. 2014.

Lateral earth pressure coefficients for potential granular backfill and native soils at level ground conditions have been provided in the table below.

Table 14.1: Lateral Earth Pressure Coefficients.

Granular Backfill Material	ϕ' (°)	Bulk Unit Weight of Soil, γ (kN/m^3)	Lateral Earth Pressure Coefficients, K		
			Active K_a	At Rest K_0	Passive K_p
OPSS Granular A, or Granular B Type II (Compacted)	35	21	0.27	0.43	3.7
OPSS Granular B Type I (Compacted)	32	21	0.31	0.47	3.3
Existing Embankment Fill	30	20	0.33	0.50	3.0
Native Sands and Silts	29	20	0.35	0.52	2.9

A factor of safety or resistance factor has not been included in the above coefficients. A compaction surcharge should be added in accordance with Section 6.12.3 of the CHBDC. The effects of groundwater should be considered by the designer. Structures must also be designed to resist hydrostatic pressures where applicable.

15 Dewatering and Channel Diversion for Temporary Conditions

Recommendations for dewatering and channel diversion for temporary conditions have been provided in the following sections.

15.1 Dewatering

Dewatering systems should be designed in accordance with OPSS 517 and SP 517F01 July 2017, and it is recommended that any dewatering system be designed and checked by engineers with a minimum of five years of experience designing similar systems. The need for a permit to take water (PTTW) or the registration of the project on the MOECC's Environmental Activity and Sector Registry (EASR) should be determined by the Contractor.

The creek level at the time of this investigation was approximately 220.29 m. While groundwater flow through the native silts and clays is expected to be slow, higher groundwater seepage flows may be present through the more permeable upper fill sand and gravel.

Excavations for culvert construction and/or placement of fill are expected to extend below the ground and surface water level.

To facilitate construction in the dry, control of surface water and groundwater will be required. Dewatering of the site will likely require the use of coffer dams constructed across the water course. The complexity of the dewatering system will be governed by the depth of the excavation. Well points may be required. The presence of an overflow culvert located in close proximity to the culverts to be replaced could be used to facilitate pumping across the roadway, if the overflow culvert is not disturbed during excavation.

15.1.1 Preliminary Considerations for Cofferdams

The potential use of cofferdams/sheet piles during construction to control water conditions, aid in excavation and/or aid in placement of pre-loads may be considered at this location. A cofferdam system can range from earthen structures to sheet piles installed on or within low permeable soils.

Based on the subsurface conditions at the borehole locations, relatively low permeable soils are encountered (at depth) beneath the creek but are underlain by bedrock on the north side of the creek. The variability of the bedrock elevation could be problematic depending on the location of the cofferdams.

Cofferdam design should be completed by the contractor's designer and consider, but not limited to, the following potential issues:

- Requirement for bracing and/or tie backs.
- Global and internal stability.
- Sufficient seepage cut off measures be employed to avoid piping of the soil.
- Potential loss of soil adjacent to the cofferdam.
- Potential sheet pile refusal on cobbles or bedrock.

15.2 Channel Diversion

Channel diversion options are limited without the construction of a diversion and subsequent temporary culvert. The use of temporary cofferdams utilizing either controlled flow or pumping should be considered the best option for channel diversion.

16 Temporary Excavations

Excavations should be constructed in accordance with the requirements of the Occupational Health and Safety act. The soil through the embankment and the native sands and silts can be preliminarily classified as Type 3 soils, as defined by the Occupational Health and Safety Act and Regulations for Construction Projects. The soil types must be reassessed as excavations proceed and adjustments to construction methodologies should be taken as required. Cut slopes for unsupported temporary excavations shall be no steeper than those provided in previous sections of this report.

Surface surcharge loads should not be placed in close proximity to the edge of an excavation unless the stability of the excavation slope has been assessed. An operational constraint should be included within the contract documents to inform the contractor of the requirement to assess the slope where surcharges are placed in close proximity to the edge of an excavation. If a geotechnical assessment is found necessary, a Non-Standard Special Provision should be included within the contract documents to inform the contractor of the requirement that a RAQS qualified Foundation Engineering Service Provider shall be retained to conduct the analyses. Examples of the wording for these has been included in Appendix E.

Cobbles were noted during drilling operations in the fill material which could affect the installation of roadway protection measures. A notice to contractor should be included within the contract to inform the contractor of the presence of these potential obstructions. An example of the wording for this has been included in Appendix E.

17 Frost Penetration Depth

Based on OPSD 3090.100 November 2010 Foundation Frost Penetration Depths for Northern Ontario, the estimated frost depth penetration within the expected embankment fill is 2.2 m. The embankment soils anticipated within the frost depth are considered to be of low frost susceptibility (MTO Pavement Design and Rehabilitation Manual).

18 Corrosion and Sulphate Attack Potential

Corrosivity and sulphate content testing was conducted on one sample of the native soils, from approximate elevation of 219.4 m. Results of this testing are summarized above and are provided in Appendix B. The results of the tests indicate the following conditions at the test location:

- The sulphate was measured at <20 mg/kg (<0.0020%) and does not require sulphate resistant concrete since it is less than 0.1%.
- The resistivity was measured at 620 ohm-cm, which correlates to severe corrosiveness.
- The designer should consider exposure class C-1 or C-XL as required.

19 Scour Protection

Where appropriate, foundation elements should be provided with sufficient scour protection in the event of elevated creek water levels. The ultimate design of scour protection measures should be provided by engineers with sufficient experience. Scour protection should be designed in accordance with Section 1.9.5 of the CHBDC. Scour protection measures should also consider OPSS.PROV 511 Nov. 2018 and OPSS.PROV 1004 Nov. 2014. Where clay seals are considered, OPSS.PROV 1205 Apr. 2015 should be reviewed, and OPSD 810.010 Nov. 2018 for rip rap placement.

20 Erosion Protection

Exposed granular fill and native soils may be subject to erosion from surface water runoff. At areas where runoff is expected or observed during construction, the granular surface shall be provided with suitable erosion protection. Embankment slopes beyond specific erosion treatment locations should be treated as per the construction specification for seed and cover, OPSS.PROV 804 Nov. 2014. Erosion control blankets (ECB) may be utilized in conjunction with seed and cover operations. Bonded Fibre Matrix (BFM) application may also warrant consideration as an alternative treatment. These treatments should be applied at the discretion of the designer.

21 Seismic Considerations

Seismic analysis for the structure will not be required based on the following rationale as per the CHBDC S6-19. In accordance with Section 4.4.3.1 spectral ground acceleration data ($Sa_{(0.2)}$ of 0.112 and $Sa_{(1.0)}$ of 0.0585 with a peak horizontal ground acceleration of 0.652; corrected for site class) for the site was obtained from www.earthquakescanada.nrcan.gc.ca for a 2475 year return period. In accordance with Section 4.4.4, Table 4.10 and assuming the structures have a Seismic Importance Category of "Major-route and other bridges", the site is classified as Seismic Performance Category 1. As per Section 4.4.5.1, no seismic analyses are required for structures located in Seismic Performance Category 1. This site is considered Site Class D in accordance with Table 4.1 of the CHBDC S6-19.

22 Potential Construction Issues

No major construction difficulties are foreseen at this site. Issues that may require consideration include, but are not limited to:

- Should a high groundwater table be present during excavation of overburden, dewatering may be required to facilitate the construction of the graded filter, as well as blasting any bedrock. Dewatering systems should be designed in accordance with OPSS.PROV 517 Nov. 2016 and SSP 517F01 July 2017. It is recommended that any dewatering system be designed and checked by engineers with experience designing similar systems.
- There is potential for boulders greater than 1 m in diameter to be present at the surface as well as within the native soils. Removal of any boulders shall be in accordance with OPSS.PROV 201 Apr. 2019.
- Native silts and/or silty soils may be present under the pavement structure of the proposed alignment. These soils may be frost susceptible and may warrant excavation of this material prior to construction of the pavement structure. Native soils excavated from below the pavement structure should be replaced with a suitable, non-frost susceptible material in a compacted state.

23 Limitations

Conclusions and recommendations presented in this report are based on the information determined at a limited number of test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of the dewatering procedures which may be considered during construction cannot readily be determined from site investigation or boreholes. These conditions include local and seasonal fluctuations of the groundwater level, changes in soil conditions between borehole locations, thin and/or discontinuous layers of highly permeable soils, etc.

In no way does the information contained within this report reflect any environmental aspect of the site or soil.

24 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate to contact us at your convenience.

Yours truly,
For TBT ENGINEERING

Dean Vale, P.Eng.
Project Engineer

Steven Anderson, P.Eng.
Project Engineer

Steven Seller, P.Eng.
Senior Engineer
Principal Contact for MTO Foundations

APPENDIX A
Borehole Logs and Core Logs

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EXPLANAITION OF TERMS

N Value: The Standard Penetration Test (SPT) N value is the number of blows required to cause a standard 51mm O.D. split barrel sampler to penetrate 0.3m into undisturbed ground in a borehole when driven by a hammer with a mass of 63.5 kg, falling freely a distance of 0.76m. For penetrations of less than 0.3m N values are indicated as the number of blows for the penetration achieved. Average N value is denoted thus $\bar{N}$.

Dynamic Cone Penetration Test: Continuous penetration of a conical steel point (51mm O.D. 60˚ cone angle) driven by 475 J impact energy on 'A' size drill rods. The resistance to cone penetration is measured as the number of blows for each 0.3m advance of the conical point into the undisturbed ground.

Soils are described by their composition and consistency/condition.

Consistency: Cohesive soils are described on the basis of their undrained shear strength (c_u) as follows:

C_u (kPa)	0-12	12-25	25-50	50-100	100-200	>200
	Very Soft	Soft	Firm	Stiff	Very Stiff	Hard

Condition: Cohesionless soils are described on the basis of denseness as indicated by SPT N values as follows:

N (Blows/0.3m)	0-4	4-10	10-30	30-50	>50
	Very Loose	Loose	Compact	Dense	Very Dense

Minor Soil Components: Terminology used to represent the amount of minor components based on their percent of the sample by weight as follows:

% by weight	0-10	10-20	20-35	35-50
	Trace	Some	"ey" or "y"	And

ABBREVIATIONS AND SYMBOLS

Field Sampling, Insitu Testing, Laboratory Testing

S S	Split Spoon	T P	Thin Wall Piston
A S	Auger	O S	Osterberg
W S	Wash	R C	Rock Core
S T	Slotted Tube	P H	T W Advanced Hydraulically
B S	Block	P M	T W Advanced Manually
C S	Chunk	F S	Foil
V T	Vane Test (kPa)	P P	Pocket Penetrometer (kg/cm^2)
T W	Thin Wall Shellby Tube		

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EXPLANAITION OF TERMS Cont'd.

Stress and Strain

u_w	kPa	Pore Water Pressure
$_u$		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 Stress
ε	%	Linear Strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal Strains
E	MPa	Young's Modulus
G	kPa	Modulus of Shear Deformation
m	MPa	Constrained Modulus
μ		Coefficient of Friction

Mechanical Properties of Soil

m_v	kPa^{-1}	Coefficient of Volume Change
C_c		Compression Index
C_s		Swelling Index
C_a		Rate of Secondary Consolidation
c_v	m^2/s	Coefficient of Consolidation
H	m	Drainage Path
T_v		Time Factor
U	%	Degree of Consolidation
P'_o	kPa	Effective Overburden Pressure
P'_c	kPa	Preconsolidation Pressure
τ_f	kPa	Shear Strength
c'	kPa	Effective Cohesion Intercept
ϕ'	°	Effective Angle of Internal Friction
c_u	kPa	Undrainded Shear Strength
s		Sensitivity

Physical Properties of Soil

ρ_s	kg/m^3	Density of Solid Particles	e	%	Void Ratio	e_{min}	%	Void Ratio in Densest State
γ_s	kN/m^3	Unit Weight of Solid Particles	n	%	Porosity	I_D		Density Index $=\frac{e_{max}-e}{e_{max}-e_{min}}$
ρ_w	kg/m^3	Density of Water	w	%	Water Content	D	mm	Grain Diameter
γ_w	kN/m^3	Unit Weight of Water	S_r	%	Degree of Saturation	D_n	mm	n Percent Diameter
ρ	kg/m^3	Density of Soil	w_L	%	Liquid Limit	C_U		Uniformity Coefficient
γ	kN/m^3	Unit Weight of Soil	w_P	%	Plastic Limit	h	m	Hydraulic Head or Potential
ρ_d	kg/m^3	Density of Dry Soil	w_S	%	Shrinkage Limit	q	$m\ ^3/_5$	Rate of Discharge
γ_d	kN/m^3	Unit Weight of Dry Soil	I_P	%	Plasticity Index = w_L-w_P	v	m/s	Discharge Velocity
ρ_{sat}	kg/m^3	Density of Saturated Soil	I_L		Liquidity Index = $\frac{w-w_P}{I_P}$	i		Hydraulic Gradient
γ_{sat}	kN/m^3	Unit Weight of Saturated Soil	I_C		Consistency Index = $\frac{w_L-w}{I_P}$	k	m/s	Hydraulic Conductivity
ρ'	kg/m^3	Density of Submerged Soil	e_{max}	%	Void Ratio in Loosest State	j	kN/m^3	Seepage Force
γ'	kN/m^3	Unit Weight of Submerged Soil						

RECORD OF BOREHOLE No 23-BH-001

METRIC

W.P. 6022-E-0033	LOCATION Station 16+445 o/s 14.1m Lt of C/L N:5403685; E:337743 MTM Zone:14		ORIGINATED BY AF
DIST NWR HWY 17	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY TG
DATUM Geodetic	DATE 2023.05.08 - 2023.05.08	LATITUDE 48.7707092 LONGITUDE -86.5517953	CHECKED BY SS

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
221.2 / 0.0	TOPSOIL - 50 mm					Water level @ 0.15 m 9 hours after completion
220.9 / 0.1 (overprinted)	FILL - CLAY - Silty, Sandy, trace organics, brown to black, hard	1	SS	31	221	Cave @ 0.6 m.
	- - - - - - ROCKFILL	2	SS	100+		
220.0 / 1.2	BEDROCK - GRANITE See Rock Core Log for full description.	1	RC		220, 219	RC #1 REC 100% RQD 98% Temporary Standpipe installed to 1.5 m.
		2	RC		218, 217	RC #2 REC 99% RQD 100%
216.7 / 4.5	End of Borehole @ 4.5 m.					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PP=Pocket Penetrometer (Kg/cm^2)

RECORD OF BOREHOLE No 23-BH-002

METRIC

W.P. 6022-E-0033 LOCATION Station 16+449 o/s 2.9m Lt of C/L N:5403673; E:337742 MTM Zone:14 ORIGINATED BY AF

DIST NWR HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TG

DATUM Geodetic DATE 2023.05.03 - 2023.05.03 LATITUDE 48.7706013 LONGITUDE -86.5518098 CHECKED BY SS

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.2					
223.0 / 0.1	ASPHALT - 100 mm				36 56 (8)
	FILL - SAND & GRAVEL - trace silt, brown, compact	1	SS	24	40 54 (6)
					52 41 (7)
	- - - - - - SAND - some gravel, occasional cobbles - - - - - - numerous boulders	2	SS	100+	
					Cave @ 2.5 m.
219.4 / 3.8	SILT & SAND - trace gravel, trace organics, brown, very loose to loose				3 45 (52)
		3	SS	4	
		4	SS	3	Non Plastic.
		5	SS	4	Non Plastic.
216.0 / 7.2	CLAY - Sandy, grey, very soft				0 22 (78)
		6	SS	1	
214.8 / 8.4	BEDROCK - GRANITE See Rock Core Log for full description.	1	RC		RC #1 REC 97% RQD 89%
		2	RC		RC #2 REC 100% RQD 99%
211.8 / 11.4	End of Borehole @ 11.4 m.				

ELEVATION SCALE: 223, 222, 221, 220, 219, 218, 217, 216, 215, 214, 213, 212

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m³

GROUND WATER CONDITIONS

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE PP=Pocket Penetrometer (Kg/cm²)

RECORD OF BOREHOLE No 23-BH-003

METRIC

W.P. 6022-E-0033	LOCATION Station 16+422 o/s 5.0m Rt of C/L N:5403678; E:337714 MTM Zone:14		ORIGINATED BY AF
DIST NWR HWY 17	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY TG
DATUM Geodetic	DATE 2023.05.04 - 2023.05.04	LATITUDE 48.7706478 LONGITUDE -86.5521905	CHECKED BY SS

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
223.9 / 0.0	FILL - SAND - Silty, some to trace gravel, brown, compact - - - - - - numerous boulders
220.6 / 3.3	ORGANICS - trace sand, black
220.4 / 3.5	SAND - trace silt, trace organics, brown
220.2 / 3.7	SILT - trace sand, grey, loose
216.7 / 7.2	CLAY - Silty, trace to some sand, grey, very soft to soft - - - - - - Sandy
212.2 / 11.7	SAND - trace gravel, trace silt, brown, compact
210.8 / 13.1	SAND & GRAVEL - trace silt, occasional cobbles, brown
208.9 / 15.0	End of Borehole @ 15.0 m. Auger Refusal.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	14	
2	SS	19	17 62 (21)
3	SS	4	
4	SS	6	
5	SS	5	
6	SS	4	0 10 (90)
7	SS	1	0 27 (73)
8	SS	2	
9	SS	15	
10	SS	100+	

GROUND WATER CONDITIONS: water level symbol at approx. elev. 220.6

ELEVATION SCALE: 223, 222, 221, 220, 219, 218, 217, 216, 215, 214, 213, 212, 211, 210, 209

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60 — 106.3

UNIT WEIGHT γ kN/m³

REMARKS:

Water level @ 3.3 m on completion.

Cave @ 3.1 m.

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

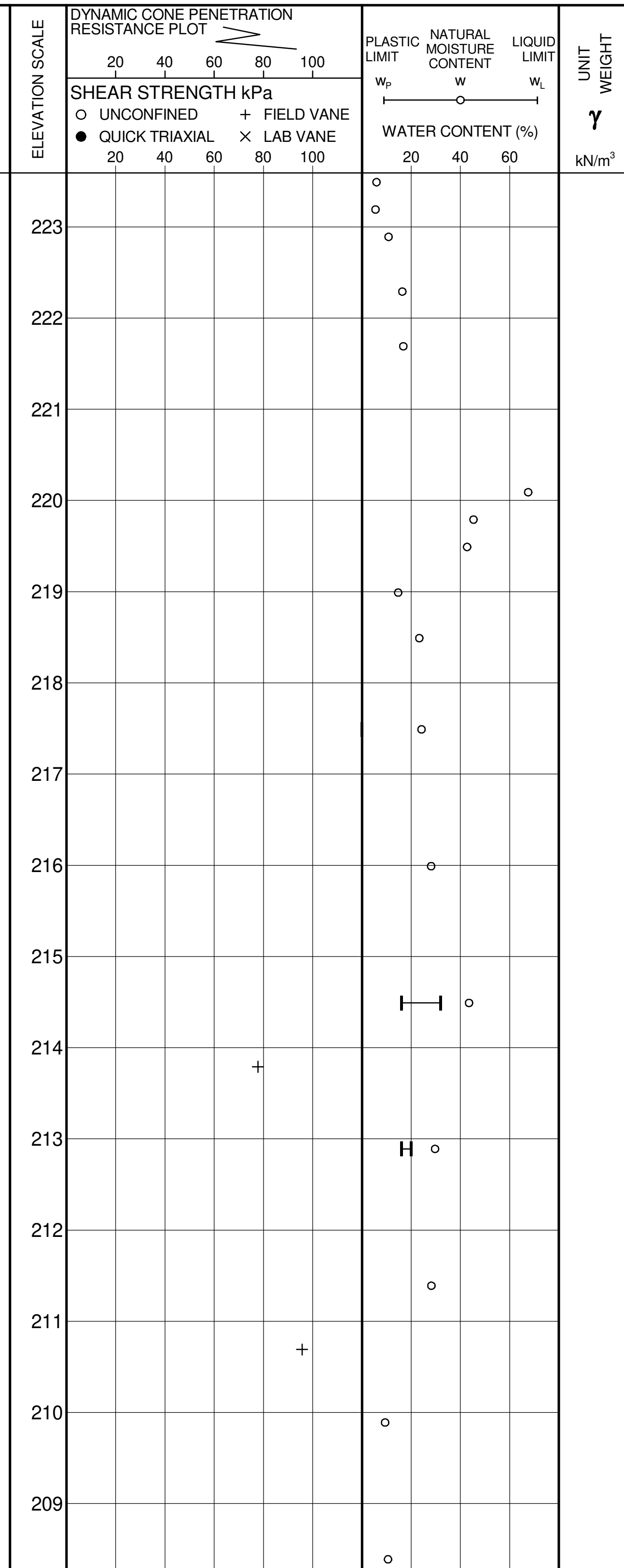
PP=Pocket Penetrometer (Kg/cm²)

RECORD OF BOREHOLE No 23-BH-004

METRIC

W.P.	6022-E-0033	LOCATION	Station 16+447 o/s 3.8m Rt of C/L N:5403668; E:337737 MTM Zone:14	ORIGINATED BY	AF
DIST	NWR HWY 17	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	TG
DATUM	Geodetic	DATE	2023.05.09 - 2023.05.09 LATITUDE 48.7705566 LONGITUDE -86.5518783	CHECKED BY	SS

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.6						
223.5 0.1	ASPHALT - 80 mm					Water @ 3.2 m 1 hour after completion.
	FILL - SAND - Silty, trace gravel, brown	1	SS	20		
		2	SS	18		
		3	SS	14		7 60 (33)
		4	SS	11		
	- - - - - - ROCK FILL				∇	
220.2 3.4		5	SS	100+		0 43 (57)
	SILT & SAND - trace organics, grey, very loose to compact (possible FILL)	6	SS	10		
219.1 4.5	- - - - - - some wood chunks	7	SS	3		
218.7 4.9	SAND - some gravel, trace organics, brown	8	SS	6		11 8 (81)
	SILT - trace to some gravel, trace sand, grey, loose	9	SS	7		
		10	SS	4		0 6 (94) Non Plasic. Cave @ 6.5 m.
216.5 7.1	CLAY & SAND to Sandy - grey, stiff	11	SS	1		
		12	TW			0 40 (60)
		13	SS	1		0 34 (66)
		14	SS	1		
210.4 13.2	SAND - Silty, some gravel, occasional cobbles, brown, compact	15	SS	12		
208.7 14.9	SAND - Gravelly, some silt, red/brown	16	SS	100+		31 54 (15)
208.2 15.4	End of Borehole @ 15.4 m.					



$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE   PP=Pocket Penetrometer (Kg/cm^2)

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP							
Project #:	23-138	**Site:**	Neys	**Logger:**	Leah Cosby	**Borehole #:**	BH1
Lab #:	23-909	**Client:**	MTO	**Date:**	17-May-23	**Page #:**	1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES: # OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES
From 1.22 To 3.02	1/1	100%	98%	**GRANITE** - red, medium- to coarse-grained, massive, mainly intact	H	U	1	F	D	C	RU	O	N	
From 3.02 To 4.47	1/2	99%	100%	**GRANITE** - grey to red, medium- to coarse-grained, massive, mainly intact	H	U	2	F	F	M	RU	O	SA	-fine-grained around 4.30 m for 10 cm
								F	V	N/A	SU	O	SA	

NOTES:

Strength (MPa)
VH = Very High = >200
H = High = 50-200
M = Medium = 15-50
L = Low = 4-15
VL = Very Low = 1-4

Weathering
U = Unweathered (No signs)
S = Slightly (Oxidized)
M = Moderately (Discoloured)
H = Highly (Friable)
C = Completely (Soil-like)

Type
B = Bedding joint
J = Cross Joint
F = Fault
S = Shear Plane

Orientation
F = Flat (0-20°)
D = Dipping (20-50°)
V = Near Vertical (>50°)

Spacing
VW = Very wide = >3m
W = Wide = 1-3m
M = Moderate = 0.3-1m
C = Close = 5-30cm
VC = Very close = <5cm

Roughness
RU = Rough undulating
RP = Rough planar
SU = Smooth undulating
SP = Smooth planar
LU = Slicken sided undulating
LP = Slicken sided planar

Aperture
O = Open
C = Closed
F = Filled

Filling
T = Tight, hard
O = Oxidized
SA = Slightly altered, clay free
S = Sandy, Clay free
Si = Sandy, silty, minor clay
NC = Non-softening clay
SC = Swelling, softening clay
N= No filling

*Strength shown above is estimated and not measured laboratory values

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP

Project #:	23-138	**Site:**	Neys	**Logger:**	Leah Cosby
Lab #:	23-891	**Client:**	MTO	**Date:**	17-May-23
Borehole #:	BH2	**Page #:**	1 of 1		

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES: # OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES
From 8.40 To 9.90	1/1	97%	89%	**GRANITE** - orange, medium- to coarse-grained, massive, intact and rubble	H	S	2	F	D	C	SU	O	SA	-black shale on fractured faces
								F	V	N/A	SU	F	SA	
From 9.90 To 11.40	1/2	100%	99%	**GRANITE** - orange, medium- to coarse-grained, massive, intact and broken pieces	H	U	2	F	D	C/M	RU	O	SA	-calcite veins beginning at 10.7 m to depth -fine-grained beginning at 10.8 m to depth
								F	V	N/A	SU	F	SA	

NOTES:

Strength (MPa)
VH = Very High = >200
H = High = 50-200
M = Medium = 15-50
L = Low = 4-15
VL = Very Low = 1-4

Weathering
U = Unweathered (No signs)
S = Slightly (Oxidized)
M = Moderately (Discoloured)
H = Highly (Friable)
C = Completely (Soil-like)

Type
B = Bedding joint
J = Cross Joint
F = Fault
S = Shear Plane

Orientation
F = Flat (0-20°)
D = Dipping (20-50°)
V = Near Vertical (>50°)

Spacing
VW = Very wide = >3m
W = Wide = 1-3m
M = Moderate = 0.3-1m
C = Close = 5-30cm
VC = Very close = <5cm

Roughness
RU = Rough undulating
RP = Rough planar
SU = Smooth undulating
SP = Smooth planar
LU = Slicken sided undulating
LP = Slicken sided planar

Aperture
O = Open
C = Closed
F = Filled

Filling
T = Tight, hard
O = Oxidized
SA = Slightly altered, clay free
S = Sandy, Clay free
Si = Sandy, silty, minor clay
NC = Non-softening clay
SC = Swelling, softening clay
N= No filling

*Strength shown above is estimated and not measured laboratory values

FULL ROCK CORE: Dry

FULL ROCK CORE: Wet

BH1 ROCK CORE: Detail #1

BH1 ROCK CORE: Detail #2

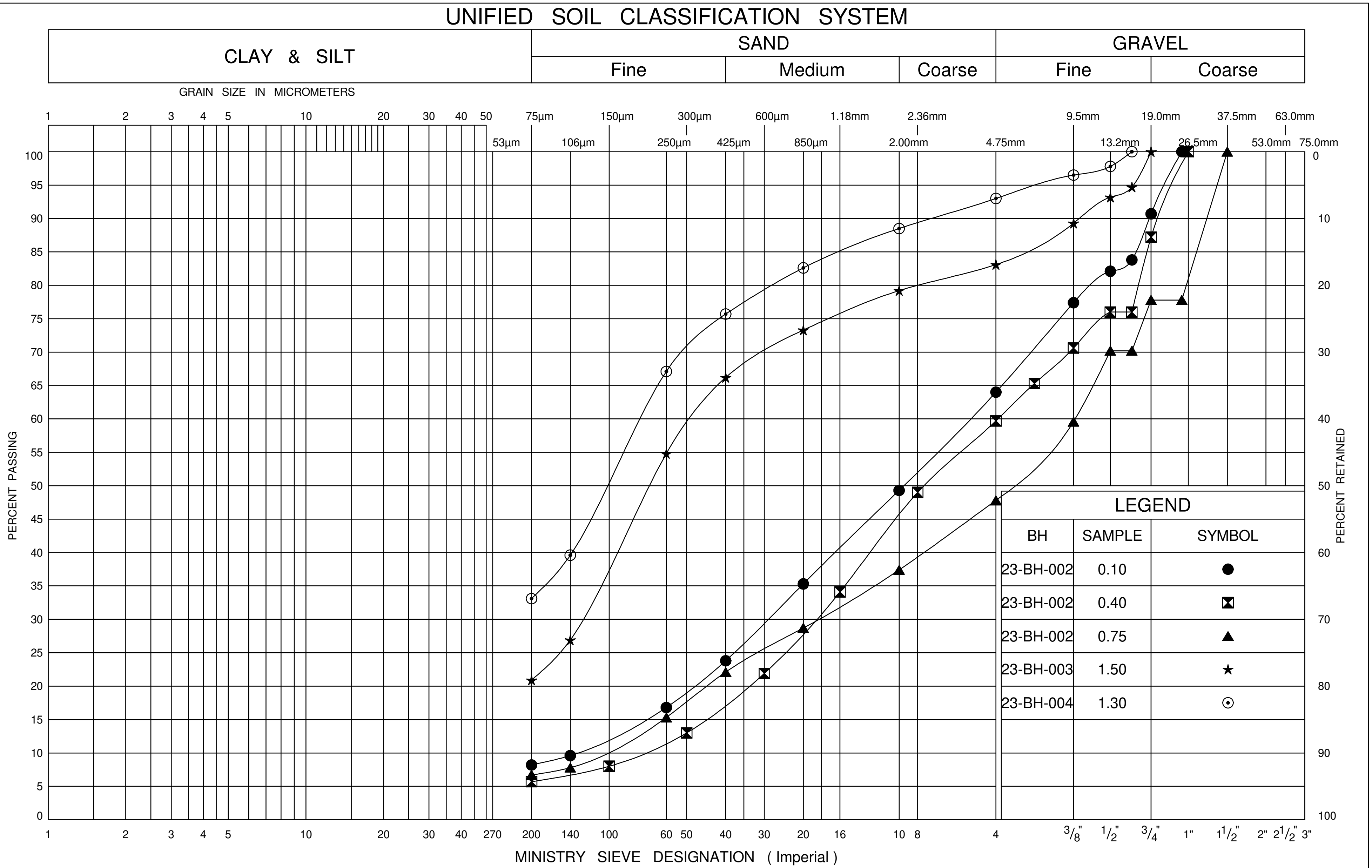
BH1 ROCK CORE: Detail #3

BH2 ROCK CORE: Detail #1

BH2 ROCK CORE: Detail #2

BH2 ROCK CORE: Detail #3

APPENDIX B
Laboratory Test Data



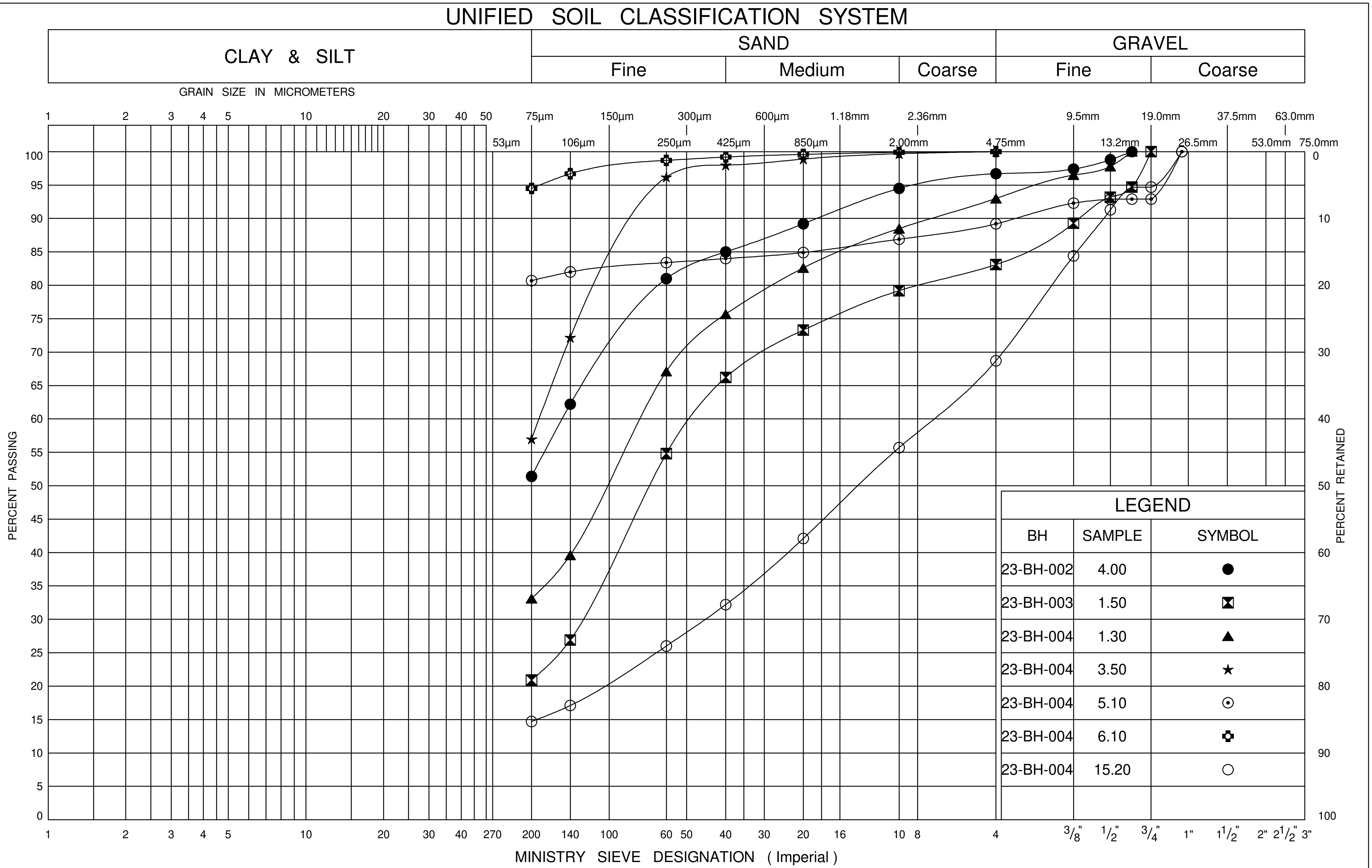
BH	SAMPLE	SYMBOL
23-BH-002	0.10	●
23-BH-002	0.40	⧗
23-BH-002	0.75	▲
23-BH-003	1.50	★
23-BH-004	1.30	⊙

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
FILL - CLAY / SAND & GRAVEL / SAND

FIG No 1
W P 6022-E-0033
Neys Creek

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
23-BH-002	4.00	●
23-BH-003	1.50	⊠
23-BH-004	1.30	▲
23-BH-004	3.50	★
23-BH-004	5.10	⊙
23-BH-004	6.10	✿
23-BH-004	15.20	○

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SILT & SAND / SILT / SAND - Silty / SAND - Gravelly

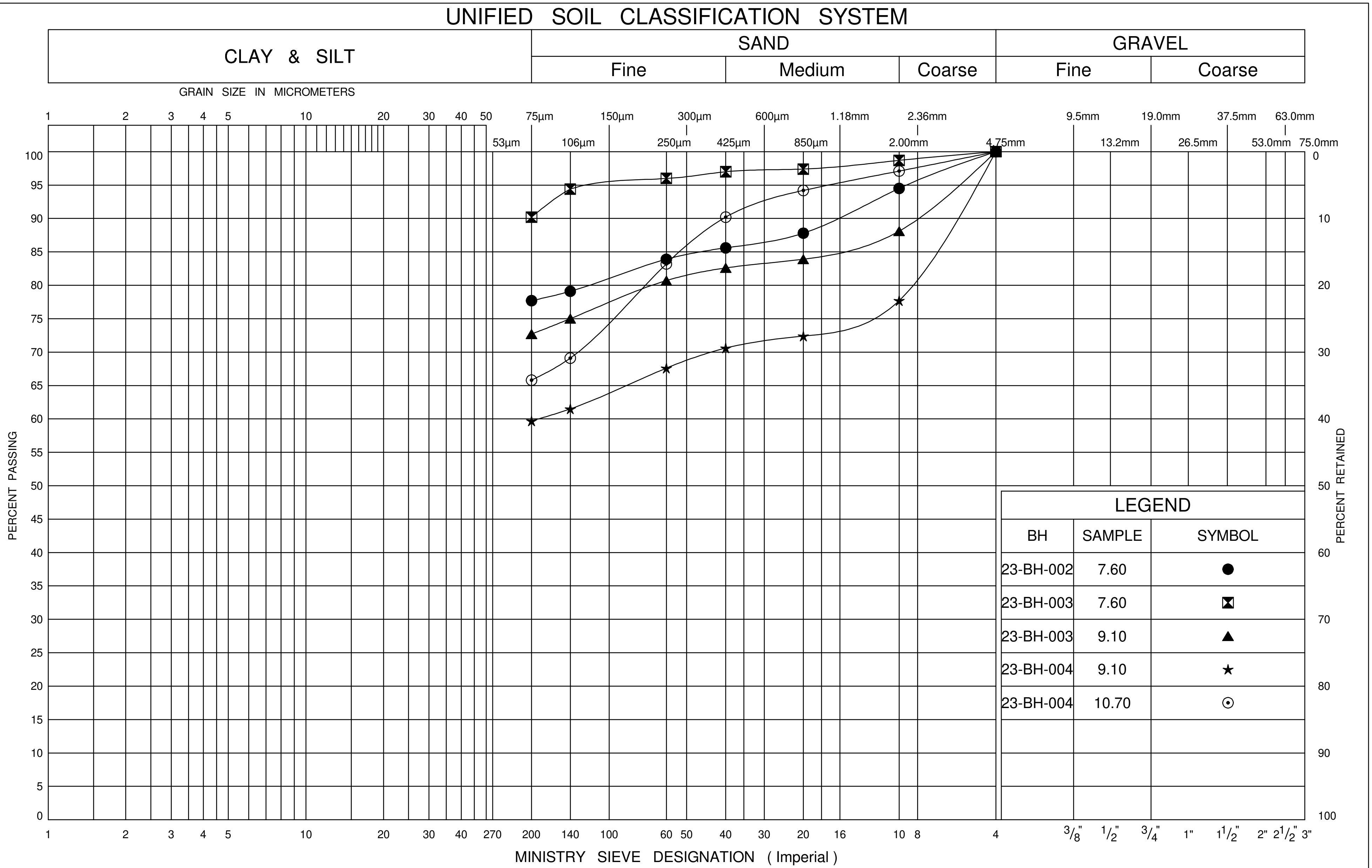
FIG No 2

W P 6022-E-0033

Neys Creek

ONTARIO MOT GRAIN SIZE 23-138 MTO NEYS CREEK.GPJ ONTARIO MOT.GDT 6-29-23

78 12 M



LEGEND		
BH	SAMPLE	SYMBOL
23-BH-002	7.60	●
23-BH-003	7.60	⊠
23-BH-003	9.10	▲
23-BH-004	9.10	★
23-BH-004	10.70	⊙

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
CLAY / CLAY & SAND

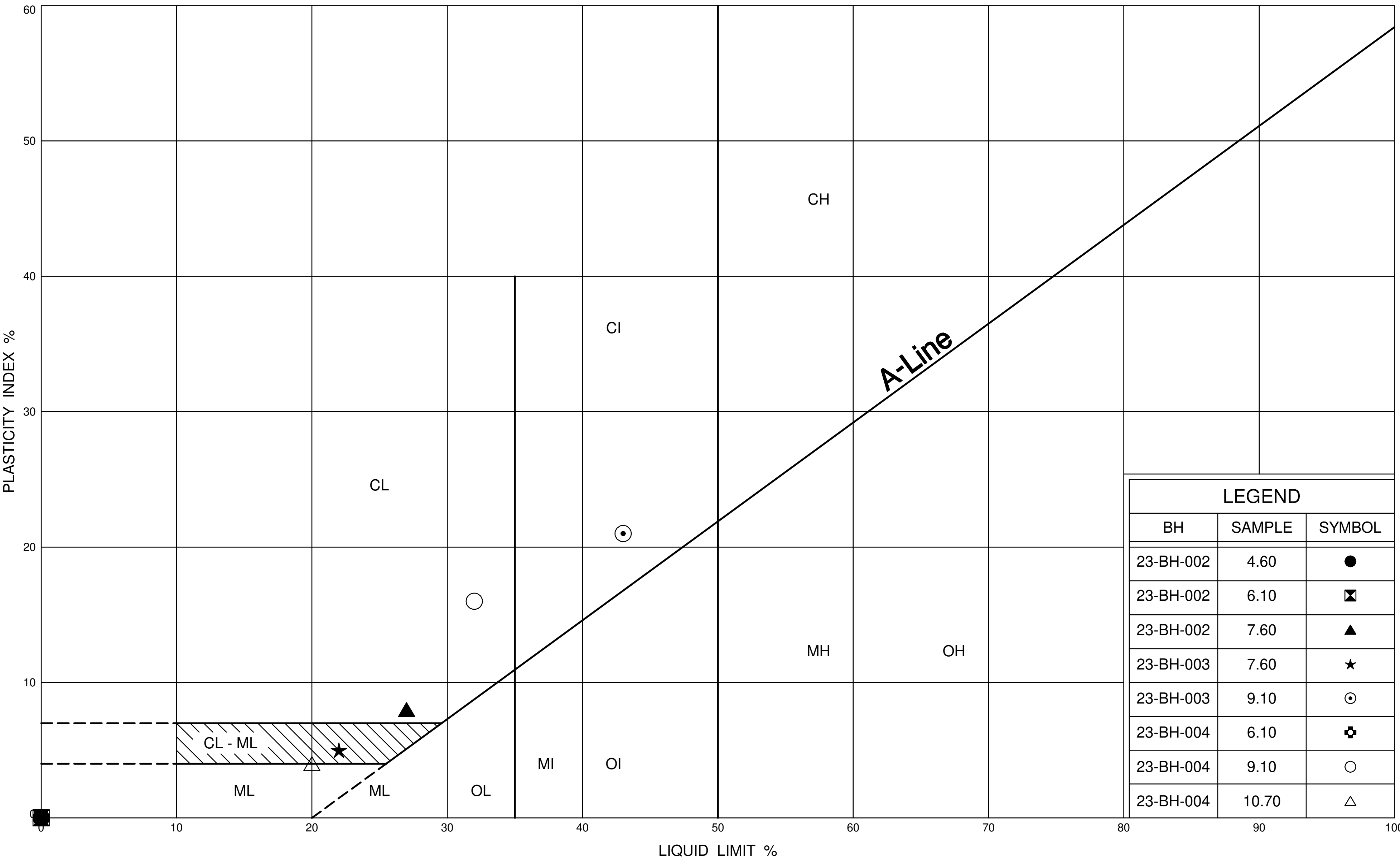
FIG No 3

W P 6022-E-0033

Neys Creek

ONTARIO MOT GRAIN SIZE 23-138 MTO NEYS CREEK.GPJ ONTARIO MOT.GDT 6-29-23

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
23-BH-002	4.60	●
23-BH-002	6.10	⧗
23-BH-002	7.60	▲
23-BH-003	7.60	★
23-BH-003	9.10	⊙
23-BH-004	6.10	✿
23-BH-004	9.10	○
23-BH-004	10.70	△

Ministry of Transportation
Ontario

PLASTICITY CHART

.

FIG No 4

W P 6022-E-0033

Neys Creek

ONTARIO MOT PLASTICITY CHART 23-138 MTO NEYS CREEK.GPJ ONTARIO MOT.GDT 6-29-23

CERTIFICATE OF ANALYSIS

Work Order	: **TY2309535**	Page	: 1 of 3
Client	: **TBT Engineering Group**	Laboratory	: ALS Environmental - Thunder Bay
Contact	: Doug Steele	Account Manager	: Cassidy Young
Address	: 1918 Younge Street Thunder Bay ON Canada P7E 6T9	Address	: 1081 Barton Street Thunder Bay ON Canada P7B 5N3
Telephone	: (807)624-5160	Telephone	: +1 807 623 6463
Project	: 23-138	Date Samples Received	: 21-Sep-2023 11:45
PO	: 9140	Date Analysis Commenced	: 22-Sep-2023
C-O-C number	: ----	Issue Date	: 25-Sep-2023 20:45
Sampler	: ----		
Site	:		
Quote number	: Standing Offer - Soil - 2023		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Greg Pokocky	Manager - Inorganics	Inorganics, Waterloo, Ontario
Niral Patel		Centralized Prep, Waterloo, Ontario

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
%	percent
µS/cm	microsiemens per centimetre
mg/kg	milligrams per kilogram
mV	millivolts
ohm cm	ohm centimetres (resistivity)
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Soil**

(Matrix: **Soil/Solid**)

Analyte	CAS Number	Method/Lab	LOR	Unit	HA Neys Culvert	----	----	----	----
				Client sampling date / time	20-Sep-2023 12:00	----	----	----	----
					TY2309535-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
Conductivity (1:2 leachate)	----	E100-L/WT	5.00	µS/cm	1600	----	----	----	----
Moisture	----	E144/WT	0.25	%	32.9	----	----	----	----
Oxidation-reduction potential [ORP]	----	E125/WT	0.10	mV	349	----	----	----	----
pH (1:2 soil:CaCl2-aq)	----	E108A/WT	0.10	pH units	5.72	----	----	----	----
Resistivity	----	EC100R/WT	100	ohm cm	620	----	----	----	----
Inorganics									
Sulfides, acid volatile	----	E396-L/WT	0.20	mg/kg	0.65	----	----	----	----
Leachable Anions & Nutrients									
Chloride, soluble ion content	16887-00-6	E236.Cl/WT	5.0	mg/kg	1000	----	----	----	----
Sulfate, soluble ion content	14808-79-8	E236.SO4/WT	20	mg/kg	<20	----	----	----	----

Please refer to the General Comments section for an explanation of any result qualifiers detected.

Please refer to the Accreditation section for an explanation of analyte accreditations.

ALS Canada Ltd.

right solutions.
right partner.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: TY2309535	Page	: 1 of 7
Client	: TBT Engineering Group	Laboratory	: ALS Environmental - Thunder Bay
Contact	: Doug Steele	Account Manager	: Cassidy Young
Address	: 1918 Younge Street Thunder Bay ON Canada P7E 6T9	Address	: 1081 Barton Street Thunder Bay, Ontario Canada P7B 5N3
Telephone	: (807)624-5160	Telephone	: +1 807 623 6463
Project	: 23-138	Date Samples Received	: 21-Sep-2023 11:45
PO	: 9140	Issue Date	: 25-Sep-2023 20:45
C-O-C number	: ----		
Sampler	: ----		
Site	:		
Quote number	: Standing Offer - Soil - 2023		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.

CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.

DQO: Data Quality Objective.

LOR: Limit of Reporting (detection limit).

RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Soil/Solid**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	*Method*	*Sampling Date*	*Extraction / Preparation*				*Analysis*			
			Preparation Date	*Holding Times Rec*	*Holding Times Actual*	*Eval*	*Analysis Date*	*Holding Times Rec*	*Holding Times Actual*	*Eval*
Inorganics : Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)										
Glass soil jar/Teflon lined cap [ON MECP] HA Neys Culvert	E396-L	20-Sep-2023	25-Sep-2023	14 days	5 days	✓	25-Sep-2023	7 days	0 days	✓
Leachable Anions & Nutrients : Water Extractable Chloride by IC										
Glass soil jar/Teflon lined cap [ON MECP] HA Neys Culvert	E236.Cl	20-Sep-2023	25-Sep-2023	30 days	5 days	✓	25-Sep-2023	28 days	0 days	✓
Leachable Anions & Nutrients : Water Extractable Sulfate by IC										
Glass soil jar/Teflon lined cap [ON MECP] HA Neys Culvert	E236.SO4	20-Sep-2023	25-Sep-2023	30 days	5 days	✓	25-Sep-2023	28 days	0 days	✓
Physical Tests : Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)										
Glass soil jar/Teflon lined cap [ON MECP] HA Neys Culvert	E100-L	20-Sep-2023	25-Sep-2023	30 days	5 days	✓	25-Sep-2023	30 days	5 days	✓
Physical Tests : Moisture Content by Gravimetry										
Glass soil jar/Teflon lined cap [ON MECP] HA Neys Culvert	E144	20-Sep-2023	----	----	----		22-Sep-2023	----	2 days	
Physical Tests : ORP by Electrode										
Glass soil jar/Teflon lined cap [ON MECP] HA Neys Culvert	E125	20-Sep-2023	23-Sep-2023	180 days	3 days	✓	25-Sep-2023	180 days	5 days	✓
Physical Tests : pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received										
Glass soil jar/Teflon lined cap [ON MECP] HA Neys Culvert	E108A	20-Sep-2023	22-Sep-2023	30 days	2 days	✓	25-Sep-2023	30 days	5 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Soil/Solid**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)	E396-L	1152369	1	10	10.0	4.7	✓
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1148816	1	16	6.2	5.0	✓
Moisture Content by Gravimetry	E144	1148031	1	20	5.0	5.0	✓
ORP by Electrode	E125	1149553	1	3	33.3	5.0	✓
pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received	E108A	1149284	1	15	6.6	5.0	✓
Water Extractable Chloride by IC	E236.Cl	1148819	1	1	100.0	5.0	✓
Water Extractable Sulfate by IC	E236.SO4	1148818	1	1	100.0	5.0	✓
Laboratory Control Samples (LCS)							
Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)	E396-L	1152369	1	10	10.0	4.7	✓
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1148816	2	16	12.5	10.0	✓
Moisture Content by Gravimetry	E144	1148031	1	20	5.0	5.0	✓
ORP by Electrode	E125	1149553	1	3	33.3	5.0	✓
pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received	E108A	1149284	1	15	6.6	5.0	✓
Water Extractable Chloride by IC	E236.Cl	1148819	2	1	200.0	10.0	✓
Water Extractable Sulfate by IC	E236.SO4	1148818	2	1	200.0	10.0	✓
Method Blanks (MB)							
Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)	E396-L	1152369	1	10	10.0	4.7	✓
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1148816	1	16	6.2	5.0	✓
Moisture Content by Gravimetry	E144	1148031	1	20	5.0	5.0	✓
Water Extractable Chloride by IC	E236.Cl	1148819	1	1	100.0	5.0	✓
Water Extractable Sulfate by IC	E236.SO4	1148818	1	1	100.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L ALS Environmental - Waterloo	Soil/Solid	CSSS Ch. 15 (mod)/APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a soil sample that has been added in a defined ratio of soil to deionized water, then shaken well and allowed to settle. Conductance is measured in the fluid that is observed in the upper layer.
pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received	E108A ALS Environmental - Waterloo	Soil/Solid	MECP E3137A	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C) and is carried out in accordance with procedures described in the Analytical Protocol (prescriptive method). A minimum 10g portion of the sample, as received, is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil by centrifuging, settling, or decanting and then analyzed using a pH meter and electrode.
ORP by Electrode	E125 ALS Environmental - Waterloo	Soil/Solid	APHA 2580 (mod)	Oxidation Redution Potential (ORP) is reported as the oxidation-reduction potential of the platinum metal-reference electrode employed in the analysis, measured in mV.
Moisture Content by Gravimetry	E144 ALS Environmental - Waterloo	Soil/Solid	CCME PHC in Soil - Tier 1	Moisture is measured gravimetrically by drying the sample at 105°C. Moisture content is calculated as the weight loss (due to water) divided by the wet weight of the sample, expressed as a percentage.
Water Extractable Chloride by IC	E236.Cl ALS Environmental - Waterloo	Soil/Solid	EPA 300.1	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection using a soil sample that has been added in a defined ratio of soil to deionized water, then shaken well and allowed to settle. Anions are measured in the fluid that is observed in the upper layer.
Water Extractable Sulfate by IC	E236.SO4 ALS Environmental - Waterloo	Soil/Solid	EPA 300.1	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection using a soil sample that has been added in a defined ratio of soil to deionized water, then shaken well and allowed to settle. Anions are measured in the fluid that is observed in the upper layer.
Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)	E396-L ALS Environmental - Waterloo	Soil/Solid	APHA 4500S2J	This analysis is carried out in accordance with the method described in APHA 4500 S2-J. After extraction the Acid Volatile Sulphide is determined colourimetrically.
Resistivity Calculation for Soil Using E100-L	EC100R ALS Environmental - Waterloo	Soil/Solid	APHA 2510 B	Soil Resistivity (calculated) is determined as the inverse of the conductivity of a 2:1 water:soil leachate (dry weight). This method is intended as a rapid approximation for Soil Resistivity. Where high accuracy results are required, direct measurement of Soil Resistivity by the Wenner Four-Electrode Method (ASTM G57) is recommended.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Leach 1:2 Soil:Water for pH/EC	EP108 ALS Environmental - Waterloo	Soil/Solid	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL	The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water.
Leach 1:2 Soil : 0.01CaCl2 - As Received for pH	EP108A ALS Environmental - Waterloo	Soil/Solid	MOEE E3137A	A minimum 10g portion of the sample, as received, is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil by centrifuging, settling or decanting and then analyzed using a pH meter and electrode.
Preparation of ORP by Electrode	EP125 ALS Environmental - Waterloo	Soil/Solid	APHA 2580 (mod)	Field-moist sample is extracted in a 1:2 ratio with DI water and then analyzed by ORP meter.
Anions Leach 1:10 Soil:Water (Dry)	EP236 ALS Environmental - Waterloo	Soil/Solid	EPA 300.1	5 grams of dried soil is mixed with 50 grams of distilled water for a minimum of 30 minutes. The extract is filtered and analyzed by ion chromatography.
Distillation for Acid Volatile Sulfide in Soil	EP396-L ALS Environmental - Waterloo	Soil/Solid	APHA 4500S2J	Acid Volatile Sulfide is determined by colourimetric measurement on a sediment sample that has been treated with hydrochloric acid within a purge and trap system, where the evolved hydrogen sulfide gas is carried into a basic solution by argon gas for analysis.

QUALITY CONTROL REPORT

Work Order	: **TY2309535**		Page	: 1 of 5
Client	: TBT Engineering Group		Laboratory	: ALS Environmental - Thunder Bay
Contact	: Doug Steele		Account Manager	: Cassidy Young
Address	: 1918 Younge Street Thunder Bay ON Canada P7E 6T9		Address	: 1081 Barton Street Thunder Bay, Ontario Canada P7B 5N3
Telephone	:		Telephone	: +1 807 623 6463
Project	: 23-138		Date Samples Received	: 21-Sep-2023 11:45
PO	: 9140		Date Analysis Commenced	: 22-Sep-2023
C-O-C number	: ----		Issue Date	: 25-Sep-2023 20:45
Sampler	: ----	(807)624-5160		
Site	:			
Quote number	: Standing Offer - Soil - 2023			
No. of samples received	: 1			
No. of samples analysed	: 1			

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percent Difference (RPD) and Data Quality Objectives
- Reference Material (RM) Report; Recovery and Data Quality Objectives
- Method Blank (MB) Report; Recovery and Data Quality Objectives
- Laboratory Control Sample (LCS) Report; Recovery and Data Quality Objectives

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Greg Pokocky	Manager - Inorganics	Waterloo Inorganics, Waterloo, Ontario
Niral Patel		Waterloo Centralized Prep, Waterloo, Ontario

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percent Difference
# = Indicates a QC result that did not meet the ALS DQO.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test-specific).

Sub-Matrix: **Soil/Solid**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 1148031)											
HA2300713-001	Anonymous	Moisture	----	E144	0.25	%	13.7	16.1	16.4%	20%	----
Physical Tests (QC Lot: 1148816)											
WT2330353-004	Anonymous	Conductivity (1:2 leachate)	----	E100-L	5.00	µS/cm	0.246 mS/cm	251	2.01%	20%	----
Physical Tests (QC Lot: 1149284)											
TY2309535-001	HA Neys Culvert	pH (1:2 soil:CaCl2-aq)	----	E108A	0.10	pH units	5.72	5.74	0.349%	5%	----
Physical Tests (QC Lot: 1149553)											
TY2309535-001	HA Neys Culvert	Oxidation-reduction potential [ORP]	----	E125	0.10	mV	349	356	1.98%	25%	----
Inorganics (QC Lot: 1152369)											
TY2309535-001	HA Neys Culvert	Sulfides, acid volatile	----	E396-L	0.29	mg/kg	0.65	0.67	0.02	Diff <2x LOR	----
Leachable Anions & Nutrients (QC Lot: 1148818)											
TY2309535-001	HA Neys Culvert	Sulfate, soluble ion content	14808-79-8	E236.SO4	20	mg/kg	<20	<20	0.004	Diff <2x LOR	----
Leachable Anions & Nutrients (QC Lot: 1148819)											
TY2309535-001	HA Neys Culvert	Chloride, soluble ion content	16887-00-6	E236.Cl	5.0	mg/kg	1000	929	7.72%	30%	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Soil/Solid**

Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	*Result*	*Qualifier*
Physical Tests (QCLot: 1148031)						
Moisture	----	E144	0.25	%	<0.25	----
Physical Tests (QCLot: 1148816)						
Conductivity (1:2 leachate)	----	E100-L	5	µS/cm	<5.00	----
Inorganics (QCLot: 1152369)						
Sulfides, acid volatile	----	E396-L	0.2	mg/kg	<0.20	----
Leachable Anions & Nutrients (QCLot: 1148818)						
Sulfate, soluble ion content	14808-79-8	E236.SO4	20	mg/kg	<20	----
Leachable Anions & Nutrients (QCLot: 1148819)						
Chloride, soluble ion content	16887-00-6	E236.Cl	5	mg/kg	<5.0	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Soil/Solid**

Analyte	CAS Number	Method	LOR	Unit	Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Physical Tests (QCLot: 1148031)									
Moisture	----	E144	0.25	%	50 %	98.4	90.0	110	----
Physical Tests (QCLot: 1148816)									
Conductivity (1:2 leachate)	----	E100-L	5	µS/cm	1409 µS/cm	97.6	90.0	110	----
Physical Tests (QCLot: 1149284)									
pH (1:2 soil:CaCl2-aq)	----	E108A	----	pH units	7 pH units	100	98.0	102	----
Inorganics (QCLot: 1152369)									
Sulfides, acid volatile	----	E396-L	0.2	mg/kg	2.54 mg/kg	102	70.0	130	----
Leachable Anions & Nutrients (QCLot: 1148818)									
Sulfate, soluble ion content	14808-79-8	E236.SO4	20	mg/kg	5000 mg/kg	100	80.0	120	----
Leachable Anions & Nutrients (QCLot: 1148819)									
Chloride, soluble ion content	16887-00-6	E236.Cl	5	mg/kg	5000 mg/kg	99.7	80.0	120	----

Reference Material (RM) Report

A Reference Material (RM) is a homogenous material with known and well-established analyte concentrations. RMs are processed in an identical manner to test samples, and are used to monitor and control the accuracy and precision of a test method for a typical sample matrix. RM results are expressed as percent recovery of the target analyte concentration. RM targets may be certified target concentrations provided by the RM supplier, or may be ALS long-term mean values (for empirical test methods).

Sub-Matrix:

Laboratory sample ID	Reference Material ID	Analyte	CAS Number	Method	RM Target Concentration	Recovery (%) RM	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Physical Tests (QCLot: 1148816)									
	RM	Conductivity (1:2 leachate)	----	E100-L	1725.6 µS/cm	103	70.0	130	----
Physical Tests (QCLot: 1149553)									
	RM	Oxidation-reduction potential [ORP]	----	E125	475 mV	103	90.0	110	----
Leachable Anions & Nutrients (QCLot: 1148818)									
	RM	Sulfate, soluble ion content	14808-79-8	E236.SO4	1070 mg/kg	104	70.0	130	----
Leachable Anions & Nutrients (QCLot: 1148819)									
	RM	Chloride, soluble ion content	16887-00-6	E236.Cl	432 mg/kg	95.8	70.0	130	----

ALS

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

[redacted] Aff

Telephone : +1 807 623 6463

COC Number: 14 -

Page 1 of 1

Report To		**Report Format / Distribution**	**Select Service Level Below** (Rush Turnaround Time (TAT) is not available for all tests)
Company:	TBT Engineering Limited	Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)	R ☐ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Doug Steele	Quality Control (QC) Report with Report ☑ Yes ☐ No	P ☑ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	1918 Yonge Street, Thunder Bay, ON, P7E 6T9	☐ Criteria on Report - provide details below if box checked	E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
		Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	807-624-5160	Email 1 or Fax mmorrison@tbte.ca, lfraser@tbte.ca	Specify Date Required for E2,E or P:
		Email 2 sseller@tbte.ca, sanderson@tbte.ca	

Invoice To		**Invoice Distribution**
Same as Report To	☑ Yes ☐ No	
Copy of Invoice with Report	☐ Yes ☐ No	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Company:		Email 1 or Fax accounting@tbte.ca
Contact:		Email 2 sseller@tbte.ca, sanderson@tbte.ca

Project Information		**Oil and Gas Required Fields (client use)**	
ALS Quote #:		Approver ID:	Cost Center:
Job #:	23-138	GL Account:	Routing Code:
PO / AFE:	9140	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:** CP	**Sampler:** LF

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH, Cl, SO4, Sulphide	Resistivity, EC, Moisture	Redox Potential	Number of Containers
	HA Neys Culvert	20-09-23	12pm	Soil	P	P	P	

Drinking Water (DW) Samples[1] (client use)	**Special Instructions / Specify Criteria to add on report (client Use)**
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	
Are samples for human drinking water use? ☐ Yes ☑ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐		SIF Observations	Yes ☐ No ☐
Ice packs	Yes ☐ No ☐	Custody seal intact	Yes ☐ No ☐
Cooling Initiated ☐	NA		

INITIAL COOLER TEMPERATURES °C	FINAL COOLER TEMPERATURES °C
16.0	

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Lucas Fraser	Date: Sept 21/23	Time: 11am	Received by:	Date:	Time:	Received by: LV	Date: 9/21/23	Time: 11:45

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-0326e v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

Drop-off No Cooler

Intake and Login Verification Form

SAMPLE INTAKE				
Priority/Emergency Service Requested			YES (circled)	NO
Time Sensitive Hold Time			YES	NO (circled)
Client:	TBT Eng.			
SAMPLE RECEIPT INFORMATION				
Mode of Delivery:		Courier	Drop Off (circled)	
Courier				
Waybill Number				
Temperature	16.0		Cooler Count —	
Cooling Method	None (circled)	Ice	Ice Packs	
SAMPLE MATRIX/BOTTLE INFORMATION				
Matrix:	Water	Soil (circled)	Air	Biota / Other
DW Schedule 24 Bottles Correct?			~~Yes~~	~~No~~
DW Metals pH Check <2			~~Yes~~	No
Regulation Circled, Works # present		~~Yes~~	~~No - Reject?~~	
# of Bottles:	1	Sample Count	1	
Green/white				
Purple/white				
Warm red/white				
Yellow/black				
Light blue/white				
Orange/black				
Others (detail)	2 Jars			
Comments on Samples and Bottles:				
Samples Requiring Preservation or Filtering:				
Layout Staff Initials Date and Time of Layout	LV 9/21/23 11:45			

ACCOUNT INFO VERIFICATION		
Priority/Emergency Service Requested	YES (circled)	NO
Confirmed all as accurate as per COC, Sample Remarks or PM		
Client ✓	Work Contact ✓	Quote ✓
RECEIPT DETAIL		
Project ✓	PO ✓	Site/LSD
Overall Description Entered	Yes	NA (circled)
Received date/time as per COC	✓	
Recipients match CoC or Sample Remarks	Yes (circled)	No
Billing Instruction added to remarks	Yes (circled)	NA
Sample Remarks/Specification Doc checked	✓	
Submission Issues communicated	Yes	NA (circled)
Sample Info communicated via Remarks	Yes	NA (circled)
VERIFICATION CHECKLIST		
Plannned Event Submission	Yes	No (circled)
Sample Name entered as per CoC	✓	
Sampling Date and time entered as per CoC	✓	
Containers selected in layout order	✓	
Sales items entered from QUOTE ONLY (and/or verified as correct)	✓	
Field Data/EC298A removed if not on COC	Yes	NA (circled)
Bottle Allocation Verified	✓	
Guideline added or auto-allocated	✓	
Due dates updated	✓	
VALIDATION		
Validation errors resolved?	Yes (circled)	No
Internal Sublet CoC created	Yes (circled)	NA
Login Comments:		
Login Staff Initials:	[signature]	

APPENDIX C
Borehole Location and Soil Strata Drawings

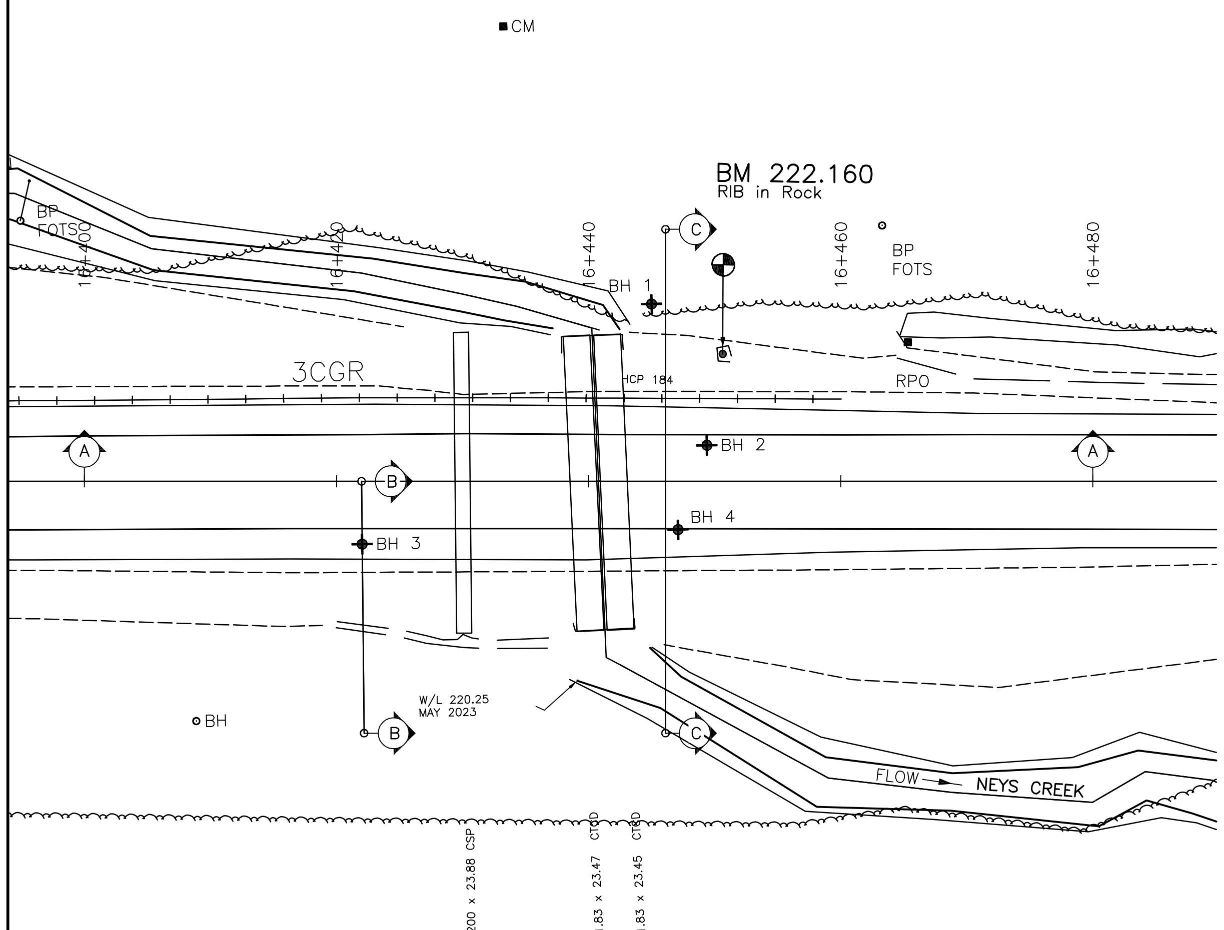
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

Ontario — Ministry of Transportation	
GEOCRES	42D-72
CONT	x
GWP	6022-E-0033

BOREHOLE LOCATIONS AND SOIL STRATA
NEYS CREEK
HIGHWAY 17, TOWNSHIP OF COLDWELL

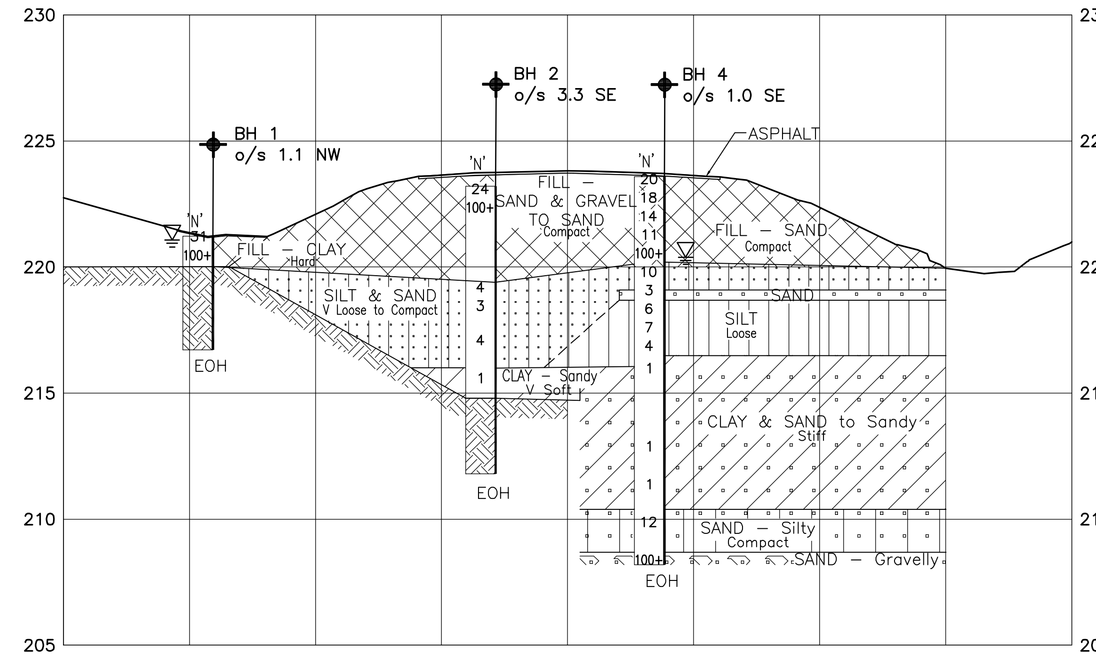
SHEET X

TBT ENGINEERING CONSULTING GROUP



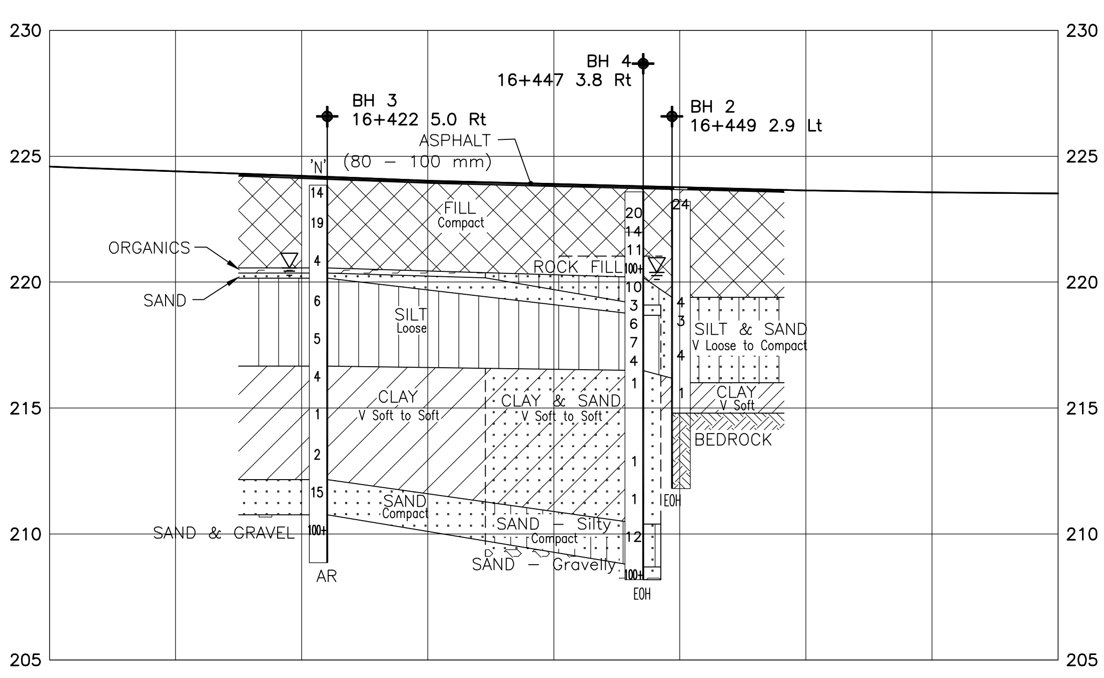
PLAN

SCALE 0 5 10 15 20m



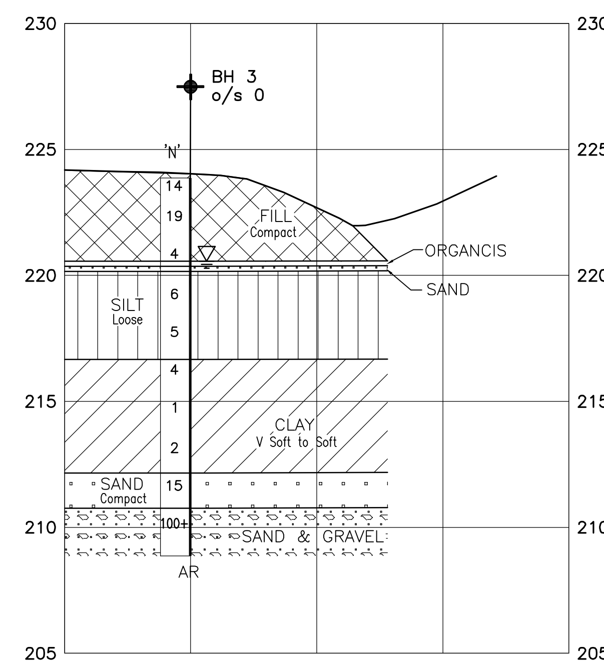
SECTION C–C

SCALE 0 5 10 15 20m



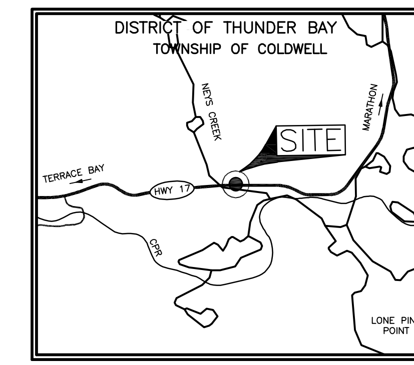
SECTION A–A

SCALE HOR 10 5 0 5 10 15 20 m
VERT 5 0 5 10 m



SECTION B–B

SCALE 0 5 10 15 20m



KEY PLAN

2.0 km 0 2.0 km

SOIL STRATA SYMBOLS

ASPHALT, ORGANICS, FILL, SILT, SILT & SAND, CLAY, SAND, SAND – Silty, SAND & GRAVEL/SAND – Gravelly, CLAY & SAND, BEDROCK

LEGEND

Symbol	Meaning
✦	Borehole
'N'	Std Pen Test (Blows/0.3m)
∇	Water Level on Completion
EOH	End of Hole

No	ELEVATION	CO-ORDINATES (MTM) NORTH	EAST
BH 1	221.22	15 5 403 684	337 743
BH 2	223.62	15 5 403 672	337 742
BH 3	223.86	15 5 403 677	337 714
BH 4	223.59	15 5 403 667	337 737

–NOTE–
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS		
2	SS	ISSUED FOR FINAL
1	SS	ISSUED FOR REVIEW

DESIGN XX	CHK XX	CODE XXXXXX	LOAD XXXX	DATE 27/09/23
DRAWN TG	CHK SS	SITE XXXXX		DWG 1

FILE NAME: Y:\Projects\2023\23-138 MTO, Preliminary Design, Neys Creek\Drawings\Foundations\Neys Creek Soil Strata.dwg
MODIFIED: 2023-09-27 16:06

APPENDIX D
Slope Stability Models

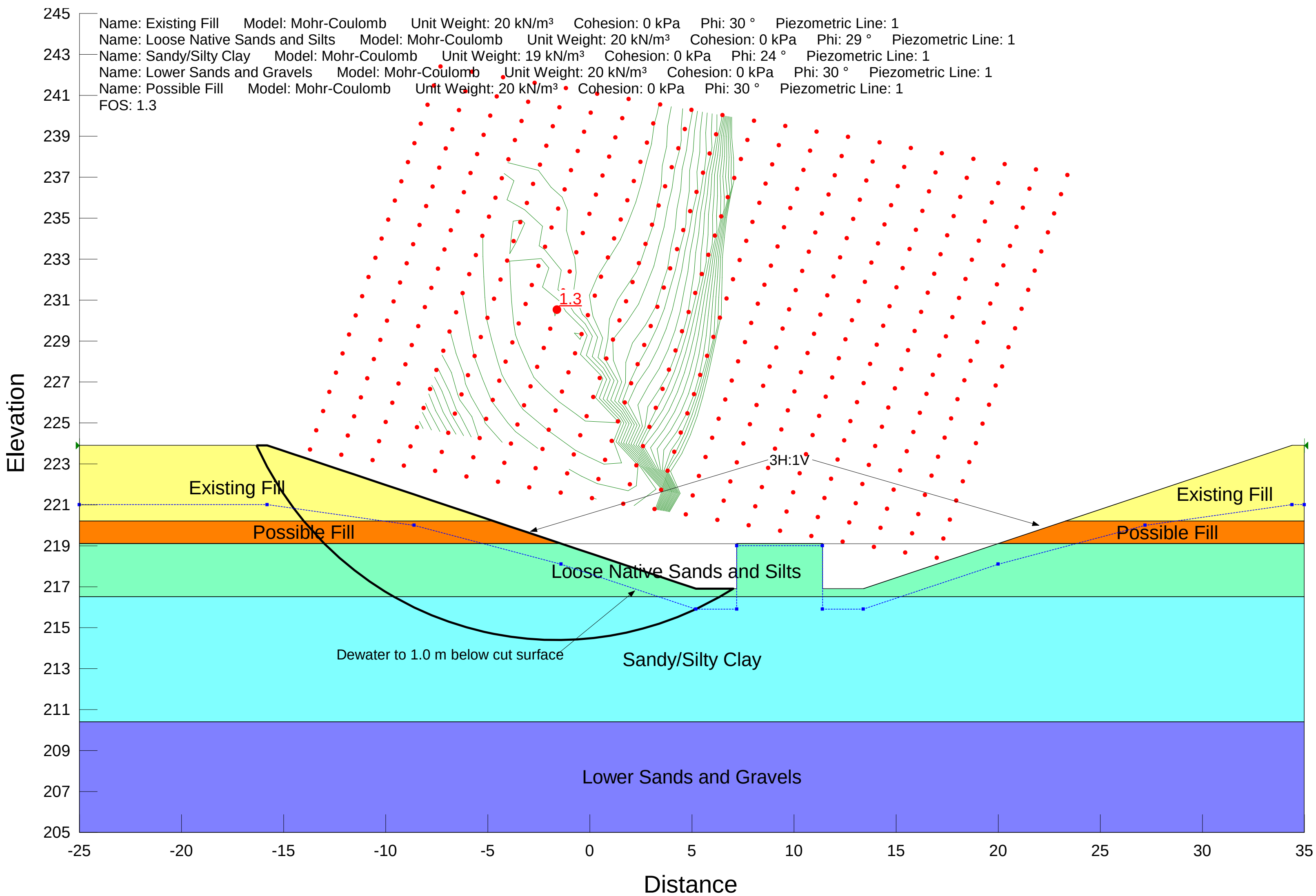


Figure D.1: Effective Stress Slope Stability Analyses of Excavation Slopes at 3H:1V with 1.0 m Dewatering.

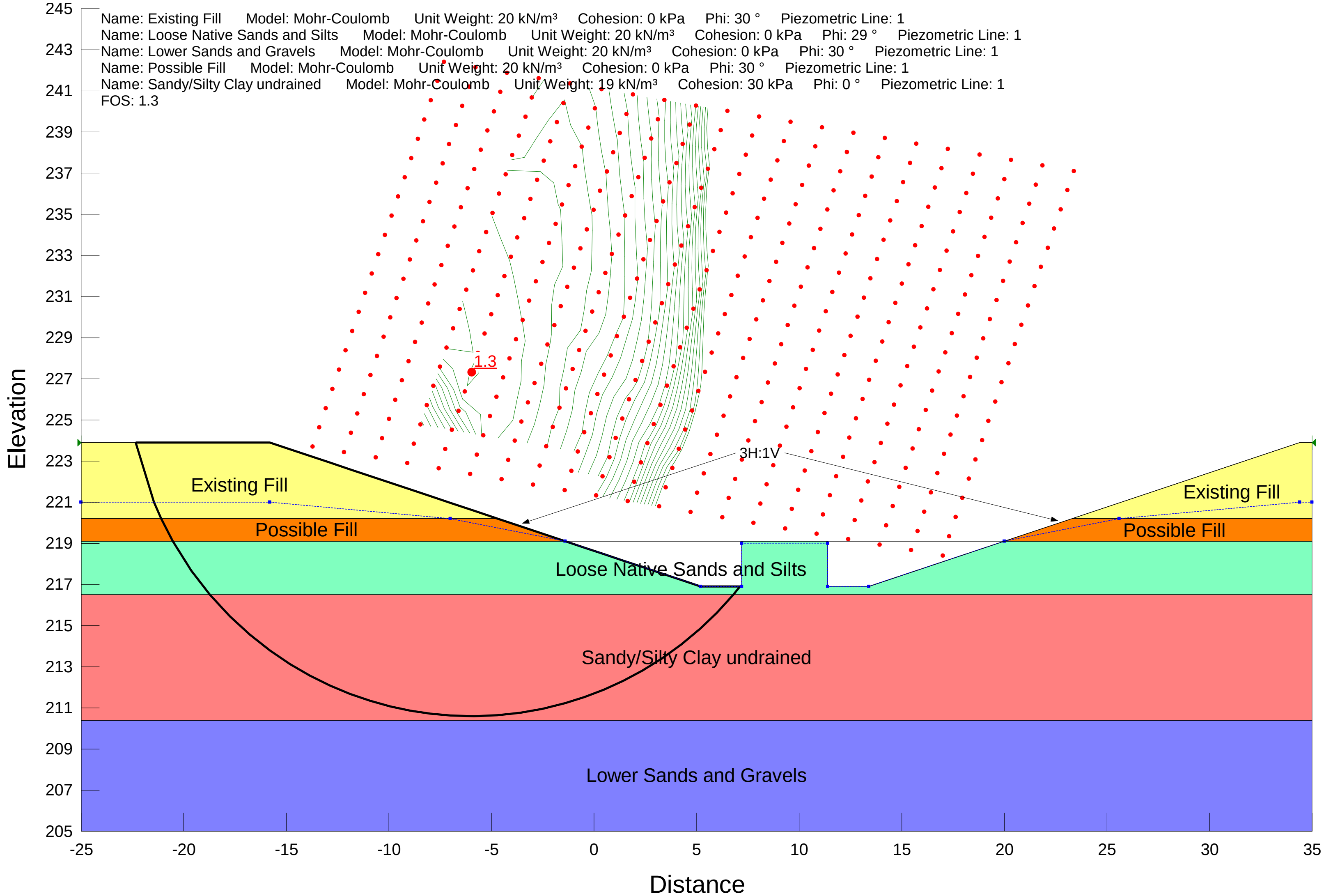


Figure D.2: Total Stress Slope Stability Analyses of Excavation Slopes at 3H:1V.

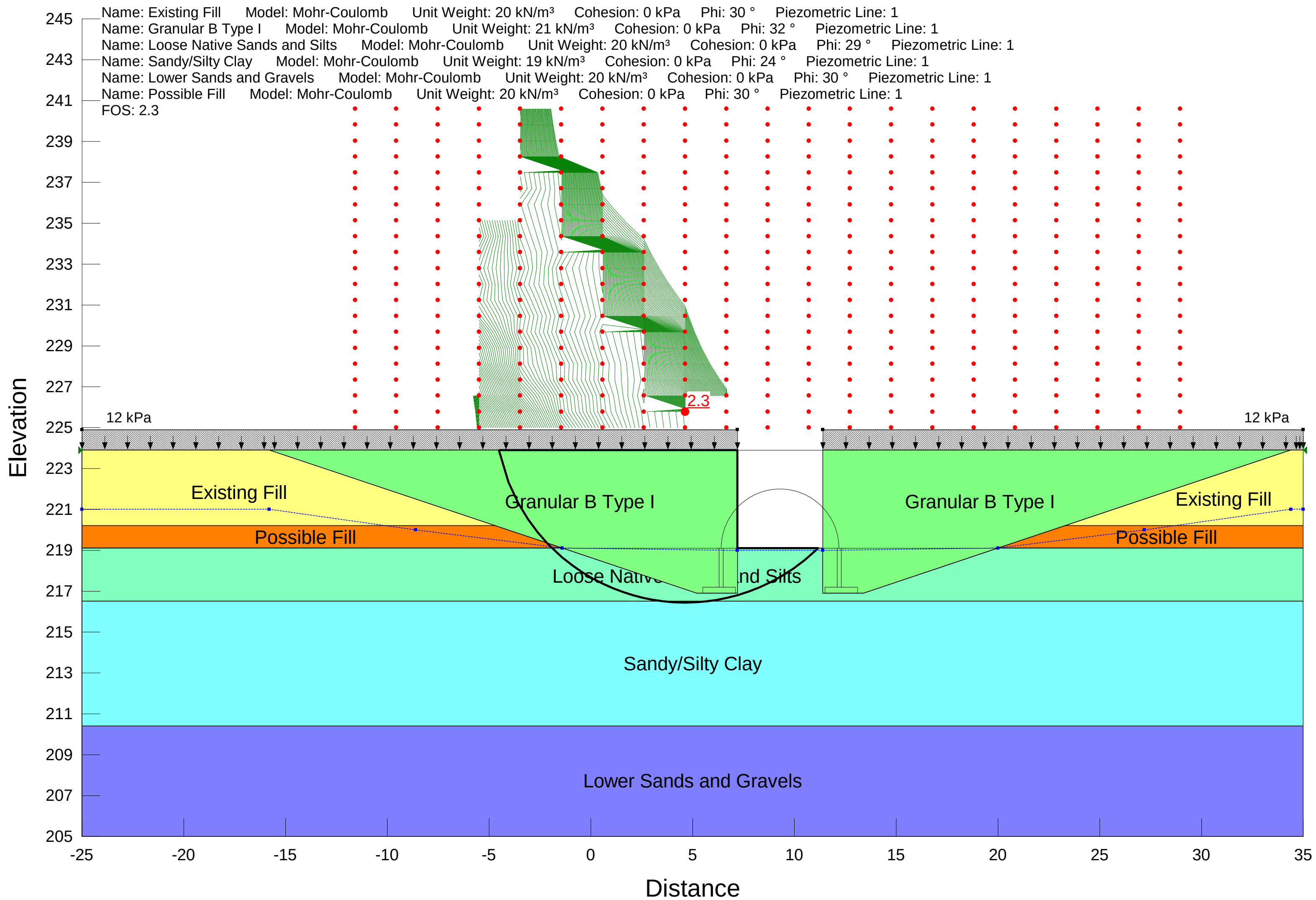


Figure D.3: Effective Stress Slope Stability Analyses of Open Bottom Culvert Final Configuration. Footings and Arch Shown for Visualization Purposes Only.

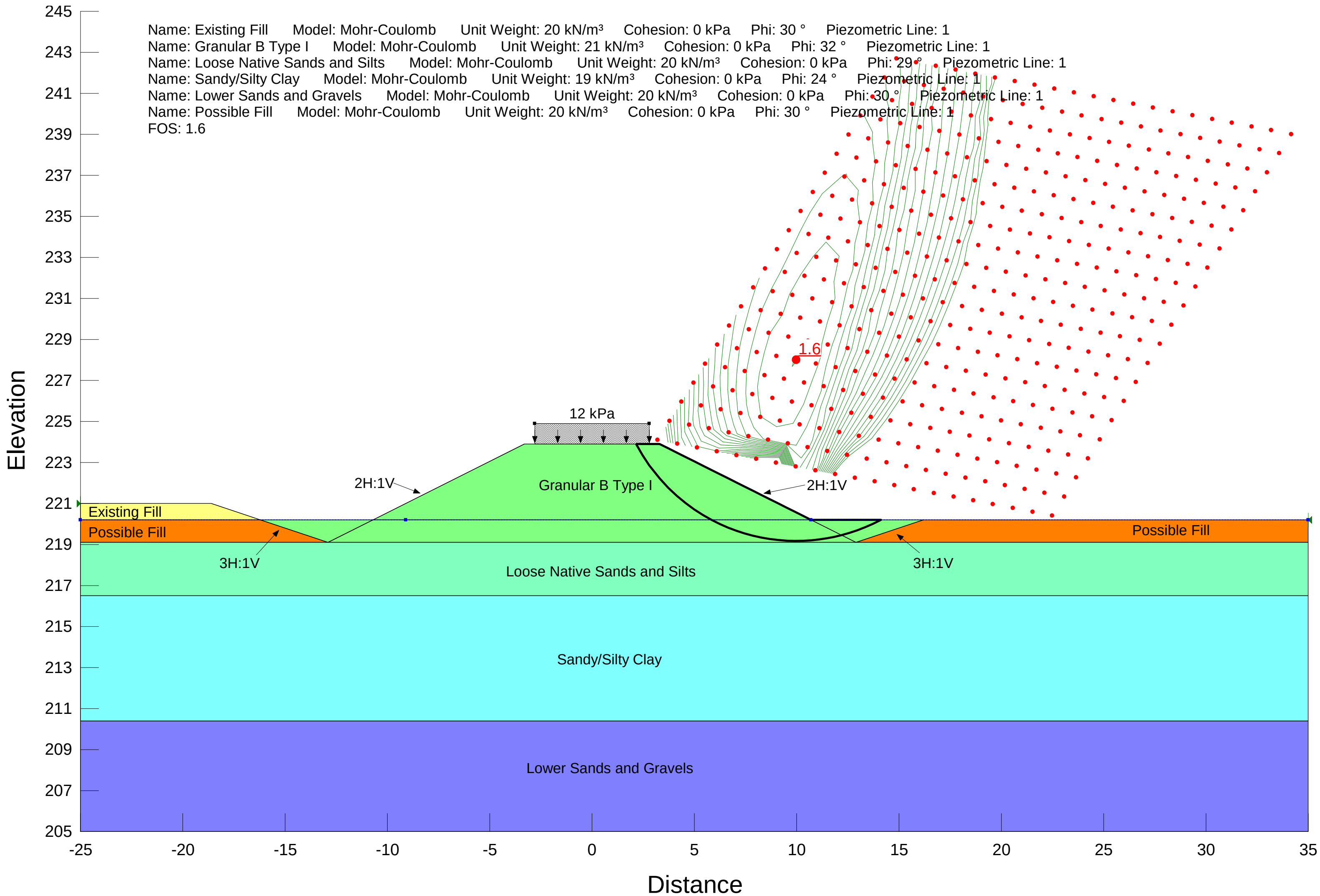


Figure D.4: Effective Stress Slope Stability Analyses of Embankment Slopes Final Configuration.

APPENDIX E
Notice to Contractor, NSSP and Operational Constraints

NOTICE TO CONTRACTOR – PRESENCE OF COBBLES AND BOULDERS

The Contractor is notified that the soils at the site of Neys Creek Culvert (Site No. 48E-0139/C0), on Highway 17, 27.4 km west of Highway 627, are expected to contain cobbles and possibly boulders which could affect the installation of temporary cofferdams, temporary shoring, and/or temporary roadway protection measures. Consideration of these obstructions must be taken in selecting appropriate methodologies, equipment for excavations and installation of temporary cofferdams, temporary shoring, and/or temporary roadway protection measures.

End of Section

TBT Engineering 1918 Yonge Street, Thunder Bay, ON P7E 6T9 807-624-5160

OPERATIONAL CONSTRAINT – USE OF HEAVY EQUIPMENT AND SURCHAGES NEAR EXCAVATION

The Contractor is notified that the placement of surcharges, (eg. stockpiles, equipment, building materials) near the edge of excavations at the site of Neys Creek Culvert (Site No. 48E-0139/C0), on Highway 17, 27.4 km west of Highway 627, should be assessed. Assessment can include, but not be limited to, slope stability analysis, monitoring, and delineation of safe offset limits. The assessment should be completed by a RAQS qualified Foundation Engineering Service Provider.

Tentatively, surcharges should not be placed within 6.5 m of the crest, and surcharges outside of 6.5 m should not exceed 20 kPa.

End of Section

TBT Engineering 1918 Yonge Street, Thunder Bay, ON P7E 6T9 807-624-5160

GEOTECHNICAL ASSESSMENT - Item No.

Special Provision

1.0 SCOPE

The use of heavy construction equipment and material stockpiling may be required during construction of the culvert. The global stability impact of the surface surcharge loads on the excavation slopes must be considered during selection of the methodology and equipment employed for construction. Tentatively, for bidding purposes:

- Any material stockpiles, including excavated soils, construction materials and/or demolition debris, shall not be permitted within 6.5 m of the crest of excavation slopes;
- No heavy equipment shall be permitted within 6.5 m of the crest of excavation slopes;
- To maintain stability of the excavation slopes, the ground pressures applied by all construction equipment and any material stockpiles must be placed beyond the 6.5 m offset and shall not exceed 20 kPa;

The Contractor shall engage a Geotechnical Consultant to carry out a geotechnical assessment to assess an excavation slope where surcharges are placed in close proximity to the edge of an excavation and to aid in the selection of construction equipment and methodology.

2.0 REFERENCES

Foundation Investigation Report, Highway 17 - Neys Creek Structural Culvert Replacement, Township of Coldwell, Station 16+441, Centreline, Lat: 48.770604, Long: -86.551926, District of Thunder Bay, W.P. 6022-E-0033, G.W.P. 6028-22-00, GEOCRES No. 42D-72, dated September 27, 2023.

3.0 DEFINITIONS – Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.1 Design Requirements

Prior to commencement of construction, the Contractor shall retain a Geotechnical Consultant to assess the stability impacts of the proposed equipment loads and methodology, and to determine requirements and/or restrictions necessary to safely support the loads without a foundation or slope failure. All Foundation Engineering services required for this project shall be performed by consultant(s) listed as accepted under the MTO's RAQS for providing services under the specialty of Geotechnical (Structures and Embankments), of the medium complexity rating.

The geotechnical assessment carried out by the Contractor's Geotechnical Consultant shall include, but not be limited to, the following:

- Review of available geotechnical information and supplementing with additional subsurface information, as required.
- Determination of appropriate setbacks for heavy equipment and material stockpiles from the crest of slopes;

- Determination of the permissible ground pressure that may be applied by the equipment and material stockpiles; and
- Provision of recommendations for the support of all heavy equipment and material stockpile loads to prevent foundation failure at any location within the project limits based on the proposed equipment and methodology of the Contractor.

4.2 Submission Requirements

The Contractor shall submit the geotechnical assessment report containing details of the proposed construction equipment and methodology and the geotechnical assessment to the Contract Administrator for information purposes a minimum of two weeks prior to the mobilization of heavy equipment.

The report shall be signed and sealed by two (2) Professional Engineers licensed by the Professional Engineers of Ontario, one (1) of whom shall be the RAQS Approved Key Personnel and provide the following, as a minimum:

- Appropriate set back distances for heavy equipment and material stockpiles from excavation slopes;
- Permissible ground pressures which may be applied adjacent to excavation slopes by heavy equipment and material stockpiles;
- Recommendations for the support of all heavy equipment and material stockpile loads to prevent foundation failure.

5.0 MATERIALS – Not Used

6.0 EQUIPMENT – Not Used

7.0 CONSTRUCTION – Not Used

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT – Not Used

10.0 BASIS OF PAYMENT

Payment at the Contract price for the above tender item shall be full compensation for all labour to do the work.

Payment for costs associated with heavy construction equipment necessary to complete the work, such as design and construction of temporary works, supply, mobilization/de-mobilization, and operation shall be made under the associated items.