



**Foundation Investigation and Design Report
Pearl River Crossing
Station 21+350 to 21+450, District Thunder Bay
Highway 11/17**

GWP 128-90-00

Geocres No. 52A-234

**Prepared for
Dillon Consulting Limited**

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Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering Limited (TBTE) has been retained by Dillon Consulting Limited (Dillon) to provide foundation investigation and design services for the proposed alignment of Highway 11/17 Four Laning, in the Municipality of Shuniah, Ontario. The project limits extend from 0.3 km east of Highway 587 easterly for 14.4 km. This report covers the Pearl River Crossing identified between Stations 21+350 to 21+450. The site coordinates are as follows:

- Latitude: 48.6610347°
- Longitude: -88.6585072°

The foundation investigation was completed to investigate subsurface conditions from Station. 21+350 to Sta. 21+450 along the proposed alignment for both eastbound lane (EBL) and westbound lane (WBL) crossings. The investigation consisted of twelve boreholes total advanced along the proposed EBL and WBL alignments (six along each alignment). All initial borehole locations were determined through consultation with MTO Foundation Section and, final borehole locations were determined based on field conditions. This report (Part A) describes the subsurface conditions encountered during the investigation.

The MTO Foundation section has assigned Geocres No 52A-234 to this site.

2 Site Description

The proposed bridge site is approximately 200 m east of Road No. 5 South and 250 m south of the MTO Patrol Yard. The site was densely vegetated and trails were cleared to access both sides of the Pearl River. Surface boulders (in the order of 1.5 m in diameter) were observed on the east side of the Pearl River. The height of the existing embankment at the river ranges from 3.5 to 4.5 m with slopes ranging from 2:1, 5:1, and 10:1 horizontal to vertical. The proposed embankments for the structures have an approximate maximum height of 6.5 m along the EBL and 5.5 m along the WBL with approximate maximum fill heights of 3 and 4 m respectively. The river level was measured to be at elevation 245.8 m on November 24, 2014, within approximately 50 m of the proposed alignment (provided on MTO B&C Drawing 370-11&17-10).

Figure 2.1: Photograph taken at Borehole BR-BH-10, looking west



Figure 2.2: Photograph taken at Borehole BR-BH-10, looking south



Figure 2.3: Photograph taken at West Bank of Pearl River WBL, looking south



2.1 Surficial Geology

The proposed Pearl River crossing alignment is located from Station 21+350 to 21+450 and is located in an area primarily consisting of a veneer sand and gravel outwash plain over rock with subordinate areas of sand and gravel eskers as defined by the Ontario Ministry of Natural Resources Northern Ontario Engineering Geology Terrain Study (NOEGTS), 1981, Map No. 5046 "Black Bay Area". The material for both the outwash plain and esker is described primarily as sandy gravels and/or gravelly sands with areas that contain cobbles. The subordinate esker areas may contain pockets and layers of water laid silt and fine sand, boulders and till may exist. With reference to the NOEGTS, the esker-outwash landforms generally have the following attributes:

- Higher permeability, low compressibility, low shrink and swell tendency
- High shear strength and bearing for footings and foundations
- Forms stable slopes.

Presence of sand gravel, gravelly sand, cobbles and boulders and pockets or layers of silts and fine sand was confirmed by the field investigation.

3 Investigation Procedures

A geotechnical site investigation was undertaken on January 18 to 27, 2017. The field investigation consisted of twelve boreholes. At this site boreholes have been numbered BR-BH-01 to BR-BH-12. Initial borehole locations were determined through conversations with MTO Foundations.

The field program consisted of two boreholes at each potential abutment (eight boreholes) and one borehole at each approach (four boreholes) for a total of twelve boreholes. Where shallow refusal was encountered at several borehole locations additional attempts for further advancement was made. These additional attempts were attempted within 1 to 2 m of the original borehole location. The refusal material was cored at four boreholes (BR-BH-03, BR-BH-05, BR-BH-07, BR-BH-09) to confirm the 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 track mounted drill rig equipped with hollow stem augers and a cat head used to carry out Standard Penetration Testing (SPT). During the drilling operations for the boreholes, soil samples were obtained from the auger flights and, using the techniques of the SPT.

Borehole locations were surveyed by TBTE and were based on North American Datum 1983, MTM CSRS CBNV6-2010 Zone 16 and Canadian Geodetic Vertical Datum 1928:1978 adjustment (CGVD1928;78). Control was established from published control downloaded from Ministry of Natural Resources Cosine Online Geodetic Control Service. Multiple control points were used for control establishment and position verification.

A summary of the borehole location data is provided on the enclosed Borehole Location Plan and Strata Drawings, Appendix C.

Temporary standpipe piezometers were installed within boreholes BR-BH-01, BR-BH-02, and BR-BH-08.

All boreholes and temporary standpipe piezometers have been backfilled and/or decommissioned in accordance with O.Reg. 903.

4 Laboratory Testing

Samples which were obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content and grain size analysis. The results of this testing are shown on the Borehole Logs (Appendix A and on the laboratory data reports Appendix B). To classify the bedrock with respect to strength, point load tests were carried out on select rock core.

In addition to routine testing, four samples were selected for analytical laboratory testing. Analytical tests performed included conductivity, moisture content, pH, Redox Potential, resistivity, chloride, sulphide and sulphate testing. Test results are included in Section 5 and Appendix B.

5 Subsurface Conditions

Details of the subsurface conditions are provided on the borehole logs (Appendix A), and on the Soil Strata Drawings (Appendix C).

The subsurface soils at this site typically consist of till (sands and gravel) overlying bedrock. Bedrock was sampled at four boreholes (BR-BH-03, BR-BH-05, BR-BH-07, and BR-BH-09). Cobbles and boulders were also observed at surface.

5.1 Topsoil

A 100 mm thick layer of topsoil (sand with organics) was encountered at the surface of Borehole BR-BH-1 to BR-BH-6 and BR-BH-10, with a 150 mm thick layer of topsoil at Borehole BR-BH-11.

5.2 Till

Till consisting of a mixture of gravel, sand and silt with occasional to numerous cobbles and boulders was encountered at all boreholes. The till was identified below the topsoil at Boreholes BR-BH-01 to BR-BH-06, BR-BH-10 and BR-BH-11, and at the surface of Boreholes BR-BH-07 to BR-BH-09 and BR-BH-12. The till extended to auger refusal at the maximum depth augered at all borehole locations ranging in from 2.4 to 6.5 m (elevations ranging 247.2 to 243.1 m).

Grain size analyses completed on selected samples indicate that the material can consist of 21-62 % gravel, 27-64 % sand, and 6-28 % silt/clay sized particles. This material is in compact to very dense condition with SPT "N" values ranging from 23 to 76 blows / 0.3 m. Numerous blow counts of 100+ blows/ 0.3 m were recorded; however they were identified to be on cobbles or boulders.

Four samples of this material were submitted for corrosivity and conductivity testing, detailed results are provided in Appendix B. The results are summarized as follows:

Table 5.1: Analytical Testing Results

Test	Unit	BR-BH-3	BR-BH-5	BR-BH 7	BR-BH-11
Conductivity	mS/cm	0.122	0.139	0.165	0.127
Moisture	%	9.01	21.7	14.7	6.51
Acidity/Basicity	pH	6.71	5.95	7.22	6.96
Redox Potential	mV	258	320	298	236
Resistivity	ohm*cm	8180	7180	6070	7850
Chloride	ppm	13.3	9.4	<5.0	7.1
Sulphide (as S)	mg/kg	<0.2	<0.2	<0.2	<0.2
Sulphate	ppm	<20	<20	<20	36

5.3 Bedrock and Refusal

Auger refusal was encountered at all boreholes. At several borehole locations where shallow auger refusal was encountered, one or more additional attempts to drill deeper were made. Auger refusal, at boreholes where refusal material was not sampled, may be on bedrock, cobbles, or boulders. In addition to auger refusal, SPT "N" values greater than 100 were encountered at the auger refusal depths.

Bedrock was confirmed below the till at Borehole BR-BH-3, BR-BH-5, BR-BH-7 and BR-BH-9 at depths of 3.4 m, 5 m, 6.2 m and 3.6 m, respectively. The table below summarizes the auger refusal and bedrock confirmation for each borehole. Generally, the bedrock encountered was red to white sandstone. Zones of friable sandstone was identified in the bedrock cores at BR-BH-03 and zones or rubble were identified at BR-BH-05, and BR-BH-07. Detailed bedrock core log and photos are provided in Appendix A.

Table 5.2: Borehole Refusal

Location	Auger Refusal Depth (m)		Auger Refusal Elevation (m)		Confirmed Bedrock
	Final Max.	Shallow Earlier Attempt	Final Min.	Shallow Earlier Attempt	
BR-BH-1	4.6	1.9	245.7	248.4	No
BR-BH-2	2.8	1.4	246.2	246.2	No
BR-BH-3	3.4	-	245.1	-	Yes
BR-BH-4	2.8	2.6	246.4	246.6	No
BR-BH-5	5.0	-	244.9	-	Yes
BR-BH-6	6.5	1.6	243.4	248.3	No
BR-BH-7	6.2	-	243.7	-	Yes
BR-BH-8	6.4	-	243.1	-	No
BR-BH-9	3.6	-	245.2	-	Yes
BR-BH-10	2.9	1.8	245.4	246.5	No
BR-BH-11	2.9	1.7	245.6	246.8	No
BR-BH-12	2.4	0.6	247.2	249.0	No

In order to classify the bedrock with respect to strength, twelve point load tests were completed on selected core samples. The test results are tabulated below:

Table 5.3: Estimated Uniaxial Compressive Strength of Bedrock

Borehole	Test Depth From Ground Surface (m)	*Estimated Uniaxial Compressive Strength (MPa)
BR-BH-03	4.2	187
	5.3	104
	6.2	151
BR-BH-05	4.7	113
	7.3	133
	8.5	62
BR-BH-07	7.1	83
	8.2	85
	9.8	110
BR-BH-9	4.5	110
	5.7	147
	6.6	118

** Estimated based on published correlations with point load testing*

Based on the estimated uniaxial compressive strength of the intact rock, the bedrock is generally very strong (uniaxial compressive strengths greater than 100 MPa) with three instances of strong material at Borehole BR-BH-5 at a depth of 8.5 m, Borehole BR-BH-7 at depths 7.1 m and 8.2 m.

The rock quality designation (RQD) is an indirect measure of the number of fractures and the amount of jointing in the rock mass. The RQD is expressed as a percentage of the ratio of the 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 following limits.

Table 5-4: RQD / Rock Quality Designation

RQD (%)	Rock Quality
0 – 25	Very Poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

The RQD measured over the core lengths ranged from 86 to 96.6 % indicating the rock quality varies from good to excellent.

6 Groundwater

The groundwater levels were read upon completion of drilling and within temporary standpipe piezometers installed at Boreholes BR-BH-01, BR-BH-02, and BR-BH-08. Measured groundwater levels have been provided below. The river level was measured to be at elevation 245.8 m on November 24, 2014, within approximately 50 m of the proposed alignment (provided on MTO B&C Drawing 370-11&17-10). Groundwater levels will vary from season to season and from the effects of heavy precipitation events.

Table 6.1: Groundwater Levels for Boreholes with Temporary Standpipes

Location	Surface Elevation (m)	Groundwater Level (elev. m)		
		Completion of Drilling	on March 22, 2017	on April 22, 2017
BR-BH-01	250.3	Dry @ 245.7	Dry @ 245.7	245.8
BR-BH-02	249	Dry @ 246.2	Frozen	Dry @ 246.2
BR-BH-08	249.5	246.2	Dry @ 246.2	Dry @ 246.2

Table 6.2: Groundwater Levels at Completion

Location	Surface Elevation (m)	Groundwater Level at Completion of Drilling (m)
BR-BH-01	250.3	Dry @ 245.7
BR-BH-02	249	Dry @ 246.2
BR-BH-03	248.5	Dry @ 245.1
BR-BH-04	249.2	Dry @ 246.4
BR-BH-05	249.9	245.5
BR-BH-06	249.9	245.7
BR-BH-08	249.5	246.2
BR-BH-09	248.8	247.6
BR-BH-10	248.3	Dry @ 245.4
BR-BH-11	248.5	Dry @ 245.6
BR-BH-12	249.6	Dry @ 247.2

It should be noted that the relatively high-water level upon completion at Borehole BR-BH-09 could have been influenced by the drilling techniques and the possible low permeability of the encountered bedrock and native till.

7 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 Limited. The field operations were supervised by Atif Nazir, Marshal John and Alan Finke. Laboratory testing was supervised by T. Fummerton C.E.T. This report was prepared by Steven Seller, P.Eng, and reviewed by W. Hurley, P.Eng (TBTE designated principal contact identified for MTO Foundation Engineering projects).

Part B - FOUNDATION DESIGN RECOMMENDATIONS

8 Introduction

TBT Engineering Limited (TBTE) has been retained by Dillon Consulting Limited (Dillon) to provide foundation investigation and design services for the proposed crossing of Pearl River at Station 21+350 to 21+450 in the Municipality of Shuniah, Ontario. The site coordinates are as follows:

- Latitude: 48.6610347°
- Longitude: -88.6585072°

The foundation investigations as described in Part A, were completed to investigate subsurface conditions at this site. The investigations consisted of the advancement of twelve boreholes, and laboratory testing. The Part A report describes the subsurface conditions encountered during the investigation.

The foundation soils at this site consists of till (gravely sand to sandy gravel) overlying the sandstone bedrock.

The purpose of this section of the report (Part B) is to provide approach embankment design and structure foundation recommendations for the new crossing at the Pearl River. These are based on the conditions encountered at the borehole locations, TBTE's interpretation of the subsurface conditions at the site and analyses of embankment stability.

9 Structure Foundation

Multiple foundation systems have been considered for the proposed crossing. Design recommendations for viable foundation systems are presented below based on the subsurface conditions encountered on site.

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

9.1 Initial Review of Foundation Options

Several options for the proposed crossing were reviewed from a foundations perspective and are presented below. Options reviewed address closed bottom culverts, structures on footings, structures on piles.

Table 9.1: Foundation Options

Option		Advantages	Disadvantages	Comments
Closed Bottom Culvert	Typical, steel or concrete culvert with appropriate bedding.	<ul style="list-style-type: none"> - least costly option - less excavation required than structures with footings - least construction time required 	<ul style="list-style-type: none"> - requires construction within the water course 	-
	Footings	<ul style="list-style-type: none"> - longer spans may be considered to minimize construction within the existing channel - footing on bedrock can be considered to reduce / limit frost effects - footings can be founded on granular pads, native soils and/or bedrock 	<ul style="list-style-type: none"> - excavation of overburden is required - variance in bedrock elevation from opposite river banks needs to be addressed - subexcavation below water is required to place granular fill 	Recommended Option
Structures	Piles	<ul style="list-style-type: none"> - high capacities can be achieved - excavation below water level may be reduced or eliminated - longer spans may be considered to minimize construction within the existing channel 	<ul style="list-style-type: none"> - inadequate pile lengths to achieve lateral capacity may occur. - limited pile length due to shallow bedrock line - rock sockets may be required 	-

9.2 Closed Bottom Culverts

Closed bottom culvert(s) can be placed on and in compacted granular material in an earth excavation or embankment. Either steel pipe/arch or concrete box culverts may be considered. 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; 802.020, 802.024, 802.031, 802.034, 802.051, and 802.054. The designer should choose which is the most appropriate drawing for the actual culvert chosen.

9.3 Spread Footings

The preferred structural option for this project is two single span bridges founded on spread footings. Spread footings are appropriate for a structural solution for the Pearl River crossings. Footings can be placed on native till, bedrock or compacted granular pad. Individual footings should not be placed on both native till and bedrock, or granular pad and bedrock.

For the foundation configurations provided bellow a resistance factor of 0.5 and 0.8 have been used for the calculation of the factored geotechnical resistance at ULS and the factored geotechnical reactions at SLS, respectively. The SLS reactions have been computed for settlements of up to 25 mm and 50 mm under foundation loading. The resistance factors are as provided in the 2014 Canadian Highway Bridge Design Code (CHBDC S6-14).

Any divergence from the conditions described herein could result in the reduction of ULS values presented. For example, if the foundation is placed shallower (less depth of cover to the underside of footing) and/or the ground is sloping away from the foundation, a reduction in the ULS values may be realized.

To eliminate the effects of frost, footings must be placed below the depth of frost penetration, placed over/within non-frost susceptible fills (such as rock fill) which extend from the top of creek low water level or backfill (whichever will govern) to the depth of frost penetration, or directly on bedrock.

9.3.1 Spread Footings on Native Till

Geotechnical resistances at ULS and geotechnical reactions at SLS for typical footings founded on very dense native till are provided below, and are subject to the following conditions:

- A minimum depth of cover 2.2 m (depth of soil to the underside of the foundation) will provide adequate frost protection.
- The foundations will be placed within an embankment and the resistances are subject to the effects of sloping ground.
- Footing must be structurally designed to be relatively inflexible (rigid).
- Underside of footing shall not be higher than elevation 246 m.
- Vertically and concentrically loaded foundations in compression

- Individual footings shall not be constructed on both till and bedrock. If bedrock is encountered at the footing elevation the bedrock should be excavated to 0.5 m below the underside of the footing. The excavated material shall be replaced with compacted Granular B Type II, or rock fill, compacted to 95 % Standard Proctor maximum dry density.

**Table 9.2: Geotechnical Resistances and Reactions
Footings on Compact Native Till**

Effective Footing Width (m)	Depth of Cover to Underside of Footing (m)	Factored Geotechnical Resistance, ULS (kPa)	Factored Geotechnical Reaction, SLS (kPa) for 25 mm settlement	Factored Geotechnical Reaction, SLS (kPa) for 50 mm settlement
1.2	2.2	375	Exceeds ULS	Exceeds ULS
1.5	2.2	395	Exceeds ULS	Exceeds ULS
1.8	2.2	415	380	Exceeds ULS
2.0	2.2	425	360	Exceeds ULS
3.0	2.2	495	295	370

9.3.2 Spread Footings on Bedrock

Footings may be placed entirely on the sandstone bedrock. Should the bedrock surface prove to be undulating and/or be steeply sloping, rock excavation and/or rock dowels/anchors may be required. The foundation should not be founded on both soil and bedrock. A suitable concrete leveling course may be used to “smooth” the rock surface.

Prior to forming for concrete placement the following precautions should be adhered to:

- All existing overburden must be removed from beneath the foundation footprint to expose sound intact bedrock, free of loose rock fragments.
- Zones of weathered, fractured, or friable bedrock must be removed to expose only intact material.
- Hand cleaning/pressure washing may be required if a suitable bearing surface cannot be prepared by mechanical means.
- The bedrock surface should be inspected by a qualified geotechnical engineer familiar with the design requirements.

In the event that steep bedrock or vertical drops are encountered within the footprint of the foundation, the following shall be adhered to:

- As a general rule, the edge of the footing should be located so that it does not intercept a line drawn upward at a slope of 2H:1V from the base of a near vertical slope.
- Where the edge of the foundation must be located within close proximity to a near vertical drop, or near a localized depression, the foundation should be extended over the vertical drop and appropriate concrete and reinforcement should be provided
- Where mechanical rock excavation is used to provide a level base for the foundation care must be taken to not damage the rock bearing surface/capacity.
- Where blasting methods are used to provide a level base of the foundation, effects of over blasting must be considered. Where over blasting occurs additional rock excavation may be required to remove the fractured rock.
- Where sloping bedrock is encountered, rock dowels/anchors may be considered to resist shear forces.
- Area of over excavation or deep bedrock may use concrete fill or concrete leveling course to restore the founding grades. Concrete strength shall as a minimum match the that of the structural concrete.

Spread footings with a minimum footing with of 0.5 m founded on tightly jointed bedrock may be designed on a factored geotechnical resistance of 1000 kPa in terms of limit states design (ULS). SLS reactions for settlements up to 25 mm have been estimated to exceed ULS capacities

The abutment walls should be backfilled in accordance with OPSD 3101.150.

9.3.3 Spread Footings on Compacted Granular Pad

Foundations may be placed on a granular pad overlying bedrock to provide grade revisions or to prevent hard points below the footings. The pads should be constructed using Granular B, Type II or rock fill. Adequate frost protection must be provided to the footing configuration to ensure that frost does not extend into the granular pad.

Geotechnical resistances at ULS and geotechnical reactions at SLS for typical footings

founded on a compacted granular pad over very dense native till are provided below, and are subject to the following conditions:

- A minimum depth of cover 2.2 m (depth of soil to the underside of the foundation) will provide adequate frost protection.
- The foundations will be placed within an embankment and the resistances are subject to the effects of sloping ground.
- Underside of footing shall not be higher than elevation 246 m.
- Footing must be structurally designed to be relatively inflexible (rigid).
- Minimum compacted granular pad thickness of 0.5 m constructed of Granular B Type II or rock fill, placed on very dense native till.
- The minimum depth of cover will provide adequate frost protection.
- Vertically and concentrically loaded foundations in compression
- Individual footings shall not be constructed on both pad and bedrock. If bedrock is encountered at the footing elevation the bedrock should be excavated to 0.5 m below the underside of the footing. The excavated material shall be replaced with the same material used for the compacted pad.

**Table 9.3: Geotechnical Resistances and Reactions
Footings on Compacted Granular Pad**

Effective Footing Width (m)	Depth of Cover to Underside of Footing (m)	Minimum 0.5 m Thick Compacted Granular Pad	Factored Geotechnical Resistance, ULS (kPa)	Factored Geotechnical Reaction, SLS (kPa) for 25 mm settlement	Factored Geotechnical Reaction, SLS (kPa) for 50 mm settlement
1.2	2.2	0.5	600	440	Exceeds ULS
1.5	2.2	0.5	605	390	Exceeds ULS
1.8	2.2	0.5	610	355	Exceeds ULS
2.0	2.2	0.5	615	335	Exceeds ULS
3.0	2.2	0.5	660	280	555

9.4 Resistance to Lateral Loads

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

- Between granular pads and pre -cast concrete
 - Co-efficient of friction of 0.5
- Between cast in place concrete and granular pads
 - Co-efficient of friction of 0.55

- Between cast in place concrete and till subgrade
 - Co-efficient of friction of 0.4
- Between cast in place concrete and clean bedrock
 - Co-efficient of friction of 0.7

10 Approach Embankments

The proposed approach embankments are anticipated to be a maximum of 4 m in height, measured from original grade, and will be constructed using Granular B Type II, Granular A (pavement structure) and rock fill for various features. The compact to very dense native till foundation soils are not problematic, and minor variations in embankment height are not expected to affect overall performance.

10.1 Geotechnical Model

Stability modeling was completed out using Slope/W software and limit equilibrium analysis using the Morgenstern-Price method.

Stability analyses for global stability have been completed to investigate potential configurations for the proposed embankment during construction for the proposed bridge. The design is based on providing a minimum calculated factor of safety (FoS) of 1.33 (resistance factor of 0.75) during construction and a (FoS) of 1.54 (resistance factor of 0.65) for permanent embankments/slopes. The resistance factors are as provided in the CHBDC S6-14. The provided factors of safety are for global stability of the embankment/slope. Stability modeling considers global stability only, as defined as slip surfaces which extend through both the embankment and foundation soils. A uniformly distributed traffic load of 12 kPa over the traversable lane(s) was applied in all cases.

Soil properties established for the embankment and foundation soils are presented below.

Table 10-1: Stability Analyses Soil Properties

Soil	Effective Stress Strength Properties		Unit Weight γ (kN/m ³)
	Effective Angle of Internal Friction, ϕ' (degrees)	Effective Cohesion Intercept, C' (kPa)	
Till	33	0	21
Compacted Granular B Type I	32	0	21
Rock Fill	40	0	18
Till & Bedrock Interface	29	0	21

10.2 Embankment Stability

The following assumptions were made for the analysis:

- Assumed water levels to be maintained at natural levels for profile excavation
- All organic material shall be removed from beneath the footprint of the approach embankments.
- Foundations constructed at elevation no higher than 246 m.
- Bridge will be a minimum of 22 m long centered on the river.
- Stability modeling consider global stability only.
- Preliminary rock protection was modelled.

The following recommendations have been derived from the analysis:

- Cut slopes through existing till shall be constructed at 2.1(H):1(V), or flatter see Figure 10.1.
- Footings must extend a minimum of 1.5 m into the embankment measured from the center of the footing to achieve a minimum FoS of 1.54 for global stability. Figure 10.2
- Permanent slopes constructed of compacted Granular B, Type I shall be constructed at 2(H):1(V) or flatter see Figure 10.3.
- Rock protection (compacted Granular B Type I, covered with rock fill) shall be constructed at 2(H):1(V), or flatter to achieve the minimum factor safety.

Figure 10.1: Minimum Excavation Slope

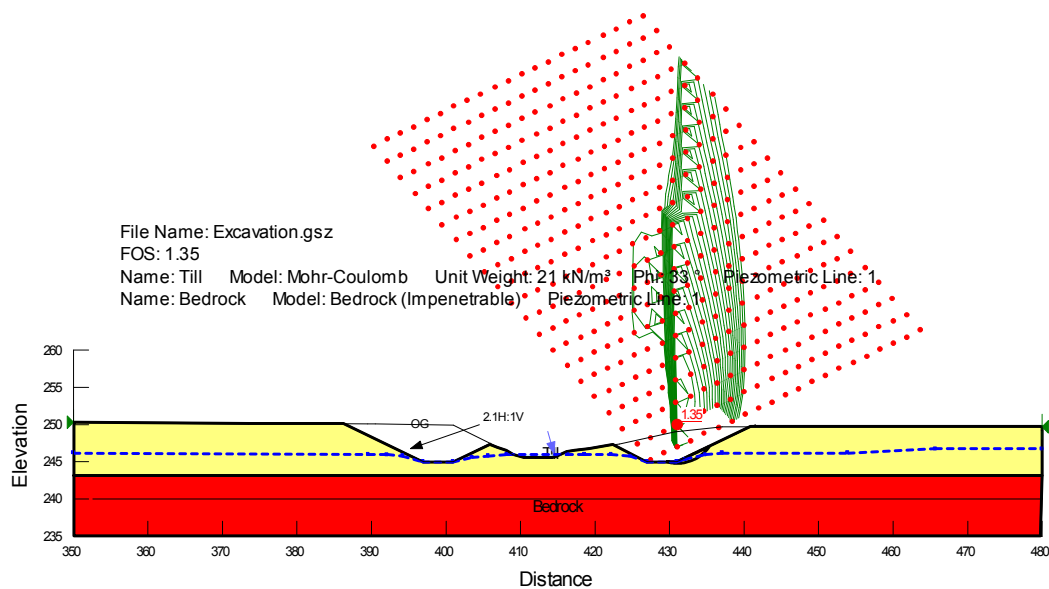


Figure 10.2: Global Stability

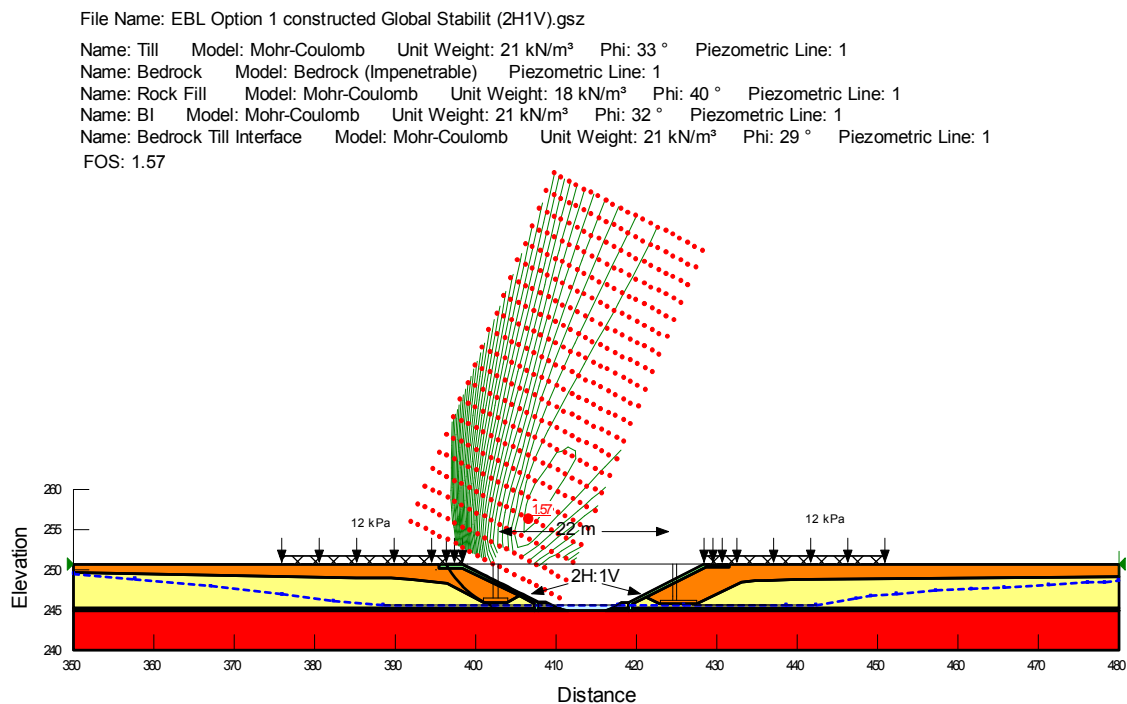
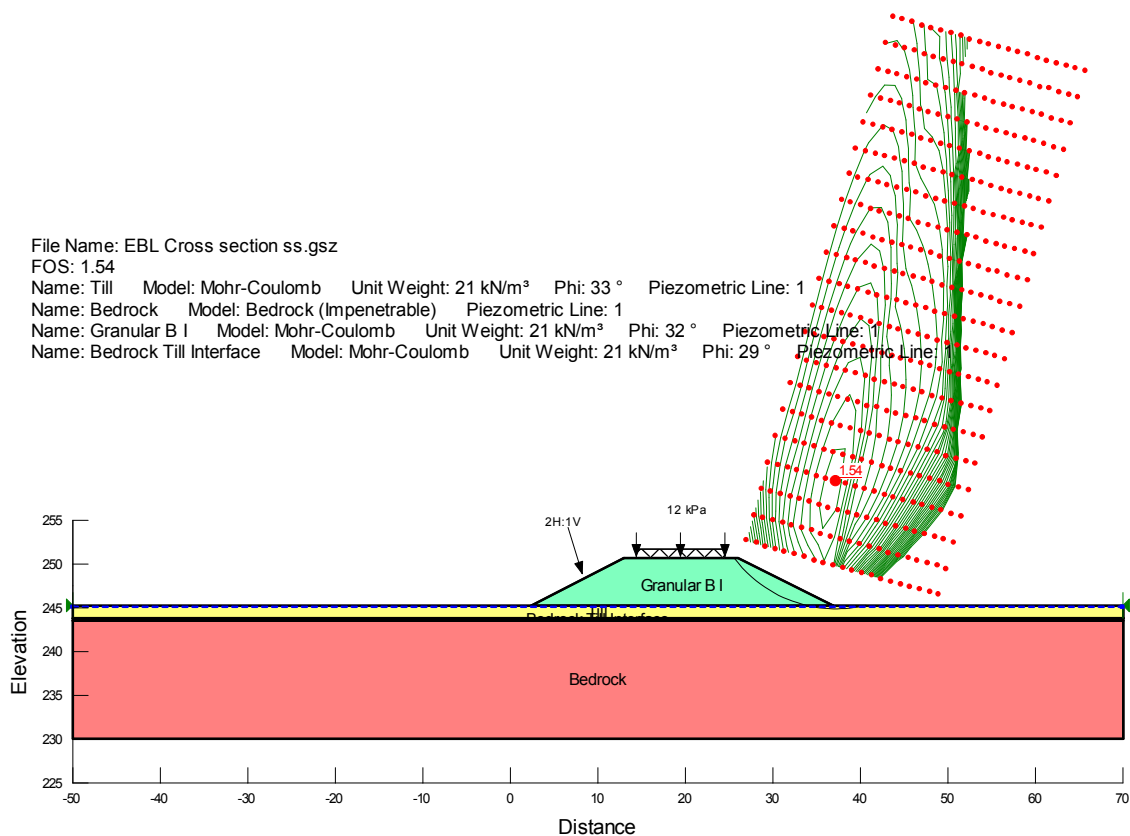


Figure 10.3: Final Cross Section



10.3 Embankment Settlement

Settlement analyses for the proposed approach embankments have been completed for a maximum 4 m high embankment. The compact to very dense native till foundation soils are not problematic, and minor variations in embankment height are not expected to affect overall performance. The results of this analysis indicate that maximum settlements of less than 25 mm are anticipated post construction, with differential settlement less than 200:1.

11 Backfill and Lateral Earth Pressures

The existing site materials are not suitable for use as structural backfill. Structural backfill should consist of Granular "B" Type I, or II. Granular "A" may be specified as structural backfill.

Lateral earth pressure coefficients for potential granular backfill and level ground conditions have been provided below.

Table 11.1: Lateral Earth Pressure Coefficients

Lateral Earth Pressure Coefficients (K)					
Compacted Granular Backfill	ϕ' (°)	Bulk Unit Weight of Soil, γ (kN/m ³)	Active K_a	At Rest K_o	Passive K_p
OPSS Granular A, or Granular B Type II	35	20	0.27	0.43	3.7
OPSS Granular B Type I	32	21	0.31	0.47	3.25

No factor of safety or resistance factor has been included in the above coefficients. A compaction surcharge should be added in accordance with the CHBDC S6-14 Section 6.12.3. The structure must also be designed to resist hydrostatic pressures where applicable.

12 Dewatering, Excavations and Channel Diversion

Excavations should be excavated and sloped in accordance with the requirements of the Occupational Health and Safety act.

The water elevation in Pearl River was at 245.8 m on November 24, 2014 (as provided), with the river bottom at approximate elevations of 245.0 and 245.5 at the EBL and WBL ends respectively. The soils below the groundwater level consist of permeable sands and gravels. Excavations for foundation 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 and groundwater will be required. Dewatering of the site will likely require the use of coffer dams constructed across the water course. It is recommended that regarding Special Provision No. 517F01 that a dewatering system be designed by an engineer and design checking engineer with a minimum of 5 years of experience designing systems of similar scope. The complexity of the dewatering system will be governed by the depth and location of the excavation and any requirements for working in the dry. The unexcavated till between the proposed

foundation locations and the river may be incorporated into the water management system. Groundwater flows into open excavations below the groundwater level may be rapid and difficult to control.

The soil through the embankment and the native sand can be preliminarily classified as Type 2 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. Excavations through the existing till should be made at 2.1(H):1(V) or flatter.

13 Estimated Frost Depth and Frost Protection

Based on OPSD 3090.100 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).

14 Corrosion and Sulphate Attack Potential

Corrosivity and sulphate content testing was conducted on several samples of the native soil, and the results are provided in Appendix B. The results of the test indicate the following conditions at the test locations:

- The maximum sulphate was measured at 36 ppm (0.0036%) and does not require sulphate resistant concrete since it is less than 0.1 %.
- The maximum pH of the soil was measured at 7.2, with resistivity ranging from 6070 to 8180 ohm-cm, and all sulphide contents less than 0.2 mg/kg.

Considering these factors, the native soils are not considered to be aggressively corrosive.

15 Scour Protection

Where appropriate, foundation elements should be provided with sufficient scour protection in the event of elevated creek levels. The ultimate design of scour protection

measures should be provided by designers with sufficient experience. Where appropriate, foundation elements should be provided with sufficient scour protection in the event of elevated creek levels. Scour protection should be designed in accordance with Section 1.9.5 of the CHBDC S6-14, where clay seals are considered OPSS 1205 should be reviewed and OPSD 810.010 for rip rap placement should be reviewed.

16 Seismic Considerations

Seismic analysis for the structures will not be required based on the following rationale as per the CHBDC S6-14. In accordance with Section 4.4.3.1 spectral ground acceleration data ($S_{a(0.2)}$ of 0.060 and $S_{a(1)}$ of 0.018 with a peak horizontal ground acceleration of 0.035) for the site was obtained from www.earthquakescanada.nrcan.gc.ca. 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 C in accordance with Table 4.1 of the CHBDC S6-14.

17 Potential Construction Issues

Major construction difficulties are not foreseen at this site. Issues which may require consideration include:

- Cobbles and boulders both at surface and below surface.
- Dewatering efforts may prove challenging and will increase in complexity with the depth of dewatering required. Some of the issues involved can include:
 - River level during construction.
 - Dewatering of the site to facilitate construction in the dry may be subject to high flow from sand and gravel tills.
 - Control of surface and groundwater during shallower excavations below the creek/groundwater level will require careful design and construction.

18 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 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 dewatering procedures which may be considered cannot readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

19 Closure

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

Yours truly,

For TBT ENGINEERING



Steven Seller, P.Eng
Project Engineer



Wayne Hurley, P.Eng.
Principal Contact for MTO Foundations

APPENDIX A

Borehole Logs

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
VT	Vane Test (kPa)	P P	Pocket Penetrometer (kg/cm ²)
T W	Thin Wall Shelby Tube		

EXPLANATION 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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	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	Undrained Shear Strength
s		Sensitivity

Physical Properties of Soil



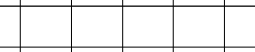

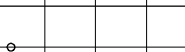



ρ_s	kg/m ³	Density of Solid Particles	e	%	Void Ratio	e_{min}	%	Void Ratio in Densest State
γ_s	kN/m ³	Unit Weight of Solid Particles	n	%	Porosity	I_D		Density Index = $\frac{e_{max}-e}{e_{max}-e_{min}}$
ρ_w	kg/m ³	Density of Water	w	%	Water Content	D	mm	Grain Diameter
γ_w	kN/m ³	Unit Weight of Water	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 /s	Rate of Discharge
γ_d	kN/m ³	Unit Weight of Dry Soil	I_P	%	Plasticity Index = $\frac{w_L-w_P}{I_P}$	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 BR-BH-01

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+373 o/s 0m of C/L WBL N:5392269; E:403568 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.27 - 2017.01.27 LATITUDE 48.6611025 LONGITUDE -88.6591074 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								20 40 60 80 100											
250.3	ORGANICS - 100 mm TILL - SAND & GRAVEL - to Sandy, trace silt, numerous cobbles, occasional boulders, brown, very dense		1	AS			250							Dry on completion. 44 49 (7)					
250.0			2	SS	75										Dry on March 22, 2017. Water level @ 4.5 m on April 22, 2017.				
0.1			3	SS	100+											On cobbles & boulders.			
			4	SS	100+												On cobbles & boulders.		
			5	SS	100+													On cobbles & boulders.	
			6	SS	57														62 30 (8)
			7	SS	100+														
245.7			End of Borehole @ 4.6 m. Auger Refusal.																
4.6																			

RECORD OF BOREHOLE No BR-BH-02

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+388 o/s 5.1m RT of C/L EBL N:5392242; E:403605 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.26 - 2017.01.26 LATITUDE 48.6608583 LONGITUDE -88.6586147 CHECKED BY S.S.

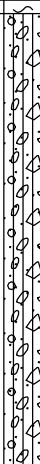

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE										
								● QUICK TRIAXIAL × LAB VANE										
							WATER CONTENT (%)											
							20	40	60	80	100	20	40	60				
249.0																		
248.0	ORGANICS - 100 mm TILL - SAND & GRAVEL - trace silt, numerous cobbles, occasional boulders, brown, very dense		1	AS													Dry on completion. Frozen surface on March 22, 2017. 50 44 (6) On cobbles & boulders. Dry on April 22, 2017.	
0.1																		
			2	SS	100+													
			3	SS	51													
			4	SS	100+												On cobbles & boulders.	
246.2																		
2.8	End of Borehole @ 2.8 m. Auger Refusal.																Temporary standpipe installed to 2.8 m. Initial attempt met auger refusal @ 1.4 m. Borehole relocated within 2 m and advanced.	

RECORD OF BOREHOLE No BR-BH-03

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+405 o/s 5.6m RT of C/L EBL N:5392252; E:403620 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger/B Casing COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.24 - 2017.01.24 LATITUDE 48.6609406 LONGITUDE -88.6584172 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
248.5							20	40	60	80	100							
248.0	ORGANICS - 100 mm		1	AS									○				Dry on completion.	
0.1	TILL - GRAVEL - Sandy, trace silt, numerous cobbles, occasional boulders, brown, very dense		2	SS	76									○				Auger refusal met @ 0.5 m. Advanced borehole with casing.
			3	SS	100+									○				59 32 (9) On cobbles & boulders.
			4	SS	75									○				
			5	SS	100+									○				
245.1	BEDROCK - Sandstone, red		1	RC														RC #1 REC 95.9% RQD 69.4%
3.4			2	RC														RC #2 REC 98.3% RQD 96.6%
	- Friable Sandstone @ 5.5 m		3	RC														RC #3 REC 100.0% RQD 95.8%
241.8	End of Borehole @ 6.7 m.																	
6.7																		

+³, ×³: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

PP=Pocket Penetrometer (Kg/cm²)

RECORD OF BOREHOLE No BR-BH-04

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+405 o/s 6.8m LT of C/L EBL N:5392262; E:403613 MTM Zone:15 ORIGINATED BY A.F.
DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
DATUM Geodetic DATE 2017.01.26 - 2017.01.26 LATITUDE 48.6610347 LONGITUDE -88.6585072 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
								○ UNCONFINED	+	FIELD VANE												
								● QUICK TRIAXIAL	×	LAB VANE												
249.2							20	40	60	80	100											
249.0	ORGANICS - 100 mm																					
0.1	TILL - SAND - Gravelly, Silty , numerous cobbles, occasional boulders, brown		1	AS												Dry on completion.						
			2	SS	100+											On cobbles & boulders.						
			3	SS	100+											25 54 (21) On cobbles & boulders.						
247.2																						
2.0	TILL - GRAVEL - Sandy, some silt, numerous cobbles, occasional boulders, brown		4	SS	100+											62 27 (11) On cobbles & boulders.						
246.4			5	SS	100+																	
2.8	End of Borehole @ 2.8 m. Auger Refusal.															Second attempt within 2 m of borehole met auger refusal @ 2.6 m.						

RECORD OF BOREHOLE No BR-BH-05

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+392 o/s 5.8m RT of C/L WBL N:5392275; E:403588 MTM Zone:15 ORIGINATED BY A.F.
DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger/B Casing COMPILED BY T.B.
DATUM Geodetic DATE 2017.01.25 - 2017.01.25 LATITUDE 48.6611556 LONGITUDE -88.6588438 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								○ UNCONFINED	+	FIELD VANE										
						● QUICK TRIAXIAL	×	LAB VANE	WATER CONTENT (%)											
						20	40	60	80	100	20					40	60			
249.9																	GR SA SI CL			
249.9 0.1	ORGANICS - 100 mm TILL - SAND - Gravelly, some silt, brown, compact		1	AS			249							○			Water level @ 4.4m on completion. 33 53 (14) Auger refusal met @ 1.4 m. Advanced with casing. 58 33 (9) On cobbles. RC #2 REC 100.0% RQD 87.2% RC #3 REC 91.9% RQD 32.2% RC #4 REC 92.1% RQD 73.7%			
			2	SS	29											○				
			3	SS	27											○				
247.9									248											
2.0	TILL - GRAVEL - Sandy, trace silt, brown, compact to very dense		4	SS	34													○		
		5	SS	83																
245.9						246														
4.0	BOULDER	1	RC																	
245.1							245								○					
244.9	TILL - SAND & GRAVEL - Silty, brown	6	SS	100+																
5.0	BEDROCK - Sandstone, red/white	2	RC																	
		3	RC			244														
		4	RC				243													
						242														
241.3						241														
241.3 8.6	End of Borehole @ 8.6 m.																			

ONTARIO MTO MOD 15-089 MTO BR.GPJ ONTARIO MTO.GDT 28/2/18

RECORD OF BOREHOLE No BR-BH-06

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+388 o/s 5.0m LT of C/L WBL N:5392281; E:403578 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.26 - 2017.01.26 LATITUDE 48.6612135 LONGITUDE -88.6589763 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)	
								○ UNCONFINED		+ FIELD VANE									
								● QUICK TRIAXIAL		× LAB VANE									
249.9							20	40	60	80	100								
249.9 0.1	ORGANICS - 100 mm TILL - SAND & GRAVEL - to Gravelly, trace to some silt, numerous cobbles, occasional boulders, brown, very dense		1	AS		▽										29 61 (10)			
			2	SS	100+												On cobbles & boulders.		
			3	SS	100+												On cobbles & boulders. Initial attempt met auger refusal @ 1.6 m		
			4	SS	100+												On cobbles & boulders.		
			5	SS	51												42 41 (17)		
			6	SS	68												Water level @ 4.2m on completion.		
			7	SS	100+												36 64 (10)		
243.4 6.5	End of Borehole @ 6.5 m. Auger Refusal.																		

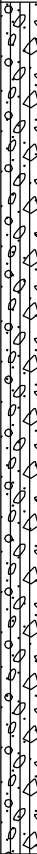

ONTARIO MTO MOD 15-089 MTO BR.GPJ ONTARIO MTO.GDT 28/2/18

RECORD OF BOREHOLE No BR-BH-07

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+428 o/s 0.6m LT of C/L WBL N:5392301; E:403613 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.18 - 2017.01.19 LATITUDE 48.6613825 LONGITUDE -88.6584902 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								20	40	60	80						100	20	40
249.9																			
0.0	TILL - SAND & GRAVEL - to Gravelly, some silt, occasional cobbles, brown, very dense		1	AS															
			2	SS	100+														
			3	SS	64														
			4	SS	71														
			5	SS	100+														
			6	SS	100+														
243.7	BEDROCK - Sandstone, red		1	RC															
6.2			2	RC															
	- Rubble @ 10.0 m		3	RC															
239.9	End of Borehole @ 10.0 m.																		
10.0																			

ONTARIO MTO MOD 15-089 MTO BR.GPJ ONTARIO MTO.GDT 28/2/18

RECORD OF BOREHOLE No BR-BH-08

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+430 o/s 9.5m RT of C/L WBL N:5392294; E:403621 MTM Zone:15 ORIGINATED BY A.F.
DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
DATUM Geodetic DATE 2017.01.19 - 2017.01.19 LATITUDE 48.6613198 LONGITUDE -88.658386 CHECKED BY S.S.

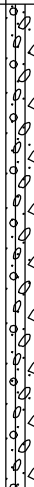

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
249.5								20	40	60	80	100					GR SA SI CL			
0.0	TILL - SAND - Gravelly, some silt to Silty, occasional cobbles and boulders, brown, compact to very dense		1	AS			249							○			Water level @ 3.3m on completion. Dry on March 22, 2017. 34 58 (8) Dry on April 22, 2017. 30 58 (12) On cobbles & boulders. 31 47 (22) 21 52 (28) On cobbles & boulders. Auger refusal met @ 5.1 m. Advanced with casing.			
				2	SS		71	248							○					
				3	SS		29	247								○				
				4	SS		100+	246								○				
				5	SS		67	245								○				
				6	SS		100+	244												
				7	SS		100+													
243.1			End of Borehole @ 6.4 m. Auger Refusal.																	Temporary standpipe installed to 2.9 m.
6.4																				

RECORD OF BOREHOLE No BR-BH-09

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+435 o/s 4.5m LT of C/L EBL N:5392277; E:403639 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.20 - 2017.01.20 LATITUDE 48.6611703 LONGITUDE -88.6581515 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								20 40 60 80 100												
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
							WATER CONTENT (%)					20 40 60								
248.8	TILL - SAND & GRAVEL - to Gravelly, some silt to trace silt, numerous cobbles, brown		1	AS		▽	248							○			Water level @ 1.2m on completion.			
			2	SS	100+										○				50 41 (9) On cobbles & boulders.	
			3	SS	100+											○				On cobbles & boulders.
			4	SS	100+											○				32 55 (13) On cobbles & boulders.
			5	SS	100+											○				
245.2	BEDROCK - Sandstone, red to white		6	RC			245								○				RC #1 REC 99% RQD %	
3.6			7	RC			244												RC #2 REC 98% RQD %	
			8	RC			243													RC #3 REC 100% RQD %
241.9	End of Borehole @ 6.9 m.						242													
6.9																				

ONTARIO MTO MOD 15-089 MTO BR.GPJ ONTARIO MTO.GDT 28/2/18

RECORD OF BOREHOLE No BR-BH-10

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+438 o/s 6.0m RT of C/L EBL N:5392271; E:403647 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.23 - 2017.01.23 LATITUDE 48.6611068 LONGITUDE -88.6580406 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
248.3							20	40	60	80	100						
248.0	ORGANICS - 100 mm, black																
0.2	TILL - GRAVEL & SAND - trace silt, trace organics, numerous cobbles, brown, compact		1	AS		248										Dry on completion.	
			2	SS	23												
			3	SS	100+		247										
			4	SS	100+												
245.4	End of Borehole @ 2.9 m. Auger Refusal.					246										52 40 (8) On cobbles & boulders. On cobbles & boulders.	
2.9																	

RECORD OF BOREHOLE No BR-BH-11

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+450 o/s 3.8m RT of C/L EBL N:5392280; E:403656 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.23 - 2017.01.23 LATITUDE 48.6611863 LONGITUDE -88.6579195 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)					
248.5							20	40	60	80	100						
248.0	ORGANICS - 150 mm, black																
0.2	TILL - SAND & GRAVEL - trace silt, numerous cobbles & boulders, brown		1	AS									○				Dry on completion.
													○				45 46 (9)
			2	SS	100+												On cobbles & boulders.
													○				On cobbles & boulders.
			3	SS	100+												
			4	SS	100+												On cobbles & boulders.
245.6	End of Borehole @ 2.9 m. Auger Refusal.																
2.9																	

+³, ×³: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

PP=Pocket Penetrometer (Kg/cm²)

RECORD OF BOREHOLE No BR-BH-12

1 OF 1

METRIC

W.P. 128-90-00 LOCATION Station 21+445 o/s 3.4m RT of C/L WBL N:5392307; E:403629 MTM Zone:15 ORIGINATED BY A.F.
 DIST NWR HWY Proposed 11/17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY T.B.
 DATUM Geodetic DATE 2017.01.18 - 2017.01.18 LATITUDE 48.6614382 LONGITUDE -88.6582747 CHECKED BY S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
249.6																	GR SA SI CL			
0.0	TILL - SAND & GRAVEL - some silt, occasional cobbles, brown, compact to dense		1	AS													Dry on completion.			
			2	SS	47															
			3	SS	28												36 53 (11)			
247.2			4	SS	100+															
2.4	End of Borehole @ 2.4 m. Auger Refusal.																Second attempt met auger refusal @ 0.6 m			

ROCK CORE LOG

Page 1 of 1

Project #: 15-089

Borehole # 3

Lab# 17-16501

Client: Dillon

Logger: L. Wells

Site: Sta. 21+405 EBL

Date: Feb. 7/17

DEPTH FROM SURFACE (m)		DEPTH (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES					
									# OF SETS	TYPE(S)	Orientation	SPACING	Roughness	APERTURE	FILLING					
From		From	1	96.8%	96.6%	Red Sandstone of the Sibley Group of Sediments - Pass Lake Formation		S	3							Friable Sandstone Zone at 5.5 m.				
To		3.40																		
		To																		
		6.73																		
From		From																		
		0.00																		
To		To																		
		0.00																		
From		From																		
		0.00																		
To		To																		
		0.00																		
From		From																		
		0.00																		
To		To																		
		0.00																		

Strength (MPa) VH = Very High = >200 H = High = 50-200 M = Medium = 15-50 L = Low = 4-15 VL = Very Low = 1-4	Discontinuity type B = Bedding Joint J = Cross Joint F = Fault S = Shear Plane	Roughness RU = Rough undulating RP = Rough planar SU = Smooth undulating SP = Smooth planar LU = Slickensided undulating LP = Slickensided planar
Weathering U = Unweathered (No signs) S = Slightly (Oxidized) M = Moderately (Discoloured) H = Highly (Friable) C = Completely (Soil-like)	Orientation F = Flat (0-20°) D = Dipping (20-50°) V = Near Vertical (>50°)	Aperture O = Open C = Closed F = Filled
Spacing VW = Very wide = >3m W = Wide = 1-3m M = Moderate = 0.3-1m C = Close = 5-30cm VC = Very close = <5cm	Filling T = Tight, hard O = Oxidized SA = Slightly altered, clay free SI = Sandy, clay free NC = Non-softening clay SC = Swelling, softening clay N = No filling	

Full Rock Core Dry



Full Rock Core Wet



Rock Core Detail



ROCK CORE LOG

Page 1 of 1

Project #: 15-089

Borehole # 5

Lab# 17-16502

Client: Dillon

Logger: L. Wells

Site: Sta. 21+391 WBL

Date: Feb. 7/17

DEPTH FROM SURFACE (m)		DEPTH (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES
									# OF SETS	TYPE(S)	Orientation	SPACING	Roughness	APERTURE	FILLING	
From	To	From 4.00	1	88.3%	86.0%	Red to White Sandstone of the Sibley Group of Sediments - Pass Lake Formation		S	4							Rubble Zone at 7.16 m
		To 8.63														
From	To	From 0.00														
		To 0.00														
From	To	From 0.00														
		To 0.00														
From	To	From 0.00														
		To 0.00														

Strength (MPa) VH = Very High = >200 H = High = 50-200 M = Medium = 15-50 L = Low = 4-15 VL = Very Low = 1-4	Discontinuity type B = Bedding joint J = Cross Joint F = Fault S = Shear Plane		Roughness RU = Rough undulating RP = Rough planar SU = Smooth undulating SP = Smooth planar LU = Slickened sided undulating LP = Slickened sided planar
	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		
Weathering U = Unweathered (No signs) S = Slightly (Oxidized) M = Moderately (Discoloured) H = Highly (Friable) C = Completely (Soil-like)			Filling T = Tight, hard O = Oxidized SA = Slightly altered, clay free SI = Sandy, clay free NC = Non-softening clay SC = Swelling, softening clay N = No filling

Full Rock Core Dry



Full Rock Core Wet



Rock Core Detail



ROCK CORE LOG

Page 1 of 1

Project #: 15-089

Borehole #7

Lab# 17-16503

Client: Dillon

Logger: L. Wells

Site: Pearl River Bridge

Date: Feb.8/17

DEPTH FROM SURFACE (m)		DEPTH (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	
									# OF SETS	TYPE(S)	Orientation	SPACING	Roughness	APERTURE	FILLING	
From		From	1	94.9%	94.3%	Red to White Sandstone of the Sibley Group of Sediments - Pass Lake Formation		S	4							Thin Shale Bedding Zone at 7.4 m. and Rubble Zone at 9.97 m.
To		6.67 To 10.02														
From		From														
To		0.00 To 0.00														
From		From														
To		0.00 To 0.00														
From		From														
To		0.00 To 0.00														
From		From														
To		0.00 To 0.00														

Strength (MPa) VH = Very High = >200 H = High = 50-200 M = Medium = 15-50 L = Low = 4-15 VL = Very Low = 1-4	Discontinuity type B = Bedding joint J = Cross Joint F = Fault S = Shear Plane		Roughness RU = Rough undulating RP = Rough planar SU = Smooth undulating SP = Smooth planar LU = Slickened undulating LP = Slickened planar
	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		
Weathering U = Unweathered (No signs) S = Slightly (Oxidized) M = Moderately (Discoloured) H = Highly (Friable) C = Completely (Soil-like)			Filling T = Tight, hard O = Oxidized SA = Slightly altered, clay free SI = Sandy, clay free NC = Non-softening clay SC = Swelling, softening clay N = No filling

Full Rock Core Dry



Full Rock Core Wet



Rock Core Detail



ROCK CORE LOG

Page 1 of 1

Project #: 15-089

Borehole #9

Lab# 17-16504

Client: Dillon

Logger: L. Wells

Site: Pearl River Bridge

Date: Feb.8/17

DEPTH FROM SURFACE (m)		DEPTH (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	
									# OF SETS	TYPE(S)	Orientation	SPACING	Roughness	APERTURE	FILLING		
From	To	From 3.60	1	99.1%	99.1%	Red to White Sandstone of the Sibley Group of Sediments - Pass Lake Formation		S	5								
		To 6.90															
From	To	From 0.00															
		To 0.00															
From	To	From 0.00															
		To 0.00															
From	To	From 0.00															
		To 0.00															

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)	Discontinuity 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°)	Roughness RU = Rough undulating RP = Rough planar SU = Smooth undulating SP = Smooth planar LU = Slickensided undulating LP = Slickensided planar
		Spacing VW = Very wide = >3m W = Wide = 1-3m M = Moderate = 0.3-1m C = Close = 5-30cm VC = Very close = <5cm	Aperture O = Open C = Closed F = Filled	Filling T = Tight, hard O = Oxidized SA = Slightly altered, clay free SI = Sandy, clay free NC = Non-softening clay SC = Swelling, softening clay N = No filling

Full Rock Core Dry



Full Rock Core Wet



Rock Core Detail

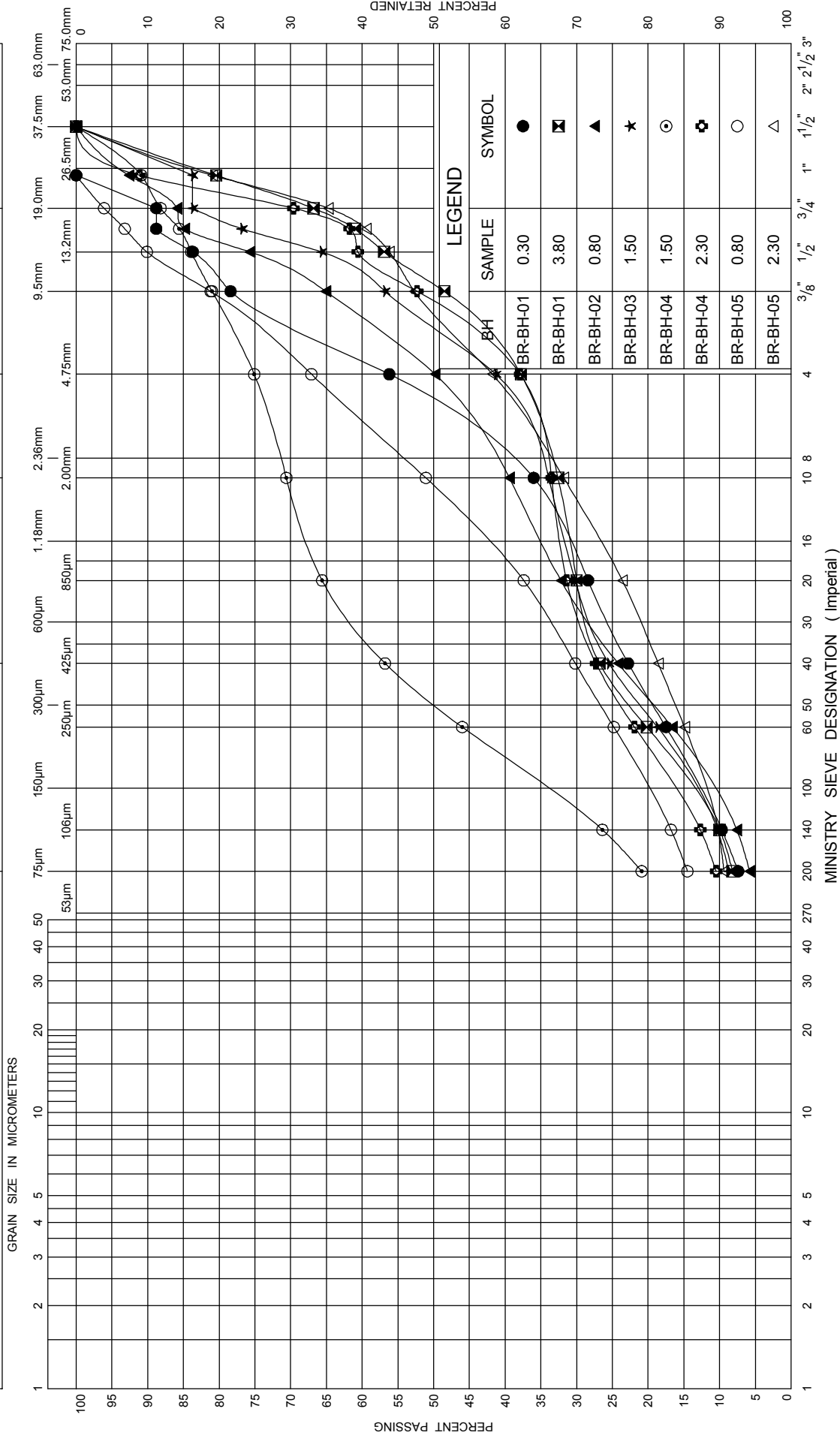


APPENDIX B

Laboratory Test Data

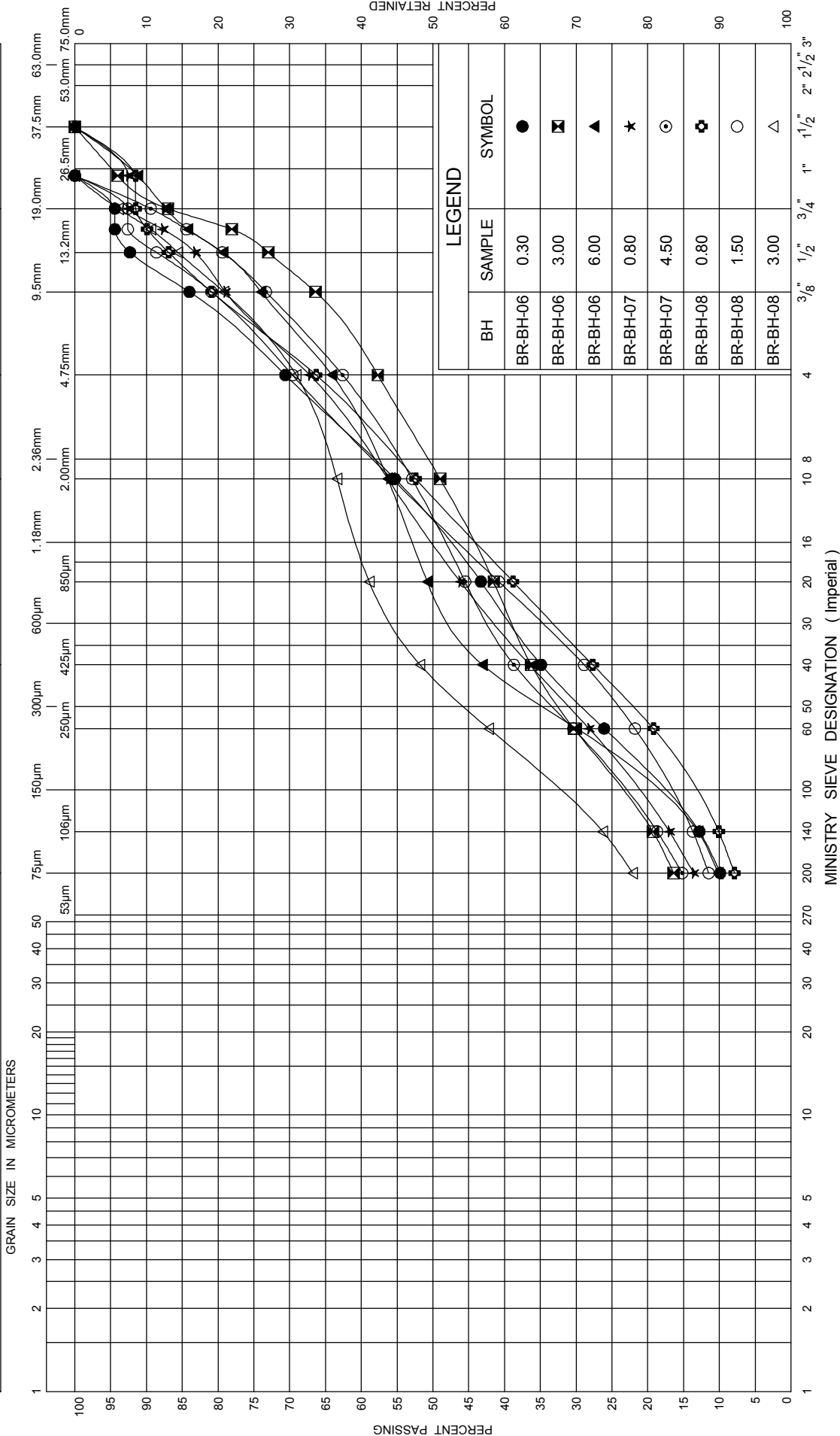
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine		Medium	Fine	Coarse



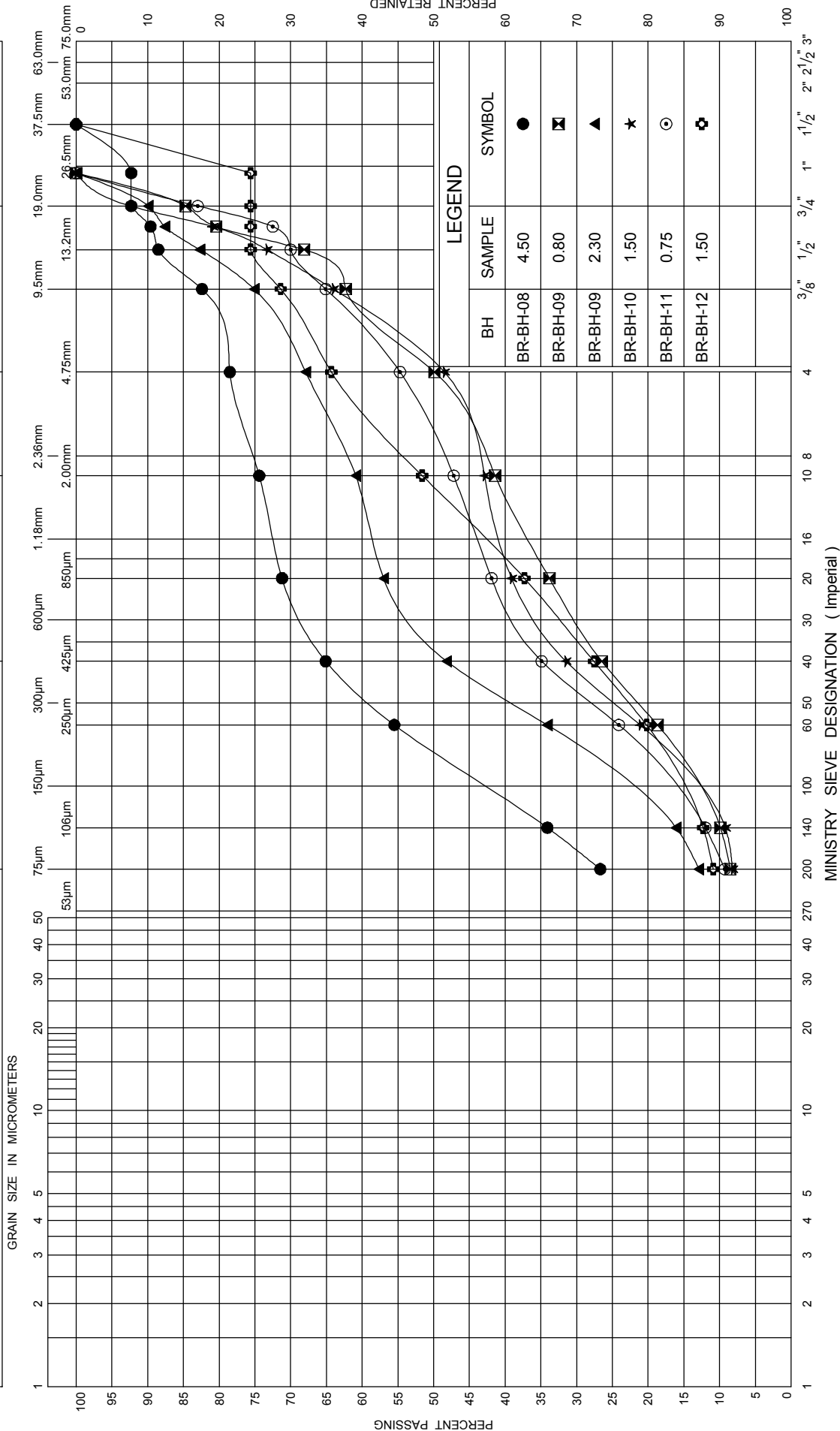
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT			SAND			GRAVEL		
Fine			Medium			Fine		
Coarse			Coarse			Coarse		



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine		Medium	Fine	Coarse





TBTE Engineering Group
ATTN: Doug Steele
1918 Young St.
Thunder Bay ON P7E 6T9

Date Received: 28-FEB-17
Report Date: 09-MAR-17 08:52 (MT)
Version: FINAL

Client Phone: 807-624-5160

Certificate of Analysis

Lab Work Order #: L1895543
Project P.O. #: NOT SUBMITTED
Job Reference: 15-089
C of C Numbers:
Legal Site Desc:

Christine Paradis
Project Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ADDRESS: 1081 Barton Street, Thunder Bay, ON P7B 5N3 Canada | Phone: +1 807 623 6463 | Fax: +1 807 623 7598
ALS CANADA LTD Part of the ALS Group An ALS Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1895543-1 BR-BH3-SS2 Sampled By: Client on 24-FEB-17 @ 10:00 Matrix: Soil							
Physical Tests							
Conductivity	0.122		0.0040	mS/cm		05-MAR-17	R3668063
% Moisture	9.01		0.10	%	01-MAR-17	01-MAR-17	R3665270
pH	6.71		0.10	pH units		02-MAR-17	R3665590
Redox Potential	258		-1000	mV		08-MAR-17	R3670304
Resistivity	8180		1.0	ohm*cm		05-MAR-17	
Leachable Anions & Nutrients							
Chloride	13.3		5.0	ppm	02-MAR-17	03-MAR-17	R3668442
Sulphide (as S)	<0.20		0.20	mg/kg	06-MAR-17	06-MAR-17	R3668506
Anions and Nutrients							
Sulphate	<20		20	ppm	01-MAR-17	03-MAR-17	R3668442
L1895543-2 BR-BH11-SS3 Sampled By: Client on 23-FEB-17 @ 10:30 Matrix: Soil							
Physical Tests							
Conductivity	0.127		0.0040	mS/cm		05-MAR-17	R3668063
% Moisture	6.51		0.10	%	01-MAR-17	01-MAR-17	R3665270
pH	6.96		0.10	pH units		02-MAR-17	R3665590
Redox Potential	236		-1000	mV		08-MAR-17	R3670304
Resistivity	7850		1.0	ohm*cm		05-MAR-17	
Leachable Anions & Nutrients							
Chloride	7.1		5.0	ppm	02-MAR-17	03-MAR-17	R3668442
Sulphide (as S)	<0.20		0.20	mg/kg	06-MAR-17	06-MAR-17	R3668506
Anions and Nutrients							
Sulphate	36		20	ppm	01-MAR-17	03-MAR-17	R3668442

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-R511-WT	Soil	Chloride-O.Reg 153/04 (July 2011)	EPA 300.0
5 grams of dried soil is mixed with 10 grams of distilled water for a minimum of 30 minutes. The extract is filtered and analyzed by ion chromatography.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
EC-WT	Soil	Conductivity (EC)	MOEE E3138
A representative subsample is tumbled with de-ionized (DI) water. The ratio of water to soil is 2:1 v/w. After tumbling the sample is then analyzed by a conductivity meter.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
MOISTURE-WT	Soil	% Moisture	Gravimetric: Oven Dried
PH-WT	Soil	pH	MOEE E3137A
A minimum 10g portion of the sample 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 and then analyzed using a pH meter and electrode.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
REDOX-POTENTIAL-WT	Soil	Redox Potential	APHA 2580
This analysis is carried out in accordance with the procedure described in the "APHA" method 2580 "Oxidation-Reduction Potential" 2012. Samples are extracted at a fixed ratio with DI water. Results are reported as observed oxidation-reduction potential of the platinum metal-reference electrode employed, in mV.			
RESISTIVITY-CALC-WT	Soil	Resistivity Calculation	APHA 2510 B
Resistivity are calculated based on the conductivity using APHA 2510B where Conductivity is the inverse of Resistivity.			
RESISTIVITY-CALC-WT	Soil	Resistivity Calculation	MOECC E3138
Resistivity are calculated based on the conductivity using APHA 2510B where Conductivity is the inverse of Resistivity.			
SO4-WT	Soil	Sulphate	EPA 300.0
SULPHIDE-WT	Soil	Sulphide (as S)	APHA 4500S2D
Sulphide in Soil analysis is based on APHA 4500 S2D. A sub-sample of the soil sample is distilled, sulphuric acid and sodium hydroxide are added to the distillate. The sample is then analyzed on a spectrophotometer.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample

mg/kg wwt - milligrams per kilogram based on wet weight of sample

mg/kg lwt - milligrams per kilogram based on lipid weight of sample

mg/L - unit of concentration based on volume, parts per million.

< - Less than.

D.L. - The reporting limit.

N/A - Result not available. Refer to qualifier code and definition for explanation.

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

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1895543

Report Date: 09-MAR-17

Page 1 of 3

Client: TBTE Engineering Group
1918 Young St.
Thunder Bay ON P7E 6T9

Contact: Doug Steele

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CL-R511-WT	Soil							
Batch	R3668442							
WG2487537-4 CRM		AN-CRM-WT						
Chloride			108.8		%		70-130	03-MAR-17
WG2487537-3 LCS								
Chloride			100.0		%		80-120	03-MAR-17
WG2487537-1 MB								
Chloride			<5.0		ug/g		5	03-MAR-17
EC-WT	Soil							
Batch	R3668063							
WG2489144-2 LCS								
Conductivity			101.3		%		90-110	05-MAR-17
WG2488249-1 MB								
Conductivity			<0.0040		mS/cm		0.004	05-MAR-17
MOISTURE-WT	Soil							
Batch	R3665270							
WG2486865-2 LCS								
% Moisture			100.3		%		90-110	01-MAR-17
WG2486865-1 MB								
% Moisture			<0.10		%		0.1	01-MAR-17
PH-WT	Soil							
Batch	R3665590							
WG2487598-1 LCS								
pH			6.91		pH units		6.7-7.3	02-MAR-17
REDOX-POTENTIAL-WT	Soil							
Batch	R3670304							
WG2487283-1 DUP		L1895543-2						
Redox Potential		236	231		mV	2.1	25	08-MAR-17
SO4-WT	Soil							
Batch	R3668442							
WG2487279-3 CRM		AN-CRM-WT						
Sulphate			95.8		%		60-140	03-MAR-17
WG2487279-4 DUP		L1895543-2						
Sulphate		36	36		mg/kg	0.3	30	03-MAR-17
WG2487279-2 LCS								
Sulphate			99.6		%		80-120	03-MAR-17
WG2487279-1 MB								

Quality Control Report

Workorder: L1895543

Report Date: 09-MAR-17

Page 2 of 3

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-WT	Soil							
Batch	R3668442							
WG2487279-1 MB								
Sulphate			<20		mg/kg		20	03-MAR-17
SULPHIDE-WT	Soil							
Batch	R3668506							
WG2489496-2 LCS								
Sulphide (as S)			98.6		%		70-130	06-MAR-17
WG2489496-1 MB								
Sulphide (as S)			<0.20		mg/kg		0.2	06-MAR-17

Quality Control Report

Workorder: L1895543

Report Date: 09-MAR-17

Page 3 of 3

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes 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 pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.



TBTE Engineering Group
ATTN: Doug Steele
1918 Young St.
Thunder Bay ON P7E 6T9

Date Received: 28-MAR-17
Report Date: 06-APR-17 10:39 (MT)
Version: FINAL

Client Phone: 807-624-5160

Certificate of Analysis

Lab Work Order #: L1905748
Project P.O. #: NOT SUBMITTED
Job Reference: 15-089
C of C Numbers:
Legal Site Desc:

Christine Paradis
Project Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ADDRESS: 1081 Barton Street, Thunder Bay, ON P7B 5N3 Canada | Phone: +1 807 623 6463 | Fax: +1 807 623 7598
ALS CANADA LTD Part of the ALS Group An ALS Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L1905748-1	L1905748-2			
		Description	Soil	Soil			
		Sampled Date	27-MAR-17	27-MAR-17			
		Sampled Time	15:10	15:00			
		Client ID	BR-BH-07	BR-BH-05			
Grouping	Analyte						
SOIL							
Physical Tests	Conductivity (mS/cm)		0.165	0.139			
	% Moisture (%)		14.7	21.7			
	pH (pH units)		7.22	5.95			
	Redox Potential (mV)		298	320			
	Resistivity (ohm*cm)		6070	7180			
Leachable Anions & Nutrients	Chloride (ppm)		<5.0	9.4			
	Sulphide (as S) (mg/kg)		<0.20	<0.20			
Anions and Nutrients	Sulphate (ppm)		<20	<20			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-R511-WT	Soil	Chloride-O.Reg 153/04 (July 2011)	EPA 300.0
5 grams of dried soil is mixed with 10 grams of distilled water for a minimum of 30 minutes. The extract is filtered and analyzed by ion chromatography.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
EC-WT	Soil	Conductivity (EC)	MOEE E3138
A representative subsample is tumbled with de-ionized (DI) water. The ratio of water to soil is 2:1 v/w. After tumbling the sample is then analyzed by a conductivity meter.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
MOISTURE-WT	Soil	% Moisture	Gravimetric: Oven Dried
PH-WT	Soil	pH	MOEE E3137A
A minimum 10g portion of the sample 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 and then analyzed using a pH meter and electrode.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
REDOX-POTENTIAL-WT	Soil	Redox Potential	APHA 2580
This analysis is carried out in accordance with the procedure described in the "APHA" method 2580 "Oxidation-Reduction Potential" 2012. Samples are extracted at a fixed ratio with DI water. Results are reported as observed oxidation-reduction potential of the platinum metal-reference electrode employed, in mV.			
RESISTIVITY-CALC-WT	Soil	Resistivity Calculation	APHA 2510 B
Resistivity are calculated based on the conductivity using APHA 2510B where Conductivity is the inverse of Resistivity.			
RESISTIVITY-CALC-WT	Soil	Resistivity Calculation	MOECC E3138
Resistivity are calculated based on the conductivity using APHA 2510B where Conductivity is the inverse of Resistivity.			
SO4-WT	Soil	Sulphate	EPA 300.0
5 grams of soil is mixed with 50 mL of distilled water for a minimum of 30 minutes. The extract is filtered and analyzed by ion chromatography.			
SULPHIDE-WT	Soil	Sulphide (as S)	APHA 4500S2D
Sulphide in Soil analysis is based on APHA 4500 S2D. A sub-sample of the soil sample is distilled, sulphuric acid and sodium hydroxide are added to the distillate. The sample is then analyzed on a spectrophotometer.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour 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.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg wwt - milligrams per kilogram based on wet weight of sample.

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

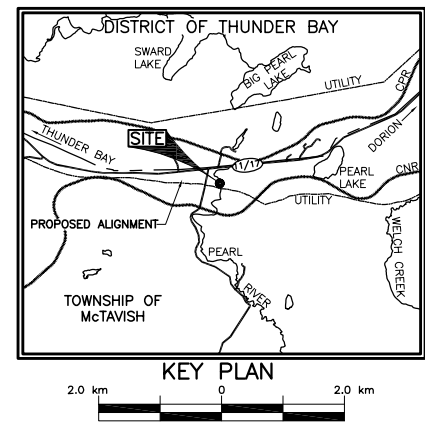
N/A - Result not available. Refer to qualifier code and definition for explanation.








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





UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

APPENDIX C
Borehole Locations and Soil Strata Drawing



SOIL STRATA SYMBOLS	
	ORGANICS
	SAND
	FILL
	SAND & GRAVEL
	GRAVEL
	BEDROCK
	TILL

LEGEND			
	Borehole		
	Std Pen Test (Blows/0.3m)		
	Water Level on completion		
	Water Level on April 22, 2017		
NFP	No Further Progress		
No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
BR-BH-01	250.3	15 5 392 269	403 568
BR-BH-02	249.0	15 5 392 242	403 605
BR-BH-03	248.5	15 5 392 252	403 620
BR-BH-04	249.2	15 5 392 262	403 613
BR-BH-05	249.9	15 5 392 275	403 588
BR-BH-06	249.9	15 5 392 281	403 578
BR-BH-07	249.9	15 5 392 301	403 613
BR-BH-08	249.5	15 5 392 294	403 621
BR-BH-09	248.8	15 5 392 277	403 639
BR-BH-10	248.3	15 5 392 271	403 647
BR-BH-11	248.5	15 5 392 280	403 656
BR-BH-12	249.6	15 5 392 307	403 629

—NOTE—

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

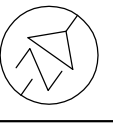
REFERENCE DRAWING SUPPLIED BY DILLION CONSULTING

[illegible]

Feb 27, 2018, 2:16pm
Drawing Name: \\Projects\2015\15-489 Dillon Consulting - Hwy 11 17 & Loring GWP 128-90-00\Foundation Strata\BR Site\NDM DRAFT.dwg
Login name: iblandin
PR-D-707 88-05
MINISTRY OF TRANSPORTATION, ONTARIO

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

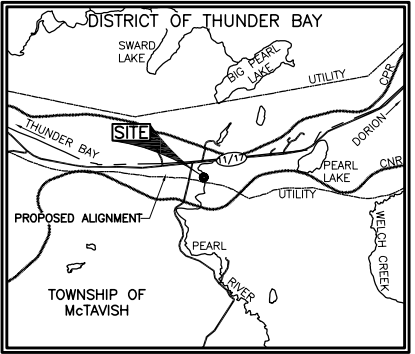
GEOCRES No. 52A-234
CONT No. 2017-xx
GWP No. 128-90-00



PEARL RIVER CROSSING STA 21+400
AT PROPOSED HWY 11/17
STRUCTURE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario
Ministry of Transportation
Northwestern Region
Structural Section



KEY PLAN
2.0 km 0 2.0 km



SOIL STRATA SYMBOLS

	ORGANICS		SAND
	FILL		SAND & GRAVEL
	GRAVEL		BEDROCK
	TILL		

LEGEND

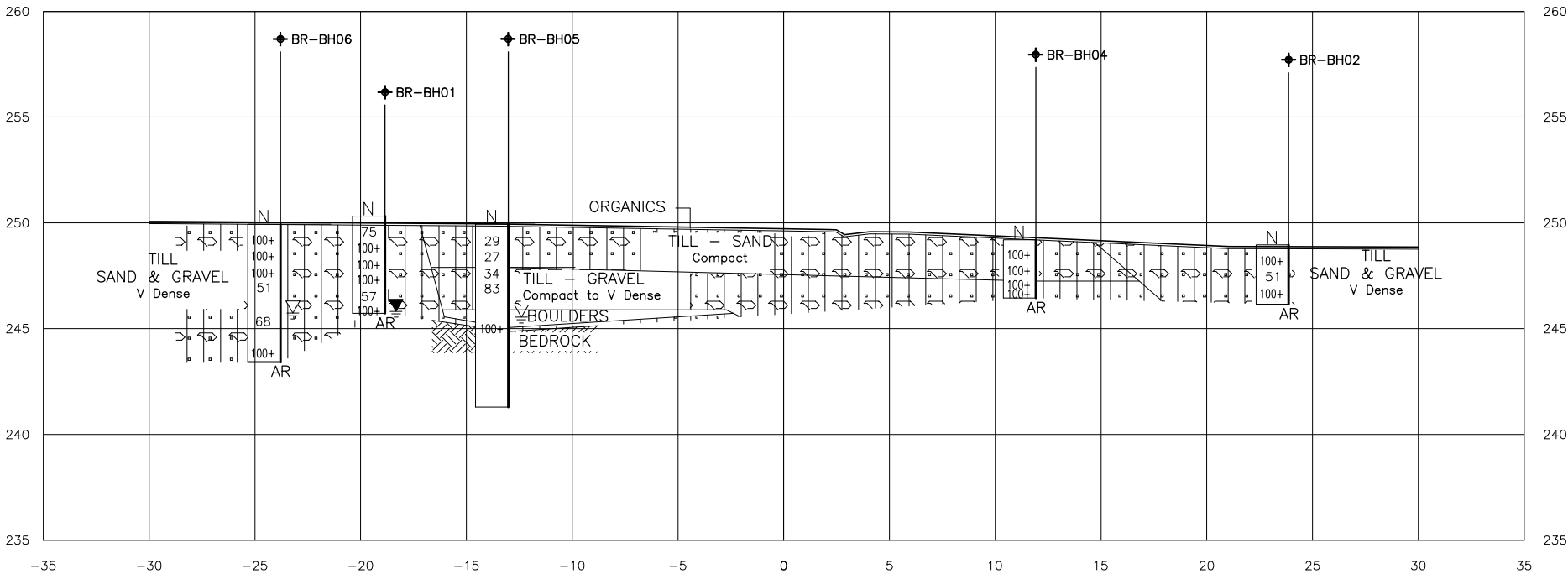
- ◆ Borehole
- 'N' Std Pen Test (Blows/0.3m)
- ▽ Water Level on completion
- ▽ Water Level on April 22, 2017
- NFP No Further Progress

No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
BR-BH-01	250.3	15 5 392 269	403 568
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BR-BH-11	248.5	15 5 392 280	403 656
BR-BH-12	249.6	15 5 392 307	403 629

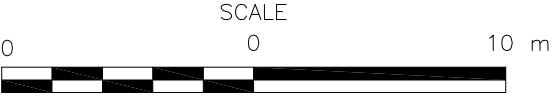
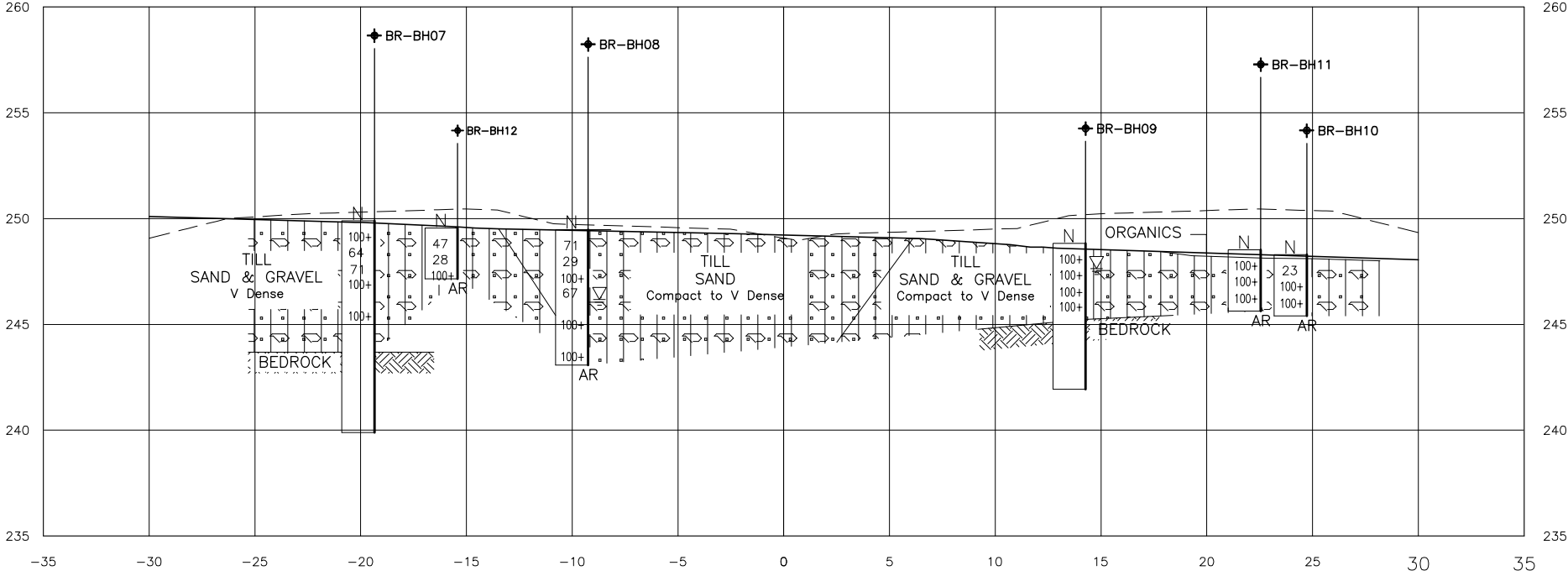
NOTE

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

SECTION C - C



SECTION D - D



REFERENCE DRAWING SUPPLIED BY DILLION CONSULTING

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS		DD/MM/YY BY		REVISION	DESCRIPTION
DESIGN	CHK	CODE	XXXXX-XX	LOAD XX-XXX-XXX	DATE XXXXXXXX
DRAWN	XX	CHK	XX	SITE XXX-XXX	DWG 2