

Foundation Investigation and Design Report

Culvert Replacement

Black River (Site No. 41S-135C)

Highway 71, 31.2 km South of Highway 17

SUBMITTED TO:

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Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering Limited (TBTE) has been retained by LH North Ltd. (LHN) to provide a foundation investigation and design report for the replacement of a culvert intersecting Highway 71 along Black River 31.2 km south of in the intersection of Highway 71 and Highway 17. This location is part of a three structure design build minor for Structural Culvert Replacements on Highway 71. The foundation investigation was conducted to provide subsurface data for the culvert replacement.

This report addresses the conditions for the Highway 71 and Black River culvert location. The remaining foundation sites Log River Culvert and Pine Lake Culvert are addressed under separate covers.

This investigation consisted of a total of five boreholes; one midpoint borehole drilled adjacent to the existing culvert, two boreholes drilled for roadway protection information, two boreholes drilled at the culvert openings, laboratory testing and geotechnical analysis of the data. This report (Part A) describes the subsurface conditions encountered during the investigation. The boreholes are labeled from BLK1 to BLK5.

2 Site Description

The foundation investigation was completed to investigate subsurface conditions for the Black River Culvert, Site No. 41S-135C along Hwy 71 in the Township of Work. The existing culvert located at this site is a 1960 mm centreline CSP. The culvert services the Black River. The new culvert will be located at the same location as the existing.

The culvert site is located in a rural area of moderate terrain relief. The area is generally tree covered and bedrock outcrops are common.

The road embankment at this location is approximately 3 to 5 m high with side slopes of approximately 2.3 horizontal to 1 vertical on both the right and left side. Rock fill is evident along the highway embankment. There is a bedrock outcrop southerly on the northbound lane side of the highway. The water level in the water course at the culvert inlet and outlet was measured, with elevations of 341.2 and 340.7 m respectively in March, 2015.

Photo 2.1 – Black River Culvert



3 Surficial Geology

Available surficial geology mapping (OGS NOEGTS Map 5057 . Rat Portage Bay) indicates the site is located in a terrain unit comprised of rock with local glaciofluvial and ground moraine deposits.

4 Investigation Procedures

A geotechnical site investigation was undertaken from March 30 to April 1, 2015. The borehole locations are illustrated on the Borehole Location and Soil Strata Drawing found in Appendix C. The investigation was carried out using a CME 750 drill rig. The CME 750 drill rig is equipped for geotechnical testing and sampling. Hollow stem auger methods were utilized.

The borehole locations were identified in the field by TBTE personnel and service clearances were completed prior to mobilizing the drill rig to site.

Soil samples were obtained at the boreholes using a split spoon sampler as a part of the Standard Penetration Testing (SPT). The SPT involves driving a thick walled sampler into the soils under a standardized energy (63.5 kg, falling 760 mm). The number of blows required to drive the sampler 0.3 m is known as the SPT blow count (N). In addition, relatively undisturbed thin wall tube samples were obtained at selected depths. Field vane testing (MTO field vane) was carried out at selected depths both within the clay soils.

SPT ~~N~~+values reported on the borehole logs and referenced in Section 6 (Sub-Surface Conditions) are uncorrected field values.

Borehole locations and elevations were surveyed by LHN.

5 Laboratory Testing

Samples which were obtained during the field investigation were subjected to laboratory testing consisting of moisture content, grain size analysis (mechanical sieves and hydrometers), consolidation testing and drained direct shear testing. The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B).

6 Sub-Surface Conditions

Details of the subsurface conditions are provided on the borehole logs (Appendix A), laboratory reports (Appendix B) and on the Soil Strata Drawing (Appendix C). Borehole logs and laboratory data from a previous investigation has been included in Appendix D.

The subsurface soils at this site typically consist of fills through the embankment which overlie sand over bedrock. Clay was encountered within two boreholes between the fill and sand, and a layer of organic material was encountered between the fill and sand at one borehole.

Numerous cobbles were present within the fill materials, and occasional cobbles within the sand. All boreholes were extended to auger refusal. Four of the five boreholes extended below the refusal using diamond casing/coring techniques. Frost was encountered at depths of 0.3 m extending to a depth of 2.2 m at Boreholes BLK 2 and 4.

6.1 Topsoil

Topsoil was encountered at the ground surface of Boreholes BLK1 and 3. The topsoil's thickness was 100 mm at both locations.

6.2 Asphalt

Asphalt was encountered at the surface of Boreholes BLK2, 4 and 5. The asphalt's thickness was 50 mm at all locations.

6.3 Fill

Fill was encountered at all boreholes and varied in thickness from 0.5 to 6.1 m extended to elevations ranging from 344.0 to 339.1. The fill ranges from sand and gravel with trace silt to silty sand with trace gravel. The test results indicate a grain size distribution of 2 to 36 % gravel, 58 to 85 % sand, and 6 to 22 % silt/clay sized particles. The presence of numerous cobbles was noted within the fill at Boreholes BLK 1, 2 and 4. The fill is very loose to very dense as indicated by N_{60} values ranging from 1 to 78 blows/0.3 m.

6.4 Organic Material

Organic material was encountered below the fill at Borehole BLK 2. The material was encountered at an elevation of 339.1 m with a thickness of 0.5 m and a natural moisture content of 46 %.

6.5 Clay

Clay with sand was encountered beneath the fill at Borehole BLK 1 and 5. The clay extended to depths ranging from 338.1 to 339.6 and varied in thickness from 2.5 to 4.4 m. Based on two Atterberg Limit tests, the low plastic clay has a natural moisture content ranging from exceeding the liquid limits to between the liquid and plastic limit. The clay is firm to stiff as indicated by insitu vane testing ranging from 25 and 68 kPa.

A consolidated undrained direct shear test was conducted on a sample from Borehole BLK 1 at a depth of 3.0 m to estimate the undrained shear strength of the clay. The test results indicate an undrained shear strength of 28 kPa is developed at a horizontal shear strain level of 4%. The peak shear strength was 36 kPa.

6.6 Sand

Native sand was present at all the borehole locations with the exception of Borehole BLK 4. The native sand was encountered beneath the clay at Borehole BLK 1 and 5, beneath the fill at Borehole BLK 3, and beneath the organic material at Borehole BLK 2. The native sand was encountered at elevations ranging from 338.1 to 339.6 m and varied in thickness from 0.2 to 5.4 m, with Borehole BLK 5 terminating within this material. Based on two grain size analysis the material consists of sand and silt with trace gravel to sand and gravel with some silt as indicated by grain size distributions of 1 to 48 % gravel, 38 to 43 % sand, and 14 to 56 % silt/clay sized particles. Numerous cobbles were noted within Borehole 2. The sand is in a very loose to dense as indicated by N_{60} values ranging from 2 to 33 blows/0.3 m.

A consolidation test was conducted on a disturbed sample of the sand material from Borehole BLK 1 at a depth of 6.1 m. The results of this consolidation test indicate a drained constrained modulus in the range of 23 MPa within the expected design normal stress range.

A consolidated drained direct shear test was conducted on a sample of sand from Borehole BLK 1 at a depth of 3.1 m to estimate the effective stress strength parameters. The lower bound of the shear strength points developed at a horizontal shear strain level of 4% is represented $\phi = 35^\circ$.

6.7 Bedrock

Bedrock was encountered at all borehole locations with the exception of Borehole BLK 5. The following table indicates the recorded bedrock elevation and depth at each borehole. Bedrock was encountered underlying the sand at Boreholes BLK 1, 2, and 3, and beneath the fill at Borehole BLK 4. Bedrock was sampled using diamond coring techniques. The bedrock is medium grained black and white foliated Tonalite. Detailed core logs and photos of the rock cores are provided in Appendix A.

Table 6.1: Bedrock

Borehole Number	Bedrock Depth (m)	Bedrock Elevation
BLK 1	8.5	332.7
BLK 2	8.6	336.7
BLK 3	2.1	339.3
BLK 4	3.7	341.2

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 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 6.2: RQD/ Rock Quality Correlation

RQD %	ROCK QUALITY
0 . 25	Very Poor
25 . 50	Poor
50 . 75	Fair
75 . 90	Good
90 . 100	Excellent

The RQD as presented on the borehole and core logs varies from 63 to 94 %. The majority of RQDs were measured to be 84 to 94 % and can be described as good to excellent, with one sample with an RQD of 63 % indicating fair quality at Borehole BLK 4.

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

Table 6.3: Estimated Uniaxial Compressive Strength

Borehole Number	Depth (m)	Elevation	*Estimated Uniaxial Compressive Strength (MPa)
BLK 1	8.9	332.2	219
	9.9	331.2	234
BLK 2	8.7	336.5	265
	10.1	335.1	199
BLK 3	2.6	338.8	207
	3.2	338.2	237
BLK 4	4.6	340.3	295
	5.9	339.0	283

* Estimated based on published correlations.

Based on the range in estimated uniaxial compressive strength, the intact bedrock is classified as very strong to extremely strong.

6.8 Ground Water

The ground water levels were observed upon completion of drilling from March 30 to April 1, 2015 at and are provided below. Ground water levels will vary from season to season and from the effects of heavy precipitation events. The water level at the culvert inlet/outlet was at elevation 341.2 and 340.7 m in March of 2015. A small beaver dam was located at the culvert inlet.

Table 6.4: Ground Water Level

Borehole	Depth below Ground Surface (m)	Elevation
BLK 1	0.5	340.7
BLK 2	4.1	341.1
BLK 3	0.5	340.6
BLK 4	2.8	342.1
BLK 5	4.8	340.7

7 Miscellaneous

Laboratory testing was completed at the TBT Engineering Limited laboratory in Thunder Bay. The drill equipment for this investigation was operated by TBT Engineering. The field operations were supervised by Alan Finke. Laboratory testing was supervised by T. Fummerton C.E.T. This report was prepared by Steven Seller, P.Eng and Gordon Maki, P.Eng., and reviewed by W. Hurley, P.Eng (TBTE designated principal contact identified for MTO Foundation Engineering projects).

Part B - FOUNDATION DESIGN REPORT

8 Introduction

TBT Engineering Limited (TBTE) has been retained by LH North Ltd. (LHN) to provide foundation investigation and design services for the proposed culvert replacements on Highway 71. There are three culvert sites along Highway 71, which require investigation. This report addresses the conditions at Black River (Site 41S-135C). The final design of the proposed culverts will be an open footing culvert, as determined by LHN.

The foundation investigation as described in Part A, were carried out to investigate subsurface conditions at this site. The investigation at Black River Culvert consisted of five boreholes; Boreholes BLK 1 to 5. A previous investigation had also been completed and the boreholes from that investigation have been provided in Appendix D.

The subsurface soils at this site typically consist of fills which overlie sand over bedrock. Numerous cobbles and boulders were present in the fill and native sand.

The purpose of this section of the report (Part B) is to provide foundation design recommendations for the anticipated foundation configuration. These are based on the conditions encountered at the borehole locations and TBTE's interpretation of the subsurface conditions at the sites.

9 Structure Foundations

The existing culvert will be replaced with an open bottom culvert using spread footings on rock fill. Unless noted otherwise, foundation design parameters are given for static, vertically and concentrically loaded foundations in compression.

9.1 Spread Footings

Spread footings are considered to be appropriate for open footing culverts. A resistance factor of 0.5 has been applied for the estimation of the factored geotechnical resistance at ULS. Settlements for SLS have been estimated assuming a uniform pressure distribution over the entire base of the foundation, with an allowance for potential of some disturbance of the founding surface during construction.

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 or placed over/within non-frost susceptible fills (such as rock fill) which extend to the depth of frost penetration.

9.2 Spread Footings on Rock Fill

Footings may be founded on a rock fill pad. Typically, the foundation element is constructed on a graded rock fill pad with a specific minimum thickness. The graded rock fill pad is to be founded on the native sand or bedrock. Through discussions with LHN, it is understood the clay soils below influence of the footing will be removed to either bedrock or native sand. For the purpose of assessing bearing capacity, the rock fill pad will extended at least 1.2 m below the underside of footing or to bedrock (where bedrock is within 1.2 m of the base of footing).

The geotechnical resistances at ULS and geotechnical reactions at SLS for typical footings founded on rock fill are provided in Table 9.1.

Table 9.1: Geotechnical Resistances and Reactions for Footings on Rock Fill

Effective Footing Width (m)	Base of footing 0.0 m below culvert invert (Minimum Depth of Cover 0.0 m)		Base of footing 0.3 m below culvert invert (Minimum Depth of Cover 0.3 m)		Base of footing 0.5 m below culvert invert (Minimum Depth of Cover 0.5 m)	
	Factored Geotechnical Resistance, ULS (kPa)	Geotechnical Reaction, SLS (kPa) for 25 mm settlement	Factored Geotechnical Resistance, ULS (kPa)	Geotechnical Reaction, SLS (kPa) for 25 mm settlement	Factored Geotechnical Resistance, ULS (kPa)	Geotechnical Reaction, SLS (kPa) for 25 mm settlement
0.6	95	390	185	390	255	390
1.0	160	260	245	260	310	260
1.5	235	190	325	190	385	190
2.0	295	160	400	160	450	160

The rock fill pad should consist of graded rock fill. The upper 150 mm of the rock fill pad should be constructed with 19 mm clear stone. The base of the pad should extend horizontally beyond the edge of the footings by a distance at least equal to the thickness of the rock fill pad provided.

A single foundation element should not be placed on both bedrock and soil. Should bedrock exist at or above the proposed underside of the footing elevation, rock excavation will be required. The bedrock should be excavated to allow for placement of a minimum of 150 mm of 19 mm clear stone below the footing. The geotechnical reactions provided above are based on a maximum of 25 mm of settlement at locations where there is significant overburden between the footing and bedrock. Given the variable depth to bedrock at this site, differential settlement of up to 25 mm should be considered under full design serviceability limit states reactions.

9.3 Global Stability of Shallow Foundations

An assessment of global stability of the proposed shallow footings was carried out using Slope/W software and limit equilibrium analysis using the Morgenstern-Price method. The soil properties established/estimated for the embankment and foundation soils are presented in Table 9.2.

Table 9.2: Stability Analyses Soil Properties

Soil	Effective Shear Strength Properties		Total Stress Shear Strength, C_u (kPa)	Unit Weight, (kN/m ³)
	Effective Angle of Internal Friction, ϕ (degrees)	Effective Cohesion Intercept, C_c (kPa)		
Fill (new granular)	35	0	-	20
Existing Fill	30	0	-	20
Rock Fill or 19 mm Clear Stone	40	0	-	18
Clay	30	0	25	20
Native Sand	30	0	-	20
Organic Material	30	0	-	12
Interface of Bedrock / Rock Fill	24	0	-	18

The stability model was established with the following conditions:

- New backfill behind the culvert will consist of compacted Granular A, or B (Type I or II) and will exist within excavation back slope of 2H:1V, or flatter through the existing fill and/or native soils.
- The rock fill pad below the footing will extend through the clay to the underlying sand.
- The footing will extend at least 0.75 m behind the culvert.
- The culvert span is 6.5 m.
- An unfactored dead load of 178 kN/m was modelled along the footing (data provided by LHN).

Stability analyses have been completed for two cases. The first case assumes the footing will be founded on a 150 mm clear stone pad over bedrock. The interface friction between the stone and bedrock was modelled with an angle of internal friction of 24°. The second case assumes the footing is sitting on a rock fill pad extending through the clay and founded on the native sand. A uniformly distributed traffic load of 20 kPa over the traversable lane(s) was applied in both cases. The results of this assessment indicate a suitable level of stability (FoS ≥ 1.3) for both cases as illustrated below in Figures 9.1 to 9.4.

Figure 9.1: Footings Over Bedrock Rock - Effective Stress Strength Parameters for Clay

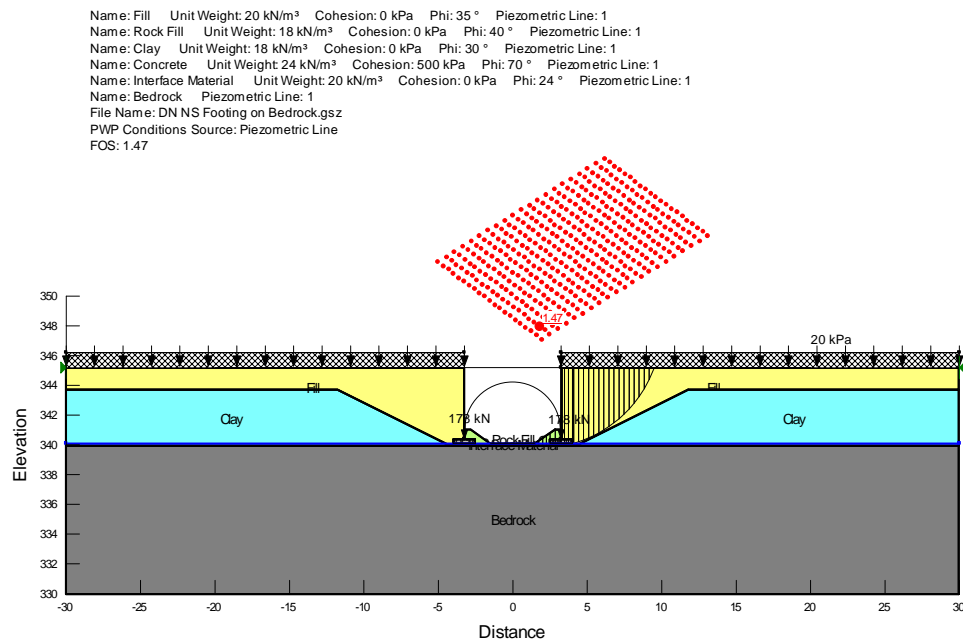


Figure 9.2: Footings Over Bedrock – Total Stress Strength Parameters for Clay

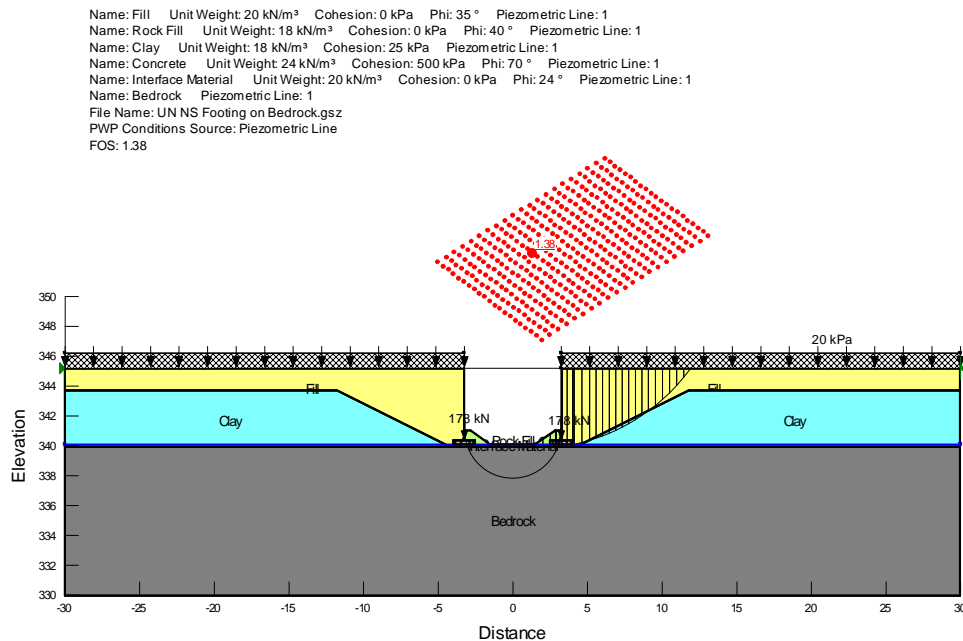


Figure 9.3: Footings Over Rock Fill Pad and Sand – Effective Stress Strength Parameters for Clay

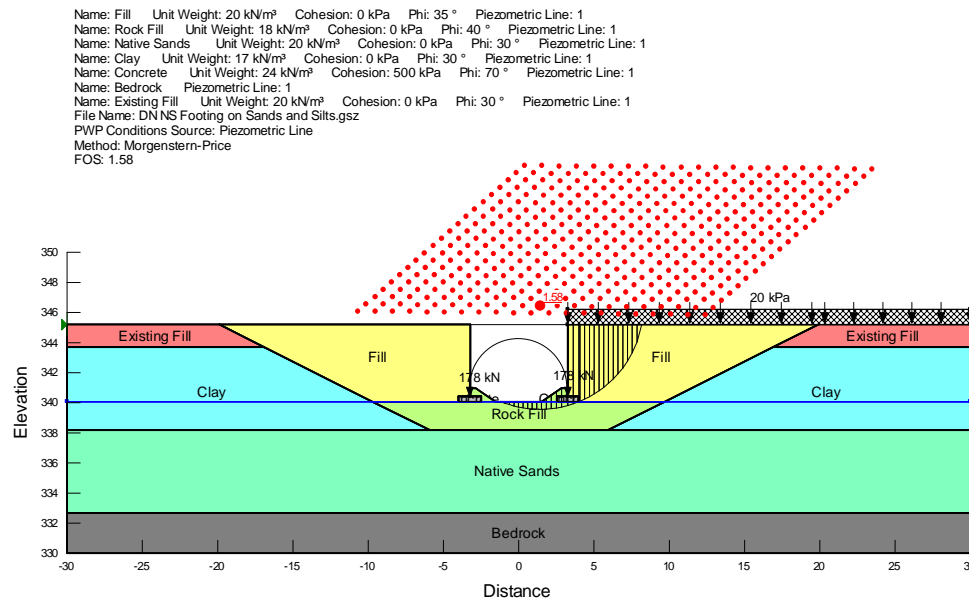
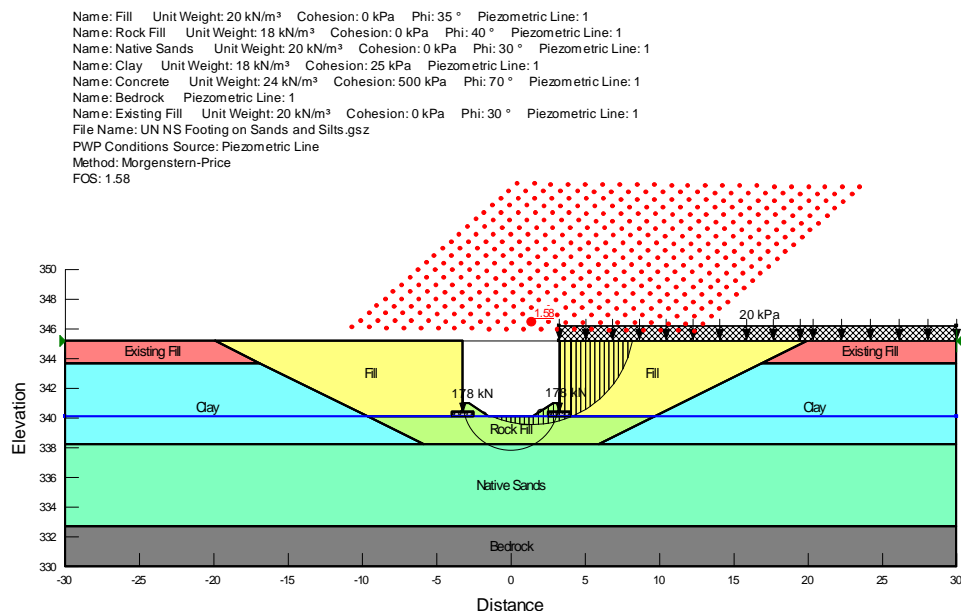


Figure 9.4: Footings Over Rock Fill Pad and Sand – Total Stress Strength Parameters for Clay



10 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 in specific zones.

Lateral earth pressure coefficients for potential granular backfill and level ground conditions have been provided in Table 10.1.

Table 10.1: Lateral Earth Pressure Coefficients

Lateral Earth Pressure Coefficients (K)					
Compacted Granular Backfill	' (°)	Bulk Unit Weight of Soil, (kN/m ³)	Active Ka	At Rest Ko	Passive Kp
OPSS Granular A, or Granular B Type II	35	20 - 22	0.27	0.43	3.7
OPSS Granular B Type I	32	20 - 22	0.31	0.47	3.3

No factor of safety or resistance factor has been included in the above coefficients. A compaction surcharge should be added in accordance with the CHDBC. The culvert must also be designed to resist hydrostatic pressures where applicable.

Resistance to lateral forces between the footing and the 19 mm clear stone fill should be calculated in accordance with Section 6.7.5 of the CHDBC. The coefficient of friction for the proposed precast concrete footing and the 19 mm clear stone may be taken as $\tan(24^\circ) = 0.45$.

11 Roadway Protection

The overall embankment fill thickness is in the order of 4.4 to 6.1 m. The use of roadway protection during construction may be required depending on final culvert configuration and construction staging requirements. It is understood that staging requirements are being addressed by others.

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 soils below the ground water level consist of coarse grained permeable fills, clays, and permeable native sands. Groundwater flows in to open excavations below the ground water level may be rapid. The current creek level is less than 1 m above invert.

To facilitate construction in the dry, control of surface and ground water will be required. Excavations for footing construction and/or placement of rock fill are expected to extend below the ground water level. The potential for base heave during construction is a possibility due to the presence of a thin cohesive soil layer which is underlain by a non-cohesive soil. If the soils heave during excavation the disturbed soils will experience a loss of strength and will affect design values provided above. To prevent base heave and to stabilize a dry excavation, dewatering (typically in the form of well points) will be required to lower the ground water to a level below the depth of the planned excavation. The use of a sheet pile cut-off wall is not considered practical due to presence of cobbles and boulders within the fill and due to the variability of the bedrock depth. Construction in the wet with immediate backfilling with rock fill and/or placement of tremie concrete may also be considered.

13 Scour Protection

Where appropriate, foundation elements should be provided with sufficient scour protection in the event of elevated river levels. Scour protection should be designed taking into account hydrologic and hydraulic concerns and in accordance with Section 1.9.5 of the Canadian Highway Bridge Design Code.

14 Estimated Frost Depth and Frost Protection

Based on the Ontario Provincial Standard Drawing 3090.1 Foundation Frost Depth for Northern Ontario+the estimated frost depth penetration within the expected embankment fill is 2.4 m. The embankment soils anticipated within the frost depth are considered to be of low frost susceptibility (MTO Pavement Design and Rehabilitation Manual). Frost treatments should conform to OPSD 803.031.

15 Potential Construction Issues

No major construction difficulties are foreseen at this site. Issues which may require consideration include:

-
- Control of surface and groundwater during excavation below the creek/groundwater level.
 - Potential for construction in the wet
 - Staging and Roadway Protection Requirements.
 - Some rock excavation may be required.

16 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the borehole 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.

17 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



Gordon Maki, P.Eng
Senior Project Engineer



Steven Seller, P.Eng
Project Engineer



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

APPENDIX A

Borehole Logs

TBT Engineering Consulting Group		RECORD OF Borehole No BLK 1		1 OF 1 METRIC										
W.P. _____ PROJECT Black River		SITE _____		ORIGINATED BY AF										
DIST 61 HWY 71 LOCATION MTM 16 N5490447.74, E228354.763		TBTE JOB# 15-026		COMPILED BY TB										
DATE 2015 March 30 BOREHOLE TYPE Hollow Stem Auger		DATUM GEODETIC		CHECKED BY GM										
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 (%)				
341.2 0.1	TOPSOIL - 100 mm FILL - SAND - some silt, trace gravel, numerous cobbles, brown, very loose CLAY - some sand, with organics, grey, firm		1	AS		341							7 78 (15) Water @ 0.5 m upon completion.	
340.6 0.6			2	SS	3	340								
			3	SS	6	339								
			4	SS	1	338								
338.1 3.1	SAND & SILT - trace gravel, grey, very loose to loose		5	TW		338							0 15 52 33	
			6	SS	2	337								
			7	SS	2	336								
			8	SS	5	335								
332.7 8.5	BEDROCK - Tonalite - medium grained, black & white foliated		1	RC		334							1 43 (56)	
						333								
331.2 10.0	End of Borehole @ 10.0 m.					332							RC # 1 REC = 100% RQD = 91.7%	

ONL_MOT_BH_MTM_DIST_15-026_BLACK_RIVER.GPJ ONL_MOT.GDT 15/5/1

\times^3, \star^3 : Numbers refer to Sensitivity NP Non Plastic ○ 3% STRAIN AT FAILURE



W.P.		PROJECT	Black River	SITE		ORIGINATED BY	AF
DIST	61	HWY	71	LOCATION	MTM 16 N5490445.931, E228367.268	TBTE JOB#	15-026
DATE	2015 March 31	BOREHOLE TYPE	Hollow Stem Auger	DATUM	GEODETIC	CHECKED BY	GM

[illegible]

✕³, ★³: Numbers refer to Sensitivity
 NP Non Plastic

ON MOT BH MTM DIST 15-026 BLACK RIVER.GPJ ON MOT.GDT 15/5/1

TBT Engineering Consulting Group			RECORD OF Borehole No BLK 3			1 OF 1		METRIC				
W.P. _____ PROJECT Black River			SITE _____			ORIGINATED BY AF						
DIST 61 HWY 71 LOCATION MTM 16 N5490432.871, E228382.075			TBTE JOB# 15-026			COMPILED BY TB						
DATE 2015 April 1 BOREHOLE TYPE Hollow Stem Auger			DATUM GEODETIC			CHECKED BY GM						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L			WATER CONTENT (%)
341.4 340.0 0.1	TOPSOIL - 100 mm FILL - SAND & GRAVEL - trace silt, brown, very loose		1	AS			341					Water @ 0.5 m upon completion.
			2	SS	1		340					
			3	SS	3		339.5					
339.5 339.3 0.2	SAND & GRAVEL - Silty, grey/brown											36 58 (6)
	BEDROCK - Tonalite - medium grained, black & white foliated		1	RC			339					
338.1 3.3	End of Borehole @ 3.3 m.											

TBT Engineering Consulting Group			RECORD OF Borehole No BLK 4			1 OF 1 METRIC										
W.P. _____ PROJECT Black River			SITE _____			ORIGINATED BY AF										
DIST 61 HWY 71 LOCATION MTM 16 N5490420.861, E228358.599			TBTE JOB# 15-026			COMPILED BY TB										
DATE 2015 March 31 BOREHOLE TYPE Hollow Stem Auger			DATUM GEODETIC			CHECKED BY GM										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa				WATER CONTENT (%)				
344.9 344.0	ASPHALT - 50 mm FILL - SAND - Gravelly, some silt, numerous cobbles, brown		1	AS												Water @ 2.8 m upon completion. Frost 0.3 to 2.2 m. 22 65 (14) On cobbles. On cobbles.
			2	AS												
			3	SS	100+											
			4	SS	100+											
	----- - ROCK FILL															
341.2 3.7	BEDROCK - Tonalite - medium grained, black & white foliated		1	RC												RC # 1 REC = 100% RQD = 62.8%
339.0 5.9	End of Borehole @ 5.9 m.															

TBT Engineering Consulting Group		RECORD OF Borehole No BLK 5		1 OF 1 METRIC	
W.P. _____ PROJECT Black River SITE _____ ORIGINATED BY AF					
DIST 61 HWY 71 LOCATION MTM 16 N5490459.572, E228378.516 TBTE JOB# 15-026 COMPILED BY TB					
DATE 2015 April 1 BOREHOLE TYPE Hollow Stem Auger DATUM GEODETIC CHECKED BY GM					

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W _p	W	W _L			
345.5 0.0	ASPHALT - 50 mm FILL - SAND - some gravel, brown, very dense		1	AS									Water @ 4.8 m upon completion.	
345.0			2	AS										
344.0			3	SS	78									
1.5	CLAY - Sandy, brown to grey, stiff		4	SS	21								0 32 37 31	
343.0			5	SS	8									
342.0			6	SS	3									
341.0			7	SS	10									
339.6 5.9	SAND & GRAVEL - some silt, occasional cobbles, brown, dense		8	SS	33								48 38 (14)	
338.7 6.8			End of Borehole @ 6.8 m. Auger Refusal.											

ONL_MOT_BH_MTM DIST 15-026 BLACK RIVER.GPJ ONL_MOT.GDT 15/5/1

\times^3, \star^3 : Numbers refer to Sensitivity
 NP Non Plastic

\circ 3% STRAIN AT FAILURE

ROCK CORE LOG

Page 1 of 1

Project #: 15-026

BLK1

Lab# 16503

Client: LH North

Logger: Jason Arnold

Site: HWY 71 - Pinewood

Date: Tuesday, April 8, 2014

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°)

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 = Slickened sided undulating
LP = Slickened 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

GENERAL DESCRIPTION
(Rock type(s), %, colour, texture, etc.)

Medium grain, black and white foliated tonalite. Foliation ~35
DTCA defined by biotite. One joint has a smooth, brown, rusty
surface.

% RQD
(m)

100.0%
(1.52)

% REC
(m)

100.0%
(1.52)

BOX/RU
N

1/1
1/2

DEPTH
(m)

From

8.45

To

9.98

From

To

From

To

From

To

STRENGTH

WEATHERING

S

DISCONTINUITIES

OF SETS

1

TYPE(S)

J

Orientation

D

SPACING

M

Roughness

SP

APERTURE

O

FILLING

O

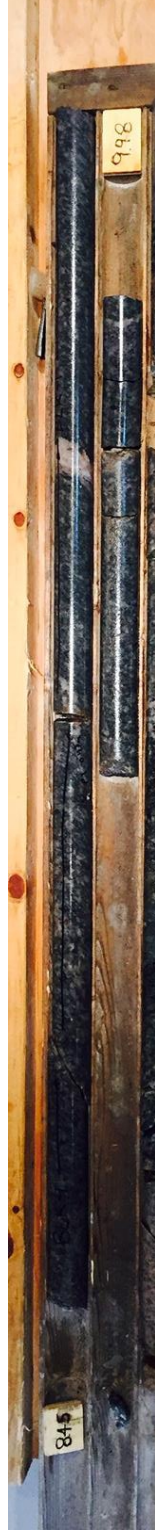
OCCASIONAL FEATURES

P1 - 8.92 m
P2 - 9.91 m

Full Rock Core Dry



Full Rock Core Wet



ROCK CORE LOG

Page 1 of 1

Project #: 15-026

BLK2

Lab# 16504

Client: LH North

Logger: Jason Arnold

Site: HWY 71 - Pinewood

Date: Tuesday, April 8, 2014

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°)

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 = Slickened sided undulating
LP = Slickened 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

GENERAL DESCRIPTION
(Rock type(s), %, colour, texture, etc.)

Medium grain, black and white foliated tonalite. Foliation ~35 DTCA defined by biotite. Joint surfaces are smooth, brown and rusty. Granite Aplite dykes - 8.55-8.75 m and 9.50-9.73 m.

% RQD
(m)

88.0%
(1.38)

% REC
(m)

100.0%
(1.57)

BOX/RU
N

1/3
1/4

DEPTH
(m)

From

8.55

To

10.12

From

To

From

To

From

To

STRENGTH

WEATHERING

OF SETS

3

TYPE(S)

J

Orientation

D

SPACING

M

Roughness

SP

APERTURE

O

FILLING

O

OCCASIONAL FEATURES

P1 - 8.67 m
P2 - 10.06 m

Full Rock Core Dry



Full Rock Core Wet



ROCK CORE LOG

Page 1 of 1

Project #: 15-026

BLK3

Lab# 16505

Client: LH North

Logger: Jason Arnold

Site: HWY 71 - Pinewood

Date: Tuesday, April 8, 2014

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°)

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 = Slickened sided undulating
LP = Slickened 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

OCCASIONAL FEATURES

P1 - 2.55 m
P2 - 3.24 m

DISCONTINUITIES

WEATHERING

STRENGTH

GENERAL DESCRIPTION
(Rock type(s), %, colour, texture, etc.)

Medium grain, black and white foliated tonalite. Foliation ~35 DTCA defined by biotite. Joint surfaces are smooth, brown and rusty. Conjugate dykes ~10cm wide each, between ~2.70-2.90 m depth, the upper dyke a pink granite aplite, lower dyke a white tonalite aplite.

% RQD
(m)

% REC
(m)

BOX/RU
N

DEPTH
(m)

From

To

From

To

From

To

From

To

OF SETS

TYPE(S)

Orientation

SPACING

Roughness

APERTURE

FILLING

Full Rock Core Dry



Full Rock Core Wet



ROCK CORE LOG

Page 1 of 1

Project #: 15-026

BLK4

Lab# 16506

Client: LH North

Logger: Jason Arnold

Site: HWY 71 - Pinewood

Date: Tuesday, April 8, 2014

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°)

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 = Slickened sided undulating
LP = Slickened 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

GENERAL DESCRIPTION
(Rock type(s), %, colour, texture, etc.)

Medium grain, black and white foliated tonalite. Foliation ~35 DTCA defined by biotite. Joint surfaces are smooth, brown and rusty. Granite aplite dyke 4.33-4.82 m.
Green chloritic fault gouge zone from 5.19-5.60 m depth with white silica flooding. RQD of this zone = 0%

% RQD
(m)

% REC
(m)

BOX/RU
N

DEPTH
(m)

From

3.70

To

5.89

2/1
2/2

100.0%
(2.20)

68.0%
(1.50)

STRENGTH

WEATHERING

OF SETS

TYPE(S)

Orientation

SPACING

Roughness

APERTURE

FILLING

OCCASIONAL FEATURES

P1 - 4.55 m
P2 - 5.40 m
P3 - 5.85 m

Full Rock Core Dry



Full Rock Core Wet

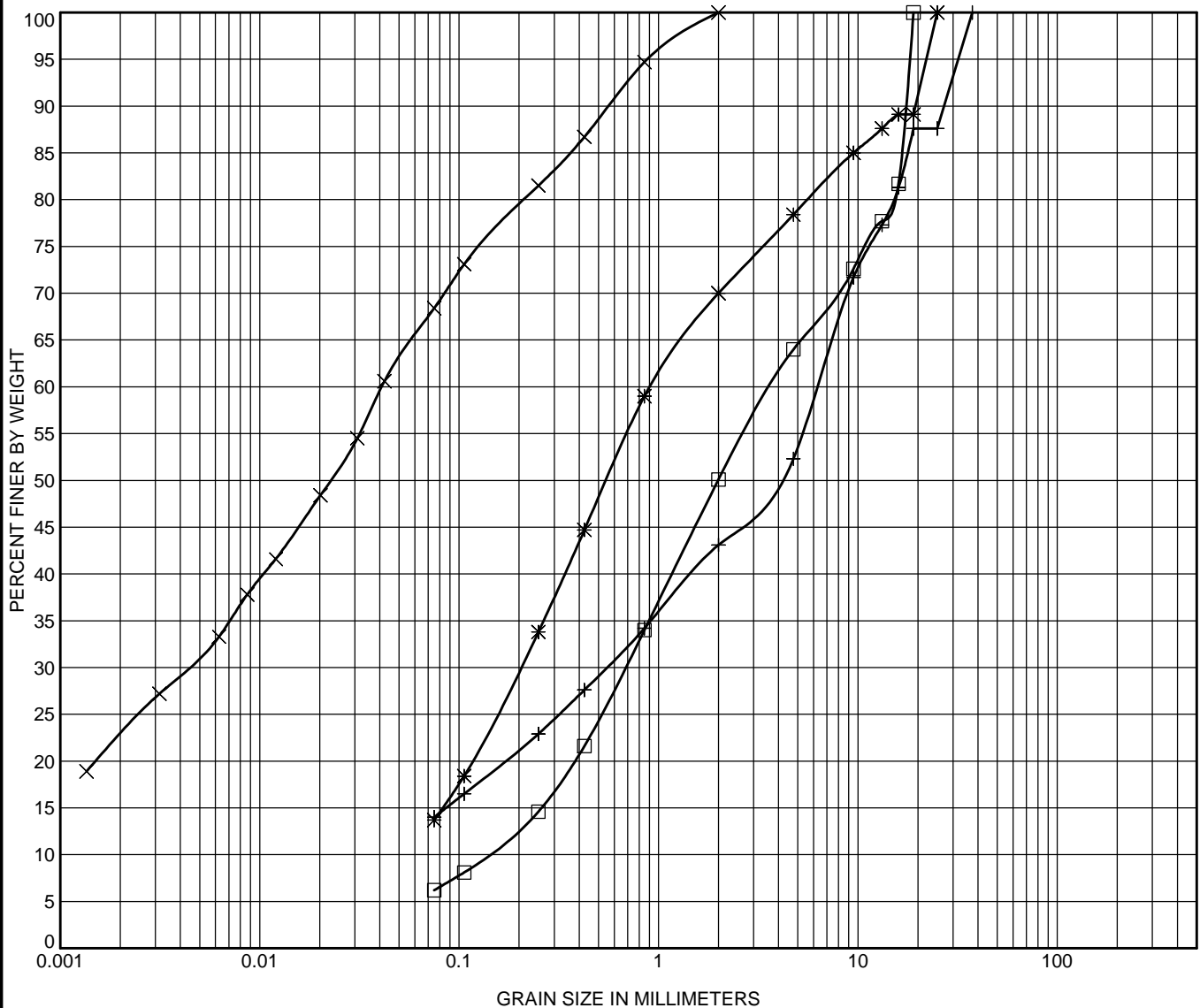


Rock Core Detail (green chloritic fault gouge 5.19-5.60 m)



APPENDIX B

Laboratory Test Data



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ BLK 3	1.50	19	3.703	0.68	0.136	36.0	57.8	6.2	
* BLK 4	0.75	25	0.919	0.202		21.6	64.7	13.7	
× BLK 5	2.40	2	0.041	0.004		0.0	31.6	68.4	
+ BLK 5	6.10	37.5	6.254	0.547		47.7	38.3	14.0	



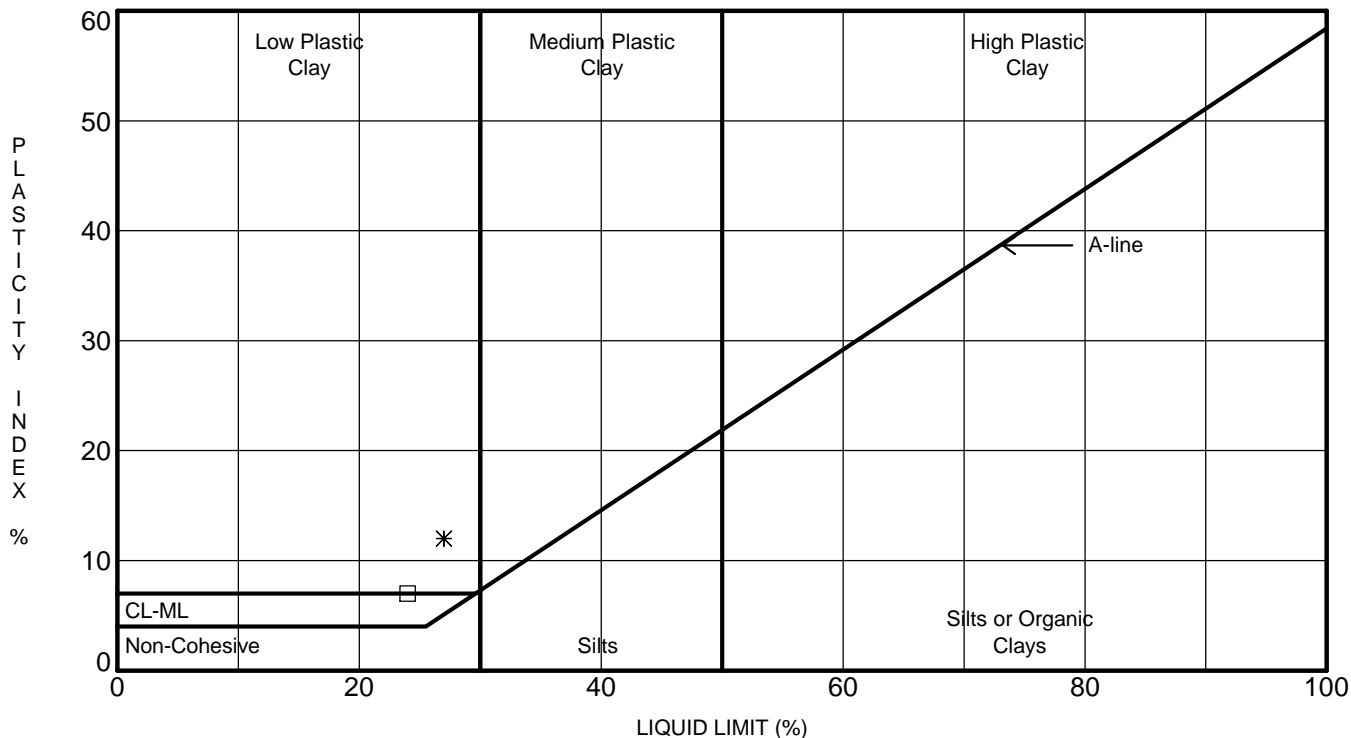
TBT Engineering Ltd.
1918 Yonge Street
Thunder Bay, Ontario P7E 6T9
PH: 807-624-5160
FX: 807-624-5161
Email: tbte@tbte.ca
Web: www.tbte.ca

GRAIN SIZE DISTRIBUTION

Project: Black River

W P:

DIST: 61 HWY: 71



Remarks:

Borehole No.	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%	
□ BLK 1		1.50	24	17	7	26	
* BLK 5		2.40	27	15	12	18	



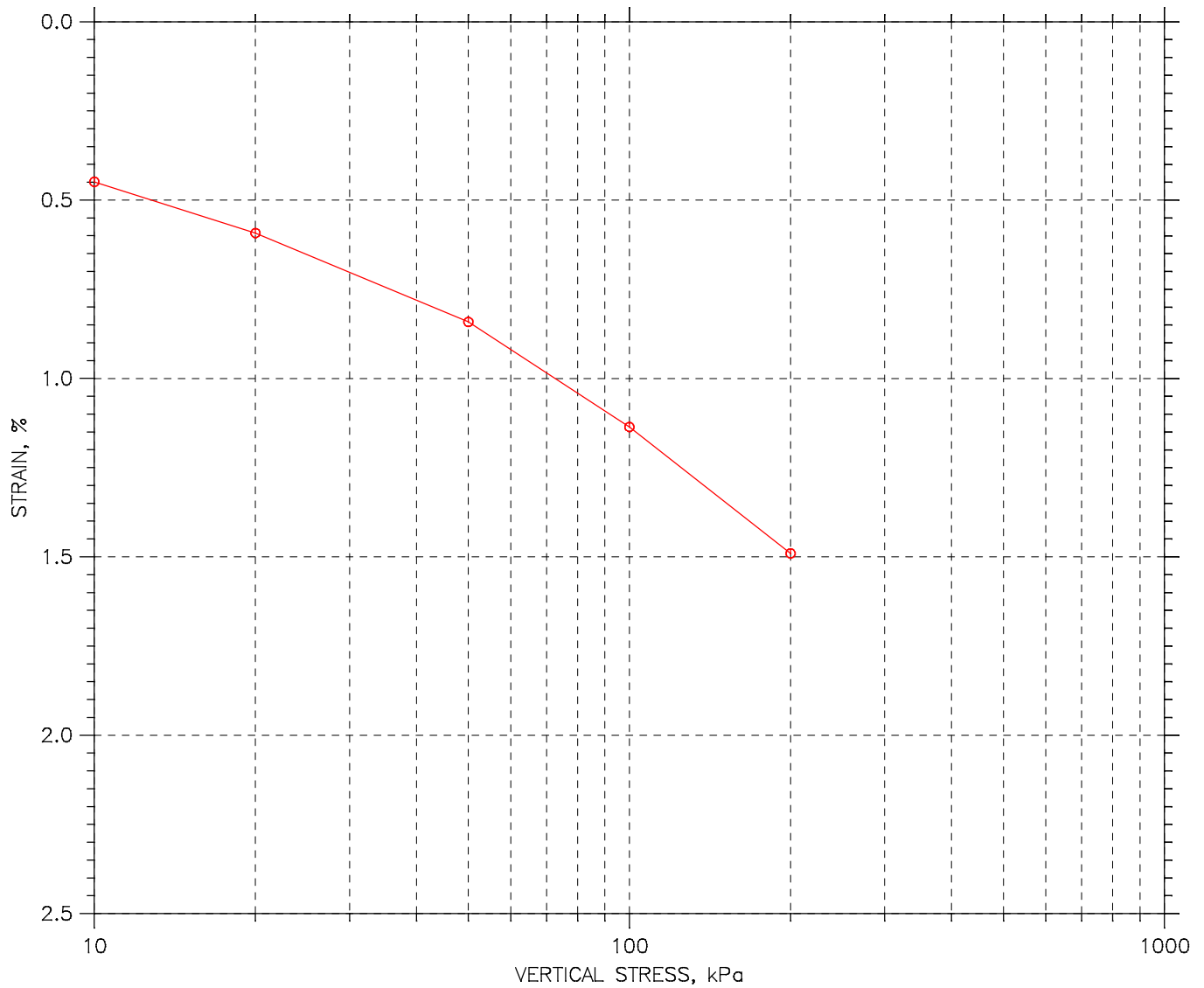
TBT Engineering Ltd.
 1918 Yonge Street
 Thunder Bay, Ontario P7E 6T9
 Telephone: 807-624-5160
 Fax: 807-624-5161

ATTERBERG LIMIT RESULTS


W P:
 District: 61
 Highway: 71

CONSOLIDATION TEST DATA

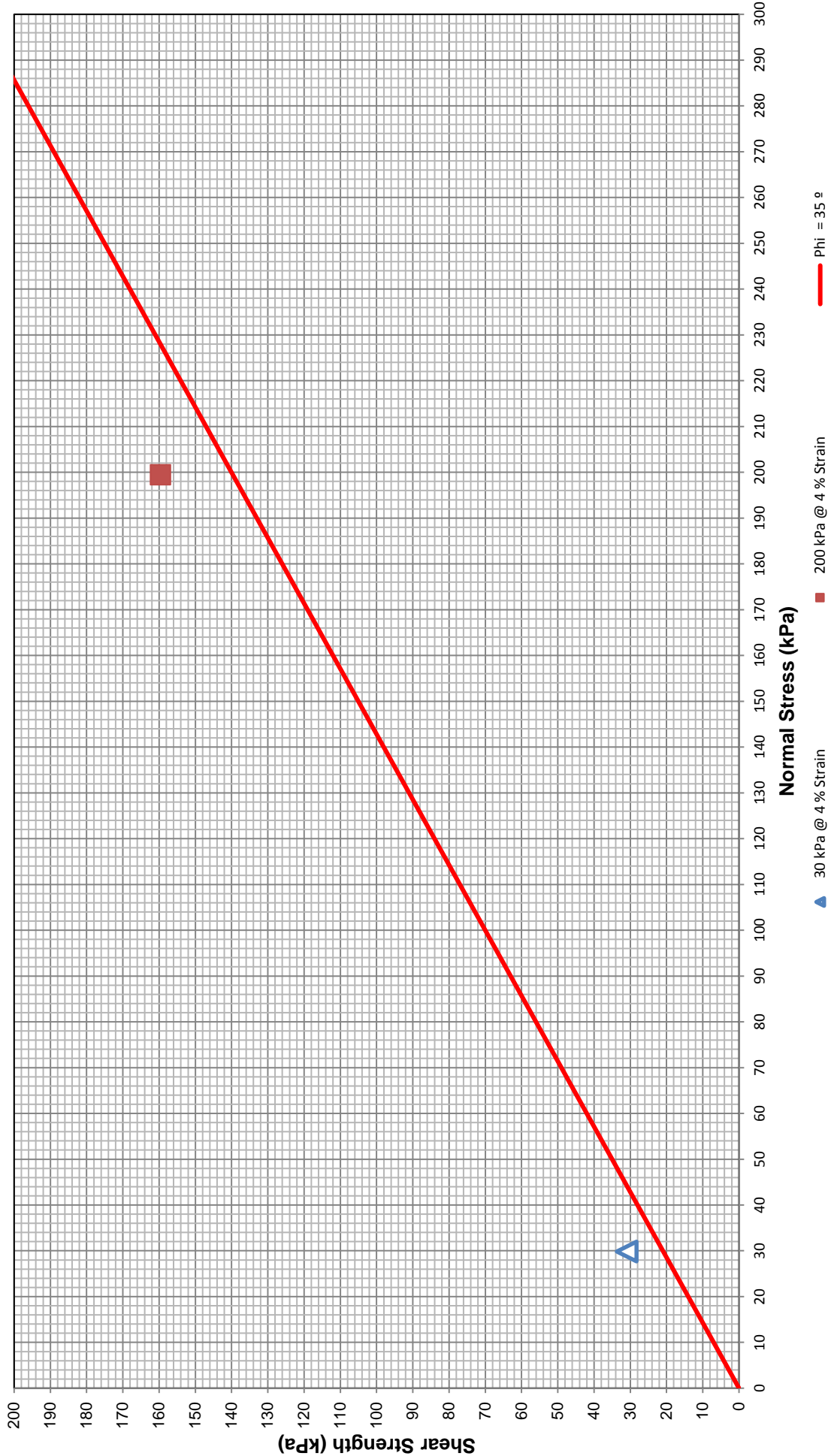
SUMMARY REPORT



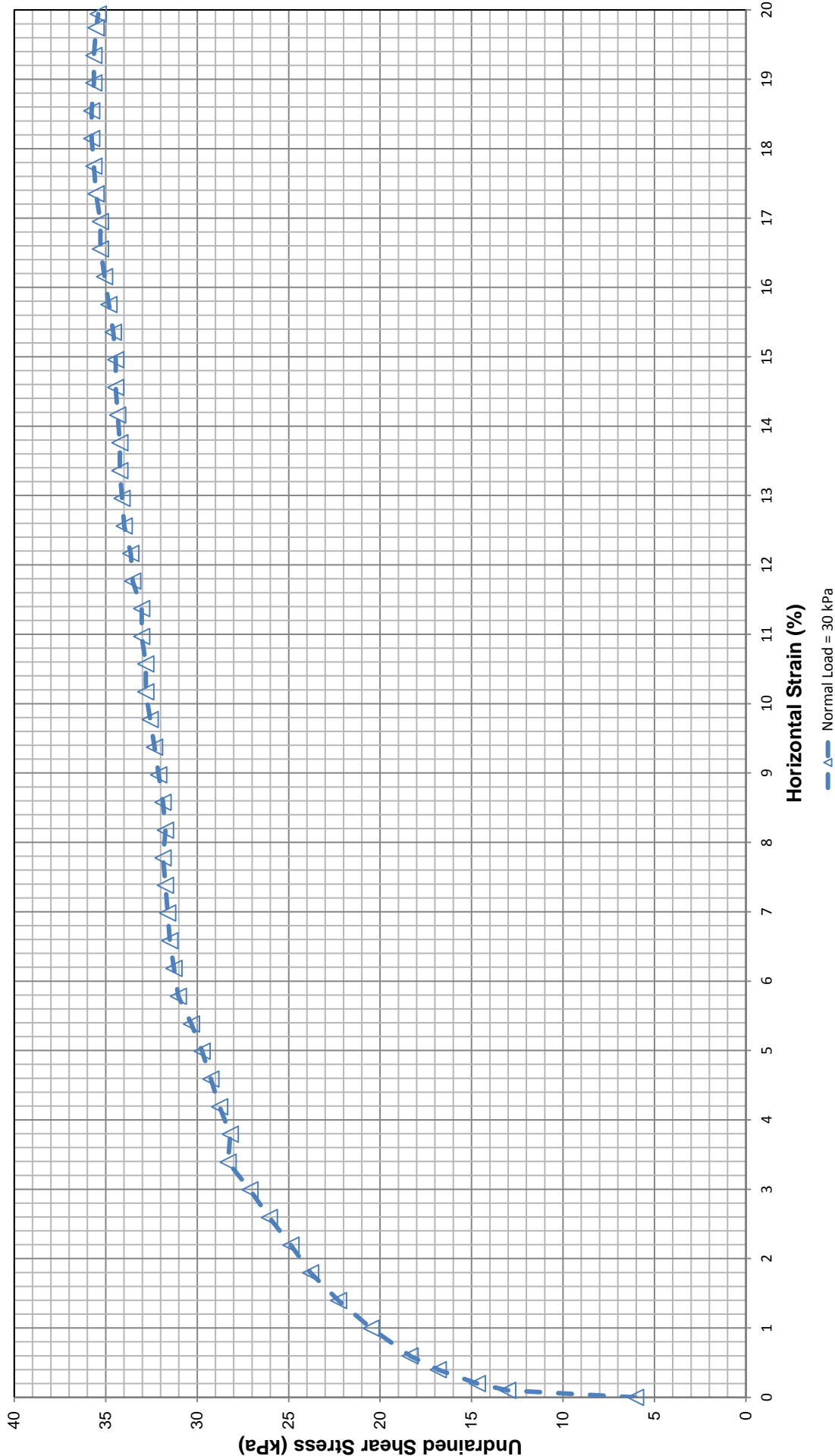
				Before Test	After Test
Overburden Pressure: 0 kPa		Water Content, %		18.86	20.97
Preconsolidation Pressure: 0 kPa		Dry Unit Weight, N/m ³		15290	15520
Compression Index: 0		Saturation, %		71.39	82.36
Diameter: 50.15 mm	Height: 27.71 mm		Void Ratio	0.70	0.67
LL: NP	PL: NP	PI: NP	GS: 2.65		

	Project: LH North		Location: Black Lake	Project No.: 14-026-A
	Boring No.: BLK1		Tested By: Tim	Checked By: GM
	Sample No.: SS 7		Test Date: April 29/15	Depth: 6.1 m
	Test No.: 1		Sample Type: SS	Elevation:
	Description: Sand			
	Remarks:			

Drained Direct Shear Test - Sand
BH BLK 1, Depth 3.1 m

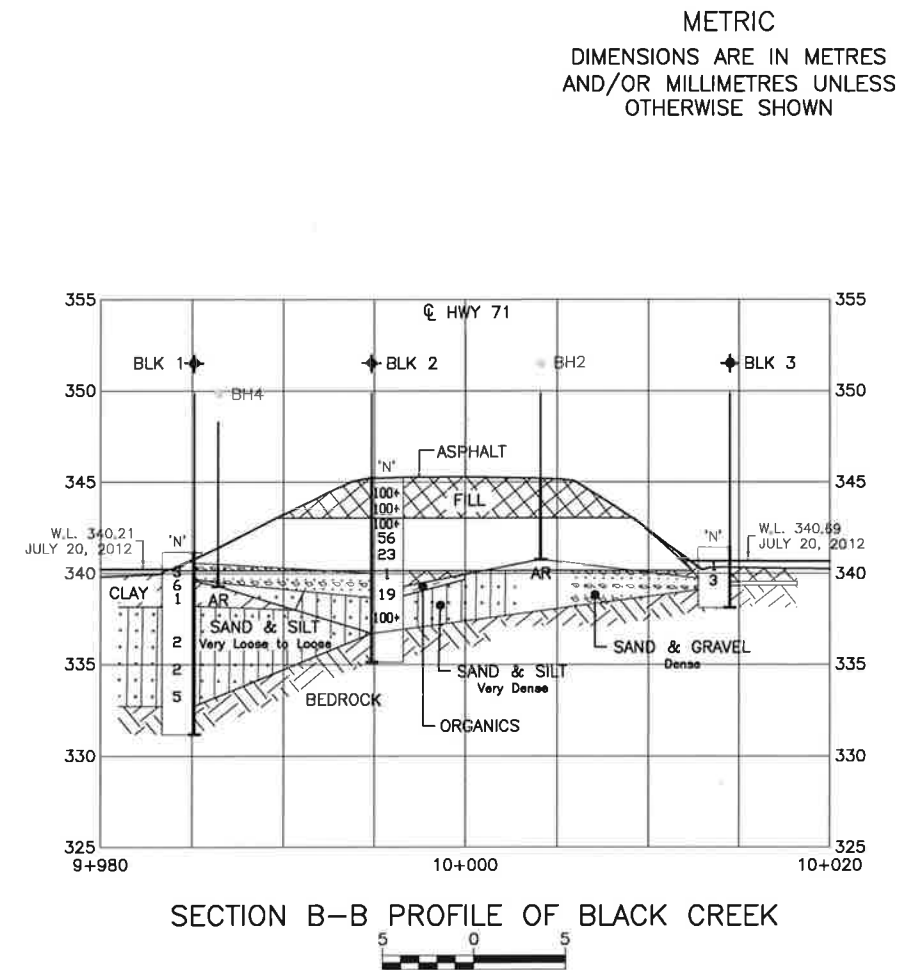
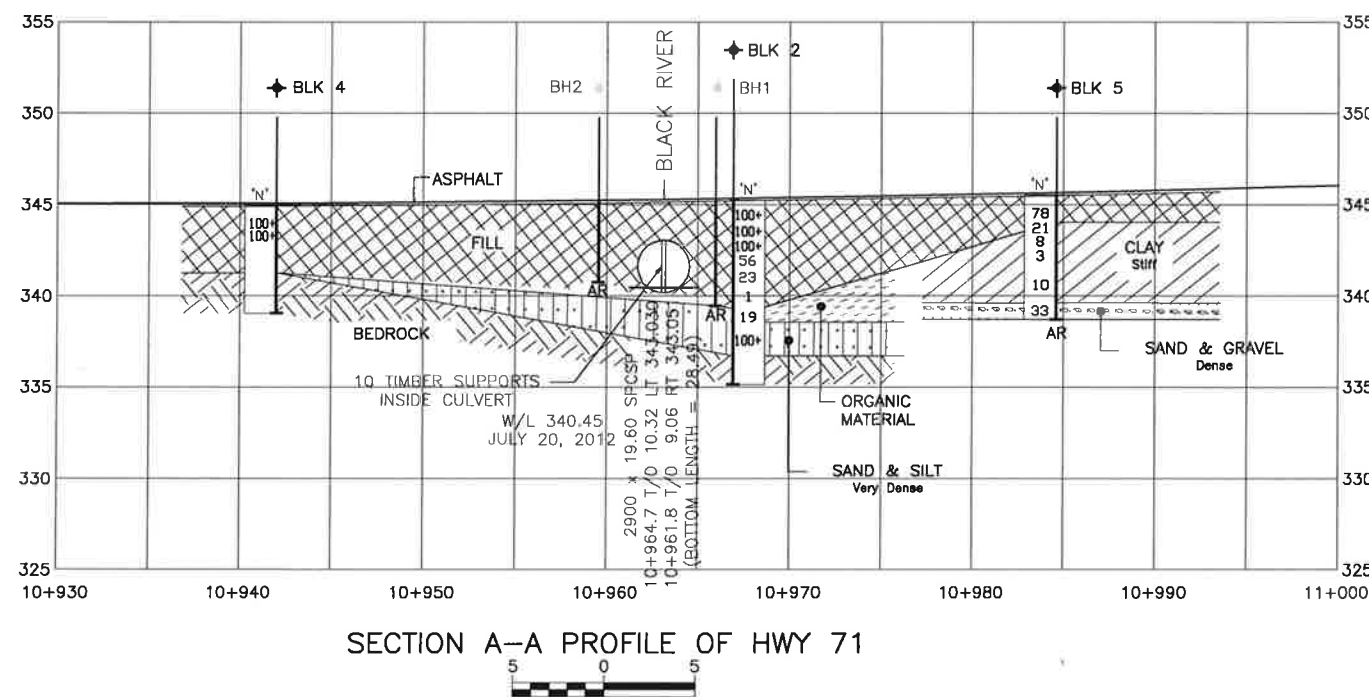
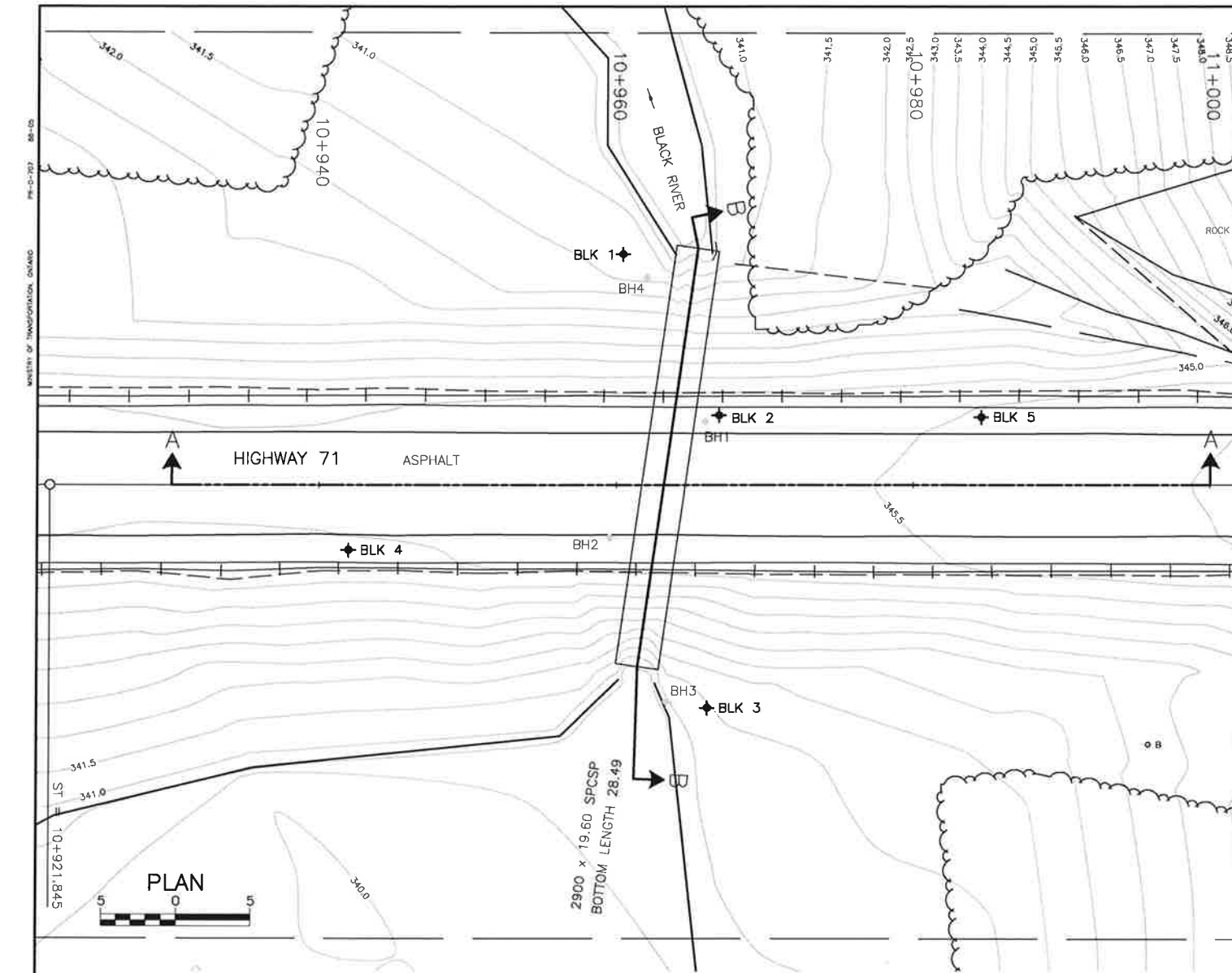


Consolidated Undrained Direct Shear Test Clay - BH BLK 1, Depth 3.0 m



APPENDIX C

Borehole Locations, and Soil Strata Drawing



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

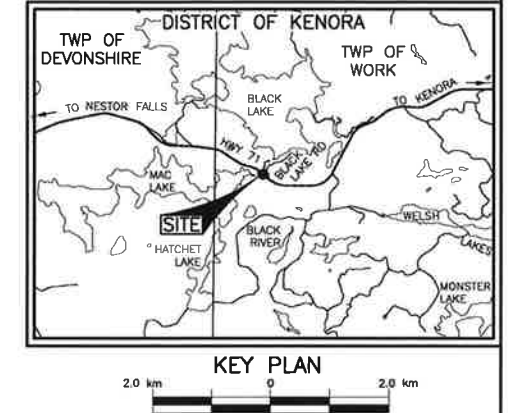
GEOCRES No. _____
CONT No. _____
WP No. XXXX-XX-XX

BLACK RIVER CULVERT
AT HWY 71
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ministry of Transportation
Northwestern Region
Structural Section

TBT ENGINEERING
CONSULTING GROUP



SOIL STRATA SYMBOLS	
	TOPSOIL/ORGANICS
	SAND
	SAND & GRAVEL
	CLAY
	SAND & SILT
	BEDROCK

LEGEND			
	Borehole		
	Previous Borehole		
	Std Pen Test (Blows/0.3m)		
	Water Level		
	Auger Refusal		

No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
BLK 1	341.2	16 5 490 448	228 355
BLK 2	345.2	16 5 490 446	228 367
BLK 3	341.4	16 5 490 433	228 382
BLK 4	344.9	16 5 490 421	228 359
BLK 5	345.5	16 5 490 460	228 379
BH1	345.2	16 5 490 445	228 367
BH2	345.2	16 5 490 435	228 369
BH3	340.4	16 5 490 431	228 380
BH4	340.3	16 5 490 448	228 357

REVISIONS		DESCRIPTION	
02/05/15	TB	DRAFT	
DESIGN	CHK	CODE XXXX-XX	LOAD XX-XX-XXX DATE 20140513
DRAWN	TB	CHK	GM/SITE DWG 1

APPENDIX D

Previously Completed Boreholes and Laboratory

RECORD OF BOREHOLE No BH1										1 OF 1		METRIC				
W.P. 6013-E-0023		LOCATION Black River Culvert: STA, 10+966, 4.0 m LT				ORIGINATED BY JF										
DIST HWY 71		BOREHOLE TYPE Hollow Stem Auger - 80 mm ID				COMPILED BY ML										
DATUM LOCAL		DATE 2014 05 06				CHECKED BY DB										
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			20	40	60	80					
101.4	GROUND SURFACE															
	FILL - SAND - some gravel, trace silt, brown, compact to very dense		AS1	AS												
			SS2	SS	37											
	- COBBLES															
99.6 1.8			SS3	SS	100+											
			SS4	SS	13											
			SS5	SS	17											
	- COBBLES															
97.3 4.1	- trace organics		SS6	SS	100+											
	- COBBLES															
96.5 4.9			SS7	SS	100+											
96.2 5.3	SAND - some silt, trace gravel, brown, loose		SS8	SS	9											
95.6 5.8	End of Borehole at 5.8 m Auger Refusal on Possible Bedrock															

ON MOT-HIGH VANES GS-TB-018732 BLACK RIVER CULVERT.GPJ DST_MIN.GDT 6/17/14

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

METRIC

UN_MU1-HIGH VANES GS-1B-01873Z BLACK RIVER CULVERT.GPJ DST_MIN.GDT 8/17/14

[illegible]

ENCLOSURE 2

RECORD OF BOREHOLE No BH3

1 OF 1

METRIC

W.P. 6013-E-0023 LOCATION Black River Culvert: STA. 10+964, 14.5 m RT ORIGINATED BY JF
 DIST HWY 71 BOREHOLE TYPE Hollow Stem Auger - 80 mm ID COMPILED BY ML
 DATUM LOCAL DATE 2014 05 06 CHECKED BY DB

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	20					
96.6	GROUND SURFACE												
	SAND & GRAVEL - brown		AS1	AS									Surface Water = 1.0 m
96.1													
0.5	CLAY - Silty, with sand, trace organics, brown		AS2	AS									0 32 47 22
													CPT 1171 kPa
95.1													
1.5	SAND - some clay, trace silt and organics, brown, compact		AS3	AS									CPT 1722 kPa
94.3													
2.3	End of Borehole at 2.3 m Auger Refusal on Possible Bedrock												

ON MOT-HIGH VANES GS-TB-018732 BLACK RIVER CULVERT.GPJ DST_MIN.GDT 6/17/14

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

ENCLOSURE 3

RECORD OF BOREHOLE No BH4

1 OF 1

METRIC

W.P. 6013-E-0023 LOCATION Black River Culvert: STA. 10+962, 14.0 m LT ORIGINATED BY JF
 DIST HWY 71 BOREHOLE TYPE Hollow Stem Auger - 80 mm ID COMPILED BY ML
 DATUM LOCAL DATE 2014 05 06 CHECKED BY DB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	50 100 150 200 250	W _p	W		
96.5	GROUND SURFACE												
	SAND & GRAVEL - brown		AS1	AS		96							Surface Water = 0.5 m
95.7													
0.8	SAND - trace clay and silt, occasional boulders, brown												
95.5													
1.0	End of Borehole at 1.0 m Auger Refusal on Possible Bedrock												

ON_MOT-HIGH VANES GS-TB-018732 BLACK RIVER CULVERT.GPJ DST_MIN.GDT 6/17/14

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

ENCLOSURE 4

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

Fine

SAND

Medium

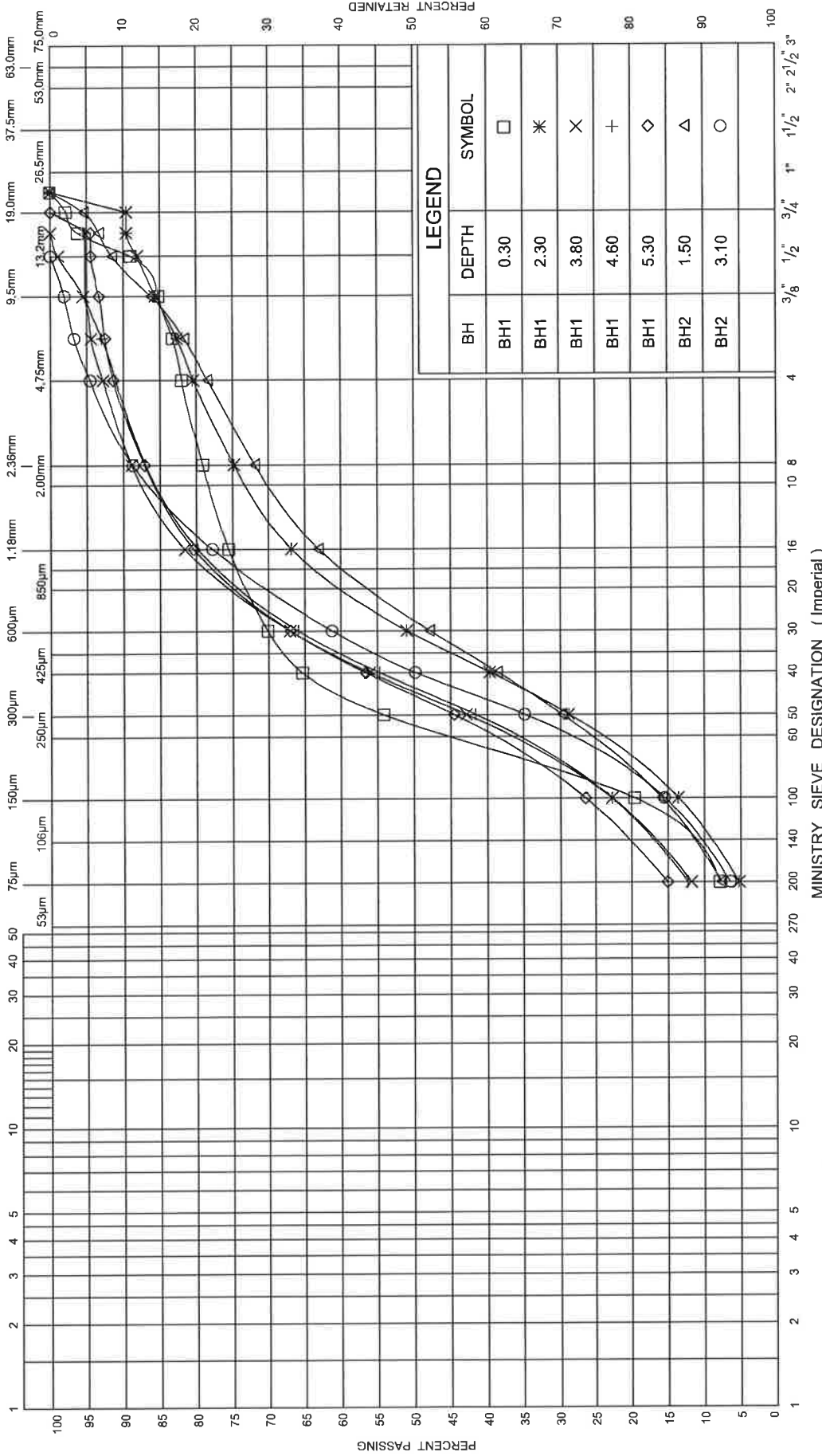
Coarse

Fine

GRAVEL

Coarse

GRAIN SIZE IN MICROMETERS



GRAIN SIZE DISTRIBUTION
SAND - TRACE TO SOME SILT

ENCLOSURE 5

W P 6013-E-0023

HIGHWAY 71



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Coarse

Medium

Fine

Coarse

GRAIN SIZE IN MICROMETERS

