



**Foundation Investigation Report
Culvert Replacement, Knife Creek
Station 15+640, Township of Dahl, Algoma District
Highway 17**

GWP 5119-06-00

**Geocres No: 42C-041
Site No: 38C-154/C**

**Prepared for
MTO Northeastern Region**

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Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ministry of Transportation Northeastern Region (MTO) to provide a foundation investigation and design services for the proposed culvert replacement at station 15+640, Township of Dahl, district of Algoma. The site is located within the boundaries of Obatanga Provincial Park, approximately 37.6 km east of the junction of Highway 17 and Highway 631 (White River). The site coordinates are as follows:

- Latitude: 48.331565°
- Longitude: -85.027971°

This project has been assigned Geocres No. 42C-041 and structural site number 38C-154/C.

The foundation investigation was conducted to provide subsurface data to for stability analysis of finished grade and safe excavation slopes, provide commentary on conceptual cofferdam design and roadway protection measures, and for replacement recommendations including but not limited to lateral earth pressures, foundation types (deep and shallow) and associated ULS resistances and SLS reactions.

A total of eight boreholes were advanced for this investigation. Two boreholes were advanced through the embankment at the culvert location, three at the inlet and three at the outlet (two of the boreholes at each end of the culvert were at potential cofferdam locations). All borehole locations were determined through consultation with the MTO. This report (Part A) describes the subsurface conditions encountered during the investigation.

2 Site Description

The foundation investigation was conducted to investigate subsurface conditions at the culvert located at station 15+640 Township of Dahl, Algoma District. Knife creek flows through triple structural corrugated steel culverts beneath an embankment that crosses low lying terrain. As provided in the terms of reference, the three culverts are 2.7 m wide x 25 m long, with approximate 1.5m of cover. The maximum height of the embankment is approximately 2.0 m. The culvert inverts on the right are typically 416.1, and 416.3 on the left. Based on survey data provide the creek level was measured at elevation 417.6 m.

Photo 2.1 – Near Station 15+640, Facing South



Photo 2.2 – Near Station 15+640, Facing North



2.1 Surficial Geology

Available surficial geology mapping (OGS NOEGTS Map 5096 – Pukaskwa River) indicates the site is located along the boundary between organic and rock knob terrain. The organic terrain is over a sand outwash plain with mainly low local relief with wet drainage. TBTE's investigation encountered silt beneath organic material in the "greenfield" borehole locations. The rock knob terrain has areas of till ground moraine and peat organic terrain, with moderate dry relief. Bedrock outcrops were observed roughly 400 m east of the site, and organic terrain was observed west and north of the site.

3 Investigation Procedures

A geotechnical site investigation was undertaken between September 20 and October 3, 2016. A total of 8 boreholes were advanced during the field investigation. The borehole

locations and depths were determined through conversations with the MTO and are illustrated on the Borehole Location Plan found in Appendix C.

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 conduct Standard Penetration Testing (SPT). Soil samples were obtained at the boreholes from the auger flights and using a split spoon sampler as a part of the SPT. Rock cores were obtained using NQ diamond coring techniques.

All aspects of implementation of geotechnical test holes (were completed in accordance with the Ministry of Environment Regulation 903, as amended by Regulation 128/03. Boreholes on the road surface were capped with cold mix asphalt upon decommissioning.

Borehole locations were surveyed by TBTE and were referenced to elevations provided on MTO Plate No. 692-17/13-0 WP 267-90-00 Station 15+500 to 16+200 Surveyed September 1994 TWP of Dalh. The provided MTO Plate drawing is based on NAD 83 CSRS MTM Zone 13, and Canadian Geodetic Vertical Datum CGVD28.

4 Laboratory Testing

Samples which were obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content, liquid and plastic limit tests, 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). In order to classify the bedrock with respect to strength, point load tests were carried out on select rock cores.

In addition to routine testing, a single sample (BH2, SS4) was 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 with Appendix B, laboratory test data and summarized on Table 5.1.

5 Subsurface Conditions

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

The subsurface soils at this site typically consist of organics or fill over silt overlying bedrock. Bedrock was sampled when encountered.

5.1 Asphalt

Asphalt was encountered at the surface of Boreholes 1 and 2. Boreholes 1 and 2 were advanced through the roadway embankment. The asphalt was 75 mm thick.

5.2 Organic Material

Organic material was encountered at the surface of Boreholes 6 and 8, and extended to a depth of 1.6 and 1.4 m, (elev. 416.5 m) respectively. The organic material is in a very loose condition as indicated by “N” values of 2 and 3 blows/0.3 m. The natural moisture content of this material ranges from 50 % to 183%.

5.3 Granular Fill

Granular embankment fill, comprised of gravels and sands with occasional cobbles, was encountered beneath the asphalt at Boreholes 1 and 2. The fill extended to depths of 2.2 and 2.3 m (elev. 417.4 and 417.5 m respectively). Two samples were selected for grain size distribution testing. The test results indicated a grain size distribution of 7 to 58% gravel, 38 to 70% sand, and 4 to 23% silt/clay sized particles. Numerous cobbles were noted in Borehole 1. The material is in a dense to very dense condition as indicated by “N” values ranging from 36 to 100+ blows/0.3 m.

5.4 Sand

A sand layer was encountered beneath the fill at Borehole 1 and beneath the organic material at Borehole 8. The sand had a thickness of 0.7 and 1.5 m, extending to elevations of 416.7 and 415 m at Boreholes 1 and 8, respectively. The material is in a very loose to compact condition as indicated by “N” values ranging from 3 to 19 blows/0.3 m. A single sample was selected for grain size distribution testing. The test results indicated a grain size distribution of 15 % gravel, 74 % sand, and 11 % silt/clay sized particles.

5.5 Silt

Silt was encountered beneath the embankment fill at Borehole 2, the organics at Borehole 6, the sand at Boreholes 1 and 8 and at the surface of Boreholes 3, 4, 5, and 7. The silt extended to auger refusal at depths ranging from 7.5 to 9.5 m (elev. 409.0 to 411.1 m) on the north side of the highway (at Boreholes 1, 3, 4 and 5). The thickness of the silt was unknown at Boreholes 2, 6, 7 and 8 as these boreholes terminated within the silt stratum at depths ranging from 10.6 to 12.7 m (elev. 406.7 to 407.5 m). Sixteen samples were selected for grain size distribution testing. The test results indicated a grain size distribution of 0 to 21% gravel, 0 to 34% sand, and 62 to 100% silt/clay sized particles. The material is in a very loose to very dense condition as indicated by “N” values ranging from 1 to 90 blows/0.3 m. Six samples were selected for Atterberg limit testing, and all samples were found to be non-plastic (silt).

A sample of this material from Borehole 2 was 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	Result
Conductivity	mS/cm	0.362
Moisture	%	12.1
Acidity/Basicity	pH	7.78
Redox Potential	mV	123
Resistivity	ohm*cm	2760
Chloride	ppm	91.8
Sulphide (as S)	mg/kg	<0.2
Sulphate	ppm	42

5.6 Bedrock

Bedrock was confirmed below the silt at Boreholes 1, 3, 4 and 5 (elevations 410.2m, 409.9m, 411.1m, and 409.0m, respectively). Generally, the bedrock encountered was un-weathered, grey and white gneiss. Detailed bedrock core logs and photos are provided as Appendix D.

In order to classify the bedrock with respect to strength, 12-point load tests were completed on selected core samples. The test results are tabulated below:

Table 5-2: Estimated Uniaxial Compressive Strength of Bedrock

Borehole	Test depth from ground surface (m)	Test Elevation (m)	*Estimated Uniaxial Compressive Strength (MPa)
1	9.7	410.0	393
1	10.7	409.0	519
1	11.8	407.9	448
3	9.0	409.0	404
3	10.5	407.5	527
3	11.1	406.9	432
4	8.7	409.9	493
4	9.2	409.4	450
4	10.5	408.1	156
5	9.8	408.6	407
5	10.6	407.8	246
5	12.1	406.3	503

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

Based on the estimated uniaxial compressive strength of the intact rock, the bedrock is generally extremely strong (uniaxial compressive strengths greater than 250 MPa). Two occurrences of very strong (100 to 250 MPa) rock were at Borehole 4 at 10.5m, and Borehole 5 at 10.6m.

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 5-3: 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 93 to 100% indicating the rock quality is excellent.

6 Ground Water

Groundwater levels were measured upon completion of drilling operations and are summarized in the table below. Groundwater levels will vary from season to season and from the effects of heavy precipitation events.

Table 6.1: Groundwater Levels

Borehole	Groundwater Depth (m)	Groundwater Elevation (m)	Date Measured
4	1.1	417.5	Sept 28, 2016
5	1.6	416.8	Sept 29, 2016
6	1.0	417.1	Sept 30, 2016
7	1.0	417.1	Oct 2, 2016
8	1.2	416.7	Oct 3, 2016

7 Miscellaneous

Laboratory testing was completed 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 Walter Mainville. Laboratory testing was supervised by T. Fummerton C.E.T. This report was prepared by Craig Johnson, P.Eng and Steven Seller, P.Eng, and reviewed by W. Hurley, P.Eng (TBTE designated principal contact identified for MTO Foundation Engineering projects).

8 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.

9 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 LIMITED



Steven Seller, P.Eng
Senior Project Engineer



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

APPENDIX A

Borehole Logs

EXPLANATION OF TERMS USED IN REPORT

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 63.5kg, 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 OR DENSENESS.

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

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE

STRESS AND STRAIN

u_w kPa	PORE WATER PRESSURE
u kPa	PORE PRESSURE RATIO
σ kPa	TOTAL NORMAL STRESS
σ' kPa	EFFECTIVE NORMAL STRESS
τ kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$ kPa	PRINCIPAL STRESSES
ϵ %	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$ %	PRINCIPAL STRAINS
E kPa	MODULUS OF LINEAR DEFORMATION
G kPa	MODULUS OF SHEAR DEFORMATION
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_α	RATE OF SECONDARY CONSOLIDATION
C_v m ² /s	COEFFICIENT OF CONSOLIDATION
H m	DRAINAGE PATH
T_v	TIME FACTOR
U %	DEGREE OF CONSOLIDATION
σ'_{vo} kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p kPa	PRECONSOLIDATION PRESSURE
T_f kPa	SHEAR STRENGTH
c' kPa	EFFECTIVE COHESION INTERCEPT
ϕ' °	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u kPa	APPARENT COHESION INTERCEPT
ϕ_u °	APPARENT ANGLE OF INTERNAL FRICTION
T_R kPa	RESIDUAL SHEAR STRENGTH
τ_r kPa	REMOULDED SHEAR STRENGTH
S_r	SENSITIVITY = $\frac{c_v}{T_v}$

PHYSICAL PROPERTIES OF SOIL

ρ_s kg/m ³	DENSITY OF SOLID PARTICLES	e 1, %	VOID RATIO	e_{min} 1, %	VOID RATIO IN DENSEST STATE
γ_s kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n 1, %	POROSITY	I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w kg/m ³	DENSITY OF WATER	w 1, %	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 = $w_L - w_p$	v m/s	DISCHARGE VELOCITY
ρ_{sat} kg/m ³	DENSITY OF SATURATED SOIL	I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	HYDRAULIC GRADIENT
γ_{sat} kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k m/s	HYDRAULIC CONDUCTIVITY
ρ' kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max} 1, %	VOID RATIO IN LOOSEST STATE	j kN/m ²	SEEPAGE FORCE
γ' kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL				

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 5119-06-00 LOCATION Knife Creek N:5355264.472; E:228612.697 MTM Zone:13 ORIGINATED BY WM
 DIST NER HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SW
 DATUM Geodetic DATE 2016.09.20 - 2016.09.20 LATITUDE 48.331512 LONGITUDE -85.02764 CHECKED BY CJ

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 (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
419.7							20	40	60	80	100									
418.9	ASPHALT - 75 mm		1	AS													58 38 (4)			
	FILL - GRAVEL & SAND - trace silt, brown, dense to very dense		2	SS	100+															
	----- - white & brown																			
	----- brown, numerous cobbles		2	SS	49															
417.4	SAND - Silty, grey, compact		4	SS	19															
416.7	SILT - some sand, grey, trace gravel, loose to compact		5	SS	7												3 19 (78)			
			6	SS	14															
			7	SS	6															
			8	SS	19															
			9	SS	100+															
410.2	BEDROCK - grey and white gneiss		1	RC													RC #1 REC 100% RQD 100%			
407.1	End of Borehole @ 12.6 m.																			
12.6																				

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

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 5119-06-00 LOCATION Knife Creek N:5355287.823; E:228579.711 MTM Zone:13 ORIGINATED BY WM
 DIST NER HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SW
 DATUM Geodetic DATE 2016.09.20 - 2016.09.20 LATITUDE 48.331718 LONGITUDE -85.028089 CHECKED BY CJ

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	20	40	60	80						100
								● QUICK TRIAXIAL × LAB VANE	20	40	60	80						100
419.7																		
418.9	ASPHALT - 75 mm		1	AS														
	FILL - SAND & GRAVEL to trace gravel - Silty, brown, dense to very dense		2	SS	72													
			3	SS	36													
417.5																		
2.2	SILT - trace sand, grey, very dense to compact		4	SS	45													
			5	SS	70													
			6	SS	92													
			7	SS	10													
			8	SS	15													
			9	SS	16													
			10	SS	12													
			11	SS	14													
407.0																		
12.7	End of Borehole @ 12.7 m.																	


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

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 5119-06-00 LOCATION Knife Creek N:5355273.629; E:228567.735 MTM Zone:13 ORIGINATED BY TP
 DIST NER HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SW
 DATUM Geodetic DATE 2016.09.21 - 2016.09.21 LATITUDE 48.331589 LONGITUDE -85.028248 CHECKED BY CJ

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 (%)					GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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418.0	0.0	SILT - some to trace sand, brown, loose to dense					417																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									</

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 5119-06-00 LOCATION Knife Creek N:5355258.094; E:228598.445 MTM Zone:13 ORIGINATED BY WM
 DIST NER HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SW
 DATUM Geodetic DATE 2016.09.27 - 2016.09.28 LATITUDE 48.331453 LONGITUDE -85.027831 CHECKED BY CJ



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										W _p W W _L		
								● QUICK TRIAXIAL × LAB VANE												
418.6							20	40	60	80	100									
0.0	SILT - Sandy to trace sand, trace gravel, loose to very dense		1	AS			418										Non-plastic 4 34 (62)			
			2	SS	8		417											0 5 (95) Water level @ 1.1m upon completion.		
			3	SS	11		416													
			4	SS	19		415													
			5	SS	18		414											0 2 (98)		
								413												
			6	SS	90		412													
								411												
								410												
411.1	BEDROCK - grey and white gneiss		1	RC		409											RC #1 REC 100% RQD 93%			
7.5																				
408.0	End of Borehole @ 10.6 m.					408														
10.6																				

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 5119-06-00 LOCATION Knife Creek N:5355252.716; E:228593.41 MTM Zone:13 ORIGINATED BY WM
 DIST NER HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SW
 DATUM Geodetic DATE 2016.09.29 - 2016.09.29 LATITUDE 48.331404 LONGITUDE -85.0278979 CHECKED BY CJ

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 (%)			GR	SA	SI	CL		
								20	40	60					80	100	20					40	60
418.4																							
0.0	SILT - Sandy to trace sand, trace to some organics, brown, loose to very dense		1	AS		▽	418												0 31 (69)				
			2	SS	5			417															
	----- - grey		3	SS	5			416												Water @ 1.6m upon completion.			
			4	SS	23			415												Non-plastic			
			5	SS	14			414												0 0 (100)			
								413															
			6	SS	66			412															
								411															
			7	SS	29			410															
	----- - numerous cobbles & boulders							409												Auger refusal @ 7.6m. Advanced with casing.			
409.0							408																
9.4	BEDROCK - grey and white gneiss		1	RC			407																
							406																
406.0																							
12.4	End of Borehole @ 12.4 m.																						

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

ONTARIO MTO MOD 16-138 MTO - KNIFE CREEK.GPJ ONTARIO MTO.GDT 8/6/17

1 OF 1

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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					
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	WATER CONTENT (%)					
418.1 0.0	ORGANICS - black, very loose		1	AS			418								
			2	SS	2		417							146	Water level @ 1.0m upon completion.
416.5 1.6	SILT - grey, very loose to compact		3	SS	1		416							182.9	Non-plastic
		4	SS	1	415									0 0 (100)	
		5	SS	3	414										
		6	SS	18	413										
		7	SS	26	412										
		8	SS	21	411										
		9	SS	18	410										
					409										
					408										
406.9 11.2	----- - some gravel, trace sand		10	AS		407								21 7 (72) Could not perform SPT.	
	End of Borehole 11.2 m.													Drill rods jammed in hollow stem auger.	

ONTARIO MTO MOD 16-138 MTO - KNIFE CREEK,GPJ ONTARIO MTO,GDT 8/6/17

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

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 5119-06-00 LOCATION Knife Creek N:5355289.06; E:228595.153 MTM Zone:13 ORIGINATED BY WM
 DIST NER HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SW
 DATUM Geodetic DATE 2016.02.10 - 2016.02.10 LATITUDE 48.331731 LONGITUDE -85.027881 CHECKED BY CJ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
418.1														
0.0	FILL - SAND & GRAVEL, trace silt, brown		1	AS			418							41 51 (8)
417.5			2	SS	3		417							Water level @ 1.0m upon completion.
0.6	SILT - some organics, brown, very loose to compact		3	SS	25		416							
	----- - grey		4	SS	15		415							Non-plastic
			5	SS	23		414							
			6	SS	16		413							0 1 (99)
			7	SS	14		412							
			8	SS	25		411							
			9	SS	30		410							
							409							
							408							
407.5	End of Borehole 10.6 m.													
10.6														

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

RECORD OF BOREHOLE No 8

1 OF 1

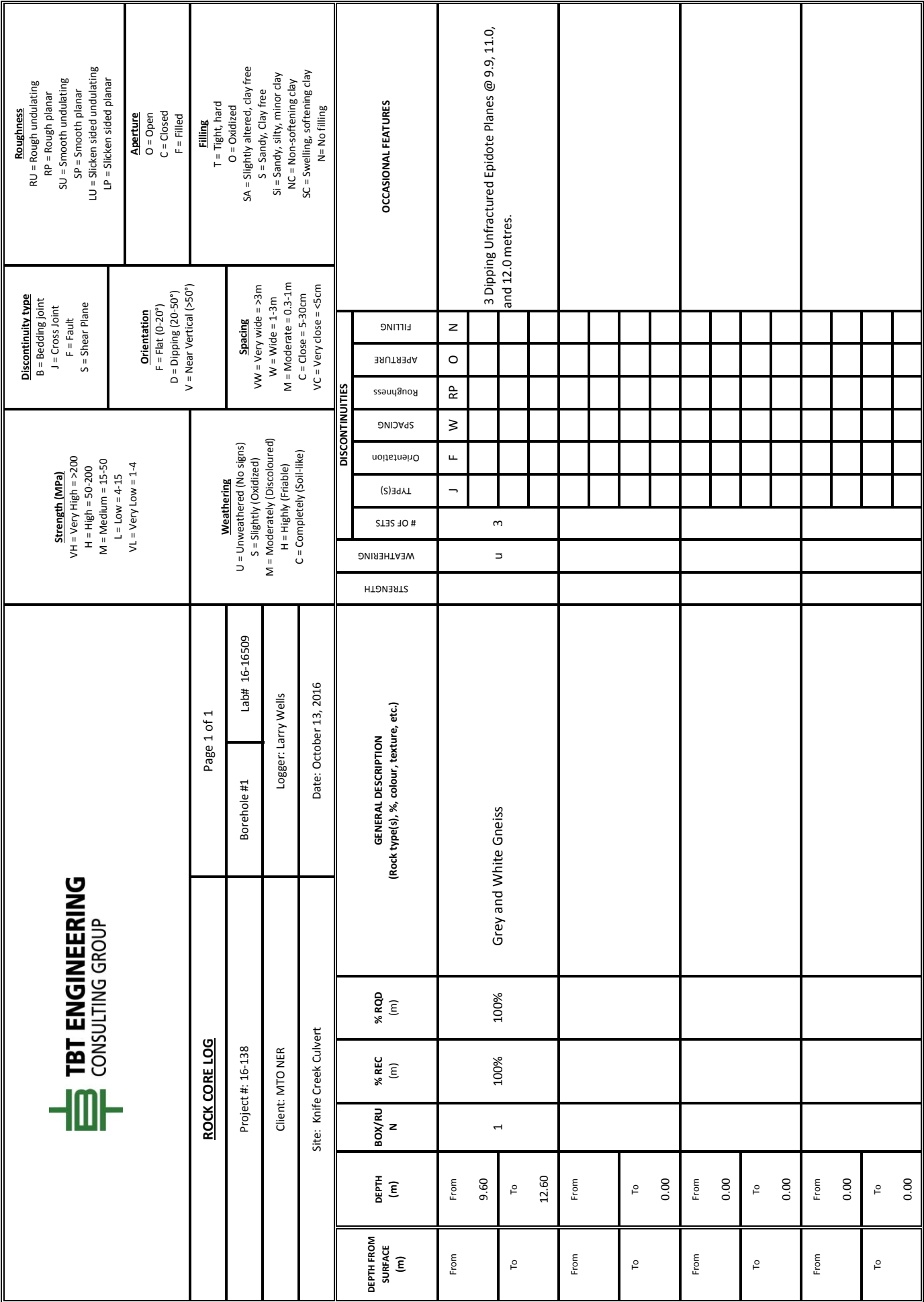
METRIC

W.P. 5119-06-00 LOCATION Knife Creek N:5355296.975; E:228601.858 MTM Zone:13 ORIGINATED BY WM
 DIST NER HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SW
 DATUM Geodetic DATE 2016.03.10 - 2016.03.10 LATITUDE 48.331803 LONGITUDE -85.027792 CHECKED BY CJ

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					
20	40	60	80	100	20	40	60	80	100	20	40	60	80	100	

417.9	0.0	TOPSOIL/ORGANICS - brown/black, very loose		1	AS			417																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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ONTARIO MTO MOD 16-138 MTO - KNIFE CREEK GPJ ONTARIO MTO.GDT 8/6/17



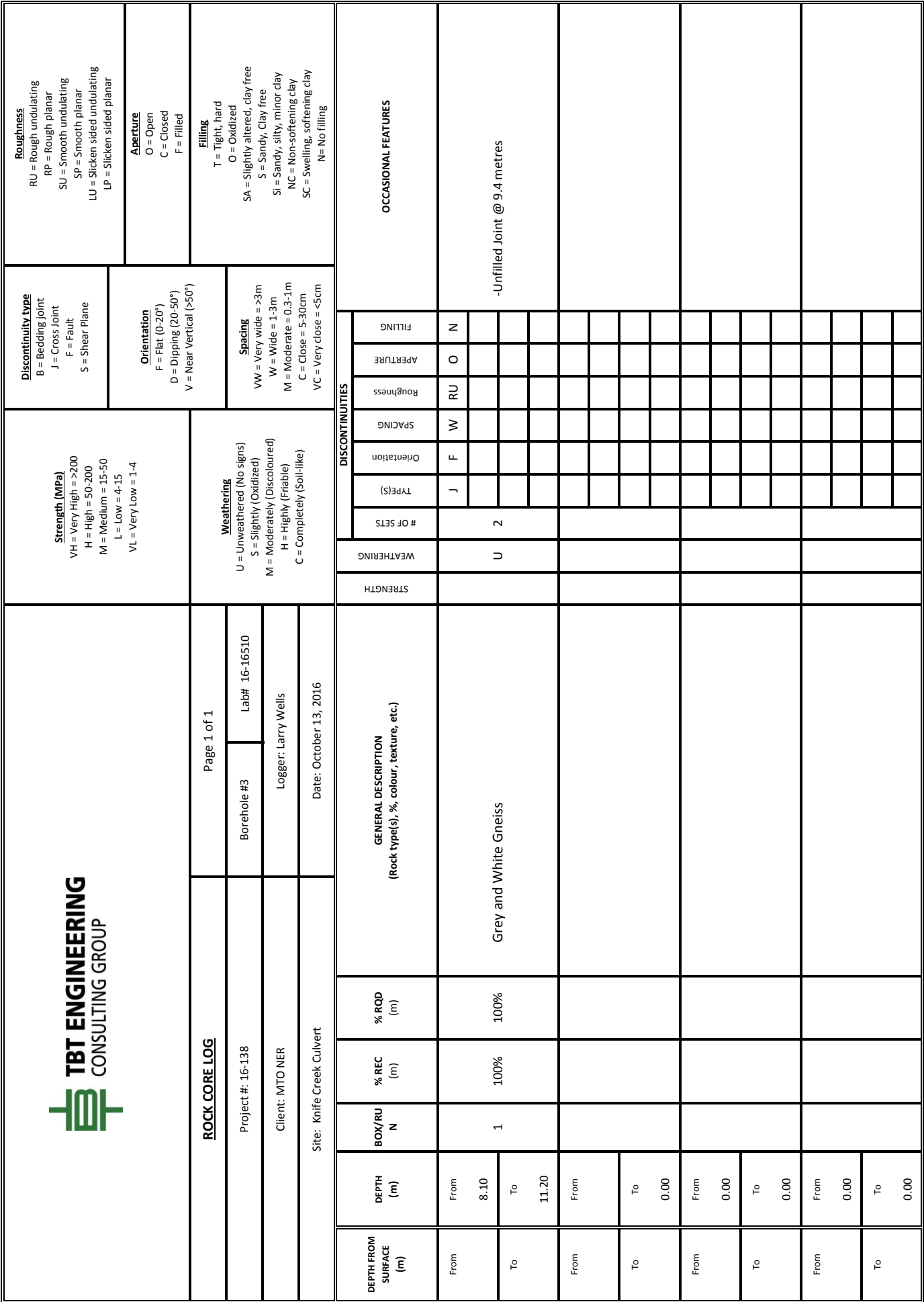
Full Rock Core Dry



Full Rock Core Wet



-3.0 metre core of Archean Gneiss



Full Rock Core Dry



Full Rock Core Wet



-3.1 metre core of Archean Gneiss

ROCK CORE LOG

Page 1 of 1

Project # 16-138

Borehole #4

Lab# 16-16511

Client: MTO NER

Logger: Larry Wells

Site: Knife Creek Culvert

Date: October 12, 2016

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 undulating
LP = Slickened 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

DISCONTINUITIES

STRENGTH

WEATHERING

OF SETS

TYPE(S)

Orientation

SPACING

Roughness

APERTURE

FILLING

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

% RQD
(m)

% REC
(m)

BOX/RU
N

DEPTH
(m)

DEPTH FROM
SURFACE
(m)

Grey and White Gneiss

93%

100%

1

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Full Rock Core Dry



Full Rock Core Wet



-3.1 metre core of Archean Gneiss

ROCK CORE LOG

Page 1 of 1

Project #: 16-138

Borehole # 5

Lab# 16-16512

Client: MTO NER

Logger: Larry Wells

Site: Knife Creek Culvert

Date: October 12, 2016

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 = Slickensided undulating
LP = Slickensided 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

DISCONTINUITIES

STRENGTH

WEATHERING

OF SETS

TYPE(S)

Orientation

SPACING

Roughness

APERTURE

FILLING

OCCASIONAL FEATURES

Grey and White Gneiss

Epidote Joint Filling @ 10.3 m

Full Rock Core Dry



Full Rock Core Wet

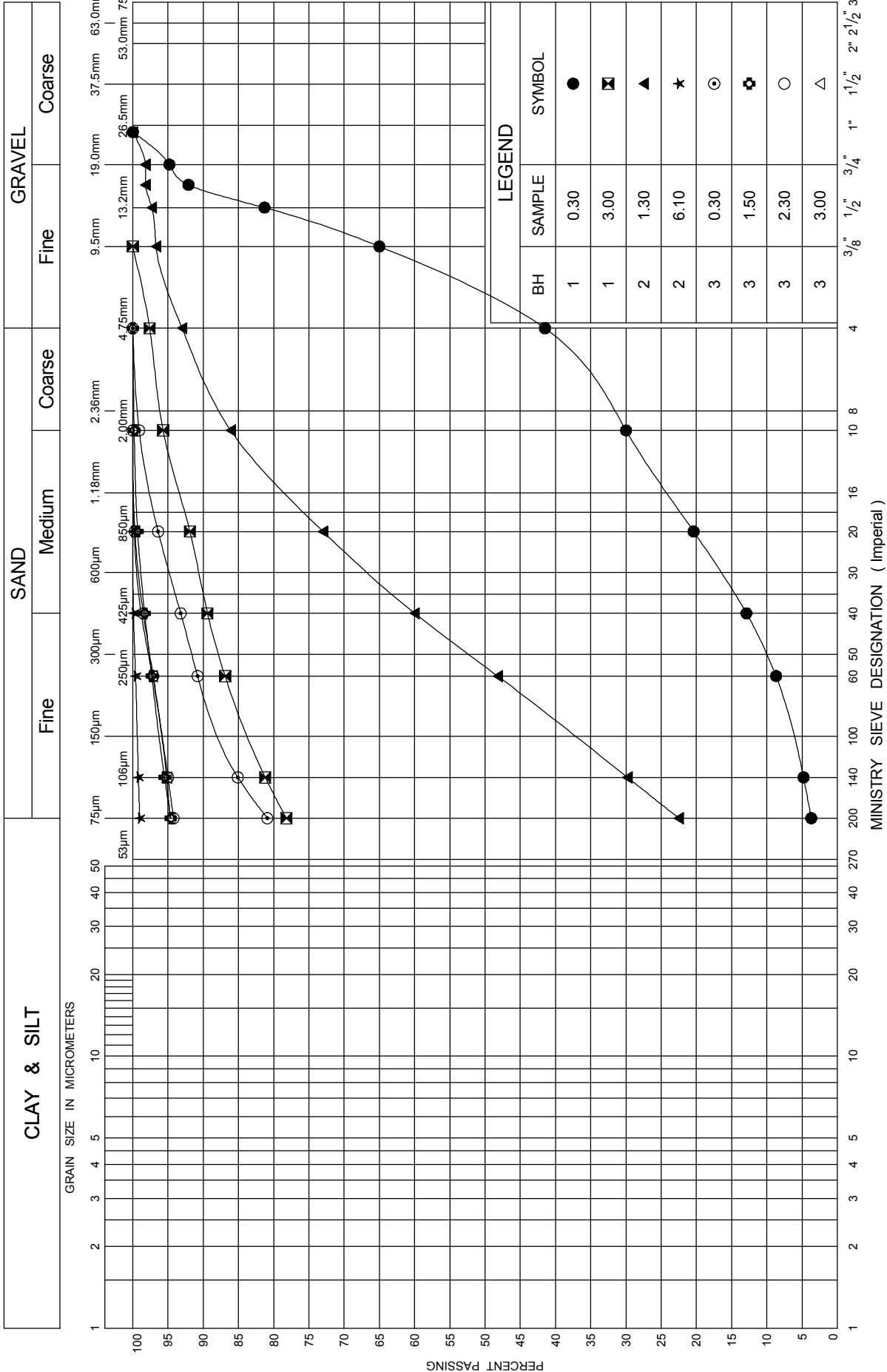


-3 metre core of Archean Gneiss

APPENDIX B

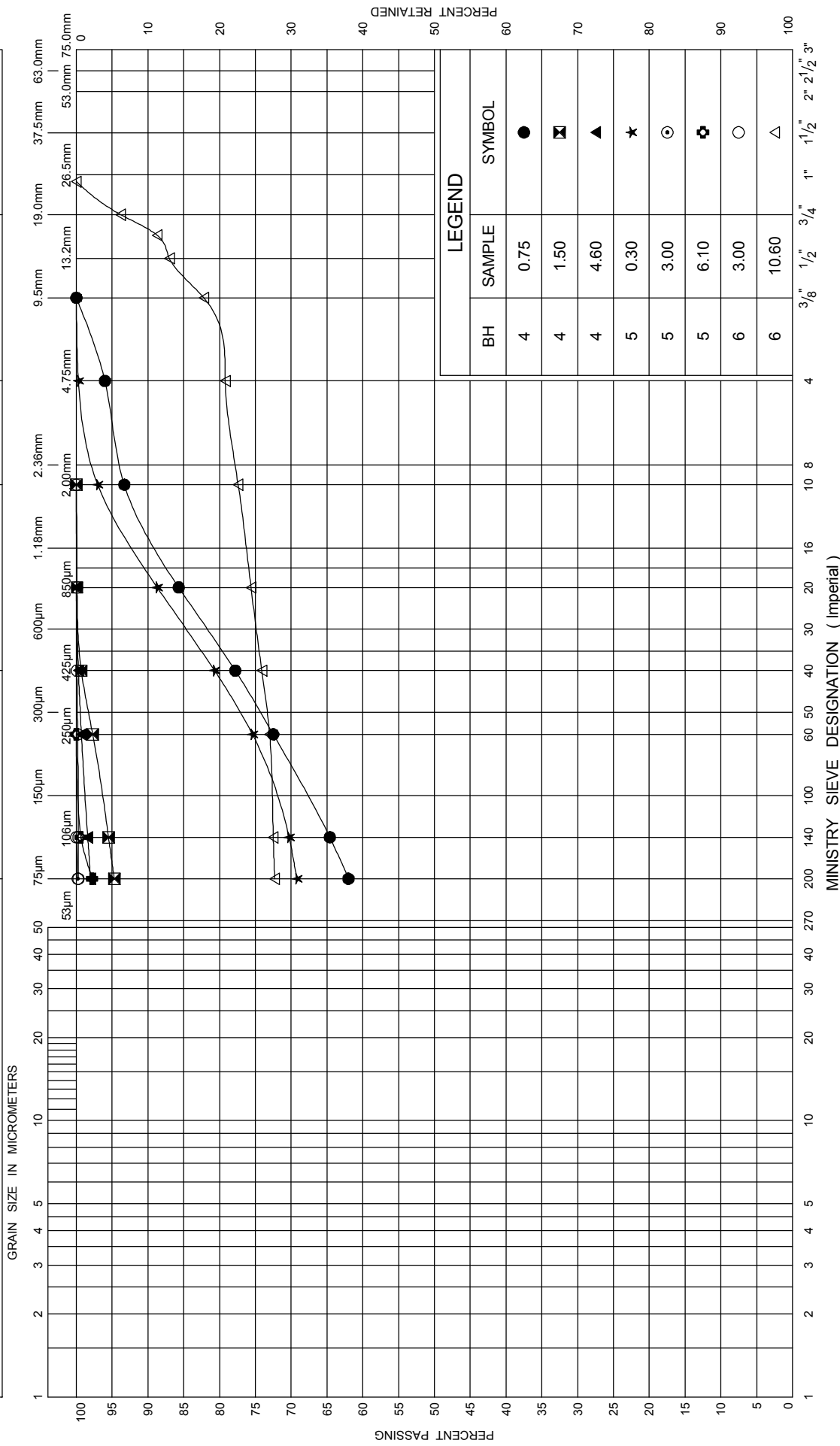
Laboratory Test Data

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT			SAND			GRAVEL		
Fine			Medium			Fine		
Coarse			Coarse			Coarse		



GRAIN SIZE DISTRIBUTION

FIG No

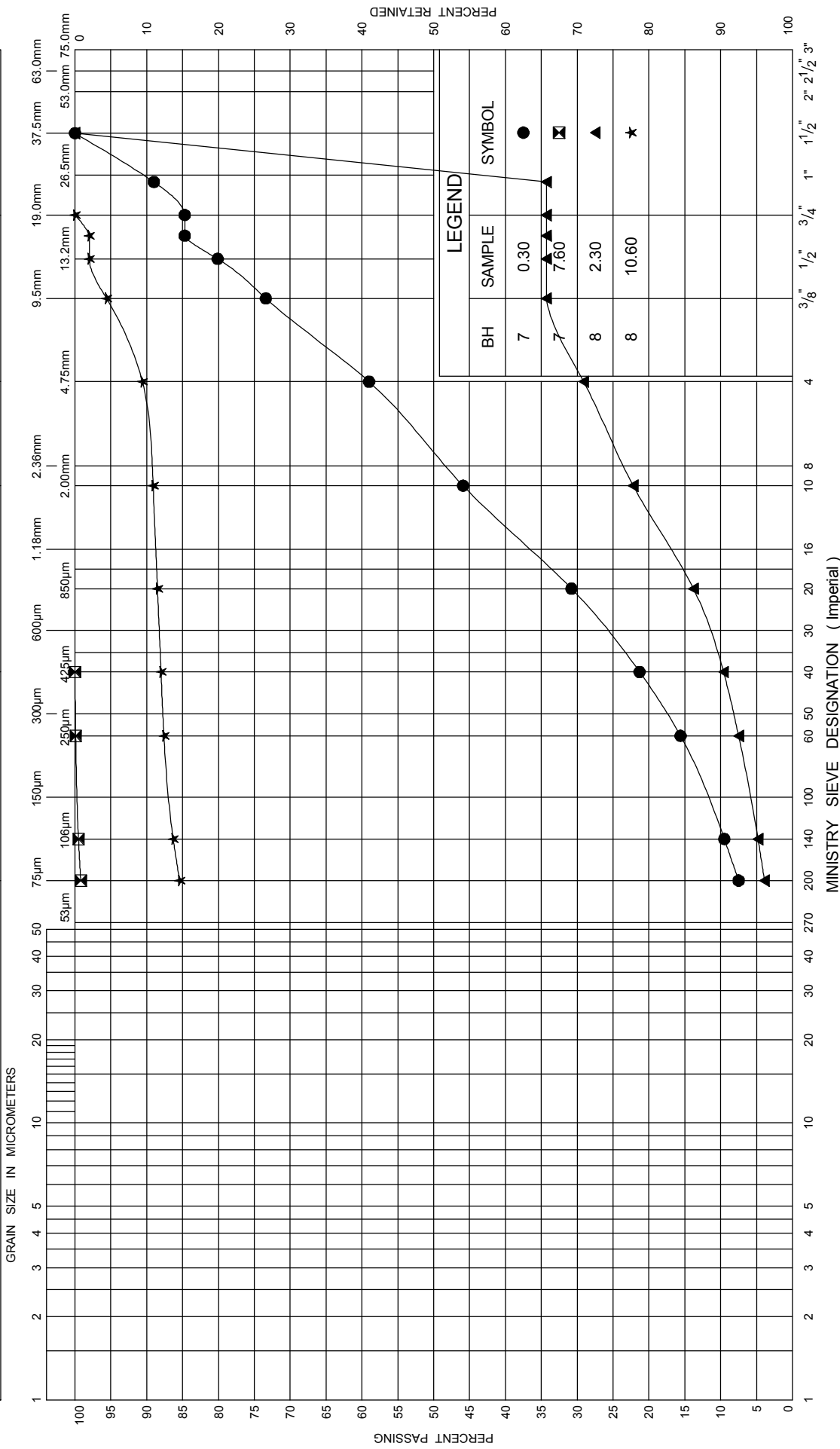
W P

Culvert Investigation



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT			SAND			GRAVEL		
Fine			Medium			Fine		
Coarse			Coarse			Coarse		

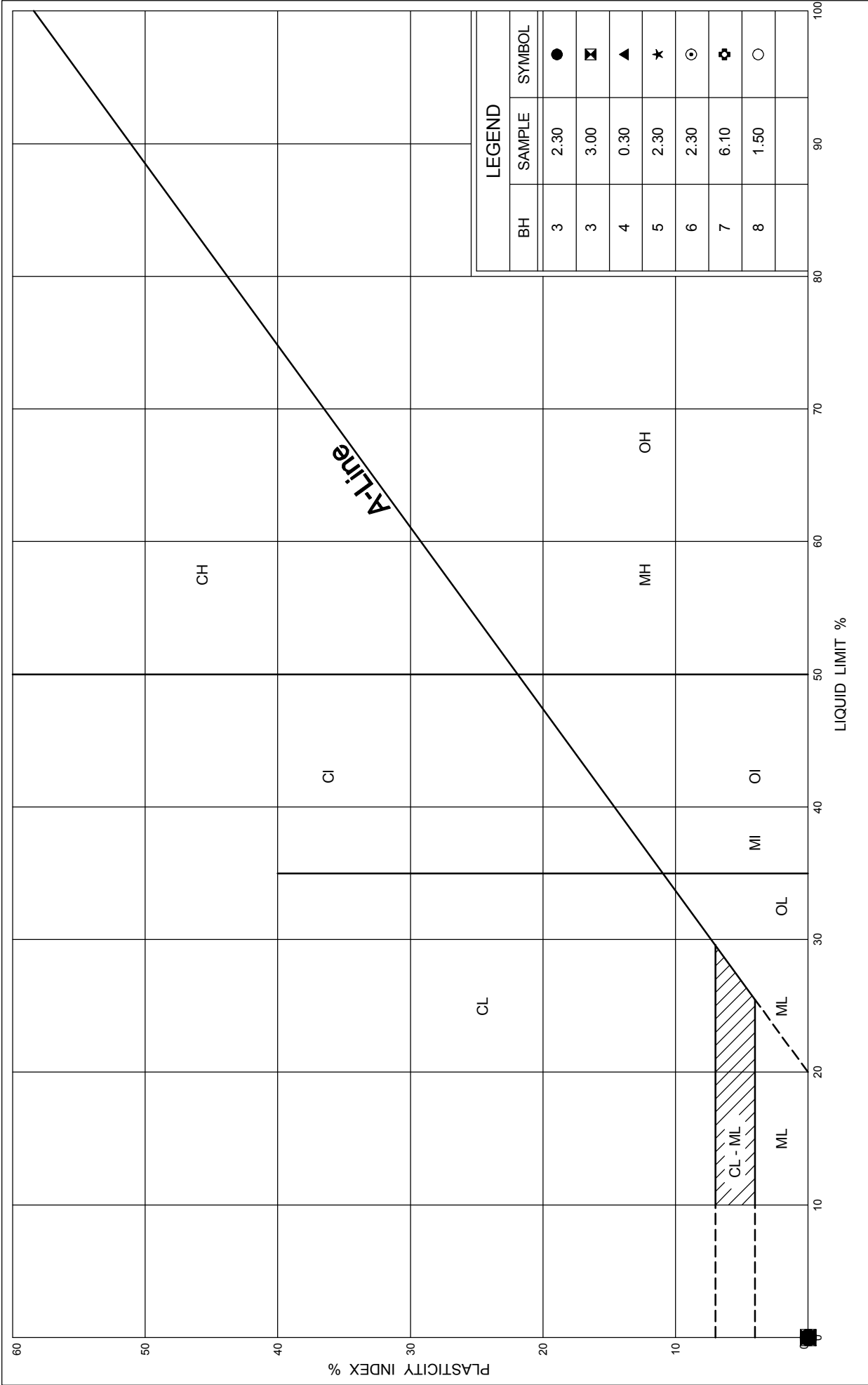


GRAIN SIZE DISTRIBUTION

FIG No

W P

Culvert Investigation



PLASTICITY CHART

FIG No

W P

Culvert Investigation

Ministry of
Transportation



Ontario

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID Description Sampled Date Sampled Time Client ID	L1851607-1 Soil 20-SEP-16 09:00 KNIFE CREEK - BH2 SS4				
Grouping	Analyte						
SOIL							
Physical Tests	Conductivity (mS/cm)	0.362					
	% Moisture (%)	12.1					
	pH (pH units)	7.78					
	Redox Potential (mV)	123					
	Resistivity (ohm*cm)	2760					
Leachable Anions & Nutrients	Chloride (ppm)	91.8					
	Sulphide (as S) (mg/kg)	<0.20					
Anions and Nutrients	Sulphate (ppm)	42					

APPENDIX C
Borehole Locations and Soil Strata Drawing

Oct 31, 2017 12:05pm Login name: iblunden
Drawing Name: \\Projects\2016\16-138 MTD NER Hwy 17 Pavt Engr\Foundations\Knife Creek\Knife Creek FNDN Final Revision 2.dwg

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN

GEOCREs No. 42C-041

CONT No. 201x-xx-xxxx

GWP No. 5119-06-00

SHEET
1

Ministry of Transportation
Northwestern Region
Structural Section

TBT ENGINEERING
CONSULTING GROUP

SOIL STRATA SYMBOLS			
	TOPSOIL/ ORGANICS		SILT
	FILL - SAND OR GRAVEL		GRAVEL
	SAND		BEDROCK

LEGEND			
	Borehole		
'N'	Std Pen Test (Blows/0.3m)		
	Water Level		
	Water Level on Completion		
EOH	End of Borehole		
AR	Auger Refusal		
oB	Bell Pole		
oH	Hydro Pole		
• RIB	Round Iron Bar		
No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
BH 1	419.7	13 5 355 264	228 613
BH 2	419.7	13 5 355 288	228 580
BH 3	418.0	13 5 355 274	228 568
BH 4	418.6	13 5 355 258	228 598
BH 5	418.4	13 5 355 253	228 593
BH 6	418.1	13 5 355 272	228 621
BH 7	418.1	13 5 355 289	228 595
BH 8	417.9	13 5 355 297	228 602

NOTE: ELEVATIONS ARE REFERENCED FROM PLAN PLATE NO. 692-17/13-0 WP No. 267-90-00 PROFILE ELEVATION.

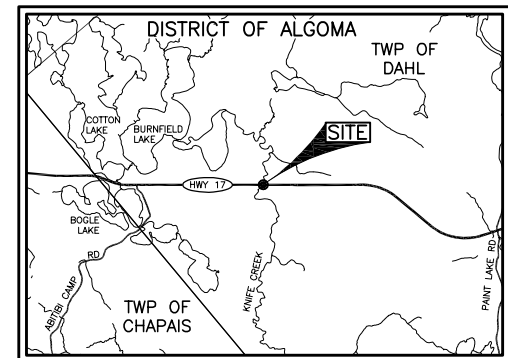
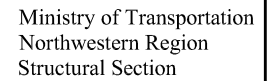
-NOTE-
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS		DESCRIPTION	
171031	TB	FINAL REVISION 2	
170928	TB	UPDATE WITH SURVEY INFORMATION	
CO-ORDINATES Lat 48.331565° Long -85.027971°			
DESIGN	CHK	CODE XXXXX-XX	LOAD XX-XX-XX DATE 20161224
DRAWN	TB	CHK GM/SITE	38C-154/C APPENDIX

GEOCRES	No. 42C-041
CONT	No. 201x-xx-xxxx
GWP	No. 5119-06-00

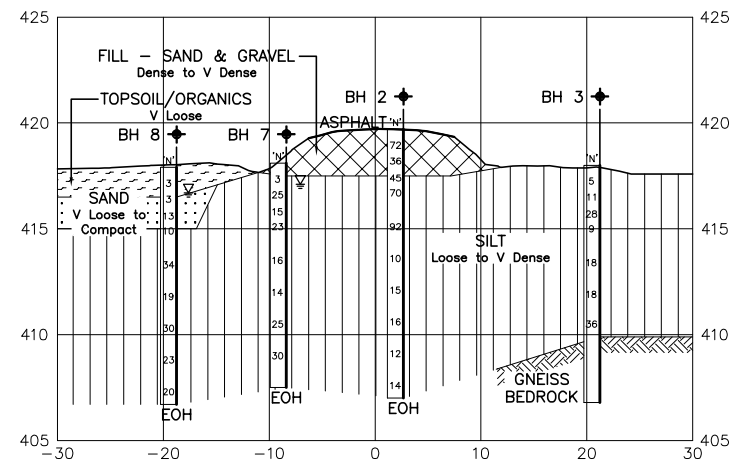


SHEET
2



KEY PLAN

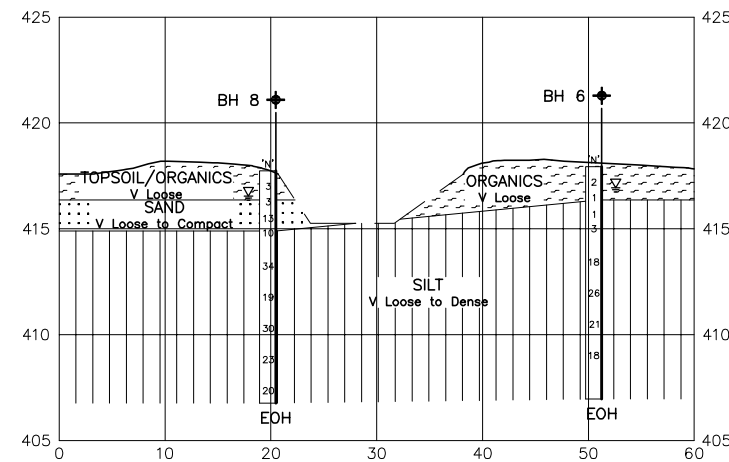
2.0 km 2.0 km



SCALE

HOR 10 0 10 m

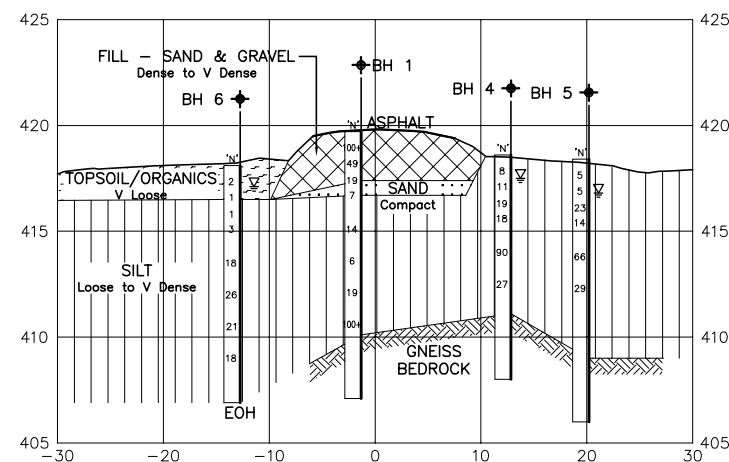
VERT 5 0 5 m



SCALE

HOR 10 0 10 m

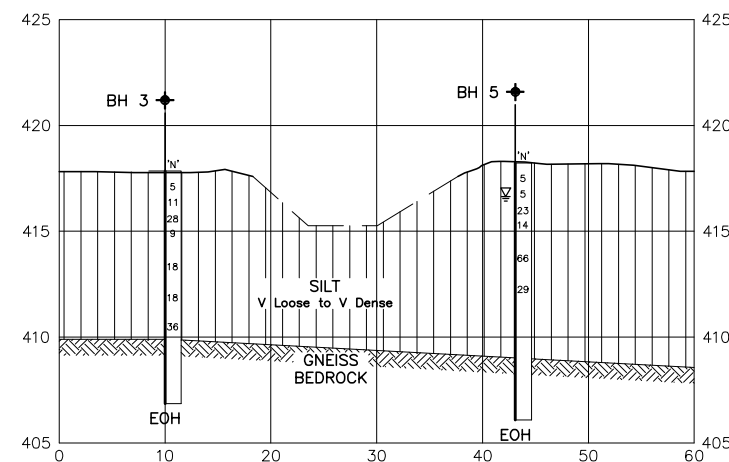
VERT 5 0 5 m



SCALE

HOR 10 0 10 m

VERT 5 0 5 m












SCALE

HOR 10 0 10 m

VERT 5 0 5 m



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	FILL — SAND OR GRAVEL	
	SAND	
		
		
		

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