

# Foundation Investigation and Design Report

## Culvert Replacement

Log River (Site No. 45-278C)

Highway 71, 37.3 km North of Highway 11

### SUBMITTED TO:

LH North Ltd.  
36 Rubin Drive  
Murillo, ON  
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**SUBMITTED BY:**  
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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 at Log River 37.3 km north of in the intersection of Highway 71 and Highway 11. 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 Log River culvert location. The remaining foundation sites, Black River Culvert and Pine Lake Culvert are addressed under separate covers.

This investigation consisted of a total of five boreholes; two 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 LOG 1 to LOG 5.

## 2 Site Description

The foundation investigation was completed to investigate subsurface conditions for the Log River Culvert, Site No. 45-278C along Hwy 71 in the Township of Menary. 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 2.5 m high with side slopes of approximately 2 horizontal to 1 vertical on both the right and left side. The water level in the water course at the culvert inlet and outlet was measured, with elevations of 337.0 and 336.9 m respectively in March, 2015.

**Photo 2.1 – Log River Culvert**





### **3 Surficial Geology**

Available surficial geology mapping (OGS NOEGTS Map 5069 – Rainy Lake) indicates the site is located in a bedrock knob terrain unit comprised of till ground moraine and a silty clay glaciolacustrine plain with moderate local relief.

### **4 Investigation Procedures**

A geotechnical site investigation was undertaken from April 2 to 8, 2015. The borehole locations are illustrated on the Borehole Location and Soil Strata Drawing found in Appendix C. The investigation was completed 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 overlay clay. The clay overlies sand and gravel above the bedrock. Organic material was encountered beneath the embankment fill at one borehole location and at ground surface of the two boreholes off the embankment. Frost was encountered at a depth of 0.6 m at Borehole LOG 1.

### **6.1 Asphalt**

Asphalt was encountered at the surface of Boreholes LOG 2, 4 and 5. The asphalt's thickness varied from 60 to 70 mm.

### **6.2 Fill**

Fill was encountered at Boreholes LOG 2, 4 and 5 and varied in thickness from 1.5 to 5.2 m and was encountered at an elevation of 339.0 m. The fill ranges from sandy clay to sandy gravel with trace silt. The test results indicate a grain size distribution of 15 to 68 % gravel, 27 to 70 % sand, and 6 to 16 % silt/clay sized particles. The presence of occasional to numerous cobbles was noted within the fill. The fill is very loose to compact as indicated by "N" values ranging from 3 to 49 blows/0.3 m. The majority of "N" values indicate the fill is loose.

### **6.3 Organic Material**

Organic material was encountered at ground surface at Borehole LOG 1 and 3 and beneath the fill at LOG 5. The material was encountered at elevations 337.2, 337.1 and 336.1 at Boreholes LOG 1, 3 and 5 respectively. The organic material ranged in thickness from 0.4 to 1.8 m. The natural moisture contents range from 74 to 225%.

### **6.4 Clay**

Two clay formations were identified within all the boreholes; a varved clay formation and a massive clay formation. The two formations are encountered throughout the boreholes in various vertical orders.

#### 6.4.1 Massive Clay

The massive clay was encountered at two distinct general elevations; 330 and 336 m. The material encountered at elevations ranging from 330 to 331.9 m varied in thickness ranging from 1.5 to 2.8 m, with Borehole LOG 5 terminating within this strata. The clay encountered at elevations ranging from 335.3 to 337.6 m varied in thickness from 0.7 to 1.8 m. A single grain size analysis indicates the material can consists of 0 % gravel, 27 % sand, 36 % silt and 37 % clay sized particles, occasional cobbles were also noted within this material. Based on a single Atterberg Limit test, the clay is of low plasticity with a natural moisture content between the liquid and plastic limit. The clay is stiff to very stiff as indicated by insitu vane testing ranging from 63 and 100+ kPa.

#### 6.4.2 Varved Clay

Varved clay and sand to trace sand was identified within all the boreholes at elevations ranging from 333.9 to 336.9 m with thickness ranging from 2 to 5 m. The clay has a varved structure with alternating layers of varying silt content and plasticity.

Atterberg limit testing of eight samples indicates this material ranges typically from medium (four samples) to high plasticity (three samples) with one sample (LOG 4 at 3.0 m) of low plasticity. The natural moisture contents for samples are between the liquid and plastic limits. Grain size analyses performed on eight samples indicates the material contains 0 % gravel, 2 to 43 % sand, 13 to 56 % silt, and 37 to 78 % clay sized particles.

Thin walled tube samples obtained during the field investigation revealed slickensides and desiccated structures within the varved clay. Due to the presence of slickensides and desiccated structure, residual shear strengths of this material should be for design.

A consolidated undrained direct shear test was conducted to estimate the undrained shear strength of the clay on a sample from Borehole LOG 2 at a depth of 6.1 m. The peak undrained shear strength is 69 kPa and the post peak undrained shear strength is 64 kPa indicating stiff clay. Field vane tests, in the varved clay indicated undrained shear strengths of 70 kPa to over 100 kPa with remolded strengths ranging from 21 to 79 kPa. The presence of sand, silt and varves within the deposit have likely inflated the results of the field vane tests.

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A consolidation test was completed on a sample of the varved clay from Borehole LOG 2 at a depth of 6.1 m. Consolidation parameters estimated from the test are as follows:

- $e_o = 0.72$
- $C_r = 0.036$
- $C_c = 0.19$
- $P'_o = 75 \text{ kPa}$
- $P'_c = 200 \text{ kPa}$
- $OCR = 2.7$
- $C_v$  as measured varies from 24 to 53  $\text{mm}^2/\text{min}$ . (between effective vertical stresses of 50 to 400 kPa). However, given varved/desiccated structure of this stratum the insitu  $C_v$  will be higher.

#### 6.5 Sand

Sand with trace silt and some gravel to silty sand with trace gravel was present beneath the clay at Boreholes LOG 3 and 4. The sand was encountered at elevations of 328.5 and 329.4 m at Boreholes LOG 3 and 4, respectively. Both boreholes terminated within this material. Based on grain size analyses the material consists of 2 to 24 % gravel, 66 to 68 % sand, and 7 to 32 % silt/clay sized particles with occasional cobbles present. The sand is dense as indicated by “N” values of 35 and 45 blows/0.3 m.

#### 6.6 Gravel

Gravel with some sand and some silt was present beneath the clay at Borehole LOG 1 at an elevation of 330.2 m with a thickness of 1.6 m. Based on a grain size analysis the material consists of 45 % gravel, 26 % sand, and 17 % silt/clay sized particles with occasional cobbles present.

#### 6.7 Bedrock

Bedrock was encountered at Boreholes LOG1 and 2. The following table indicates the recorded bedrock elevation and depth at each borehole. Bedrock was encountered underlying the gravel at Borehole LOG 1, and beneath the clay at LOG 2. Bedrock was sampled using diamond coring techniques. The bedrock is medium grained and weakly foliated to massive Biotite Granite. 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
LOG 1	8.6	328.6
LOG 2	11.4	327.7

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 94 to 95 % indicating excellent quality.

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)
LOG 1	8.9	328.3	327
	10	327.2	279
LOG 2	11.5	327.6	171
	13.4	325.7	266

\* 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 April 2 to April 8, 2015 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 337.0 and 336.9m in March of 2015.

**Table 6.4: Ground Water Level**

Borehole	Depth below Ground Surface (m)	Elevation
LOG 1	0.1	337.1
LOG 2	1.6	337.5
LOG 3	0.2	336.9
LOG 4	1.7	337.4

## 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 Log River Culvert (Site 45-278C). 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 Log River Culvert consisted of five boreholes; Boreholes LOG 1 to 5.

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 clay. For the purpose of assessing bearing capacity, the rock fill pad will be extended at least 1.7 m below the underside 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	290	185	290	225	290
1.0	160	190	225	190	230	190
1.5	165	140	170	140	175	140
2.0	140	110	145	110	190	110

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.

### 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, $\gamma$ (kN/m <sup>3</sup> )
	Effective Angle of Internal Friction, $\phi'$ (degrees)	Effective Cohesion Intercept, $C'$ (kPa)		
Fill (B type 2 or A)	35	0	-	20
Rock Fill	40	0	-	18
Existing Fill	30	0	-	20
Organic Material	30	0	-	12
Clay	28	0	60	18
Clay - Varved	12	0	20	18

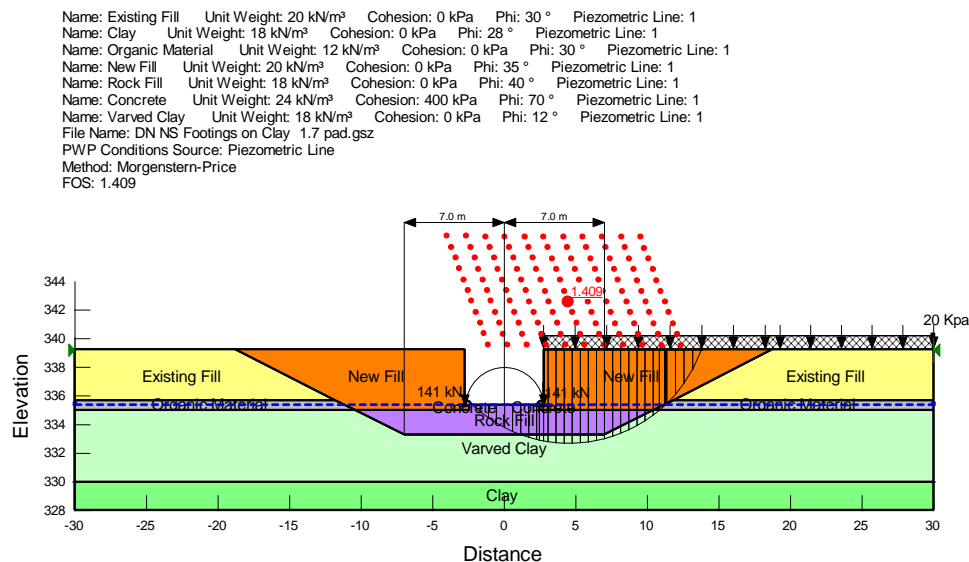


The stability model was established with the following conditions:

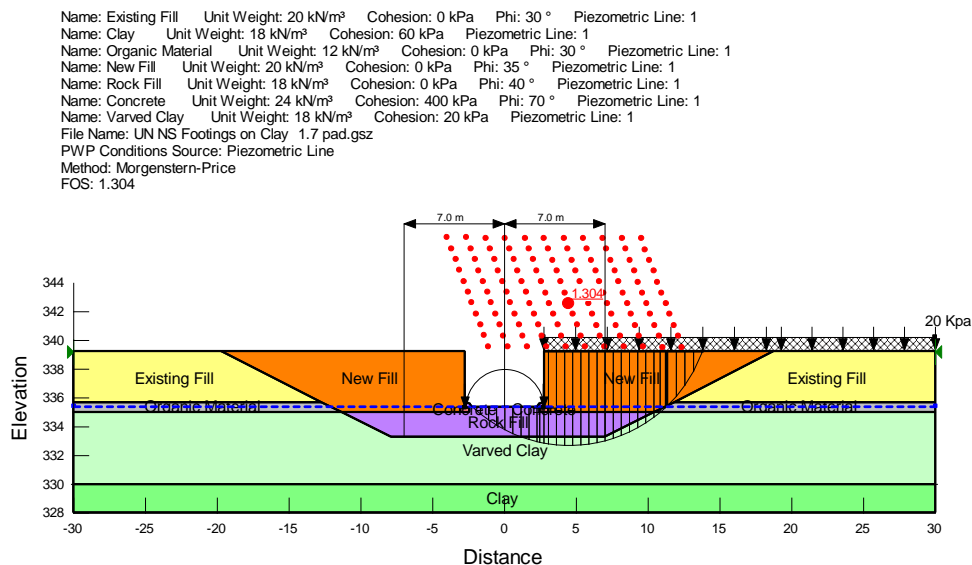
- New backfill behind the culvert will consist of compacted Granular A, or B (Type I or II) and will exist within excavation back slope of 2H:1V, or flatter through the existing fill and/or native soils.
- The rock fill pad below the footing will extend at least 1.7 m below the footing to or below el. 333.3 m. In order to achieve a minimum FoS of 1.3, the base of the rock fill pad must extend at least 7.0 m out from the culvert centerline.
- The footing will extend at least 0.3 m behind the culvert.
- The culvert span is 5.5 m.
- An unfactored dead load of 141 kN/m was modelled along the footing (data provided by LHN).

Stability analyses have been completed for assuming the rock fill pad will be founded on the native clay. Analyses were carried out assuming both effective stress and total stress strength parameters for the clay soils. A uniformly distributed traffic load of 20 kPa over the traversable lane(s) was applied. The results of this assessment indicate a suitable level of stability (FoS >= 1.3) as illustrated below in Figures 9.1 and 9.2.

**Figure 9.1: Effective Stress Strength Parameters for Clay**



**Figure 9.2: 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	$\phi'$ (°)	Bulk Unit Weight of Soil, $\gamma$ (kN/m³)	Active $K_a$	At Rest $K_o$	Passive $K_p$
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 1.5 to 5.2 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 approximately 2.1 m above the existing 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. There is a potential for base heave during construction due to the presence of permeable non-cohesive soils underling the clay strata. If the soils heave during excavation the disturbed soils will experience a loss of strength and will affect design values provided above. All disturbed soils would likely need to be removed. To prevent base heave and to stabilize a dry excavation, dewatering (typically in the form of well points installed into the granular soils below the clay) 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 alone through the granular soils is not considered practical due to presence bedrock below the permeable soils (the presence of bedrock will limit an effective seepage cut-off seal). In addition, the presence of cobbles may limit advancement of sheet piles. 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 2.3 m. The embankment soils anticipated within the frost depth are considered to be of low frost susceptibility with occasional seams/pockets of highly frost susceptible clays (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.

## **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 LOG 1			1 OF 1		METRIC				
W.P. _____ PROJECT <b>Log River</b> SITE _____ ORIGINATED BY <b>AF</b>												
DIST <b>61</b> HWY <b>71</b> LOCATION <b>MTM 16 N5427275.757, E237022.103</b> TBTE JOB# <b>15-026</b> COMPILED BY <b>TB</b>												
DATE <b>2015 April 2</b> BOREHOLE TYPE <b>Hollow Stem Auger</b> DATUM <b>GEODETIC</b> CHECKED BY <b>GM</b>												
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES					
						○ UNCONFINED    ✕ FIELD VANE ■ SPT (N)        ★ LAB VANE	WATER CONTENT (%) 20 40 60 80 100					
337.2												
0.0	ORGANIC MATERIAL - brown/black		1	AS								Water level @ 0.1 m on completion. Frost to 0.6 m.
336.8												
0.4	CLAY - some sand, organics, grey, very stiff		2	SS	1							0 27 36 37
			3	SS	1							
335.0												
2.2	CLAY - varved, trace sand, grey, very stiff		4	TW								0 7 23 70
			5	SS	6							
333.0												
4.2	CLAY - grey, stiff to very stiff		6	SS	5							
			7	TW								
330.2												
7.0	GRAVEL - Sandy, some till, occasional cobbles, grey		8	SS	100+							45 26 (17) On cobble.
328.6												
8.6	BEDROCK - Biotite Granite, medium grained, very weakly foliated		1	RC								RC # 1 REC = 98% RQD = 94%
327.0												
10.2	End of Borehole @ 10.2 m.											

ONL\_MOT\_BH\_MTM DIST 15-026 LOG RIVER.GPJ ONL\_MOT.GDT 15/6/9

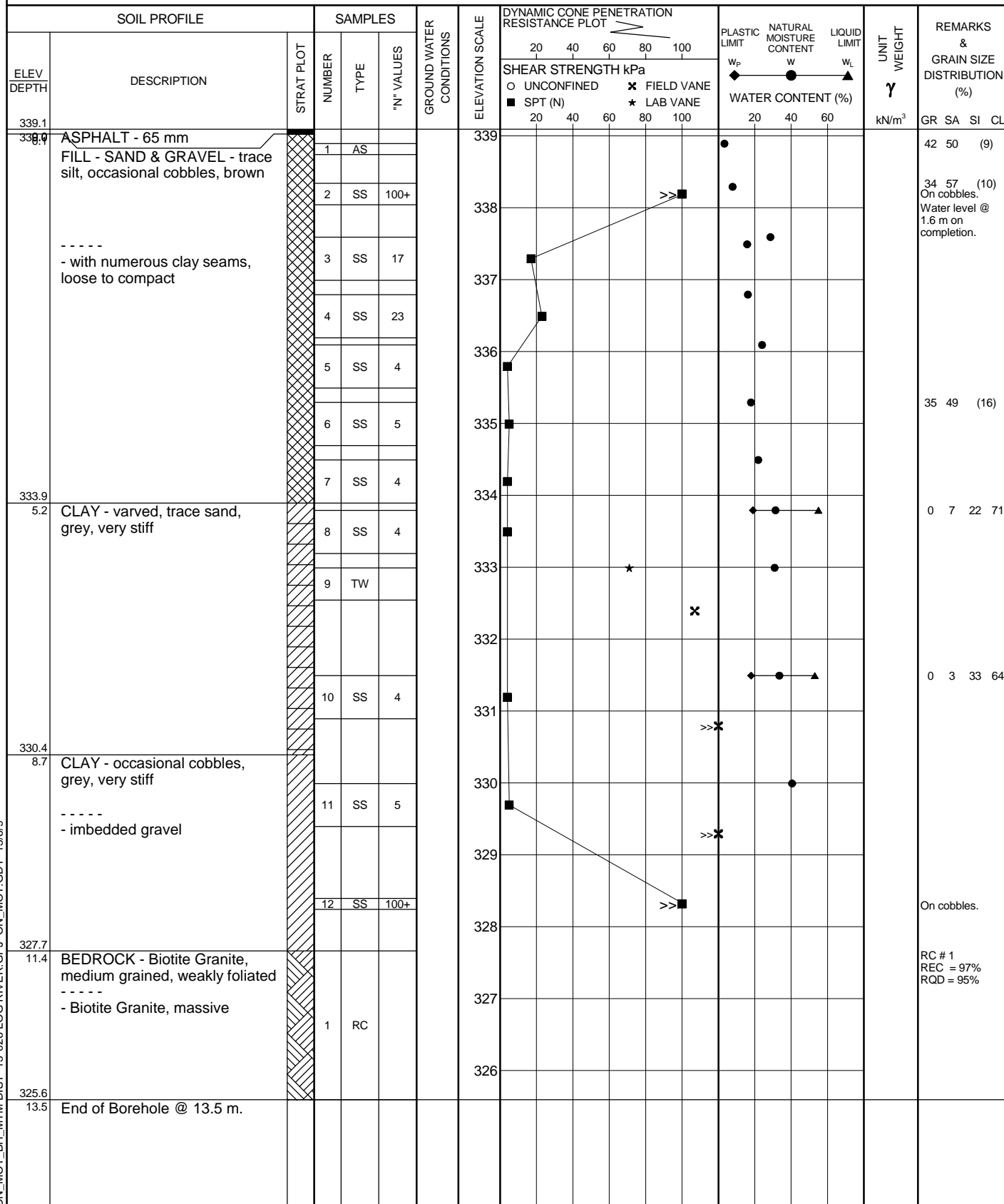
✕<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity NP Non Plastic ○ 3% STRAIN AT FAILURE

TBT Engineering Consulting Group **RECORD OF Borehole No LOG 2** 1 OF 1 **METRIC**

W.P. \_\_\_\_\_ PROJECT **Log River** SITE \_\_\_\_\_ ORIGINATED BY **AF**

DIST **61** HWY **71** LOCATION **MTM 16 N5427285.952, E237003.3** TBTE JOB# **15-026** COMPILED BY **TB**

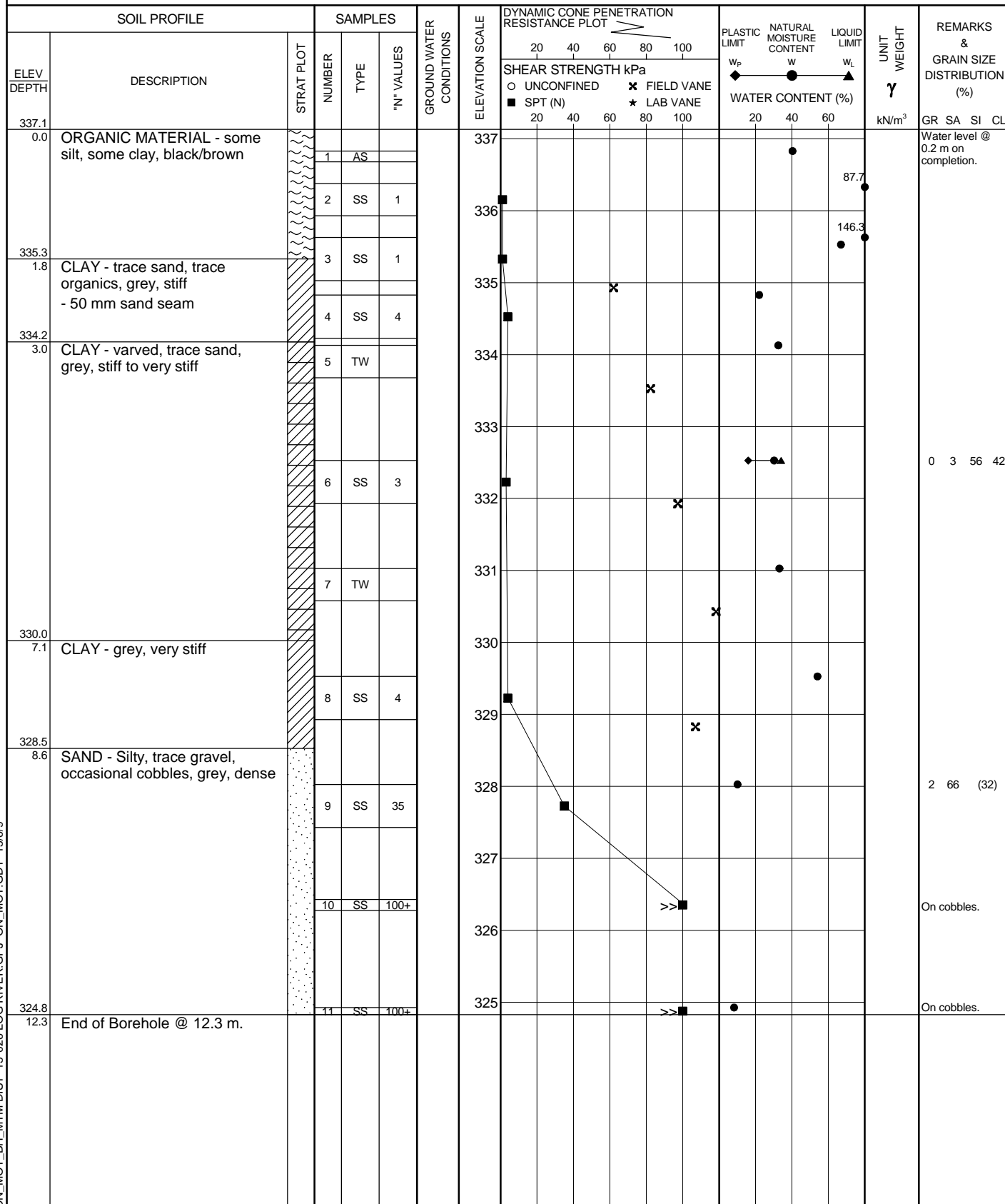
DATE **2015 April 7** BOREHOLE TYPE **Hollow Stem Auger** DATUM **GEODETIC** CHECKED BY **GM**



ONL\_MOT\_BH\_MTM\_DIST\_15-026 LOG RIVER.GPJ ONL\_MOT\_GDT\_15/6/9

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

<b>TBT Engineering Consulting Group</b>		<b>RECORD OF Borehole No LOG 3</b>		1 OF 1	<b>METRIC</b>
W.P. _____	PROJECT <b>Log River</b>	SITE _____	ORIGINATED BY <b>AF</b>		
DIST <b>61</b>	HWY <b>71</b>	LOCATION <b>MTM 16 N5427277.015, E236995.408</b>	TBTE JOB# <b>15-026</b>	COMPILED BY <b>TB</b>	
DATE <b>2015 April 6</b>	BOREHOLE TYPE <b>Hollow Stem Auger</b>	DATUM <b>GEODETIC</b>	CHECKED BY <b>GM</b>		



ONL\_MOT\_BH\_MTM\_DIST\_15-026 LOG RIVER.GPJ ONL\_MOT\_GDT\_15/6/9

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



W.P.	PROJECT	Log River	SITE	ORIGINATED BY	AF
DIST 61 HWY 71	LOCATION	MTM 16 N5427296.394, E237012.759	TBTE JOB#	COMPILED BY	TB
DATE	BOREHOLE TYPE	Hollow Stem Auger	DATUM	CHECKED BY	GM
2015 April 8			GEODETIC		

ON MOT BH MTM DIST 15-026 LOG RIVER.GPJ ON MOT.GDT 15/6/9

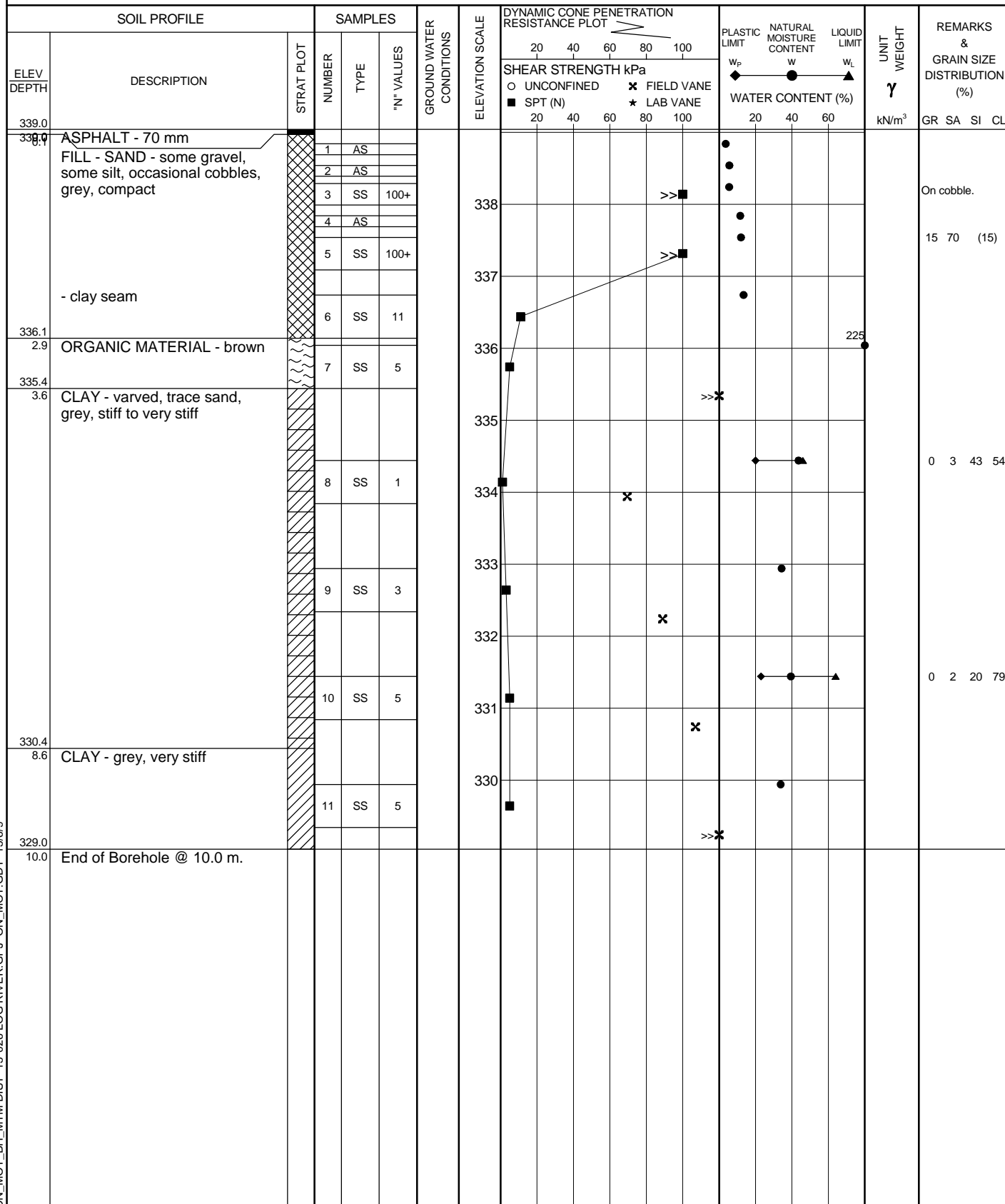
✕<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity  
 NP Non Plastic

TBT Engineering Consulting Group **RECORD OF Borehole No LOG 5** 1 OF 1 **METRIC**

W.P. \_\_\_\_\_ PROJECT **Log River** SITE \_\_\_\_\_ ORIGINATED BY **AF**

DIST **61** HWY **71** LOCATION **MTM 16 N5427261.288, E237001.173** TBTE JOB# **15-026** COMPILED BY **TB**

DATE **2015 April 8** BOREHOLE TYPE **Hollow Stem Auger** DATUM **GEODETIC** CHECKED BY **GM**



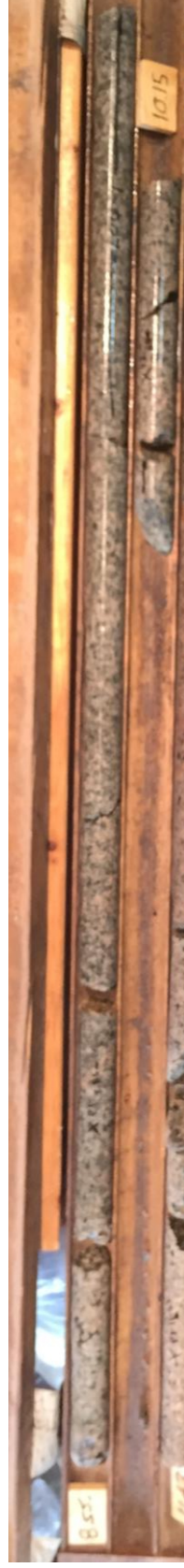
ONL\_MOT\_BH\_MTM DIST 15-026 LOG RIVER.GPJ ONL\_MOT.GDT 15/6/9



## Full Rock Core Dry



## Full Rock Core Wet



## Rock Core Detail (P1 – 8.85 m depth)







## Full Rock Core Dry



## Full Rock Core Wet

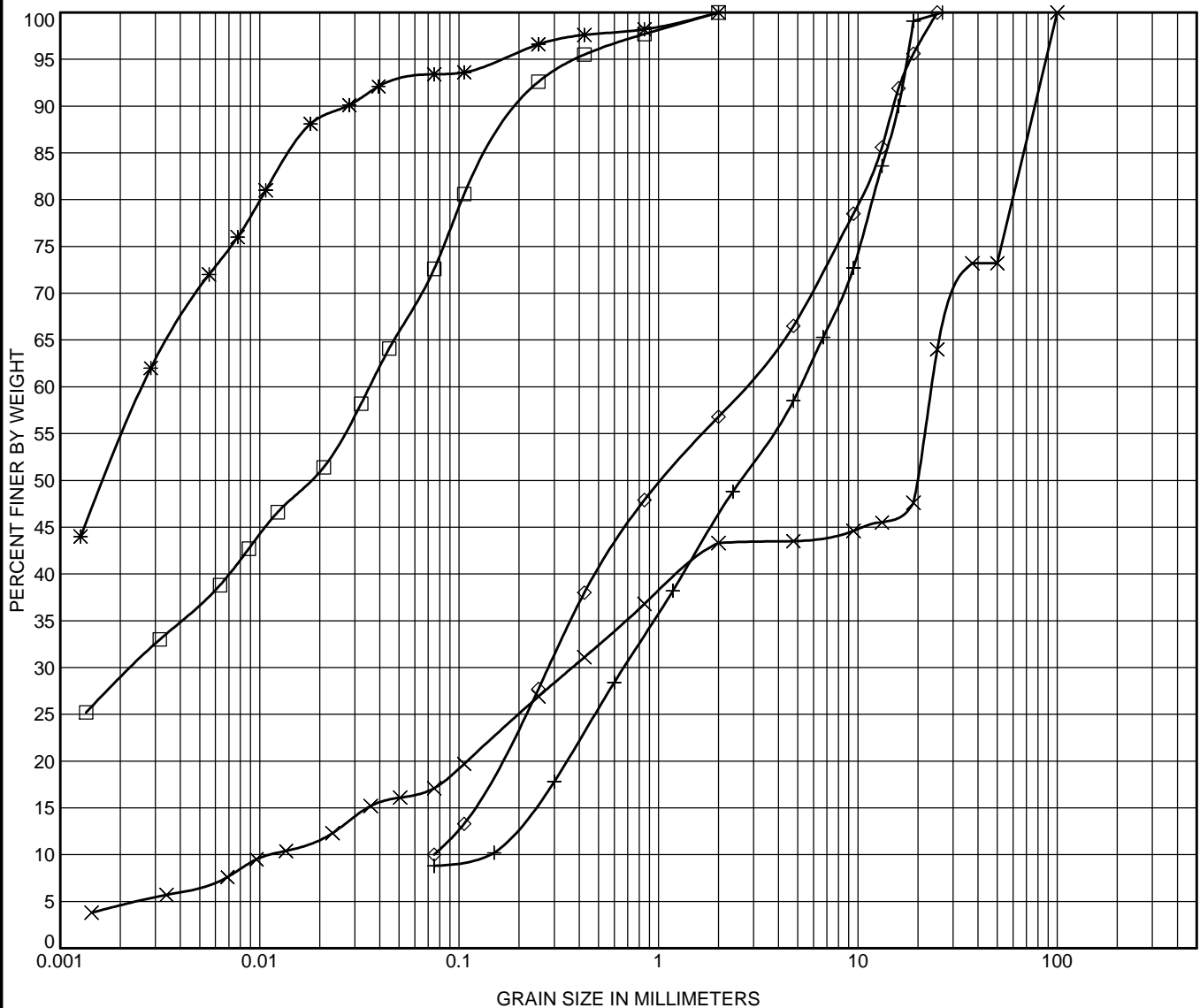


## Rock Core Detail (P1 – 11.53 m depth)



## **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
□ LOG 1	1.50	2	0.036	0.002		0.0	27.4	72.6	
* LOG 1	3.00	2	0.003			0.0	6.6	93.4	
× LOG 1	7.60	100	23.381	0.37	0.012	45.4	26.4	17.1	
+ LOG 2	0.20	26.5	5.124	0.67	0.136	41.5	49.7	8.8	
◇ LOG 2	0.75	25	2.66	0.281	0.075	33.5	56.5	10.0	



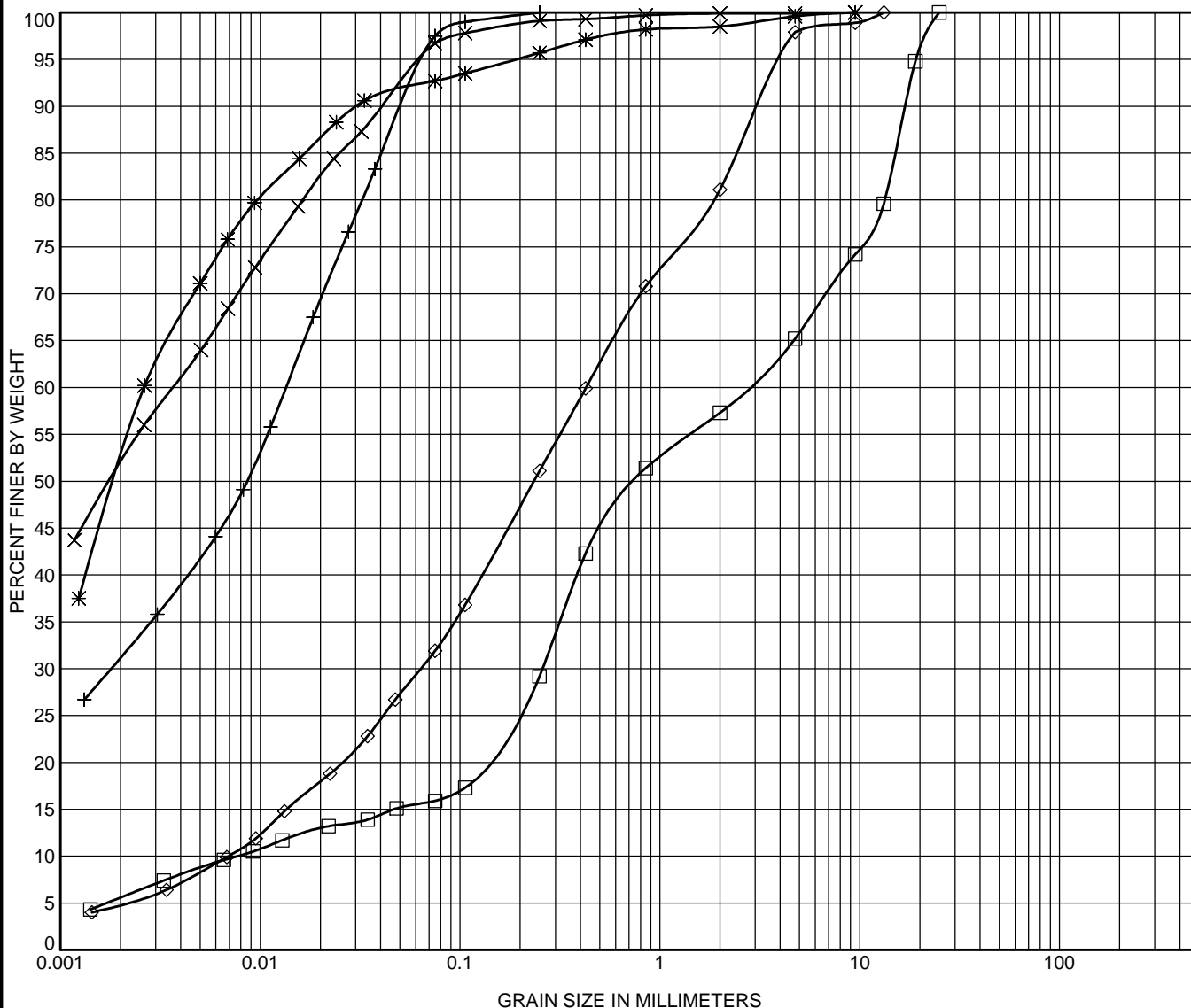
TBT Engineering Ltd.  
1918 Yonge Street  
Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: tbte@tbte.ca  
Web: www.tbte.ca

## GRAIN SIZE DISTRIBUTION

Project: Log River

W P:

DIST: 61 HWY: 71



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ LOG 2	3.80	25	2.688	0.258	0.008	34.8	49.3	15.9	
* LOG 2	5.30	9.5	0.003			0.4	6.9	92.7	
× LOG 2	7.60	9.5	0.004			0.1	3.2	96.7	
+ LOG 3	4.60	0.25	0.013	0.002		0.0	2.5	97.5	
◇ LOG 3	9.10	13.2	0.428	0.063	0.007	2.1	66.0	31.9	



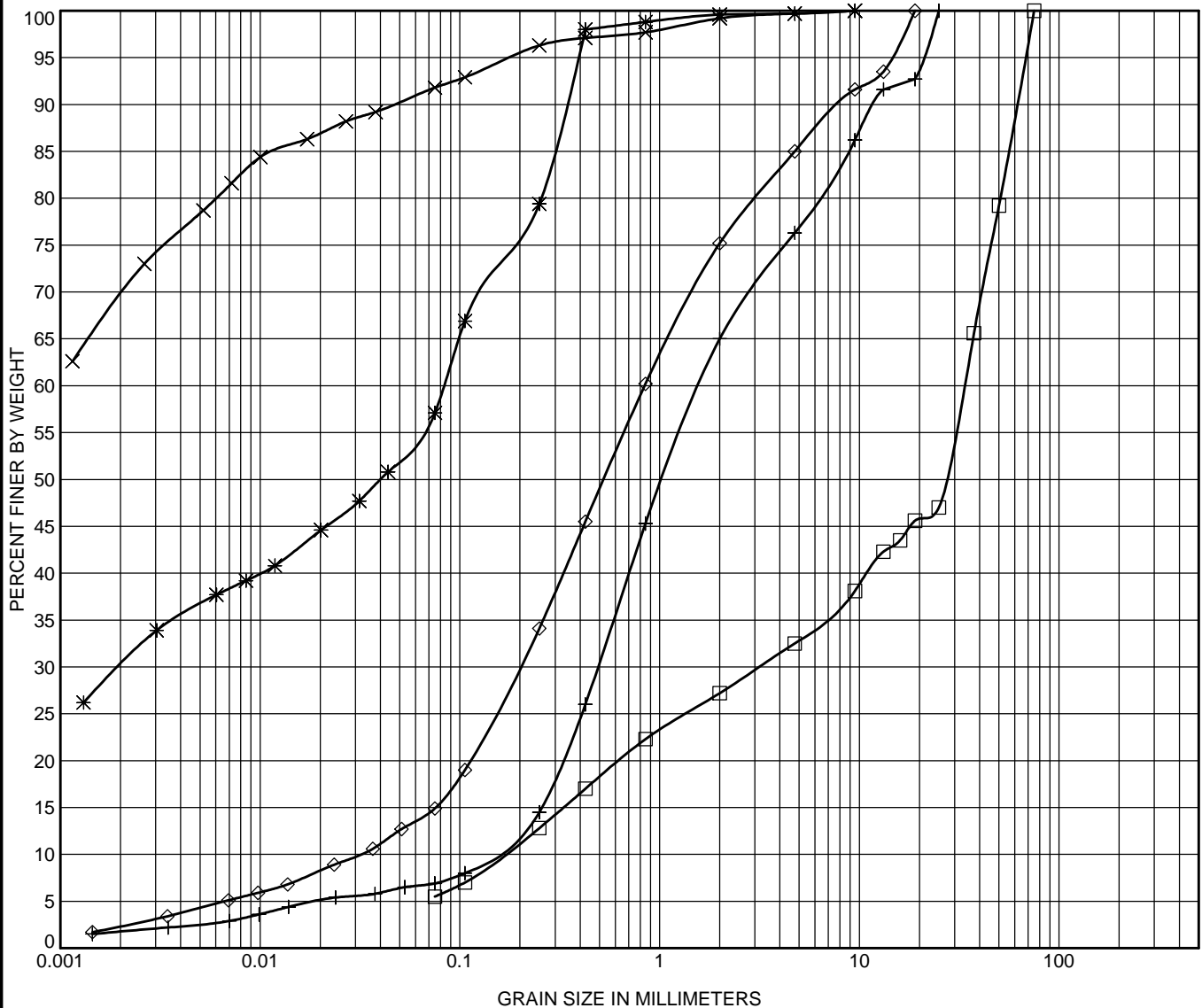
TBT Engineering Ltd.  
1918 Yonge Street  
Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: [tbte@tbte.ca](mailto:tbte@tbte.ca)  
Web: [www.tbte.ca](http://www.tbte.ca)

## GRAIN SIZE DISTRIBUTION

Project: Log River

W P:

DIST: 61 HWY: 71



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ LOG 4	0.50	75	33.191	3.159	0.165	67.5	27.0	5.5	
* LOG 4	3.00	9.5	0.083	0.002		0.3	42.6	57.1	
× LOG 4	6.10	9.5				0.3	7.9	91.8	
+ LOG 4	9.70	25	1.61	0.491	0.138	23.7	69.4	6.9	
◇ LOG 5	1.50	19	0.842	0.198	0.031	15.0	70.1	14.9	



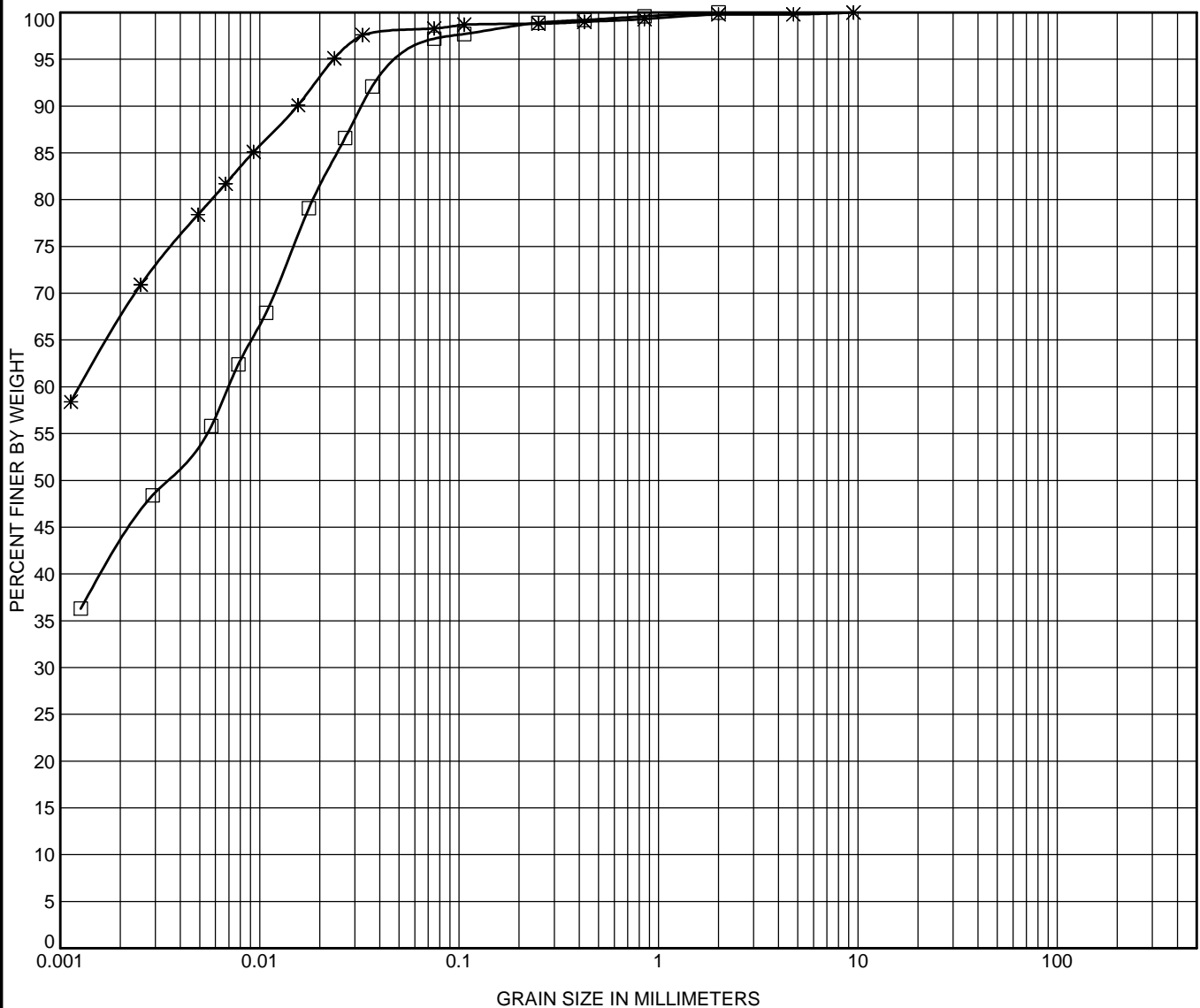
TBT Engineering Ltd.  
1918 Yonge Street  
Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: tbte@tbte.ca  
Web: www.tbte.ca

## GRAIN SIZE DISTRIBUTION

Project: Log River

W P:

DIST: 61 HWY: 71



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ LOG 5	4.60	2	0.007			0.0	2.8	97.2	
* LOG 5	7.60	9.5	0.001			0.2	1.5	98.3	



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 Web: [www.tbte.ca](http://www.tbte.ca)

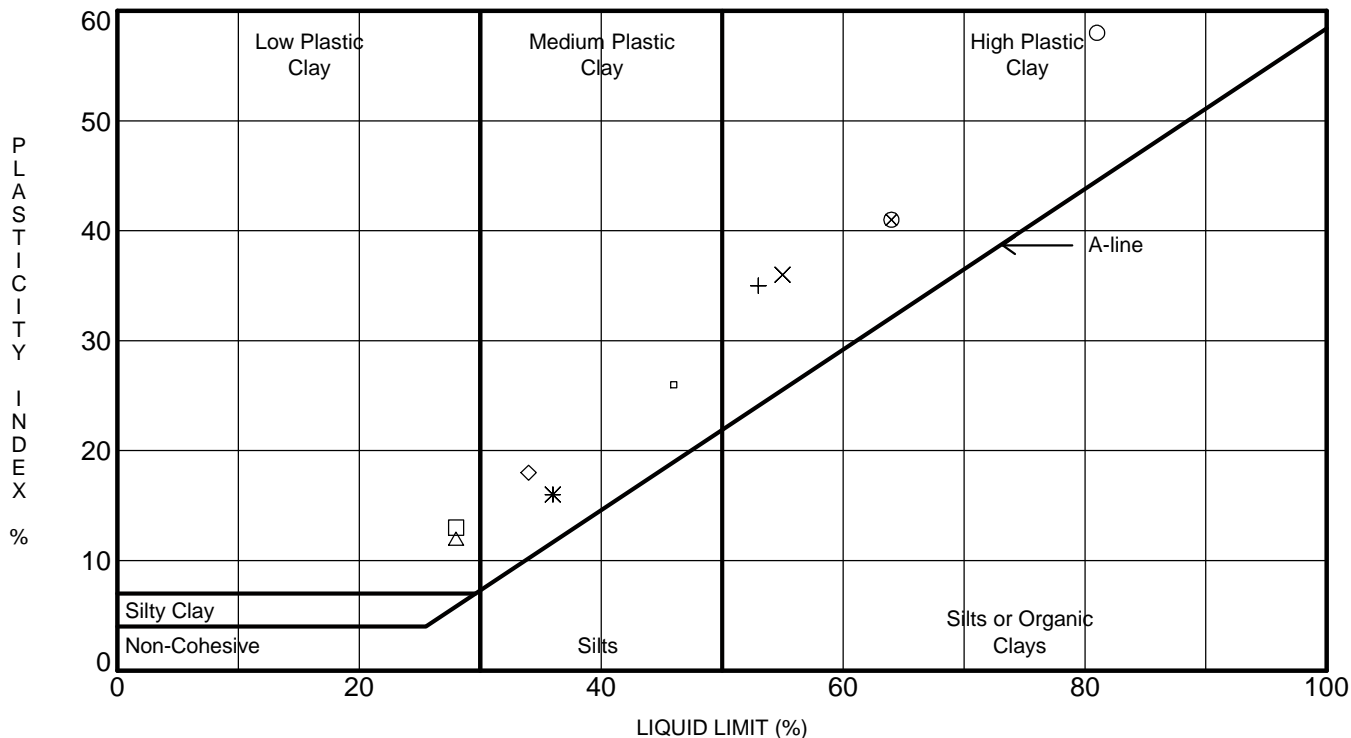
### GRAIN SIZE DISTRIBUTION

Project: Log River

W P:

DIST: 61 HWY: 71





Test Hole	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%	
□ LOG 1		1.50	28	15	13	24	
* LOG 1		3.00	36	20	16	30	
× LOG 2		5.30	55	19	36	31	
+ LOG 2		7.60	53	18	35	34	
◇ LOG 3		4.60	34	16	18	30	
△ LOG 4		3.00	28	16	12	26	
○ LOG 4		6.10	81	23	58	49	
▣ LOG 5		4.60	46	20	26	44	
⊗ LOG 5		7.60	64	23	41	39	



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

## ATTERBERG LIMIT RESULT

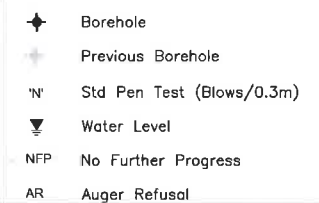
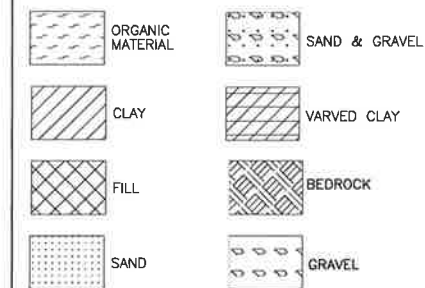
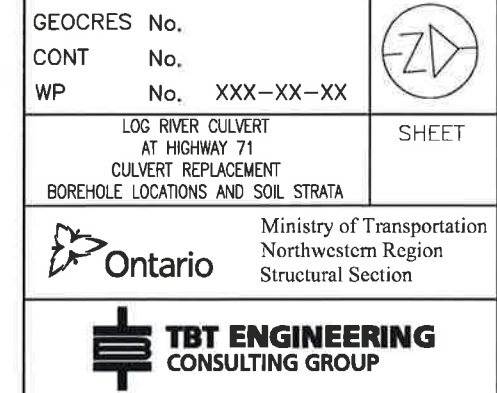
Project:

Location:

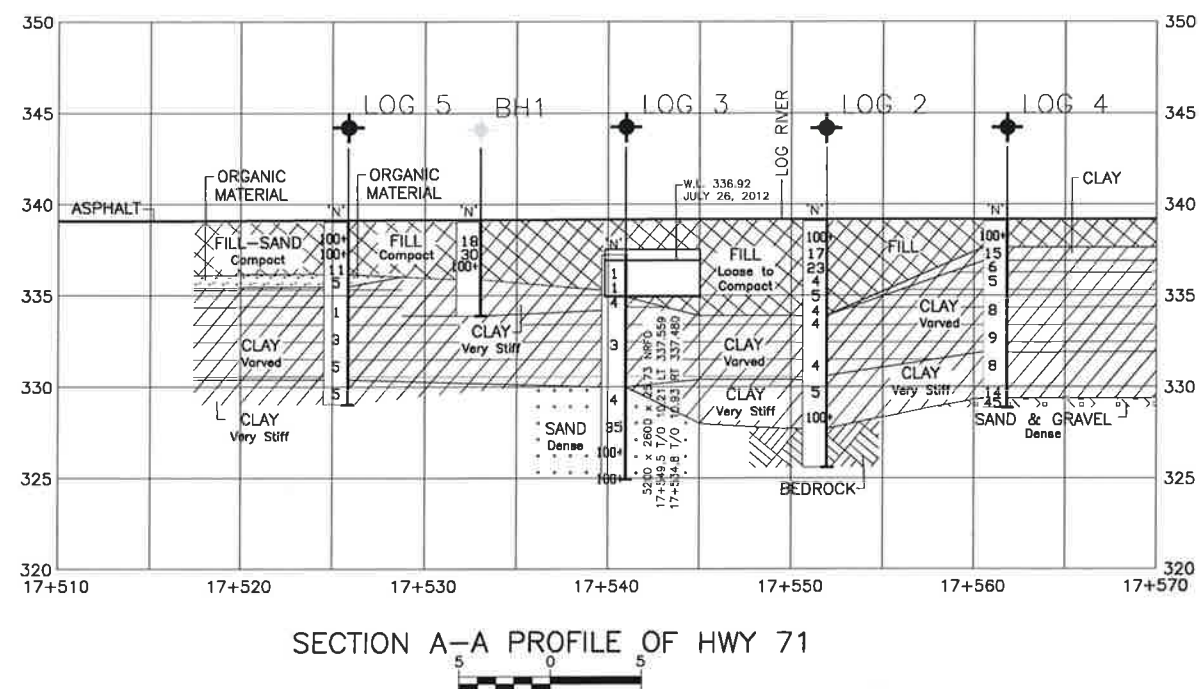
Number:

## **APPENDIX C**

### **Borehole Locations, and Soil Strata Drawing**



No	ELEVATION	CO-ORDINATES (UTM)	
		NORTH	EAST
LOG 1	337.2	16 5 427 276	237 022
LOG 2	339.1	16 5 427 286	237 003
LOG 3	337.1	16 5 427 277	236 995
LOG 4	339.1	16 5 427 298	237 013
LOG 5	339.0	16 5 427 261	237 001
BH01	339.1	16 5 427 268	237 009
BH2	339.1	16 5 427 284	237 003
BH3	336.9	16 5 427 267	237 023
BH4	336.3	16 5 427 286	236 992



—NOTE—

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

[illegible]

## **APPENDIX D**

### **Previously Completed Boreholes and Laboratory**

# RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. 6013-E-0023 LOCATION Log River Culvert: STA. 17+533, 4.0 m RT ORIGINATED BY JF  
 DIST HWY 71 BOREHOLE TYPE Hollow Stem Auger - 80 mm ID COMPILED BY ML  
 DATUM LOCAL DATE 2014 05 05 CHECKED BY DB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
100.9	GROUND SURFACE													
	FILL - SAND & CRUSHED GRAVEL - some silt, brown		AS1	AS										Water level at 0.7 m on completion 24 62 (14)
100.1														
0.8	FILL - SAND & GRAVEL - some silt, occasional cobbles, brown, compact to dense		SS2	SS	18		100							
			SS3	SS	30		99							
98.6	FILL - SAND - with silt and gravel, trace clay, brown, very dense  - COBBLES		SS4	SS	100+									SPT 50/112 mm 22 53 (25)
98.1	ROCKFILL - some clay, sand and gravel		RC1	RC			98							
97.6	CLAY - Silty, with rocks and boulders TCR - 40%		RC2	RC										
							97							
							96							

ON\_MOT GS-TB-018733 LOG RIVER CULVERT.GPJ DST\_MIN.GDT 6/4/14

NR = NO RECOVERY

+ <sup>3</sup>, X <sup>3</sup>: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 1

# RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. 6013-E-0023 LOCATION Log River Culvert: STA. 17+549, 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 05 CHECKED BY DB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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						
100.9	GROUND SURFACE													
	FILL - SAND & CRUSHED GRAVEL - trace silt, brown		AS1	AS										Water level at 0.7 m on completion
100.1														
0.8	FILL - SAND & GRAVEL - some silt, trace clay, brown, compact		SS2	SS	22		100							45 38 (17)
			SS3	SS	29		99							
98.6	FILL - SAND - with silt, some gravel, trace clay, brown, very dense  - COBBLES		SS4	SS	100+									SPT 50/40 mm
														13 60 (27)
98.1	ROCKFILL - some clay, sand and gravel TCR - 37%		RC1	RC			98							
97.6	CLAY - Silty, with rocks and boulders TCR - 36%		RC2	RC										
							97							
							96							
					</									

ON\_MOT GS-TB-018733 LOG RIVER CULVERT.GPJ DST\_MIN.GDT 6/4/14

NR = NO RECOVERY

+ 3, X 3: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE




ENCLOSURE 2

# RECORD OF BOREHOLE No BH3

1 OF 1

METRIC

W.P. 6013-E-0023 LOCATION Log River Culvert: STA. 17+534, 17.0 m RT ORIGINATED BY JF  
 DIST HWY 71 BOREHOLE TYPE Hollow Stem Auger - 80 mm ID COMPILED BY ML  
 DATUM LOCAL DATE 2014 05 05 CHECKED BY DB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
98.7	GROUND SURFACE							20	40	60	80	100					
	TOPSOIL																
98.4 0.3	SAND - with silt and gravel, some clay and organics, grey		AS1	AS			98										29 45 (26)
97.8 0.9	CLAY - Sandy, some silt, grey, stiff																
			AS2	AS			97										
			AS3	AS			96										CPT 1033 kPa CPT 1378 kPa
95.7 3.0	End of Borehole at 3.0 m																
						</											

ON\_MOT\_GS-TB-018733 LOG RIVER CULVERT.GPJ DST\_MIN.GDT 6/4/14

NR = NO RECOVERY

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

○<sup>3</sup>% STRAIN AT FAILURE

ENCLOSURE 3

# RECORD OF BOREHOLE No BH4

1 OF 1

METRIC

W.P. 6013-E-0023 LOCATION Log River Culvert: STA. 17+549, 15.0 m LT ORIGINATED BY JF  
 DIST HWY 71 BOREHOLE TYPE Hollow Stem Auger - 80 mm ID COMPILED BY ML  
 DATUM LOCAL DATE 2014 05 05 CHECKED BY DB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
98.1	GROUND SURFACE							20   40   60   80   100		W <sub>P</sub> W   W <sub>L</sub>				
	TOPSOIL						98							
97.8														
0.3	SAND - Silty, some gravel and organics, brown												11   57   (32)	
97.3			AS1	AS										
0.8	CLAY - Silty, trace sand, grey, very stiff						97						CPT 896 kPa	
													CPT 1205 kPa	
			AS2	AS										
							96							
			AS3	AS										
95.1														
3.0	End of Borehole at 3.0 m													
</														

ON\_MOT\_GS-TB-018733 LOG RIVER CULVERT.GPJ DST\_MIN.GDT 6/4/14

NR = NO RECOVERY

+ <sup>3</sup>, X <sup>3</sup>: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 4