FOUNDATION INVESTIGATION REPORT
PROPOSED CULVERT REPLACEMENT
HIGHWAY 17 OVER BLACK BIRD CREEK
G.W.P. 462-00-00

Geocres Number: 42D-025

Report to

Cook Engineering

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FOUNDATION INVESTIGATION REPORT
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed culvert replacement on Highway 17.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, borehole logs, a stratigraphic profile and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction of the foundations and approach embankments for the culvert was developed from the data obtained in the course of the present investigation.

Thurber carried out the investigation as a sub-consultant to Cook Engineering, under the Ministry of Transportation Ontario (MTO) Agreement Number 6004-E-0010.

2 SITE DESCRIPTION

The site of the proposed culvert replacement lies on Highway 17 in the Township of Syine, approximately 9.7 km east of the east limits of Terrace Bay, Ontario.

The general site area is located within the physiographic region known as the Canadian Shield, characterized by Pre-Cambrian bedrock outcrops with the low areas filled by outwash sands, clays and muskeg deposits. Drainage in the area is generally poorly developed but at the site it is controlled by Black Bird Creek.

North of the highway, the creek approaches the site from the west, flowing parallel to the highway and just beyond the toe of the highway embankment. At the site, it turns abruptly, passes under the highway and flows off in a generally southerly direction.

Along the south side of the highway and generally to the west of the culvert location, the ground consists of a muskeg deposit with areas of open water. The approximate extent of the open water is illustrated in the Pedo Sketch at the end of the text.

The area surrounding the site is wooded and there are no buildings in the immediate vicinity.

Appendix E contains a series of annotated colour photographs that help illustrate the site setting.

For the purposes of the investigation, the centreline of the existing culvert is assumed to lie at Sta. 10+000 with the stationing increasing to the west.

3 SITE INVESTIGATION AND FIELD TESTING

Thurber carried out site investigation and field testing for this project between November 8 and November 11, 2004.

The site investigation for the replacement culvert consisted of drilling and sampling a total of four boreholes to depths of approximately 11.1 to 12.6 m. In the boreholes at the north shoulder and north end of the culvert, effective refusal to augering was encountered on assumed bedrock. In the borehole at the south end of the potential detour culvert, a dynamic cone penetration test was driven from the end of sampling at 11.1 m to effective refusal on assumed bedrock at a depth of 18.6 m. The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The boreholes were advanced by hollow stem auger drilling techniques and samples were obtained using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Where soft cohesive soils were encountered, undisturbed, thin-wall tube samples were obtained and insitu shear strength testing was carried out using the MTO shear vane.

A standpipe piezometer, consisting of 25 mm PVC pipe with 1.5 m slotted screen, was installed in each of two of the four deep boreholes drilled at the culvert alignment to monitor the groundwater level.

The completion details for the piezometer are shown in Table 3.1.

Table 3.1 – Piezometer Details

Piezometer Location	Piezometer Details	
	Tip Depth	Completion Details
BH 04-1	12.2	Piezometer with 1.5 m tip installed at 12.2. Sand filter to 10.4, bentonite seal to 9.8, grout to 0.9 and bentonite seal to the surface.
BH 04-4	10.7	Piezometer with 1.5 m tip installed at 10.7. Sand filter to 8.8, bentonite seal to 8.2, grout to 0.9 and bentonite seal to the surface.

On completion of the investigation all boreholes were grouted to the surface, the upper 3 m of the piezometer pipes were removed and the hole grouted with bentonite, in accordance with MOE requirements.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The inspector logged the boreholes and the recovered samples and processed them for transport to Thurber's Oakville office.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A.

Selected samples were subjected to gradation analysis (sieve and hydrometer) and Atterberg limit testing and the results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B. A total of sixteen samples were selected for this testing.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in this appendix and on the attached Borehole Locations and Soil Strata Drawing. An overall description of the stratigraphy is given in the following paragraphs however the factual data presented in the borehole logs governs any interpretation of the site conditions.

In general terms, the site was found to be underlain by the highway embankment fill, peat, sandy silt, silty clay, silty sand and assumed bedrock.

More detailed descriptions of the individual strata are presented below.

5.2 Fill

Boreholes drilled through and at the toe of the highway embankment encountered a layer of sand and gravel fill with occasional cobbles overlying sand and silt fill, apparently placed during the construction of the Highway 17 embankment. The fill extending to 1.5 m below the highway surface is described as sand and gravel. The underlying fill and the fill at the edges of the embankment are described as silt, sandy, trace gravel, trace clay. The fill contains rootlets and trace organics.

Based on SPT values generally ranging from 2 to 13 blows for 0.3 m of penetration, the fill is classified as loose to compact. Higher values of SPT of 57 and 85 recorded under the shoulder may indicate dense conditions under the highway, but were probably influenced by frozen ground conditions.

The measured natural moisture contents ranged from 3 to 41% and the soil is described as dry to moist.

The thickness of the fill layer ranged from 0.5 m at the north and south toes of the embankment to 4.6 m under the highway. The grain size distributions of selected samples of the fill are plotted on the Record of Borehole sheets and shown in Figure B1 in Appendix B.

5.3 Sandy Silt

The borehole drilled for the detour culvert (BH 04-4) encountered a layer of brown sandy silt at the surface, extending to a depth of 0.8 m. The silt contained traces of clay and organic material and is considered to be recent stream alluvium.

Based on an SPT value of 7 blows for 0.3 m of penetration, the silt is classed as loose.

The measured natural moisture content was 63%, which is due in part to the traces of clay and organic material.

5.4 Peat

The boreholes drilled at the toe of the embankment and beyond encountered a deposit of fibrous peat. The peat was not encountered in the borehole drilled through the embankment, indicating that the peat may have been removed during highway construction.

North of the embankment, the peat was 1.0 m thick and extended to a depth of 1.5 m. To the south of the embankment, the peat was 2.1 to 2.5 m deep and extended to a depth of 2.9 to 3.0 m below the original ground surface. Layers of organic silt were noted in the peat north of the embankment.

The SPT values recorded in the peat ranged from 2 to 4 blows for 0.3 m of penetration and the peat is described as being soft. The measured natural moisture contents ranged from 85 to 464%.

The grain size distribution of a selected sample of the organic silt is plotted on the Record of Borehole sheet and shown in Figure B2 Appendix B. The results of an Atterberg limit test are shown in Figure B6.

5.5 Sandy Silt

The borehole drilled south of the highway in the vicinity of the detour culvert encountered a layer of sandy silt below the peat. This soil layer contained rootlets and wood fibres.

Based on an SPT of 2 blows for 0.3 m of penetration, the deposit is classified as very loose.

The measured natural moisture content was 39% and the soil is described as wet.

The layer of sandy silt was found to be 1.7 m thick and to extend to a depth of 4.6 m.

The grain size distribution of a selected sample of this soil is plotted on the Record of Borehole sheet and shown in Figure B3, Appendix B.

5.6 Silty Clay

Below the soils described above, all boreholes encountered a layer of grey silty clay. Based on the recorded SPT values generally ranging from 0 to 6 blows for 0.3 m of penetration, the clay is classified as very soft to firm. However, the vane shear strengths measured in the deposit range from 25 to 60 kPa, indicating soft to stiff conditions. The sensitivity of the clay ranges from 1.3 to 1.8, indicating slightly sensitive clay.

For design purposes, the undrained strength of the clay should be considered to be 40 kPa in the crust and 25 kPa lower in the deposit. In the three boreholes drilled through or immediately adjacent to the highway, the uppermost sample in the clay layer had an SPT value of 5 or 6 blows for 0.3 m of penetration, indicating that the clay has a crust. The crust is interpreted to be approximately 1.0 m thick and its recommended design strength is 40 kPa.

The recorded natural moisture contents in the clay ranged from 21 to 66% and the soil is described as moist to wet.

The thickness of the clay layer was established to be 9.9 m north of the highway. At the south end of the detour culvert, the thickness was established to be at least 6.5 m and it was interpreted (based on the dynamic come results) to be as thick as 14 m. The base of the clay layer lies at a depth of 11.4 m at the north of the embankment and as deep as 18 m at the south end of the detour culvert.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure B4 in Appendix B. The results of Atterberg limit tests are shown in Figure B6. The clay content in this layer ranged from 35 to 70% and the plasticity ranges from low to high.

5.7 Silty Sand

A layer of grey silty sand was encountered below the silty clay in the boreholes drilled at the north and south edges of the embankment, though not in the borehole drilled through the embankment. This soil is described as silty sand, some gravel. Based on SPT values generally ranging from 43 to 63 blows for 0.3 m of penetration, the sand is classified as dense to very dense.

The measured natural moisture content was 12% and the soil is described as moist to wet.

The thickness of the silty sand layer ranged from at least 1.0 m at the south end of culvert to 1.2 m at the north edge. The base of the silty sand layer lay at a depth of 12.6 m at the north edge of embankment.

The grain size distribution of a selected sample of this soil is plotted on the Record of Borehole sheets and shown in Figure B5 in Appendix B.

5.8 Depths to Refusal/Possible Bedrock

The depths at which auger refusal was encountered, or dynamic cone values exceeding 60 blows per foot at the detour, are shown in Table 5.1.

Table 5.1 – Refusal Depths

Location	Borehole	Refusal Depth (m)
North end of culvert	BH 04-1	12.6
North shoulder	BH 04-2	11.4
South end of culvert	BH 04-3	N/A
Detour culvert	BH 04-4	>=18.6

5.9 Water Levels

The initial and final groundwater depths are shown in Table 5.2.

Table 5.2 – Groundwater Depths (in metres)

Date	North End of Culvert	Detour Culvert
November 9, 2005	-	10.0
November 10, 2005	6.2	9.7
November 11, 2005	4.0	9.5

These readings were taken in standpipe piezometers installed within the clay and they have not had sufficient time to stabilize.

The groundwater level in the overlying soils (peat, silt, fill) will be governed by the creek level and will be at or above the level of the creek. In particular, higher levels are to be expected after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

The drill rig and sampling equipment used in the investigation were supplied and operated by Paddock Drilling from Thunder Bay, Ontario. Traffic control was provided by WWS Leasing of Jellicoe, Ontario.

Full time supervision of field activities, including obtaining utility clearances was carried out by Mr. George Azzopardi of Thurber.

Overall supervision of the field program, interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng.

The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Alastair E. Gorman, P.Eng., M.Sc.
Senior Foundations Engineer

P.K. Chatterji, P.Eng., Ph.D.
Review Principal.

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS Split Spoon Sample WS Wash Sample AS Auger (Grab) Sample
TW Thin Wall Shelby Tube Sample TP Thin Wall Piston Sample
PH Sampler Advanced by Hydraulic Pressure PM Sampler Advanced by Manual Pressure
WH Sampler Advanced by Self Static Weight RC Rock Core SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

∇ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

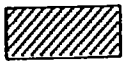
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

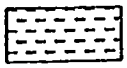
ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

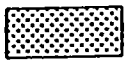
SYMBOLS



CLAYSTONE



SILTSTONE



SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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RECORD OF BOREHOLE No 04-1 1 OF 2 METRIC

W.P. 462-00-00 LOCATION 9+995, ~ 10.5 RT, D=-1.4m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 09.11.04 - 09.11.04 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0	**SAND**, trace silt, trace gravel, occasional rootlets Grey Wet (FILL)		1	SS	11				○		
0.5	**PEAT**, fibrous, trace rootlets, occasional wood fibers, organic silt layers Dark Brown - Black		2	SS	3						0 4 69 27
1.5	**Silty CLAY** Soft Grey		3	SS	5				○		
			4	SS	2				○		
			1	TW	PH				+ 1.6		
			5	SS	0					○	
			6	SS	0					○	0 0 42 58
									+ 1.8		
			7	SS	0					○	
			2	TW	PH						

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+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 0781.GPJ 05/04/05

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RECORD OF BOREHOLE No 04-1 2 OF 2 METRIC

W.P. 462-00-00 LOCATION 9+995, - 10.5 RT, D=-1.4m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 09.11.04 - 09.11.04 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
								20 40 60 80 100; 1.6	20 40 60		
			8	SS	0				○		
11.4	Silty SAND, some gravel, trace clay Very Dense Grey Wet		9	SS	63				○		17 55 25 3
12.6	AUGER REFUSAL AT 12.65 m. END OF BOREHOLE AT 12.65 m. Piezometer installation consist of 25 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)
10/11/04	6.24
11/11/04	3.95

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

$15 \overset{20}{\oplus} 5$ (10) (%) STRAIN AT FAILURE

ONTMT4S 0781.GPJ 05/04/05

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Ontario

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RECORD OF BOREHOLE No 04-2 1 OF 2 METRIC

W.P. 462-00-00 LOCATION 9+998, - 3.5 RT, D=0.0m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 10.11.04 - 10.11.04 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0	**SAND and GRAVEL**, occasional cobbles Very Dense Brown Dry to Damp		1	SS	57				○		
			2	SS	85				○		
1.5	**SAND and SILT**, fine grained, trace clay, trace gravel Compact to Loose Brown to Grey Wet		3	SS	13				○		1 44 51 4
			4	SS	4				○		6 41 43 9
			5	SS	5				○		
			6	SS	7				○		
4.6	Silty **CLAY** Firm to Soft Grey		7	SS	5			1.7	○		
	occasional sand seams		8	SS	3			1.6	⊢○		0 0 66 34

ONTMT4S 0781.GPJ 05/04/05

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+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 04-2 2 OF 2 METRIC

W.P. 462-00-00 LOCATION 9+998, ~ 3.5 RT, D=0.0m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 10.11.04 - 10.11.04 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
			9	SS	0				o		
11.4	END OF BOREHOLE AT 11.43 m. AUGER REFUSAL AT 11.43 m ON PROBABLE BEDROCK OR BOULDER. BOREHOLE GROUTED TO SURFACE.										

ONTMT4S 0781.GPJ 05/04/05

+³, ×³: Numbers refer to Sensitivity

15 10 20 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 04-3 1 OF 2 METRIC

W.P. 462-00-00 LOCATION 9+995, ~ 12 LT, D=-1.1m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 11.11.04 - 11.11.04 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
0.0	**SAND**, fine grained, trace silt, occasional rootlets Very Loose Brown to Grey Damp		1	SS	2						
0.5	**PEAT**, fibrous, occasional rootlets, occasional wood fibers Dark Brown to Black		2	SS	2						
			3	SS	2						
			4	SS	4						
3.0	Silty **CLAY** Firm to Soft Grey		5	SS	6						
			6	SS	2						0 0 67 33
			1	TW	PH			1.3			
			7	SS	0						
	becoming more plastic		8	SS	0						0 0 31 69

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 0781.GPJ 05/04/05

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 04-3 2 OF 2 METRIC

W.P. 462-00-00 LOCATION 9+995, ~ 12 LT, D=-1.1m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 11.11.04 - 11.11.04 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
			9	SS	0						
11.6	SAND, medium grained, trace silt Dense Grey Wet		10	SS	43						
12.6	END OF BOREHOLE AT 12.65 m. BOREHOLE OPEN TO 12.19 m. BOREHOLE GROUTED TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 0781.GPJ 05/04/05

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 04-4 1 OF 3 METRIC

W.P. 462-00-00 LOCATION 9+997, ~ 25LT, D=0.0m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 08.11.04 - 08.11.04 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0	Sandy **SILT**, some organics, trace clay, trace rootlets Loose Brown		1	SS	7						
0.8	**PEAT**, fibrous, trace rootlets, trace wood fibers Black		2	SS	4						
			3	SS	2						
	mixed with clayey silt, occasional sand		4	SS	4						
2.9	Sandy **SILT**, some clay, occasional rootlets, occasional wood fibers Very Loose Grey Wet		5	SS	2						0 31 58 11
4.6	Silty **CLAY** Soft Grey		6	SS	2						
			7	SS	0			1.6			0 0 65 35
			8	SS	0						
			9	SS	0						

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 0781.GPJ 06/04/05

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 04-4 2 OF 3 METRIC

W.P. 462-00-00 LOCATION 9+997, ~ 25LT, D=0.0m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 08.11.04 - 08.11.04 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60		GR SA SI CL
			10	SS	0			1.8			
11.1	END OF SOIL SAMPLING AT 11.73 m. DCPT started from 11.73 m.										
18.6	END OF DCPT AT 18.59 m. Piezometer installation consist of 25 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) 9/11/04 10.0 10/11/04 9.68										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 (20 / 10) 5 (%) STRAIN AT FAILURE

ONTMT4S 0781.GPJ 23/01/06

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 04-4 3 OF 3 METRIC

W.P. 462-00-00 LOCATION 9+997, ~ 25LT, D=0.0m ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM LOCAL DATE 08.11.04 - 08.11.04 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	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: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100	WATER CONTENT (%) 20 40 60		GR SA SI CL
	11/11/04 9.46										

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

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 0781.GPJ 05/04/05

Appendix B

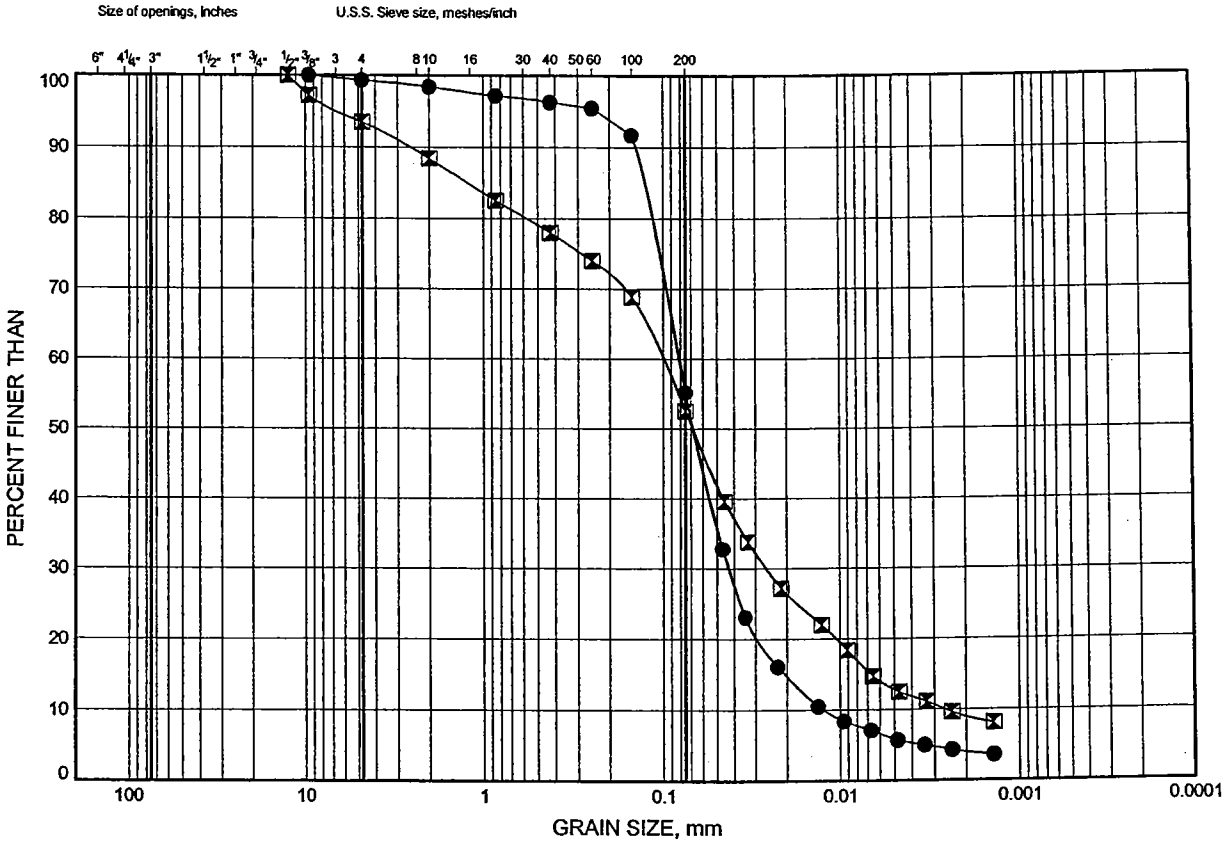
Laboratory Test Results

Black Bird Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B1

FILL



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	04-2	1.83	
⊠	04-2	2.59	

Date February 2005

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Chkd. AEG

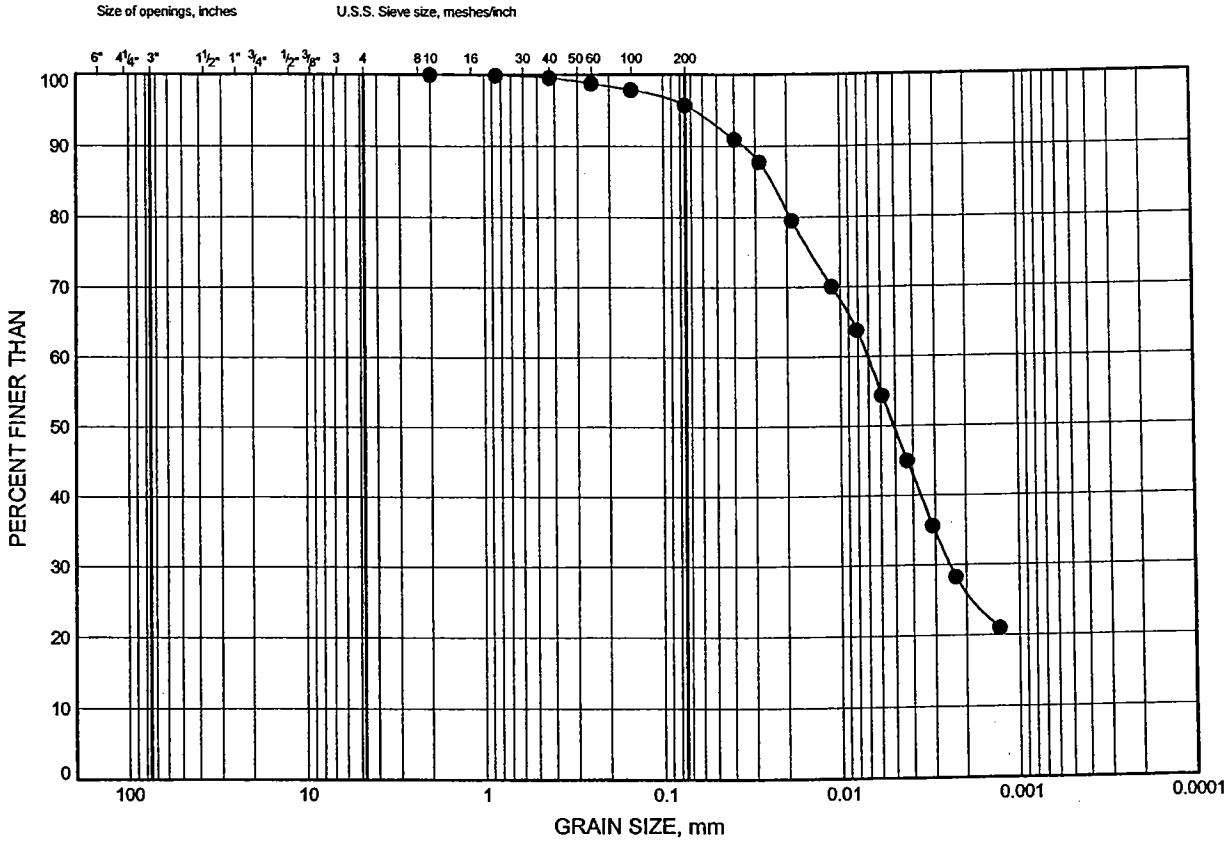
THURBGSD 0781.GPJ 04/02/05

Black Bird Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B2

ORGANIC SILT



COBBLE SIZE	GRAVEL		SAND			SILT and CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	04-1	1.07	

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Chkd. AEG

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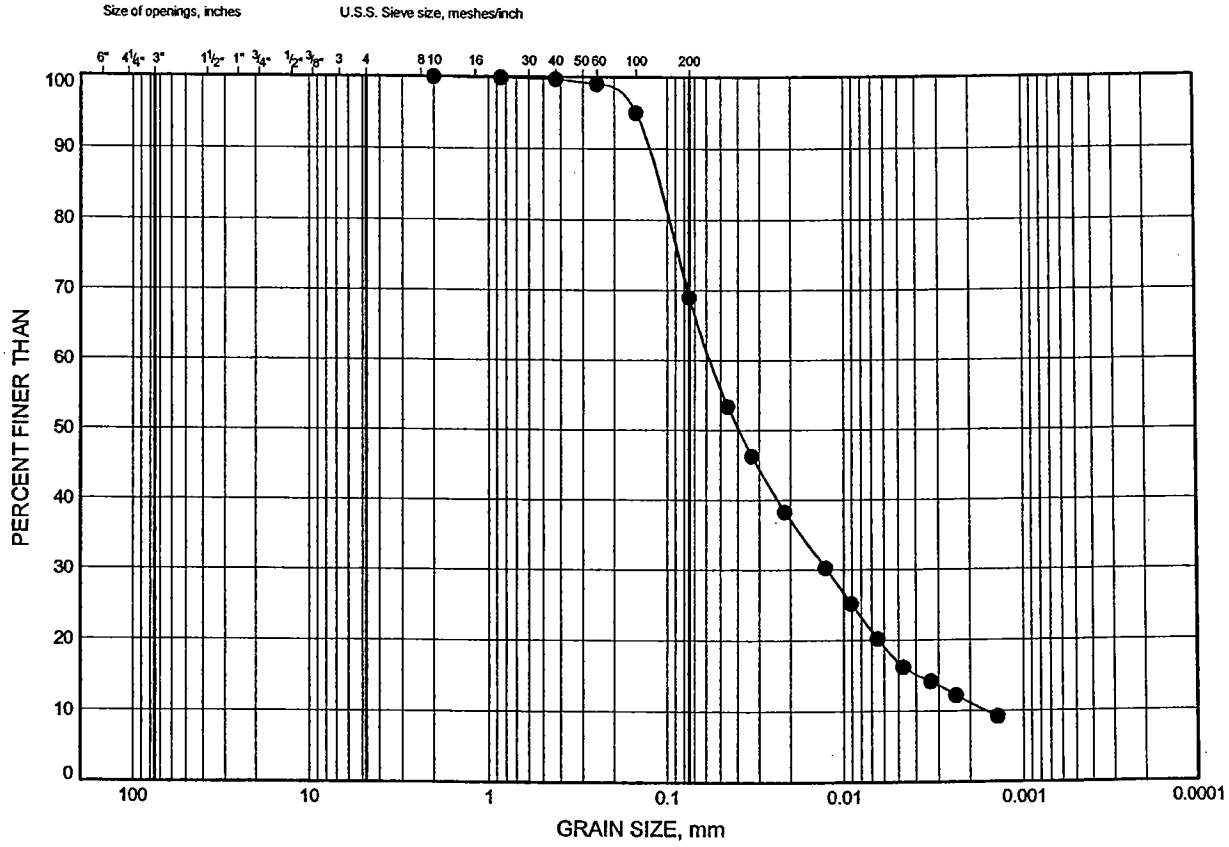
Black Bird Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B3

SANDY SILT



COBBLE SIZE	GRAVEL		SAND			FINE GRAINED
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	04-4	3.35	

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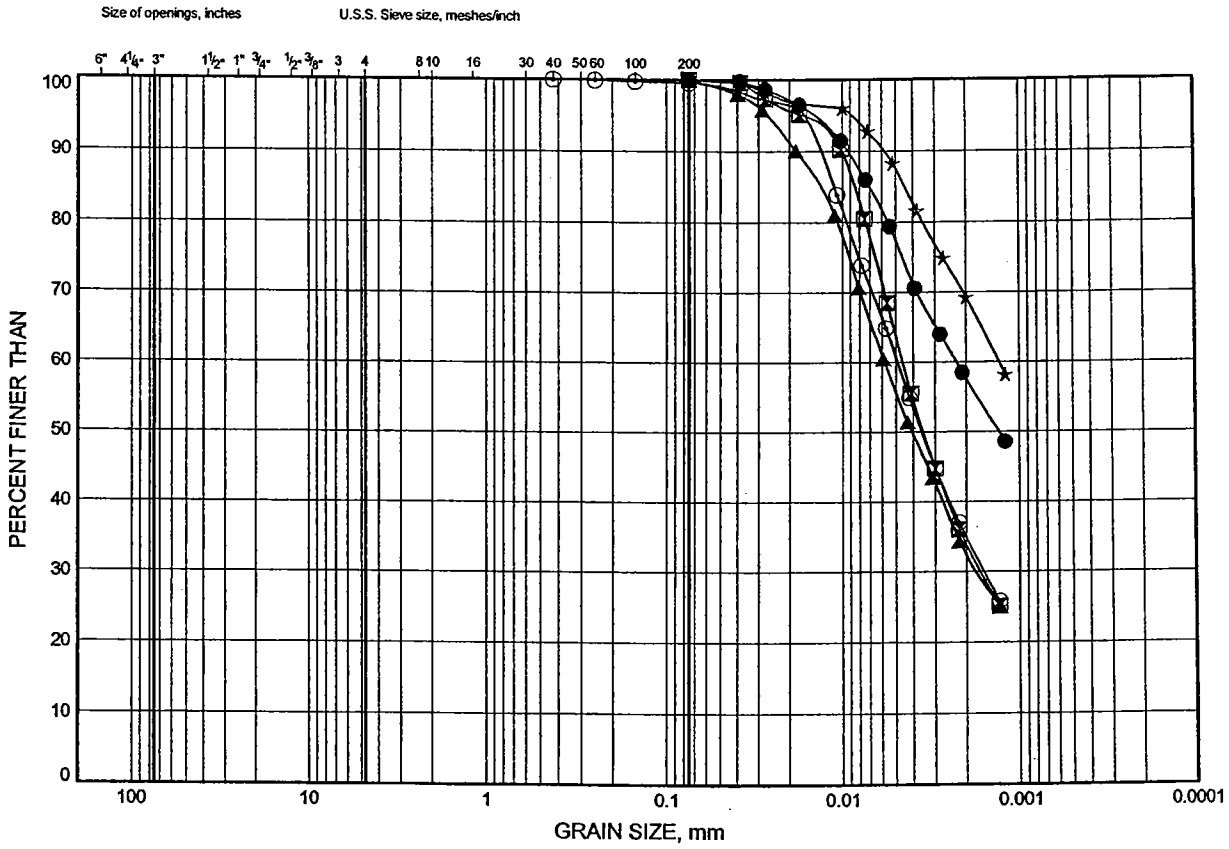
Black Bird Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



COBBLE SIZE	GRAVEL		SAND			FINE GRAINED
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	04-1	6.32	
⊠	04-2	7.85	
▲	04-3	4.80	
★	04-3	9.37	
⊙	04-4	6.32	

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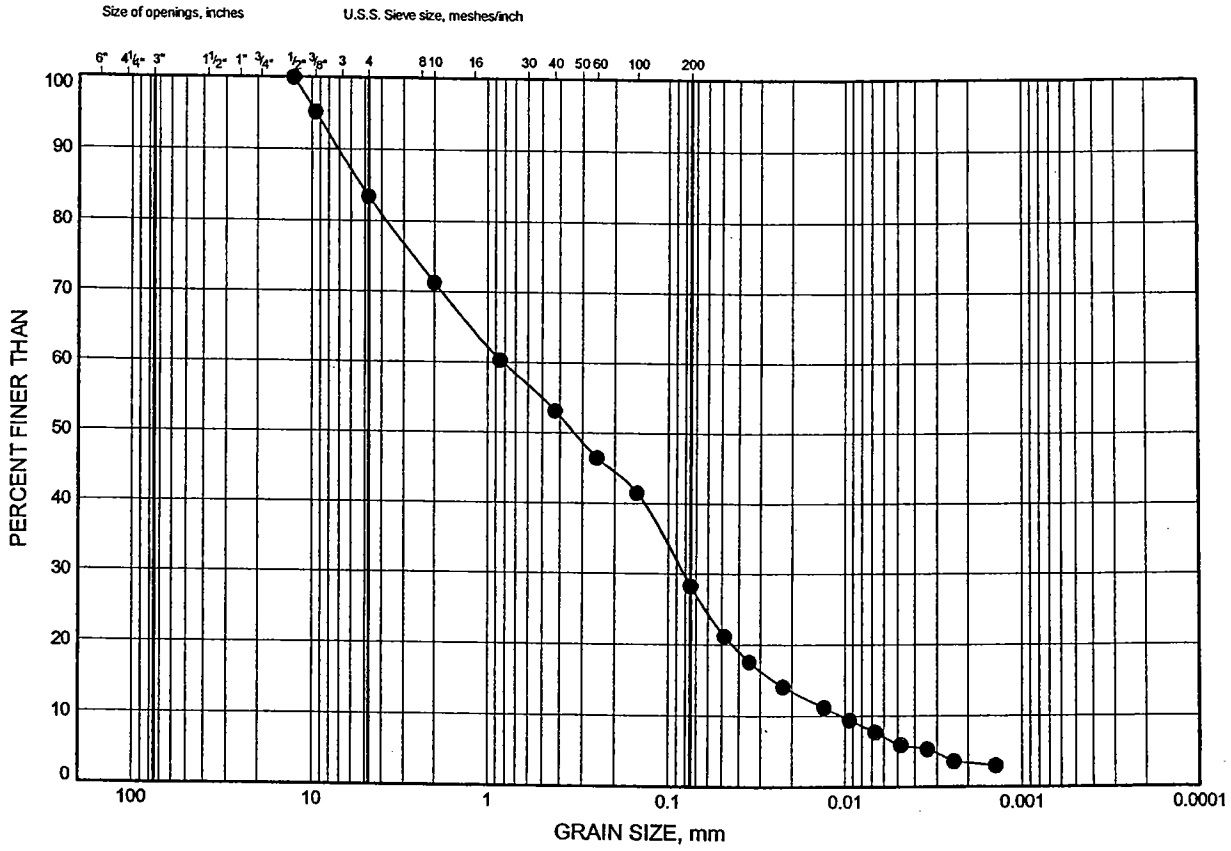
Black Bird Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY SAND



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	04-1	12.42	

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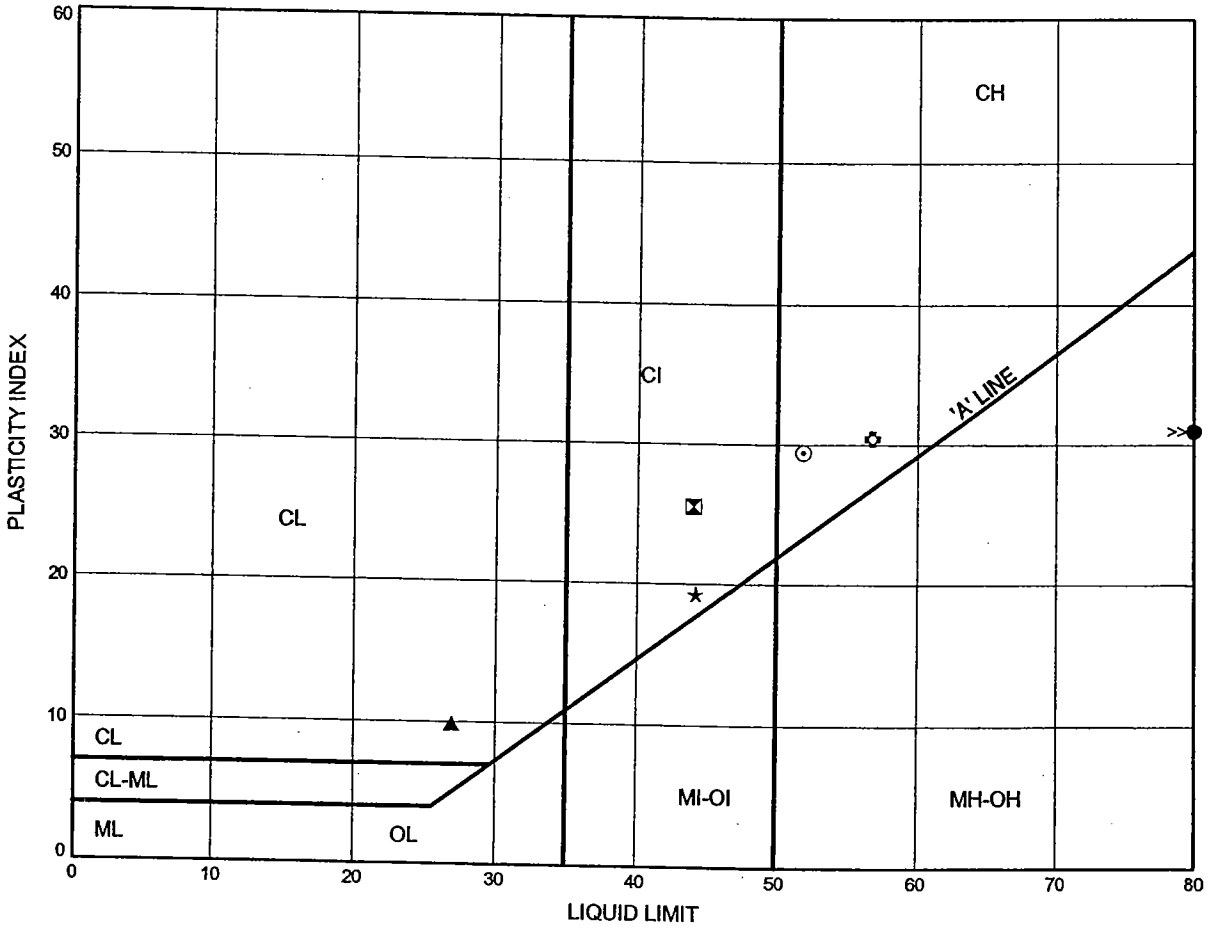
Black Bird Creek Culvert Replacement

ATTERBERG LIMITS TEST RESULTS

FIGURE B6

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	04-1	1.07	
⊠	04-1	6.32	
▲	04-2	7.85	
★	04-3	4.80	
⊙	04-3	9.37	
✿	04-4	6.32	

Date February 2005

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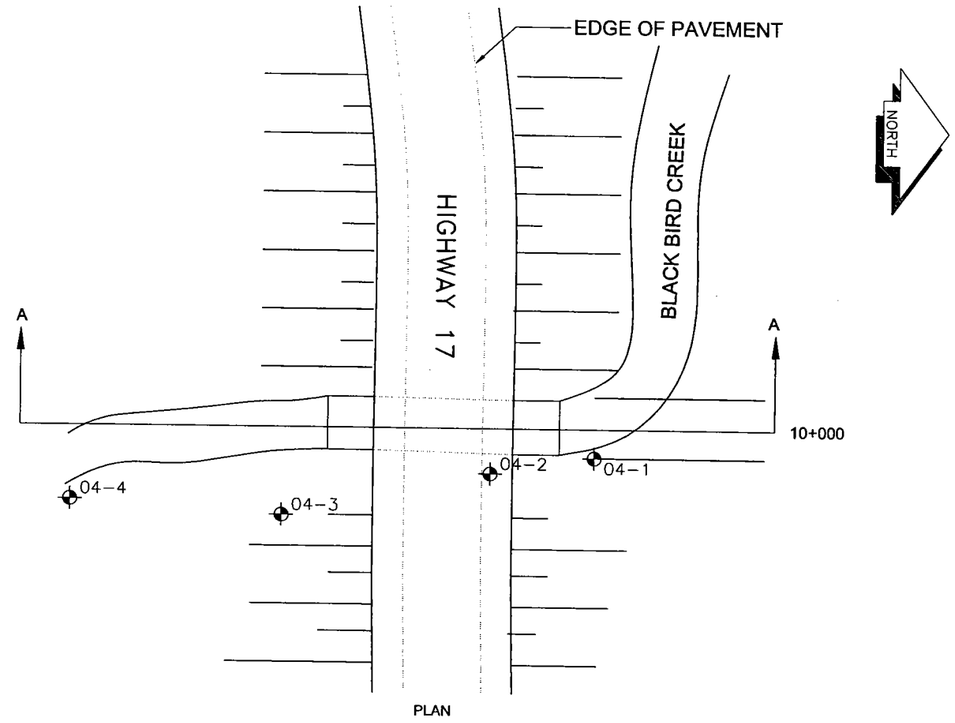
Chkd. AEG

THURBALT 0781.GPJ 04/02/05

Appendix C

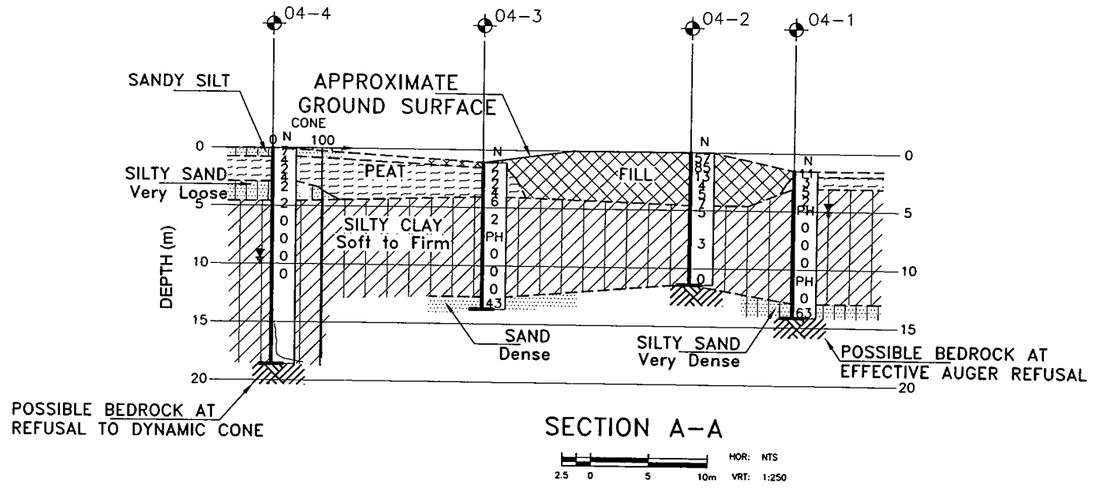
Borehole Locations and Soil Strata

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



PLAN

PLAN



SECTION A-A

HOR: NTS
2.5 0 5 10m VRT: 1:250

REGISTERED PROFESSIONAL ENGINEER
A. E. GORMAN
JAN 23/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Jan 23/06
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

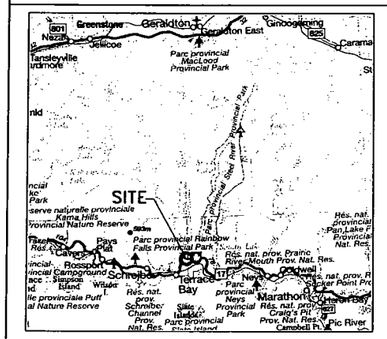
DIST	HWY 17
CONT NO	
WP NO	

BLACK BIRD CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

cookengineering
Thunder Bay, Ontario

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	BoreHole & Cone
⊕	Dynamic Cone Penetration Test (cone)
◆	BoreHole
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pushed Hydraulically
▼	WL
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)

NO	ELEVATION	NORTHING	EASTING

— NOTE —
The boundaries between soil strata have been established only at Bore Hole locations . Between Bore Holes the boundaries are interpreted.

REVISIONS		
DATE	BY	DESCRIPTION
FEB.05	AEG	ISSUED AS DRAFT FOR REVIEW

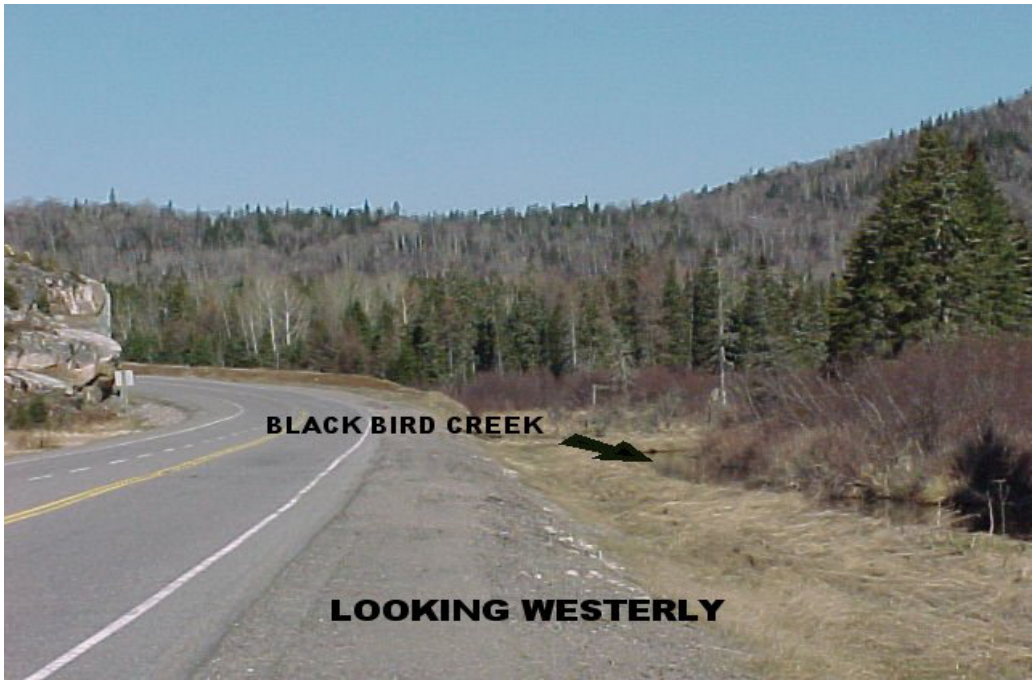
DESIGN	AEG	CHK	PKC	CODE CHBDC-00	LOAD	DATE	FEB, 2005
DRAWN	HS	CHK	AEG	SITE	STRUCT	SCHEME	DWG.

Appendix D

Site Photographs

Photograph 1 – Black Bird Creek – North End of Culvert

Photograph 2 – Black Bird Creek – South End of Culvert



Photograph 3 – Black Bird Creek – Looking Westerly on Highway 17

Photograph 4 – Black Bird Creek – Looking Easterly on Highway 17