FOUNDATION INVESTIGATION REPORT

GRANDVIEW CREEK CULVERT – WBL

HIGHWAY 11/17 - FOUR LANING

FROM 0.36 km EAST OF HIGHWAY 527 EASTERLY 12.6 km TO 1 km WEST OF MACKENZIE STATION ROAD

G.W.P. 623-89-00, SITE 48C-349/C2

Geocres Number: 52A-158

Report to

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July 31, 2012
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the proposed location of the Grandview Creek culvert under the new westbound lanes of Highway 11/17 in the Township of MacGregor, District of Thunder Bay. The new culvert is planned as part of the proposed Highway 11/17 four-laning project extending from 0.36 km east of Highway 527 to 1 km west of MacKenzie Station Road. The existing Highway 11/17 will become the new eastbound lanes of the four-lane divided highway.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic sections, laboratory test results and written descriptions of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation, under the Ministry of Transportation Ontario (MTO) Agreement Number 6009-E-0017.

2 SITE DESCRIPTION

The proposed Grandview Creek culvert is located approximately 14 km east of Thunder Bay, Ontario and approximately 10.5 km east of Highway 527. The new culvert will be situated approximately 30 m north of the existing Highway 11/17 alignment. The existing roadway embankment is approximately 5 to 6 m in height.

Grandview Creek flows from north to south at the proposed culvert location. Lands surrounding the culvert site consist of forested areas with bedrock outcrops. Cobbles and boulders were observed within the creek channel and at ground surface at various locations across the site.

Photographs in Appendix C show the general nature of the site.

The site lies near the border of the Superior and Southern Geological Provinces of the Canadian Shield. According to bedrock geology maps produced by the Ontario Geological Survey, the culvert site lies near a boundary between massive granodiorite to granite rocks and metasedimentary rocks. Bedrock core samples confirm that the site is underlain by fine grained metasedimentary rocks. Locally, the overburden consists of cohesionless deposits of gravelly sand to silty sand containing occasional cobbles and boulders.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between November 10 and 22, 2011. Six boreholes, identified as GCW-1 to GCW-6, were drilled and sampled at the site.

Boreholes GCW-1 and GCW-4 were located near the proposed culvert inlet, Boreholes GCW-2 and GCW-5 were located at the centreline of the proposed WBL, and Boreholes GCW-3 and GCW-6 were located near the culvert outlet. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata drawing included in Appendix D.

The boreholes were advanced to depths of 7.7 m to 12.2 m (elevations 233.7 to 228.9). Bedrock was proven by coring 2.3 m to 3.8 m into bedrock in all boreholes.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. Clearing and access preparation were required prior to commencement of the borehole drilling. Silt fencing was installed between the drill area and the creek to prevent migration of core water sediment into the adjacent creek.

A track mounted CME 45 drill rig was used at this site and a combination of hollow-stem augers, casing and NQ coring techniques were used to advance the boreholes. Overburden samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples and rock cores for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes during and upon completion of the drilling operations. Groundwater conditions observed after completion of coring were not representative of site conditions as water was introduced into the borehole during coring. Standpipe piezometers were installed in two boreholes for subsequent monitoring of groundwater levels. The completion details of the piezometers and boreholes are summarized in Table 3.1. The piezometers were decommissioned in general accordance with MOE Regulation 903 in late July 2012.

Table 3.1 – Piezometer and Borehole Completion Details

Borehole	Borehole Depth/ Elevation (m)	Completion Details
GCW-1	-	Backfilled with bentonite holeplug to 1.5 m, then auger cuttings to surface .
GCW-2	6.1 / 235.4	Bentonite holeplug from 11.0 m to 6.1 m. Piezometer installed at 6.1 m. Filter sand from 6.1 m to 4.0 m, then bentonite holeplug to surface.
GCW-3	-	Backfilled with bentonite holeplug to 3.1 m, then holeplug and auger cuttings to surface.
GCW-4	-	Backfilled with bentonite holeplug to 0.9 m, then auger cuttings to surface.
GCW-5	7.6 / 233.5	Piezometer installed at 7.6 m. Filter sand from 7.6 m to 5.6 m, then bentonite holeplug to surface.
GCW-6	-	Backfilled with bentonite holeplug to 1.5 m, then auger cuttings to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis. The results of these tests are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

Point load tests were carried out on selected samples of intact bedrock upon arrival at the laboratory to evaluate the unconfined compressive strength (UCS) of the bedrock. The UCS values of the rock assessed from the point load data are reported on the borehole logs.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

In general, the subsurface stratigraphy encountered at the site consisted of topsoil overlying deposits of gravelly sand, sand and silty sand to sandy silt, underlain by bedrock. Cobbles and boulders were encountered within these deposits. More detailed descriptions of the individual strata are presented below.

5.1 Topsoil

Topsoil was encountered at the surface in all boreholes. The topsoil is dark brown and typically described as sandy with trace gravel. The topsoil thickness varied from 200 mm to 600 mm.

SPT N-values recorded in the topsoil ranged from 1 to 8 blows for 0.3 m penetration, indicating a very loose to loose relative density. Moisture contents of 31% to 44% were measured.

5.2 Sand

A sand stratum was encountered below the topsoil in all boreholes. The sand was brown, dark brown or grey and contained varying amounts of gravel (trace gravel to gravelly), silt (trace silt to silty) and cobbles and boulders. The use of coring methods was required to advance the boreholes through the cobbles and boulders within the sand. Trace organics and a possible silt inclusion were encountered within the upper part of this layer.

The sand layer was 2.1 m to 3.5 m thick. The base of the sand layer was encountered at depths of 2.7 m to 4.1 m (elevations 239.0 to 237.1).

SPT N-values recorded in the native sand typically ranged from 12 to 35 blows for 0.3 m penetration, indicating a compact to dense relative density. N-values of 4 and 5 blows for 0.3 m were obtained in the upper 0.5 to 1.1 m of this unit in Boreholes GCW-4 and GCW-5, indicating a locally loose condition. SPT N-values of 50 blows for less than 125 mm of penetration were recorded locally and are believed to reflect the presence of cobbles and boulders.

The moisture content of samples of the sand ranged from 10% to 30%, reflecting the variable silt and organics content.

Five samples of the sand underwent laboratory gradation analysis. The results of this testing are presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves are plotted on Figure B1, Appendix B. The results are as follows:

Gravel %	5 to 28
Sand %	37 to 84
Silt %	9 to 41
Clay %	2 to 4

5.3 Sandy Silt

A layer of sandy silt was encountered below the sand in Boreholes GCW-1 and GCW-2. The sandy silt was brown to grey and contained some clay, trace gravel, and occasional cobbles.

The sandy silt layer was 3.4 m thick in Borehole GCW-1 and 1.2 m thick in Borehole GCW-2. The base of the sandy silt layer was encountered at depths of 6.1 m and 5.3 m (elevations 235.6 and 236.2) in Boreholes GCW-1 and GCW-2, respectively.

The SPT N-values recorded in the sandy silt layer ranged from 74 blows for 0.125 m to 100 blows for 0.025 m, indicating a very dense relative density or the presence of cobbles and boulders.

The moisture content of the sandy silt ranged from 10% to 23%.

A sample of the sandy silt underwent laboratory gradation analysis, the results of which are summarized below. The results of this test are also presented on the Record of Boreholes sheets in Appendix A and the grain size distribution curve for this sample is plotted on Figure B2, Appendix B.

Gravel %	0
Sand %	22
Silt %	65
Clay %	13

5.4 Silty Sand

Silty sand was encountered below the sand and sandy silt layers in all boreholes. The silty sand was typically grey, locally brown, and contained trace to some gravel and occasional cobbles and boulders. Coring was required to advance Boreholes GCW-1, GCW-3 and GCW-4 through the silty sand, indicating the presence of cobbles and boulders.

The thickness of the silty sand ranged from 1.4 m to 4.7 m, with the lower boundary of the silty sand encountered at depths of 4.3 m to 8.7 m (elevations 236.8 to 232.4).

SPT N-values recorded in the native silty sand ranged from 80 blows for 0.3 m penetration to 100 blows for 0.025 m penetration, indicating a dense to very dense relative density and/or the presence of cobbles and boulders.

The moisture content of samples of the silty sand ranged from 11% to 18%.

One sample of the silty sand underwent laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A and are plotted on Figure B3, Appendix B.

Gravel %	0
Sand %	55
Silt %	42
Clay %	3

5.5 Bedrock

Bedrock was proven below the silty sand by coring in all boreholes. The depths to bedrock are summarized in Table 5.1.

Table 5.1 – Depth to Bedrock at Borehole Locations

Borehole	Depth to Bedrock (m)	Top of Bedrock Elevation (m)	Method
GCW-1	7.6	234.1	Cored
GCW-2	7.2	234.3	Cored
GCW-3	8.7	232.4	Cored
GCW-4	4.7	236.8	Cored
GCW-5	4.3	236.8	Cored
GCW-6	5.4	236.6	Cored

The bedrock recovered in the cores was described as fine grained metasedimentary bedrock with occasional quartz veins. The bedrock is grey in colour with occasional white bands.

Total core recovery typically ranged from 84% to 100%. Five runs in Boreholes GCW-1 to GCW-3 yielded core recoveries of only 30% to 67%, indicating highly fractured rock or possible malfunction of the coring equipment.

RQD values recorded for the bedrock core recovered from Boreholes GCW-4 to GCW-6 ranged from 53% to 100%, indicating fair to excellent rock quality. RQD values of 0% were reported for the bedrock from Boreholes GCW-1 and GCW-2, and 0% to 62% in Borehole GCW-3 (very poor to fair quality). It is unclear whether the low RQD values reflect the presence of highly fractured bedrock or issues with the coring equipment. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, varied from 0 to greater than 25.

The unconfined compressive strength of the rock, estimated from the results of point load tests conducted on the rock core samples, typically ranged from 110 to 197 MPa, indicating a very strong intact rock. One value of 52 MPa was measured on a sample from Borehole GCW-3, indicating a strong rock. The results are summarized on the Record of Borehole sheets in Appendix A (as average per run).

5.6 Water Levels

Groundwater was measured at 1.2 m depth (elevation 239.9) in Borehole GCW-3 upon completion of the drilling. Water was added to the boreholes during coring operations and therefore natural water levels were not recorded in the remaining boreholes.

Standpipe piezometers were installed in Boreholes GCW-2 and GCW-5 following completion of drilling. The ground water depths and levels measured in the piezometers and in open Borehole GCW-3 upon completion are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
GCW-2	Dec. 02, 2011	0.5	241.0	Piezometer
GCW-3	Nov. 13, 2011	1.2	239.9	During drilling
GCW-5	Jan 30, 2012	1.1	240.0	Piezometer

The water depth in the creek at the time of the fieldwork was variable but generally in the order of 0.2 m. Based on this observation and the creek invert levels shown on the preliminary design drawings, the creek water level is estimated to be near elevation 240.6.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall, and will reflect the water level in the creek.

6 MISCELLANEOUS

The borehole locations were selected by Thurber Engineering Ltd. and staked in the field by McCormick Rankin Corporation (MRC). The co-ordinates and ground surface elevations at the boreholes were surveyed by MRC. Where boreholes required relocation from the staked location, field measurements were recorded and the surveyed coordinates and elevations adjusted accordingly.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a track mounted CME 45 drill rig and conducted the drilling, sampling and in-situ testing operations.

The field program was supervised on a full time basis by Ms. Eckie Siu and Mr. Ryan Kromer, E.I.T. of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng. Interpretation of the data and preparation of this report were carried out by Ms. Lindsey Blaine, E.I.T. and Ms. Mei Cheong, M.Phil.

The report was reviewed by Mr. Murray R. Anderson, M.Eng., P.Eng. and Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

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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

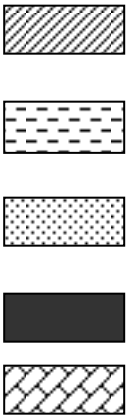
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, 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 GCW-1 1 OF 2 METRIC

W.P. 623-89-00 LOCATION N 5 376 276.4 E 378 268.8 Grandview Creek WBL ORIGINATED BY RK

HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NW/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2011.11.10 - 2011.11.10 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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)	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
241.7											
0.0 / 241.3	**TOPSOIL**, sandy Dark Brown Moist		1	SS	101/ 0.225				○		
0.4	**SAND**, some gravel to gravelly, some silt to silty Compact Brown to Grey Wet Cored through boulders (660mm) and occasional cobbles from 0.4m to 1.7m						241				
239.0			2	SS	23		240		○ ○		
2.7	Sandy **SILT**, some clay, trace gravel Very Dense Brown Moist to Wet		3	SS	64/ 0.125		239		○		
	No recovery		4	SS	100/ 0.025		238		○		
235.6	Cored through occasional cobbles (75mm to 120mm)						237				
6.1	Silty **SAND**, some gravel, occasional cobbles (from cuttings) Grey Wet						236				
234.1	Cored						235				
7.6	**METASEDIMENTARY BEDROCK**, slightly weathered, grey, highly fractured, occasional quartz veins		1	RUN			234				RUN #1 TCR=30% SCR=0% RQD=0%
							233				
231.8			2	RUN			232				RUN #2 TCR=33% SCR=0% RQD=0%

Continued Next Page

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

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

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Ontario

THURBER

RECORD OF BOREHOLE No GCW-1 2 OF 2 METRIC

W.P. 623-89-00 LOCATION N 5 376 276.4 E 378 268.8 Grandview Creek WBL ORIGINATED BY RK

HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NW/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2011.11.10 - 2011.11.10 CHECKED BY RPR

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
	Continued From Previous Page										
9.9	END OF BOREHOLE AT 10.0m. BOREHOLE BACKFILLED WITH HOLEPLUG TO 1.5m, THEN AUGER CUTTING TO SURFACE.										

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

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

ONTMT4S 1182.GPJ 6/22/12

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GCW-2

1 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 376 266.8 E 378 271.3 Grandview Creek WBL ORIGINATED BY RK

HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2011.11.12 - 2011.11.12 CHECKED BY RPR

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
241.5											
0.0	**TOPSOIL**, sandy, some silt, trace gravel Loose Dark Brown Moist		1	SS	8		241		○		
240.9 / 0.6	**SAND**, some gravel to gravelly, some silt to silty, trace clay, occasional cobbles and boulders Compact Brown to Grey Wet Cored through occasional cobbles from 0.6m to 4.1m		2	SS	30		240		○		
			3	SS	19		239		○		28 46 24 2
			4	SS	29		238		○		
237.4 / 4.1	Sandy **SILT**, some clay Very Dense Grey Wet		5	SS	74/ 0.125		237		○		0 22 65 13
236.2 / 5.3	Silty **SAND**, some gravel, occasional cobbles Very Dense Grey Wet		6	SS	93		236		○		
234.3 / 7.2	**METASEDIMENTARY BEDROCK**, slightly weathered, grey, highly fractured, occasional quartz veins Rubble zone (175mm) at 8.7m		1	RUN			235				RUN #1 TCR=100% SCR=0% RQD=0%
			2	RUN			234				RUN #2 TCR=50% SCR=0% RQD=0%
			3	RUN			233			FI 5 5 5 3	RUN #3 TCR=84% SCR=41% RQD=0% UCS=110MPa (Average)
							232				RUN #4 TCR=30% SCR=8% RQD=0%

Continued Next Page

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

15 $\oplus$ 5 (20, 10) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GCW-2 2 OF 2 METRIC

W.P. 623-89-00 LOCATION N 5 376 266.8 E 378 271.3 Grandview Creek WBL ORIGINATED BY RK

HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2011.11.12 - 2011.11.12 CHECKED BY RPR

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						
	Continued From Previous Page										
230.5	**METASEDIMENTARY BEDROCK**, slightly weathered, grey, highly fractured, occasional quartz veins		4	RUN			231				UCS=159MPa (Average)
11.0	END OF BOREHOLE AT 11.0m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec. 02/11 0.5 241.0										

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

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

ONTMT4S 1182.GPJ 6/22/12

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GCW-3 1 OF 2 METRIC

W.P. 623-89-00 LOCATION N 5 376 258.1 E 378 273.1 Grandview Creek WBL ORIGINATED BY RK

HWY 11/17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2011.11.13 - 2011.11.13 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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
241.1							241				
0.0	**TOPSOIL**, rootlets, sandy Very Loose Dark Brown		1	SS	2				○		
240.5	Moist						240				
0.6	**SAND**, some gravel to gravelly, some silt, trace clay, occasional cobbles and boulders Compact to Dense Dark Brown to Grey Moist to Wet Cored through occasional cobbles (90mm to 150mm)		2	SS	31	▽			○		
			3	SS	26		239		○		
			4	SS	31				○		
			5	SS	23		238		○		17 60 20 3
237.1											
4.0	Silty **SAND**, trace to some gravel, trace clay Compact to Very Dense Grey Wet		6	SS	80		237		○		
	Cored through occasional cobbles No recovery		7	SS	100/ 0.025		236				
			8	SS	51/ 0.125		235				
							234				
							233				RUN #1 TCR=100% SCR=39% RQD=39%
232.4										FI	
8.7	**METASEDIMENTARY BEDROCK**, slightly weathered, grey, occasional quartz veins Rubble zones from 9.1m to 9.4m, 9.5m to 9.9m, 10.5m to 10.6m		1	RUN			232			5	
			2	RUN						4	RUN #2 TCR=67% SCR=17% RQD=0% UCS=52MPa (Average)
										-	
										-	

ONTMT4S 1182.GPJ 6/22/12

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GCW-3 2 OF 2 METRIC

W.P. 623-89-00 LOCATION N 5 376 258.1 E 378 273.1 Grandview Creek WBL ORIGINATED BY RK

HWY 11/17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2011.11.13 - 2011.11.13 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa 20 40 60 80 100 (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	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						
	Continued From Previous Page										
	METASEDIMENTARY BEDROCK, slightly weathered, grey, occasional quartz veins		3	RUN			231			>10	RUN #3 TCR=100% SCR=53% RQD=14% UCS=169MPa (Average)
										6	
										>10	
										1	RUN #4 TCR=100% SCR=76% RQD=62% UCS=173MPa (Average)
			4	RUN			230			2	
	Fresh									2	
228.9										5	
							229			5	
12.2	END OF BOREHOLE AT 12.2m. WATER OBSERVED AT 1.2m DURING DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG TO 3.1m, THEN HOLEPLUG AND AUGER CUTTINGS TO SURFACE.										

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

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

ONTMT4S 1182.GPJ 6/22/12

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GCW-4 1 OF 1 METRIC

W.P. 623-89-00 LOCATION N 5 376 281.3 E 378 283.8 Grandview Creek WBL ORIGINATED BY ES

HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2011.11.22 - 2011.11.22 CHECKED BY RPR

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
241.5											
0.0	**TOPSOIL:** (200mm)										
0.2	**SAND**, some gravel, some silt, trace clay, occasional organics, occasional silt inclusions Loose to Compact Dark Brown Moist		1	SS	5		241		○		
			2	SS	13				○		18 37 41 4
240.0							240				
1.5	**SAND**, some silt, some gravel, trace clay, occasional cobbles Dense Brown Wet		3	SS	35				○		
			4	SS	30		239		○		11 72 14 3
238.2	Very Dense		5	SS	50/				○ ○		
3.3	Silty **SAND**, trace gravel, occasional cobble Grey Moist				0.125		238				
	Auger refusal at 4.3m Cored through occasional cobbles from 4.3m to 4.7m										
236.8							237				
4.7	**METASEDIMENTARY BEDROCK**, slightly to moderately weathered, grey, occasional quartz veins Quartz veins at 4.9m, 5.7m, 5.9m, 6.0m, 6.1m Sub-vertical fracture (25mm to 75mm) at 4.9m, 5.3m, 5.4m, 7.3m, 7.5m 125mm at 5.6m Vertical fracture (25mm) at 5.4m to 6.2m		1	RUN						FI 3 0 3	RUN #1 TCR=100% SCR=100% RQD=100% UCS=160MPa (Average)
	Highly broken zone from 6.2m to 6.8m						236			2 2	
	Moderately to slightly weathered		2	RUN			235			>15 >15 >15 5	RUN #2 TCR=100% SCR=67% RQD=57% UCS=154MPa (Average)
233.7							234			5	
7.8	END OF BOREHOLE AT 7.8m. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.9m, THEN AUGER CUTTINGS TO SURFACE.										

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

15 $\oplus$ 5 (20 / 10) (%) STRAIN AT FAILURE

ONTMT4S 1182.GPJ 6/22/12

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GCW-5 1 OF 1 METRIC

W.P. 623-89-00 LOCATION N 5 376 271.8 E 378 286.9 Grandview Creek WBL ORIGINATED BY ES

HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2011.11.22 - 2011.11.22 CHECKED BY RPR

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
241.1											
0.0 / 240.7	**TOPSOIL**, trace sand, trace gravel Very Loose Dark Brown Moist		1	SS	1		241				
0.4	**SAND**, trace to some gravel, some silt, trace clay, trace organics Loose to Compact Brown Wet		2	SS	4		240				
	Occasional cobbles		3	SS	28		239				
238.6			4	SS	50/						
2.5	Silty **SAND**, trace gravel, trace clay Very Dense Grey Moist				0.100						
			5	SS	50/ 0.125		238				0 55 42 3
	Auger refusal at 4.2m										
236.8							237				
4.3	**METASEDIMENTARY BEDROCK**, moderately to highly weathered, occasional quartz veins, grey		1	RUN						FI >15	RUN #1 TCR=100% SCR=73% RQD=53% UCS=100MPa (Average)
	Vertical fracture (250mm) at 4.4m									>5	
	Sub-vertical fracture (175mm) at 4.5m						236			>10	RUN #2 TCR=100% SCR=72% RQD=72% UCS=135MPa (Average)
	Vertical fracture (100mm) at 4.7m, 5.4m, 6.1m Highly broken zone from 5.1m to 5.5m		2	RUN						>25 >5	
	Quartz veins (50mm) at 7.4m 100mm at 6.4m 125mm at 6.5m						235			4 3	
	Vertical fracture (125mm) at 6.2m									1	RUN #3 TCR=100% SCR=85% RQD=80% UCS=95MPa (Average)
	Sub-vertical fracture (200mm) at 6.8m 50mm at 7.5m		3	RUN			234			4 >10	
233.4										2	
7.7	END OF BOREHOLE AT 7.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jan. 30/12 1.1 240.0										

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

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

ONTMT4S 1182.GPJ 6/22/12

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GCW-6 1 OF 1 METRIC

W.P. 623-89-00 LOCATION N 5 376 263.5 E 378 289.6 Grandview Creek WBL ORIGINATED BY ES

HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2011.11.22 - 2011.11.22 CHECKED BY RPR

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
242.0											
0.0 241.7	**TOPSOIL:** (250mm)						242				
0.3	**SAND**, trace to some gravel, trace silt and clay, occasional cobbles, trace organics Compact to Very Dense Brown Moist		1	SS	15				○		
			2	SS	50/ 0.075		241		○		
			3	SS	12				○		5 84 9 2
							240				
			4	SS	27				○		
239.0											
3.0	Silty **SAND**, trace gravel, occasional cobbles Very Dense Brown Wet		5	SS	50/ 0.150		239		○		
							238				
			6	SS	50/ 0.100				○		
	Cobbles and boulders						237				
236.6											
5.4	**METASEDIMENTARY BEDROCK**, moderately weathered, grey Sub-vertical fractures (75mm) at 5.6m		1	RUN						FI	RUN #1 TCR=100% SCR=71% RQD=71% UCS=197MPa (Average)
	Highly broken zone (275mm) at 5.9m Sub-vertical fractures (25mm to 75mm) at 5.7m, 6.1m, 6.5m, 6.6m, 6.8m 125mm at 6.4m		2	RUN			236			3 >25 3 5	RUN #2 TCR=85% SCR=77% RQD=77% UCS=169MPa (Average)
	Sub-horizontal fractures at 7.4m, 8.0m and 8.1m						235			>5 >5	
	Sub-vertical fractures (between 25mm to 100mm) at 7.3m, 7.6m, 7.7m and 8.3m		3	RUN						2 4 1	RUN #3 TCR=100% SCR=100% RQD=93% UCS=128MPa (Average)
	Quartz veins at 7.9m, 8.1m, 8.6m						234			5 1	
233.2											
8.8	END OF BOREHOLE AT 8.8m. BOREHOLE BACKFILLED WTH HOLEPLUG TO 1.5m, THEN CUTTINGS TO SURFACE.										

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

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

ONTMT4S 1182.GPJ 6/22/12

Appendix B

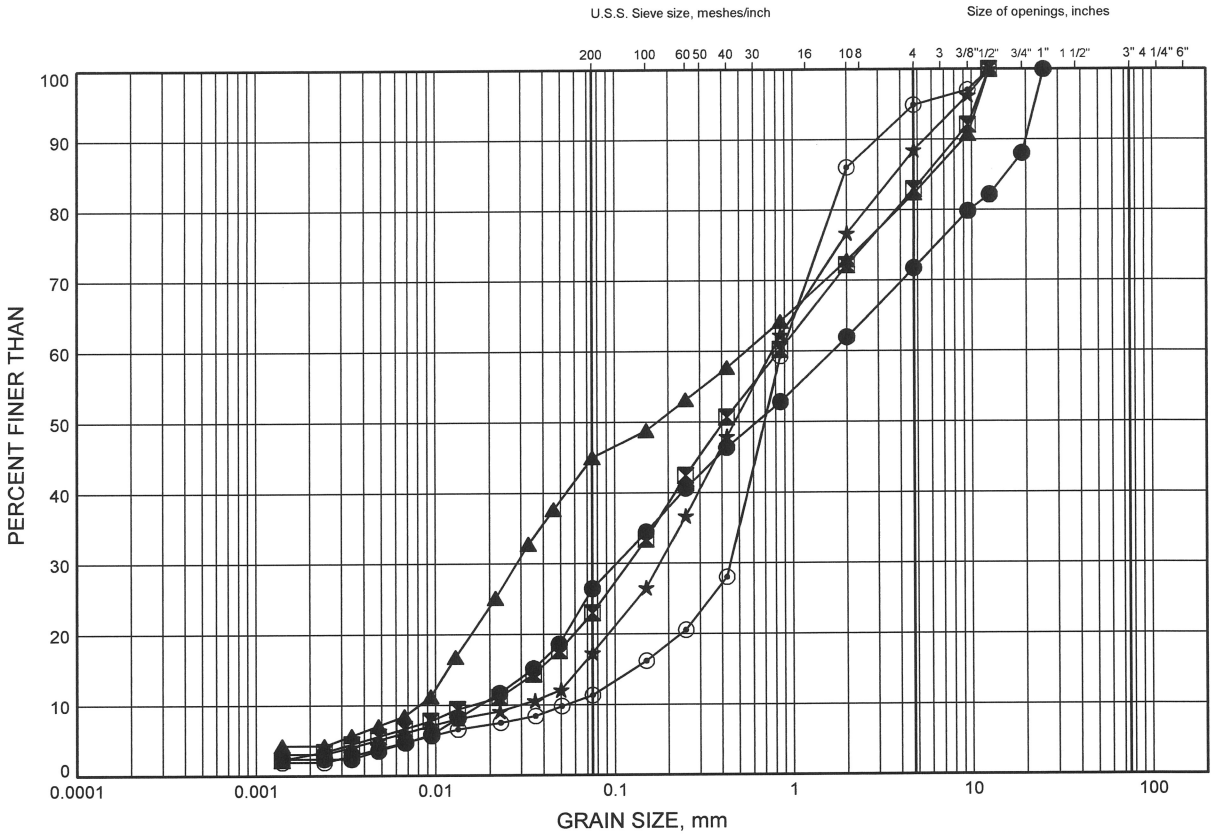
Laboratory Test Results

Grandview Creek Culvert - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GCW-2	2.59	238.91
⊠	GCW-3	3.35	237.75
▲	GCW-4	0.91	240.59
★	GCW-4	2.59	238.91
⊙	GCW-6	1.83	240.17

W.P.# 623-89-00

Prepared By AN

Checked By LRB

THURBER

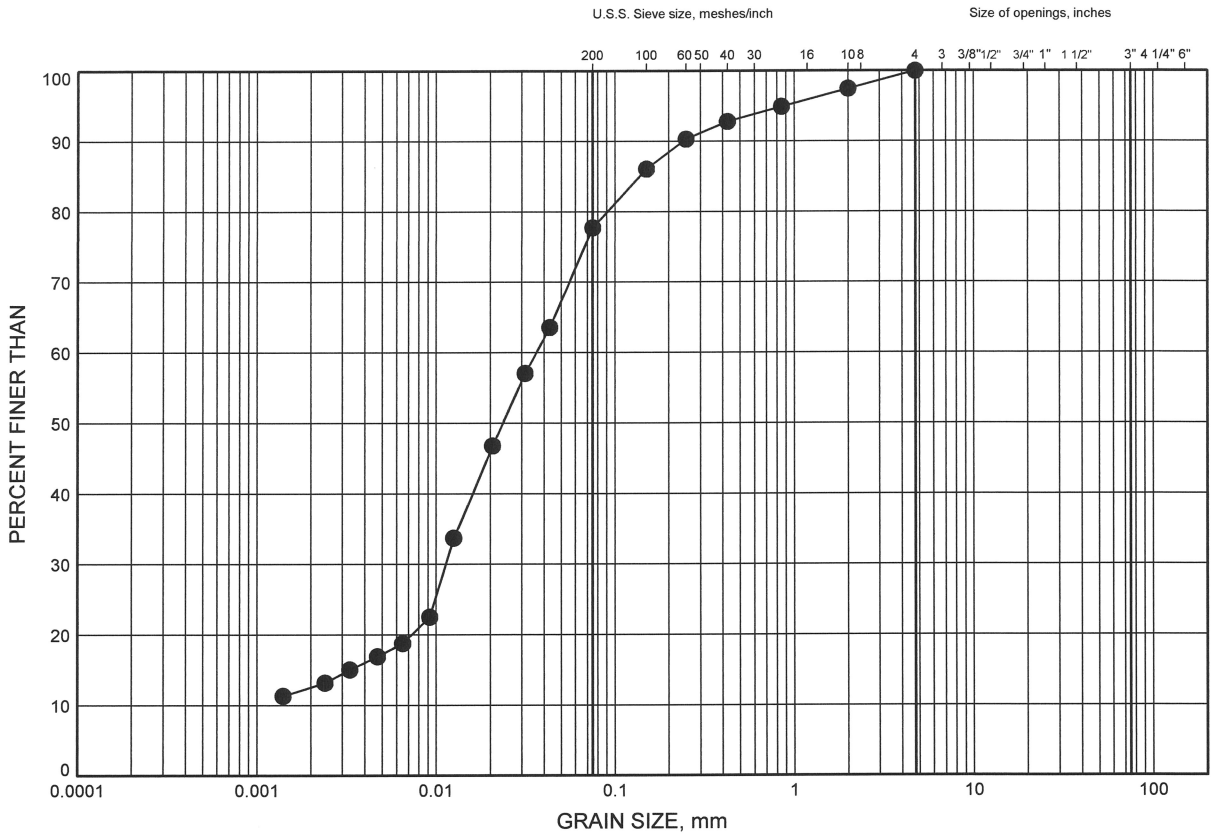
GRAIN SIZE DISTRIBUTION - THURBER 1182.GPJ 6/22/12

Grandview Creek Culvert - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B2

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GCW-2	4.88	236.62

W.P.# 623-89-00
Prepared By AN
Checked By LRB

THURBER

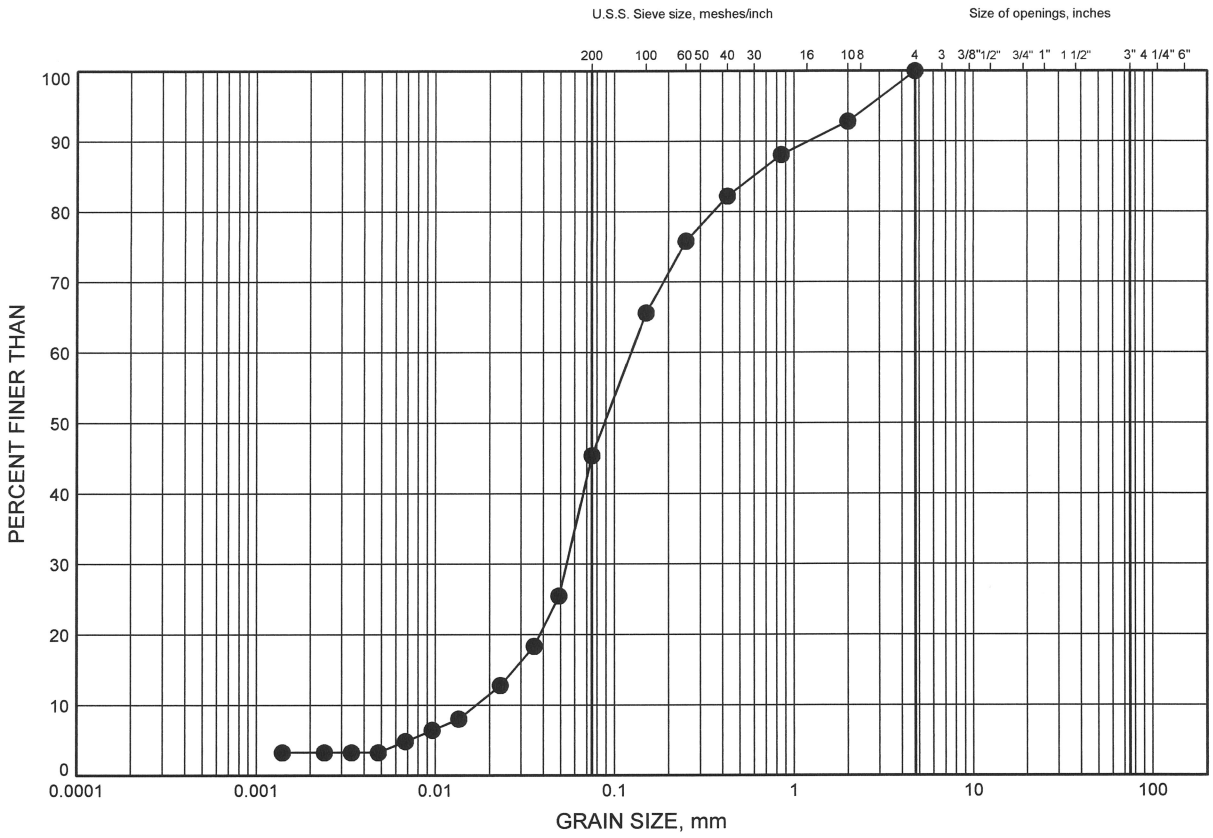
GRAIN SIZE DISTRIBUTION - THURBER 1182.GPJ 6/22/12

Grandview Creek Culvert - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GCW-5	3.35	237.75

W.P.# 623-89-00
Prepared By AN
Checked By LRB

THURBER

GRAIN SIZE DISTRIBUTION - THURBER 1182.GPJ 6/22/12

Appendix C

Site Photographs

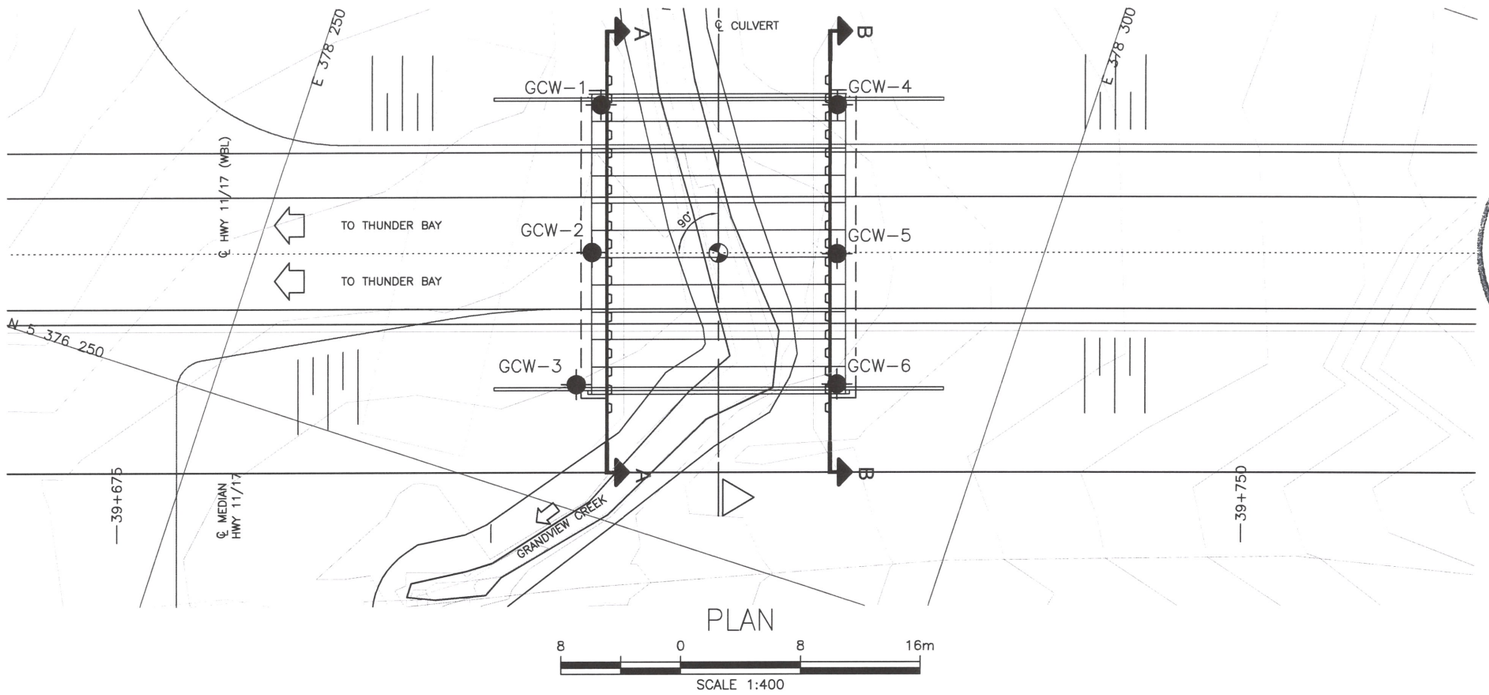
Photograph 1 – Grandview Creek looking north from existing Highway 11/17

Photograph 2 – East side of Grandview Creek looking south towards existing Highway 11/17

Appendix D

Borehole Locations and Soil Strata Drawing

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

8 0 8 16m

SCALE 1:400

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
July 31/12
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
July 31/12
PROVINCE OF ONTARIO

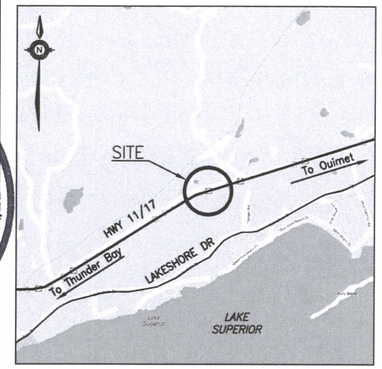
CONT No 2012–6010
WP No 623–89–00

HIGHWAY 11/17
GRANDVIEW CREEK CULVERT
WESTBOUND LANES
BOREHOLE LOCATIONS AND SOIL STRATA

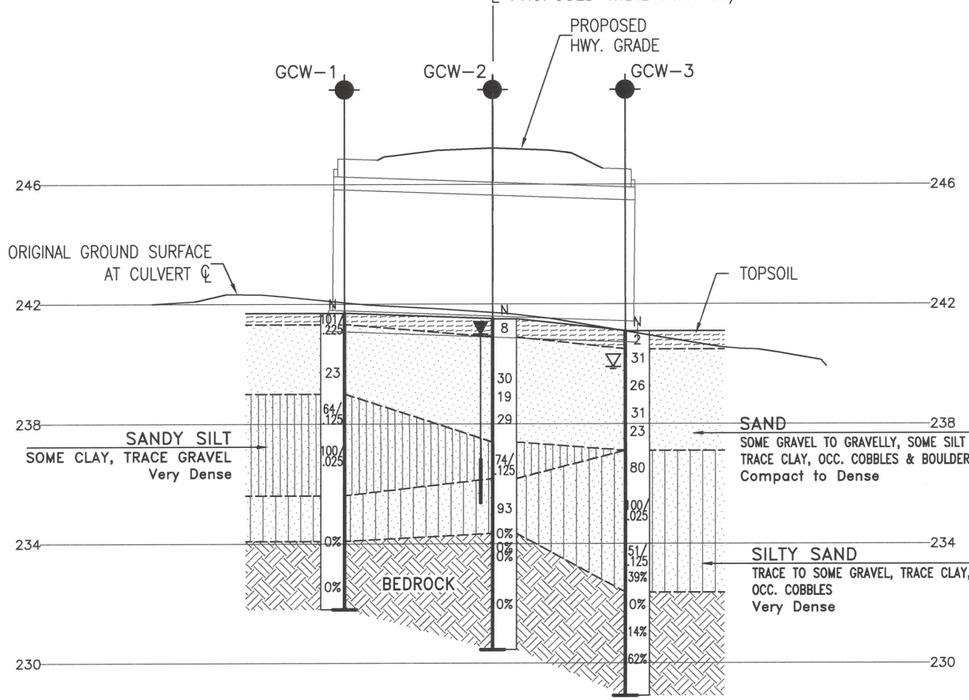
SHEET 260

Hatch Mott MacDonald

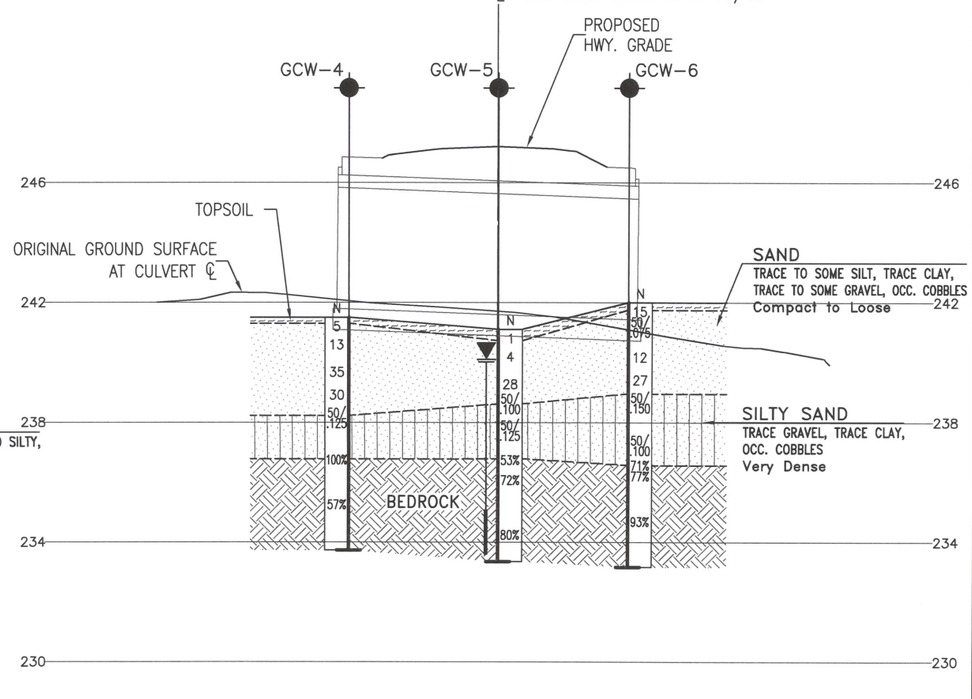
THURBER ENGINEERING LTD.



KEYPLAN



SECTION A–A



SECTION B–B

8 0 8 16m H 1:400

4 0 4 8 V 1:200

LEGEND

⊕	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▽	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
GCW–1	241.7	5 376 276.4	378 268.8
GCW–2	241.5	5 376 266.8	378 271.3
GCW–3	241.1	5 376 258.1	378 273.1
GCW–4	241.5	5 376 281.3	378 283.8
GCW–5	241.1	5 376 271.8	378 286.9
GCW–6	242.0	5 376 263.5	378 289.6

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 52A-158

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	LRB	CHK	LRB	CODE	CAN/CSA S6-06	LOAD	CL-625-ONT
DRAWN	MFA	CHK	AEG	SITE	48C-349/C2	STRUCT	DWG 2

DATE JUL. 2012

PLOTDATE: 7/25/2012 4:41 PM
FILENAME: H:\Drafting\19\1351\182\ted1182-GrandviewCreek-WBL-Revise.dwg