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FOUNDATION INVESTIGATION REPORT
RAWDON CREEK BRIDGE REPLACEMENT, HIGHWAY 62
TOWNSHIP OF HUNTINGDON
SITE 11-134, G.W.P. 4044-10-00
ASSIGNMENT NUMBER: 4015-E-0015

GEOCRES NUMBER: 31C-256

SUBMITTED TO
McINTOSH PERRY CONSULTING ENGINEERS LTD. / LEA CONSULTING LTD.
JOINT VENTURE

May 2017
14392

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the replacement of the Highway 62 Bridge over Rawdon Creek, located within the Township of Huntingdon, Ontario. Thurber carried out the investigation as a subconsultant to McIntosh Perry Consulting Engineers – LEA Engineering Joint Venture (MPCE-LEA), under Agreement No. 4015-E-0015.

Base plan mapping and the General Arrangement (GA) drawing was provided by the Ministry of Transportation (MTO) Eastern Region Structural Office for the preparation of this report.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on this data, provide a borehole location plan, record of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

2 SITE DESCRIPTION

Site 11-134 is located on Highway 62, approximately 250 m south of Moira Road in the Township of Huntingdon, Ontario. The location of the structure is shown on the inset Key Plan on Drawing No. 1 in Appendix A.

Highway 62 at this location has one through lane in each direction with narrow paved shoulders. There are concrete barriers and steel beam guide rail systems present on both sides of the highway at the creek location. It is noted that for project orientation purposes, Highway 62 will be assumed to be oriented north-south and Rawdon Creek to be oriented east-west.

Based on the GA drawing dated July 2015, the existing bridge is a single span structure, approximately 12.3 m long that carries two lanes of Highway 62 traffic over Rawdon Creek. It is proposed to construct the replacement bridge on a new alignment approximately 14.4 m west of the existing alignment.

The site is located near the boundary of three physiographic regions: the Dummer Morraine, the Peterborough Drumlin Field and the Iroquois Plain though the soil conditions on site most closely resemble those of the Iroquois Plain region. The Iroquois Plain region is characterized by the flat to undulating lake bed and beaches of the former glacial Lake Iroquois that existed during the last glacial recession. The overburden soils are comprised of glaciolacustrine sand, silt and clay deposits (though deposits of sand and gravel are also known to be present) all underlain by limestone bedrock (Chapman and Putnam, 1984).

The lands surrounding the project limits are typically agricultural with some residential properties. Storm water drainage in the area is to existing ditches and culverts. Site photographs showing the general conditions at the site are presented in Appendix E.

3 SITE INVESTIGATION

3.1 Previous Investigations

A Preliminary Foundation Investigation for this site was carried out in 2012 (Golder Associates Report No. 12-1111-0021-1). The investigation consisted of advancing one borehole at each proposed abutment (Boreholes RC-1 and RC-2). A copy of the borehole location plan and the Record of Boreholes from the preliminary investigation are provided in Appendix C.

The stratigraphy in the area of the bridge is generally described as surficial deposits of firm to stiff silty clay (on the south side of the creek) or loose to compact sand and gravel (on the north side of the creek), overlying a deposit of loose to compact silty sand to sandy silt, underlain by a deposit of compact to very dense sand and gravel, which contains cobbles and boulders, all overlying limestone bedrock. The bedrock surface was encountered at approximately elevation 123.2 m and 122.3 m at the north and south abutments, respectively.

3.2 Field Investigation

A field investigation was carried out as part of the current detailed design assignment to supplement the data from the preliminary foundation investigation.

The field investigation plan was finalized after discussion with the MTO Foundations Section. The field investigation for this site included advancing four boreholes drilled between October 3rd and 4th, 2016. The approximate locations and elevations of the boreholes are shown on Drawing No. 1 provided in Appendix A and are summarized in Table 3-1.

Table 3-1: Borehole Summary

Borehole	Location	Latitude (degrees)	Longitude (degrees)	Ground Surface Elevation (m)	Depth (m)
16-1	South Approach	44.33797	-77.47741	133.9	10.0
16-2	South Abutment	44.33814	-77.47754	133.1	13.6
16-3	North Abutment	44.33828	-77.47777	131.4	12.3
16-4	North Approach	44.33844	-77.47786	131.4	6.9

As a component of our standard procedures and due diligence, Thurber contacted Ontario One Call and MTO Electrical to obtain utility locates/clearances for the intended borehole locations.

The boreholes were advanced with an ATV mount CME55 drill rig equipped with hollow stem augers and HW casing. The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the boreholes during the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. In-situ shear vane testing was carried out within the cohesive strata. All soil samples recovered from the boreholes were placed in moisture-proof containers and transported to Thurber's Ottawa geotechnical laboratory for further examination and testing. Bedrock was cored in Boreholes 16-2, and 16-3 with HQ size coring equipment

following ASTM Standard D6032-08. Bedrock core samples were stored in core boxes for transport.

A 50 mm inside diameter PVC monitoring well was installed in Boreholes 16-2 and 16-3 to allow for measurement of the groundwater level at the site. The monitoring well construction details are illustrated on the Record of Borehole sheet for Boreholes 16-2 and 16-3, provided in Appendix B.

The boreholes without installations were backfilled with a low-permeability combination of auger cuttings, and bentonite pellets in general accordance with the intent of Ontario MOE Regulation 903.

The as-drilled locations of the boreholes and ground surface elevations at the borehole locations were surveyed by Thurber on October 5, 2016. The vertical datum used was the benchmark (GBM) 8321 identified on the plans provided by MTO, which is located on the southeast abutment of the existing bridge. The GBM has a geodetic elevation of 134.476 m.

3.3 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all soil samples in accordance with the current MTO standards. Grain size distribution analyses, and Atterberg Limits testing were also carried out on selected samples to MTO and ASTM standards. Point Load Strength Index Testing as also carried out on selected samples of the bedrock core. Chemical analysis for determination of pH, resistivity, soluble sulphate and chloride concentrations was carried out on two soil samples. A copy of the chemical analysis results are provided in Appendix D.

The laboratory test results are presented on the Record of Borehole sheets in Appendix B and are illustrated on the figures in Appendix D.

4 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Overview / General

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the site is presented on the Drawing No. 1 in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions.

In general, the stratigraphy in the area of the boreholes is characterized by silty sand, clay and silt (at the south embankment area) or silty sand with gravel (at the north embankment area), overlying sandy silt to silty sand, overlying silty sand with gravel till, underlain by limestone bedrock. This stratigraphy is generally consistent with the stratigraphy encountered in the preliminary investigation. More detailed descriptions of the individual strata are presented below.

More detailed descriptions of the individual strata are presented below.

4.2 Rootmat

A rootmat layer was encountered at the surface in all boreholes. The thickness of the rootmat ranged from 50 mm to 150 mm.

4.3 Silty Sand with Gravel

A silty sand layer with varying amounts of gravel was encountered below the rootmat in all four boreholes. The top of this layer ranges from elevation 131.2 m to 133.8 m and has a thickness ranging from 0.5 m to 2.2 m. The SPT 'N' values ranged from 3 to 28; indicating a very loose to compact condition. The moisture content of the samples tested ranged from 3% to 21%. A slight hydrocarbon odour was noted in a single sample in Borehole 16-4 at an approximate elevation 130.0 m.

4.4 Clay

A clay deposit was encountered beneath the silty sand with gravel deposit in Boreholes 16-1 and 16-2. The top of this layer ranges from elevation 132.5 m to 133.3 m and has a thickness of 1.7 m. The SPT 'N' values ranged from 12 to 21 blows; indicating stiff to very stiff consistency.

The moisture content of the samples tested ranged from 20% to 38%. The results of a grain size analysis completed on a sample of this material indicated a gravel content of 0%, sand content of 12%, silt content of 35%, and a clay content 53%. The results of the grain size analysis are illustrated on Figure 1 in Appendix D.

The results of Atterberg Limits testing completed on a sample indicated a plastic limit of 20, a liquid limit of 47, and a plasticity index of 27. Atterberg Limits analysis results are illustrated on Figure 2 in Appendix D.

4.5 Silt

A silt deposit was encountered beneath the clay strata in Boreholes 16-1 and 16-2. The top of this layer ranges from elevation 130.8 m to 131.6 m. The thickness of the deposit ranges from 0.6 m to 2.1 m. The SPT 'N' values ranged from 9 to 14; indicating a loose to compact condition.

The moisture content of the samples tested ranged from 25% to 33%. The results of grain size analysis conducted on samples of this material are summarized in Table 4-1 and are illustrated on Figure 3 in Appendix D.

Table 4-1: Gradation Results

Soil Particles	%
Gravel	0
Sand	1 to 7
Silt	87 to 92
Clay	6 to 7

Atterberg Limits testing conducted on samples of this material indicated a non-plastic silt.

4.6 Sandy Silt to Silty Sand

A silt and sand deposit was encountered beneath the silt strata in Boreholes 16-1 and 16-2 and below the silty sand with gravel strata in Boreholes 16-3 and 16-4. The top of this layer ranges from elevation 129.1 m to 130.2 m. The thickness of the deposit ranges from 2.9 m to 5.9 m. The SPT 'N' values ranged from 2 to 16; indicating a very loose to compact condition.

The moisture content of the samples tested ranged from 19% to 27%. The results of grain size analysis conducted on samples of this material are summarized in Table 4-2 and are illustrated on Figure 4 in Appendix D.

Table 4-2: Gradation Results for Sandy Silt to Silty Sand Till

Soil Particles	%
Gravel	0 to 6
Sand	23 to 49
Silt and Clay	48 to 77

Atterberg Limits testing conducted on samples of this material indicated that the fines portion to be non-plastic.

4.7 Silty Sand with Gravel (Till)

A glacial till deposit consisting of silt and sand with varying amounts of gravel was encountered beneath the sandy silt to silty sand materials in all boreholes. The top of this layer ranges from elevation 124.2 m to 126.2 m. Where completely penetrated, the thickness ranged from 1.4 m to 2.4 m. Boreholes 16-1 and 16-4 were terminated in this stratum.

The SPT 'N' values ranged from 46 to greater than 100; indicating a dense to very dense condition. Cobbles and boulders were noted in this stratum. The moisture content of the samples tested ranged from 7% to 11%. The results of grain size analysis conducted on samples of this material are summarized in Table 4-3 and are illustrated on Figure 5 in Appendix D.

Table 4-3: Gradation Results for Till

Soil Particles	%
Gravel	22 to 41
Sand	32 to 59
Silt and Clay	15 to 27

4.8 Bedrock

The overburden materials were underlain by grey limestone bedrock. The bedrock elevation at the south abutment boreholes ranged from elevation 122.3 m to 122.9 m and from 122.6 to 123.2 at the north abutment. Photographs of the bedrock core are provided in Appendix B.

Boreholes 16-2 and 16-3 were advanced into the bedrock by coring with HQ-size core bits. The total core recovery ranged from 98% to 100%, the solid core recovery ranged from 98% to 100% and the Rock Quality Designation ranged from 81% to 100%. Based on the RQD value the bedrock is classified as good to excellent quality. Based on point load strength index testing the bedrock is classified as strong to very strong. A copy of the index test results is provided in Appendix D.

4.9 Groundwater

The groundwater level in the monitoring wells installed in Boreholes 16-2 and 16-3 and the existing well from the preliminary investigation was recorded on October 24, 2016 and again on April 10, 2016. The depth below ground surface and elevation of the groundwater measured is summarized in Table 4.4.

Table 4-4: Groundwater Level Measurements

Borehole	October 24, 2016		April 10, 2017	
	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
16-2	2.6	130.5	1.5	131.6
16-3	0.95	130.5	0.01	131.4
RC-2	2.4	130.7	1.6	131.5

These observations are considered 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.

5 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole locations, and determined the ground surface elevations based on contract drawings provided by MTO. Terex Drilling Solutions of Concord, Ontario supplied and operated the drilling equipment to carry out the drilling, sampling, and in-situ testing. The drilling, and sampling operations in the field were supervised on a full time basis by Mr. Christopher Murray of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Paul Carnaffan, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.

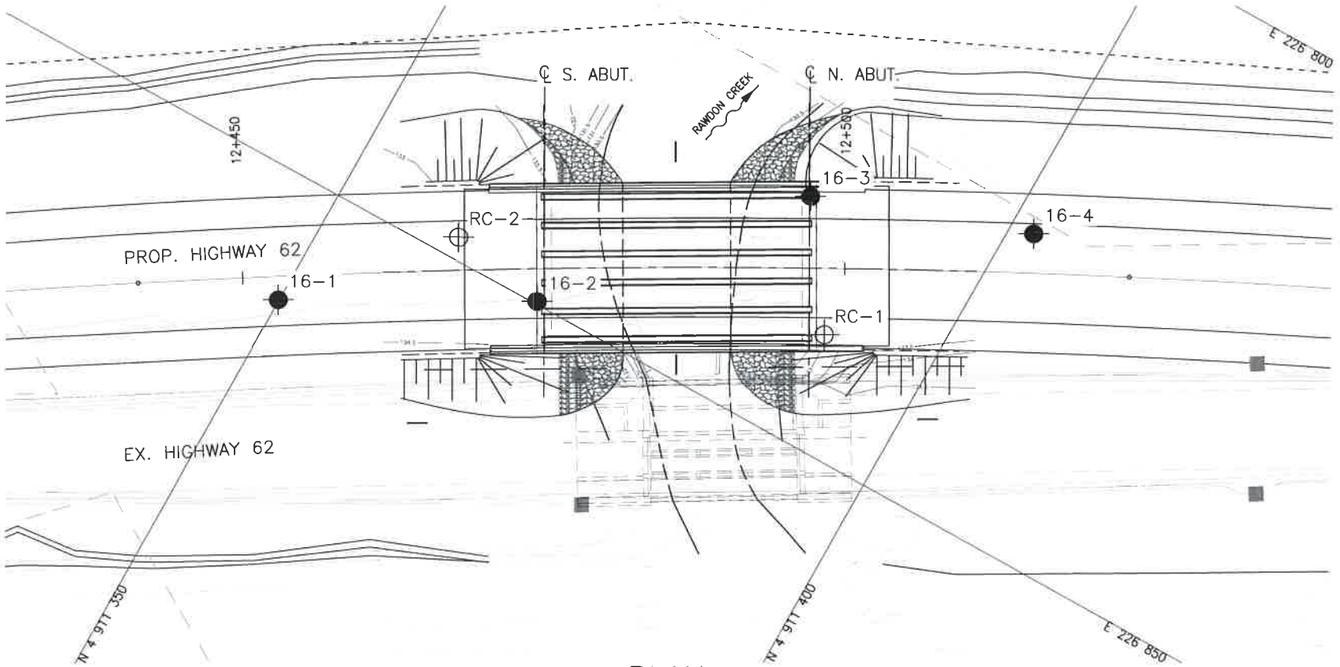
Kenton C. Power, P.Eng.
Geotechnical Engineer

Paul Carnaffan, P.Eng.
Principal | Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

APPENDIX A

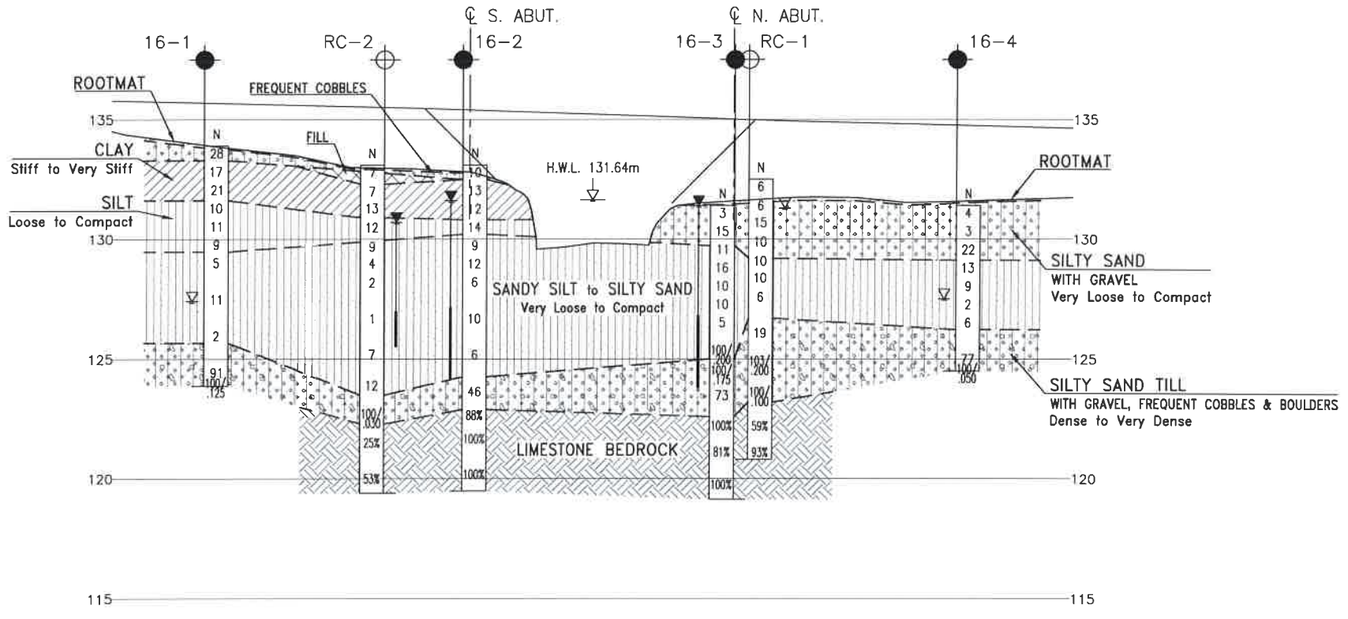
2016 INVESTIGATION
BOREHOLE LOCATIONS AND SOIL STRATA DRAWINGS



PLAN

10 0 10 20m

SCALE 1:500



PROFILE

10 0 10 20m H 1:500

5 0 5 10m V 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

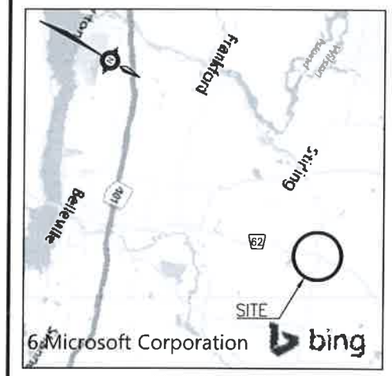
CONT No
GWP No 4044-10-00

SHEET

HIGHWAY 62
RAWDON CREEK
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole
⊕	Borehole and Cone
⊕	Preliminary Borehole (by Others)
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
16-1	133.9	4 911 349.9	226 860.0
16-2	133.1	4 911 368.8	226 849.7
16-3	131.4	4 911 384.3	226 831.1
16-4	131.4	4 911 402.0	226 824.8
RC-1	132.5	4 911 391.0	226 840.6
RC-2	133.1	4 911 360.5	226 848.2

-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.
3) Borehole locations are shown in MTM Zone 9 coordinates.

GEOCRES No. 31C-256

LICENSED PROFESSIONAL ENGINEER
PAUL CARNAFFAN
90418075
May 15/17
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P.R. CHATTERJI
May 15/17
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	KP	CHK –	CODE	LOAD	DATE APR 2017
DRAWN	MFA	CHK KP	SITE 11-134	STRUCT	DWG 1

FILENAME: K:\Drafting\14000\14392\TED-14392-BHPP-RC.dwg
PLOTDATE: 4/25/2017 1:01 PM

APPENDIX B

2016 INVESTIGATION
RECORD OF BOREHOLE SHEETS
BEDROCK CORE PHOTOGRAPHS

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SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an “A” size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

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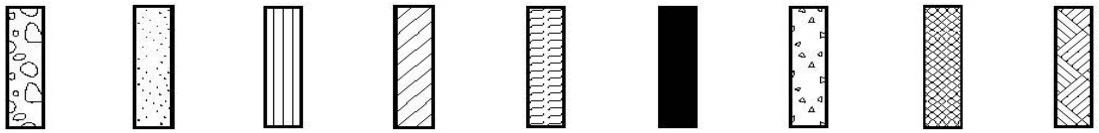
STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel

Sand

Silt

Clay

Organics

Asphalt

Concrete

Fill

Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

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MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L= Liquid Limit

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EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
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 structures are preserved.

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 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-1 1 OF 2 METRIC

GWP# 4044-10-00 LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 349.9 E 226 860.0 ORIGINATED BY CAM

HWY 62 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CAM

DATUM Geodetic DATE 2016.10.04 - 2016.10.04 CHECKED BY KCP

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
133.9											
0.0 / 0.1	**75 mm ROOTMAT**										
	Silty SAND (SM) with gravel Compact Brown		1	SS	28						
133.3 / 0.6											
	CLAY (Cl) Stiff to very stiff Brown		2	SS	17		133				0 12 35 53
			3	SS	21		132				
131.6 / 2.3											
	SILT (ML) Loose to compact Grey		4	SS	10		131				
			5	SS	11						0 1 92 7
			6	SS	9		130				
129.5 / 4.4											
	Sandy SILT (ML) to **Silty SAND (SM)** Very loose to compact Brown		7	SS	5		129				
							128				
	- slight hydro-carbon odour in sample SS8		8	SS	11	▼					
							127				
			9	SS	2		126				0 49 51 (SI+CL)
125.7 / 8.2											
	Silty GRAVEL (GM) with sand, **TILL** - frequent cobbles and boulders Very dense Brown						125				
			10	SS	91						41 32 27 (SI+CL)
123.9							124				

Continued Next Page

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

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

ONTMT4S RAWDON CREEK BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 25/4/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-1 2 OF 2 METRIC

GWP# 4044-10-00 LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 349.9 E 226 860.0 ORIGINATED BY CAM

HWY 62 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CAM

DATUM Geodetic DATE 2016.10.04 - 2016.10.04 CHECKED BY KCP

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										
10.0	End of Borehole Split Spoon refusal on inferred boulders Groundwater level was measured in the open borehole at 6.5 m BGS (elev. 127.4 m)		11	SS	100/ 125mm						

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

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

ONTMT4S RAWDON CREEK BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 25/4/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-2 1 OF 2 METRIC

GWP# 4044-10-00 LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 368.8 E 226 849.7 ORIGINATED BY CAM

HWY 62 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY CAM

DATUM Geodetic DATE 2016.10.04 - 2016.10.04 CHECKED BY KCP

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
133.1											
0.0	**75 mm ROOTMAT**						133				
0.1	**Silty SAND (SM)** with gravel - frequent cobbles Compact Brown		1	SS	10				○		
132.5											
0.6	**CLAY (Cl)** Stiff Brown		2	SS	13		132		○		
			3	SS	12				○		
130.8							131				
2.3	**SILT (ML)** Compact Grey		4	SS	14				○		0 7 87 6
130.2											
2.9	**Sandy SILT (ML)** to **Silty SAND (SM)** Loose to compact Brown		5	SS	9		130		○		
			6	SS	12		129		○		
			7	SS	6				○		0 23 73 4
							128				
			8	SS	10		127		○		
							126				
			9	SS	6		125		○		
124.2											
8.8	**Silty SAND (SM)** with gravel, **TILL** - frequent cobbles and occasional boulders Dense Brown		10	SS	46		124		○		35 50 15 (SI+CL)

Continued Next Page

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

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

ONTMT4S RAWDON CREEK BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 25/4/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-2 2 OF 2 METRIC

GWP# 4044-10-00 LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 368.8 E 226 849.7 ORIGINATED BY CAM

HWY 62 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY CAM

DATUM Geodetic DATE 2016.10.04 - 2016.10.04 CHECKED BY KCP

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
122.9							123				
10.2	**BEDROCK** Limestone Slightly weathered Moderate bedding Strong to very strong strength Good to excellent quality Grey		1	HQ			122				RUN #1 TCR=100% SCR=100% RQD=88%
			2	HQ			121				RUN #2 TCR=100% SCR=100% RQD=100%
119.5			3	HQ			120				RUN #3 TCR=100% SCR=100% RQD=100%
13.6	End of Borehole Groundwater level measured in monitoring well at 1.5 m BGS (elev. 131.6 m) on 2017/04/10										

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

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

ONTMT4S RAWDON CREEK BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 25/4/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-3 1 OF 2 METRIC

GWP# 4044-10-00 LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 384.3 E 226 831.1 ORIGINATED BY CAM

HWY 62 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY CAM

DATUM Geodetic DATE 2016.10.03 - 2016.10.03 CHECKED BY KCP

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
131.4											
0.0	**150 mm ROOTMAT**										
0.2	**Silty SAND (SM)** with gravel Very loose to compact Brown		1	SS	3		131				
			2	SS	15		130				
129.7											
1.7	**Sandy SILT (ML)** to **Silty SAND (SM)** Loose to compact Brown		3	SS	11		129				
			4	SS	16						
			5	SS	10		128				0 28 69 3
			6	SS	10						0 43 57 (SI+CL)
			7	SS	5		127				
125.0							126				
6.4	**Silty SAND (SM)** with gravel, **TILL** - frequent cobbles and occasional boulders Very dense Brown		8	SS	100/ 200mm		125				
			9	SS	100/ 175mm		124				
	- Boulder at 7.7 m to 8.0 m		10	SS	73						22 59 19 (SI+CL)
122.6							123				
8.8	**BEDROCK** Limestone Slightly weathered Thinly to moderate bedding Strong to very strong strength Excellent quality Grey		1	HQ			122				RUN #1 TCR=100% SCR=100% RQD=100%

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-3 2 OF 2 METRIC

GWP# 4044-10-00 LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 384.3 E 226 831.1 ORIGINATED BY CAM

HWY 62 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY CAM

DATUM Geodetic DATE 2016.10.03 - 2016.10.03 CHECKED BY KCP

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										
	BEDROCK Limestone Slightly weathered Moderate bedding Strong to very strong strength Good to excellent quality Grey		2	HQ			121				RUN #2 TCR=98% SCR=98% RQD=81%
			3	HQ			120				RUN #3 TCR=100% SCR=100% RQD=100%
119.1											
12.3	End of Borehole Groundwater level measured in the monitoring well at 0.01 m BGS (elev. 131.4 m) on 2017/04/10										

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

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

ONTMT4S RAWDON CREEK BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 25/4/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-4 1 OF 1 METRIC

GWP# 4044-10-00 LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 402.0 E 226 824.8 ORIGINATED BY CAM

HWY 62 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CAM

DATUM Geodetic DATE 2016.10.04 - 2016.10.04 CHECKED BY KCP

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
131.4											
0.0 / 0.1	**50 mm ROOTMAT**										
	Silty SAND (SM) with gravel Very loose to compact Brown to grey		1	SS	4		131				
			2	SS	3		130				
	- slight hydro-carbon odour in sample SS3		3	SS	22						
129.1											
2.3	**Sandy SILT (ML)** to **Silty SAND (SM)** Loose to compact Brown		4	SS	13		129				6 46 48 (SI+CL)
			5	SS	9		128				
			6	SS	2	▼	127				
126.2			7	SS	6						
5.2	**Silty SAND (SM)** with gravel, **TILL** - frequent cobbles and occasional boulders Very dense Brown		8	SS	77		126 / 125				29 50 21 (SI+CL)
124.5			9	SS	100/50mm						
6.9	End of Borehole Split Spoon refusal on inferred boulder Groundwater level was measured in the open borehole at 3.9 m BGS (elev. 127.5 m)										

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

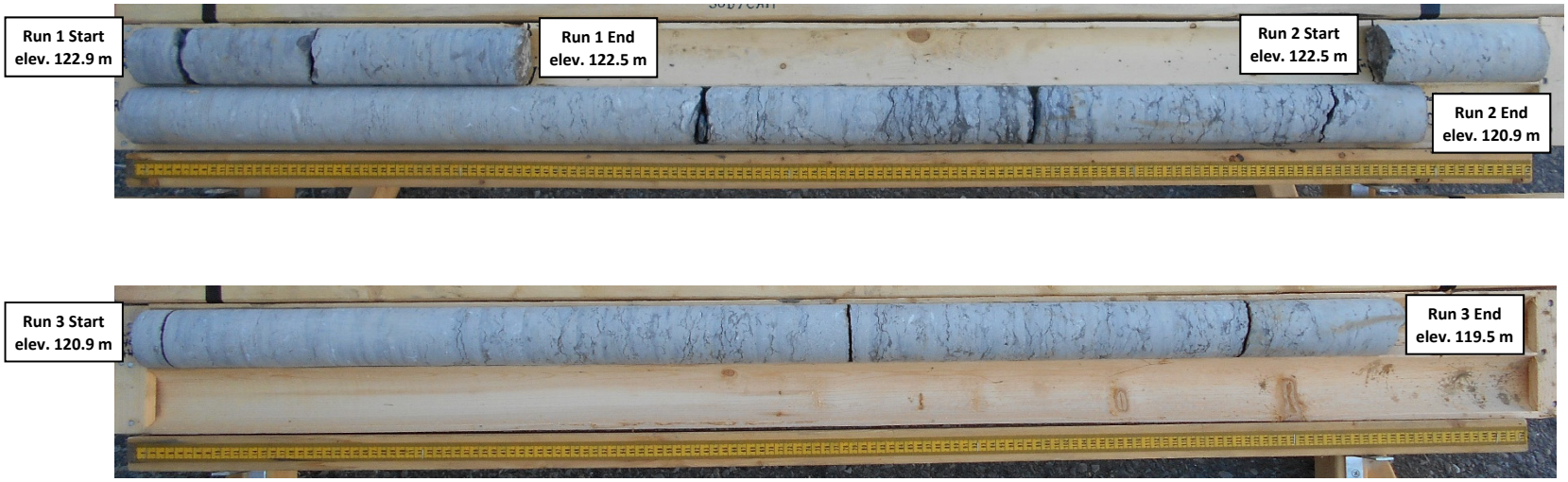
20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S RAWDON CREEK BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 25/4/17

Borehole 16-2

Run 1 to 3 (of 3)

Elevation 122.9 m to 119.5 m



THURBER ENGINEERING LTD.

Foundation Investigation
Highway 62 – Rawdon Creek Bridge
Site 11-134
Township of Huntingdon, Ontario

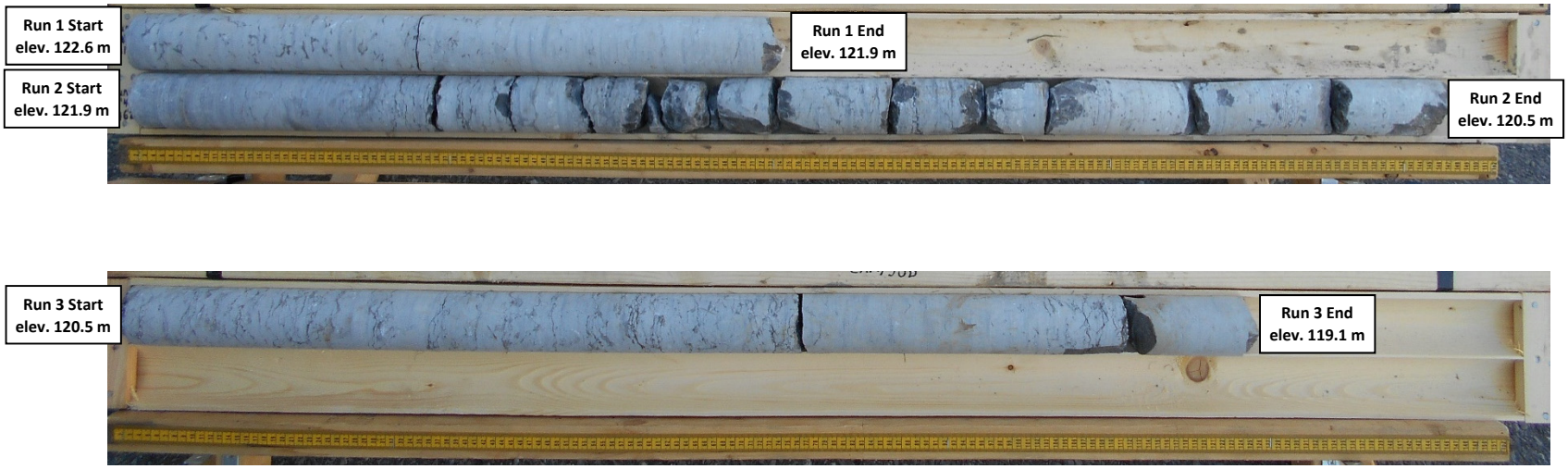
GWP: 4044-10-00

Project No.: 14392

Borehole 16-3

Run 1 to 3 (of 3)

Elevation 122.6 m to 119.1 m



THURBER ENGINEERING LTD.

Foundation Investigation
Highway 62 – Rawdon Creek Bridge
Site 11-134
Township of Huntingdon, Ontario

GWP: 4044-10-00

Project No.: 14392

APPENDIX C

PRELIMINARY INVESTIGATION
BOREHOLE LOCATIONS AND SOIL STRATA DRAWINGS
RECORD OF BOREHOLE SHEETS

MINISTRY OF TRANSPORTATION, ONTARIO

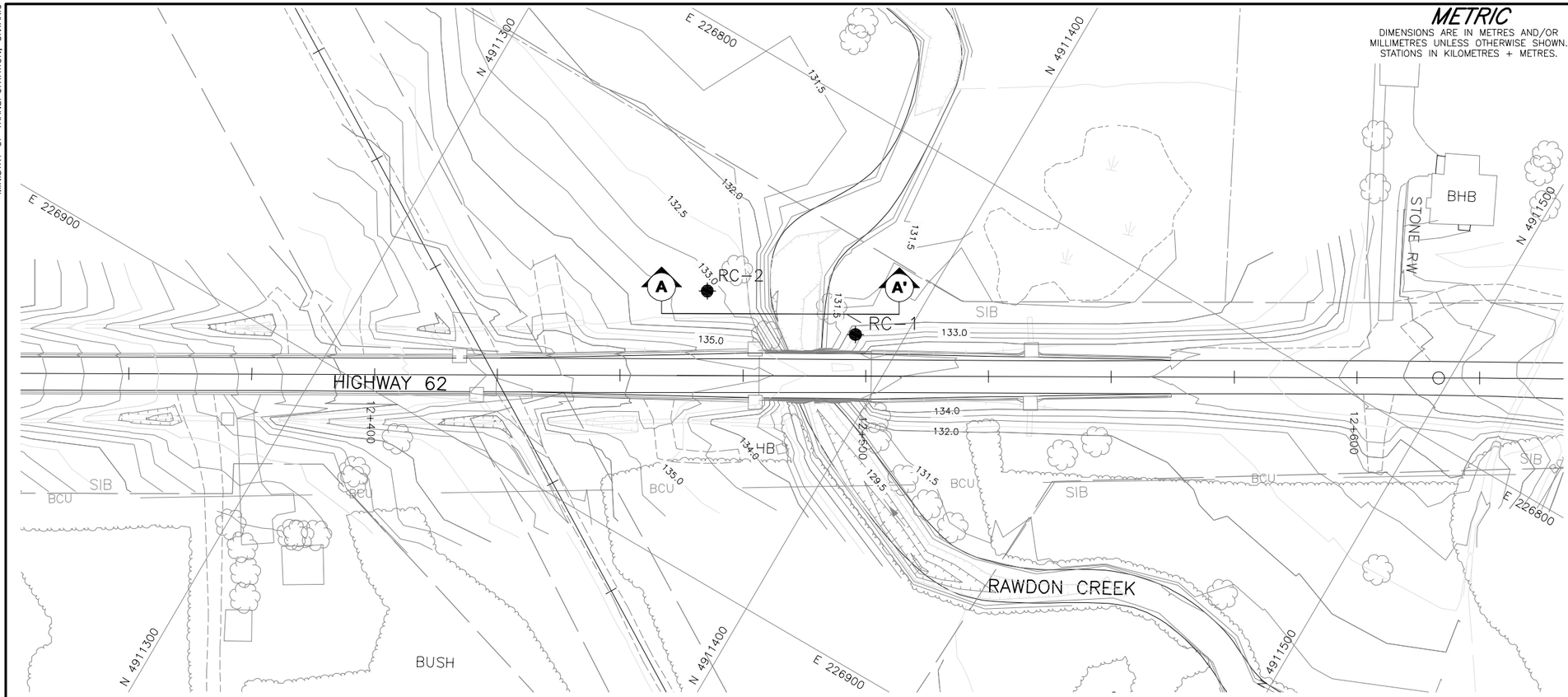
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4044-10-00

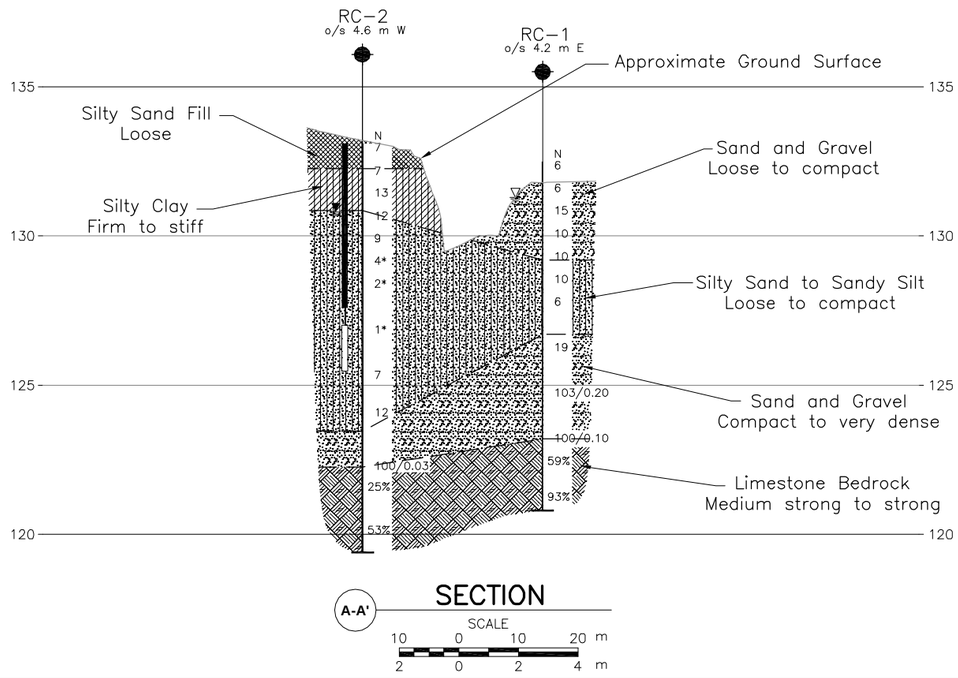
SHEET

HIGHWAY 62
RAWDON CREEK BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

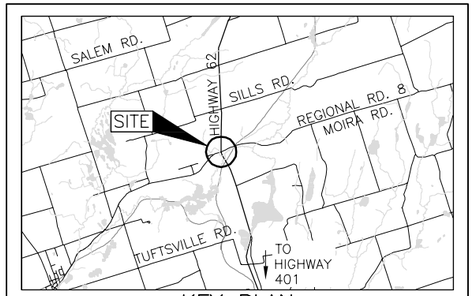
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
SCALE
10 0 10 20 m



A-A'
SECTION
SCALE
10 0 10 20 m
2 0 2 4 m



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- WL in piezometer, measured on November 29, 2012
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
RC-1	132.5	4911391.0	226840.6
RC-2	133.1	4911360.5	226848.2

DRAFT

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the preliminary design configuration as shown elsewhere in the Preliminary Design Report.

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

The complete Preliminary Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by URS, drawing file no.s ACAD-Contours_OG-Hwy62.dwg and ACAD-X-Base_Hwy62.dwg, received December 17, 2012.

NO.	DATE	BY	REVISION

Geocres No.

HWY. 62	PROJECT NO. 12-1111-0021		DIST. Eastern
SUBM'D. BM	CHKD. LCC	DATE: 2/5/2013	SITE: 11-134
DRAWN: JFC	CHKD. PKS	APPD. LCC	DWG. 1

PLOT DATE: February 5, 2013
FILENAME: I:\Projects\2012\12-1111-0021 (URS, Hastings County)\-BH-(HIGHWAY #62)\121111002 BH001.dwg

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)
A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	**Blows/300 mm or Blows/ft**
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils
Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

Golder Associates

RECORD OF BOREHOLE No RC-1

SHEET 1 OF 2

METRIC

PROJECT 12-1111-0021
W.P. 4044-10-00
DIST Eastern HWY 35
DATUM Geodetic

LOCATION N 4911391.0 ;E 226840.6
BOREHOLE TYPE CME-55, 108 mm I.D. Continuous Flight Hollow Stem Auger
DATE November 13, 2012

ORIGINATED BY BM
COMPILED BY MAS
CHECKED BY LCC

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 (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
132.5	GROUND SURFACE										
0.0	SAND and GRAVEL, trace clay, trace to some silt, containing cobbles and rootlets Loose to compact Brown to grey Moist becoming wet at approximately 1.2 m depth		1	SS	6		132		o		
			2	SS	6	▽					
			3	SS	15		131		o		31 56 10 3
			4	SS	10		130				
129.2											
3.3	Silty SAND to Sandy SILT Compact to loose Grey Wet		5	SS	10		129				
			6	SS	10				o		0 40 60 0
			7	SS	6		128				
126.7							127				
5.8	SAND and GRAVEL, trace silt, trace clay, containing cobbles and boulders Compact to very dense Grey Wet		8	SS	19		126		o		
			9	SS	103/0.20		125		o		42 50 6 2
123.2			10	SS	100/0.10		124				
9.3	Limestone (BEDROCK) Bedrock cored from 9.3 m to 11.7 m For bedrock coring details, refer to Record of Drillhole RC-1		1	RC	REC 66%		123				RQD = 59%
			2	RC	REC 98%		122				RQD = 93%
120.8							121				
11.7	END OF BOREHOLE NOTE: 1. Water encountered at a depth of approximately 1.2 m (Elev. 131.3 m) during drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 12-1111-0021.GPJ GAL-GTA.GDT 4/28/14 DD

PROJECT: 12-1111-0021

RECORD OF DRILLHOLE: RC-1

SHEET 2 OF 2

LOCATION: N 4911391.0 ;E 226840.6

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Track Mount

DRILLING CONTRACTOR: Strong Soil Search

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate; BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage; PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular; PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break; BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA β Angle	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole RC-1		123.20																		
10		Limestone (BEDROCK) Slightly weathered to fresh Thinly laminated Grey Medium strong to very strong		9.30	1																	(Axial)
11					2																	
				120.80																		
		END OF DRILLHOLE		11.70																		
12																						
13																						
14																						
15																						
16																						
17																						
18																						
19																						

GTA-RCK 004 12-1111-0021.GPJ GAL-MISS.GDT 4/28/14 DD

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: BM

CHECKED: LCC

Golder Associates

RECORD OF BOREHOLE No RC-2

SHEET 1 OF 3

METRIC

PROJECT 12-1111-0021
W.P. 4044-10-00
DIST Eastern HWY 35
DATUM Geodetic

LOCATION N 4911360.5 ;E 226848.2
BOREHOLE TYPE CME-55, 108 mm I.D. Continuous Flight Hollow Stem Auger
DATE November 13, 2012

ORIGINATED BY BM
COMPILED BY MAS
CHECKED BY LCC

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 (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
133.1	GROUND SURFACE						133				
0.0	Silty sand, trace clay, trace gravel (FILL) Loose Brown Moist		1	SS	7						
132.3											
0.8	SILTY CLAY with sand, containing rootlets Firm to stiff Brown Moist		2	SS	7		132				0 25 45 30
			3	SS	13						
130.9											
2.2	Silty SAND to Sandy SILT Loose to compact Brown becoming grey at approximately 3.7 m depth Wet		4	SS	12	▽	131				
			5	SS	9		130				0 24 76 0
			6	SS	4*		129				
			7	SS	2*		128				
			8	SS	1*		127				0 72 27 1
			9	SS	7		126				
			10	SS	12		125				
123.5							124				
9.6	SAND and GRAVEL, containing cobbles and boulders Very dense Grey Wet		11	SS	100/0.0		123				
122.3											
10.8	Limestone (BEDROCK) Bedrock cored from 10.8 m to 13.7 m For bedrock coring details, refer to Record of Drillhole RC-2		1	RC	REC 58%		122				RQD = 25%
			2	RC	REC 84%		121				RQD = 53%
119.4							120				
13.7											

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No RC-2

SHEET 2 OF 3

METRIC

PROJECT 12-1111-0021

W.P. 4044-10-00 LOCATION N 4911360.5 ;E 226848.2 ORIGINATED BY BM

DIST Eastern HWY 35 BOREHOLE TYPE CME-55, 108 mm I.D. Continuous Flight Hollow Stem Auger COMPILED BY MAS

DATUM Geodetic DATE November 13, 2012 CHECKED BY LCC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100	WATER CONTENT (%): 10 20 30	kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE										

NOTES:

* SPT "N" values considered to be affected by sample disturbance due to groundwater inflow in borehole.

1. Water encountered at a depth of approximately 2.3 m (Elev. 130.8 m) during drilling.

2. Water level in piezometer measured as follows

Date	Depth (m)	Elev. (m)
11/13/12	2.3	130.8
11/29/12	2.4	130.7

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

PROJECT: 12-1111-0021

RECORD OF DRILLHOLE: RC-2

SHEET 3 OF 3

LOCATION: N 4911360.5 ;E 226848.2

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track Mount

DRILLING CONTRACTOR: Strong Soil Search

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate; BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage; PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular; PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break; BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole RC-2		122.30																		
11		Limestone (BEDROCK) Slightly weathered to fresh Thinly laminated Grey Medium strong to very strong		10.80	1																	(Axial)
12																						
13					2																	(Axial)
				119.40																		
		END OF DRILLHOLE		13.70																		
14																						
15																						
16																						
17																						
18																						
19																						
20																						

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: BM
CHECKED: LCC

GTA-RCK 004 12-1111-0021.GPJ GAL-MISS.GDT 4/28/14 DD

APPENDIX D

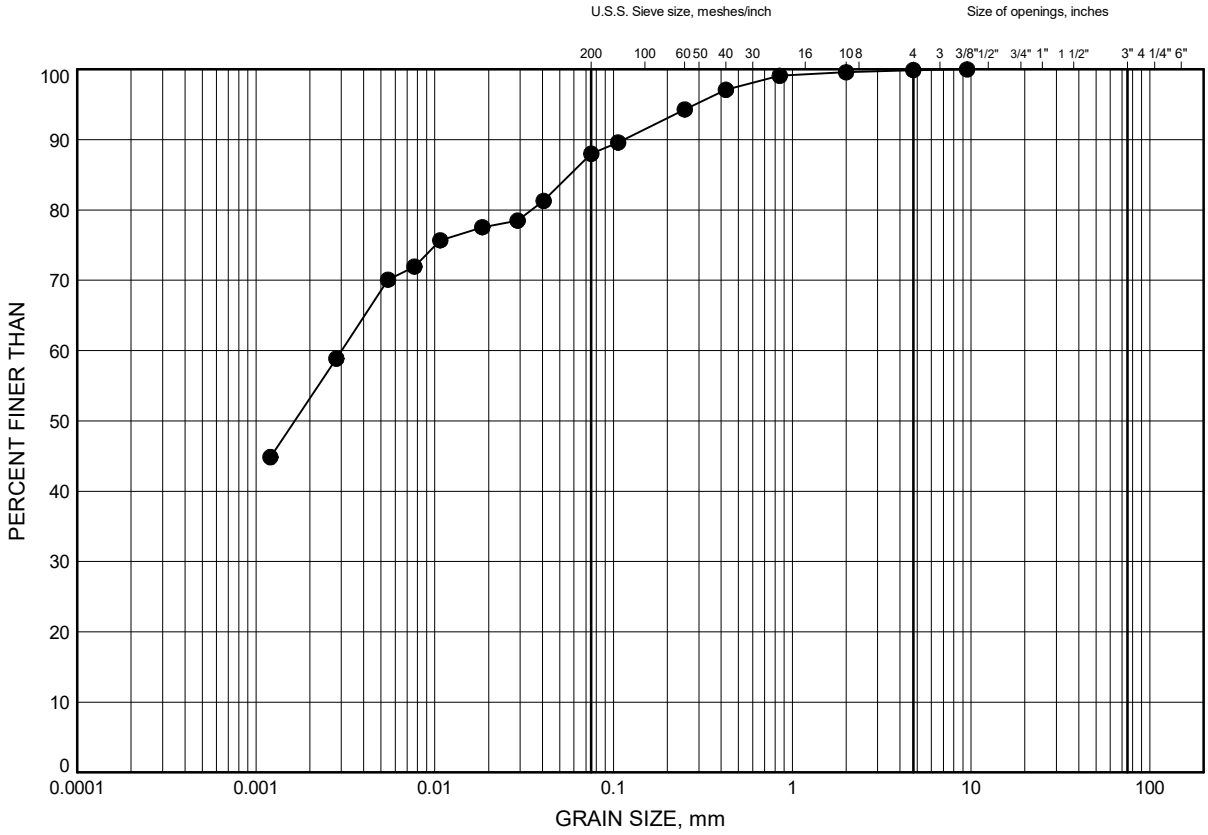
LABORATORY TEST RESULTS

Site 11-134 - Highway 62 Rawdon Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE 1

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-1	1.07	132.82

Date November 2016

GWP# 4044-10-00

THURBER

Prep'd KCP

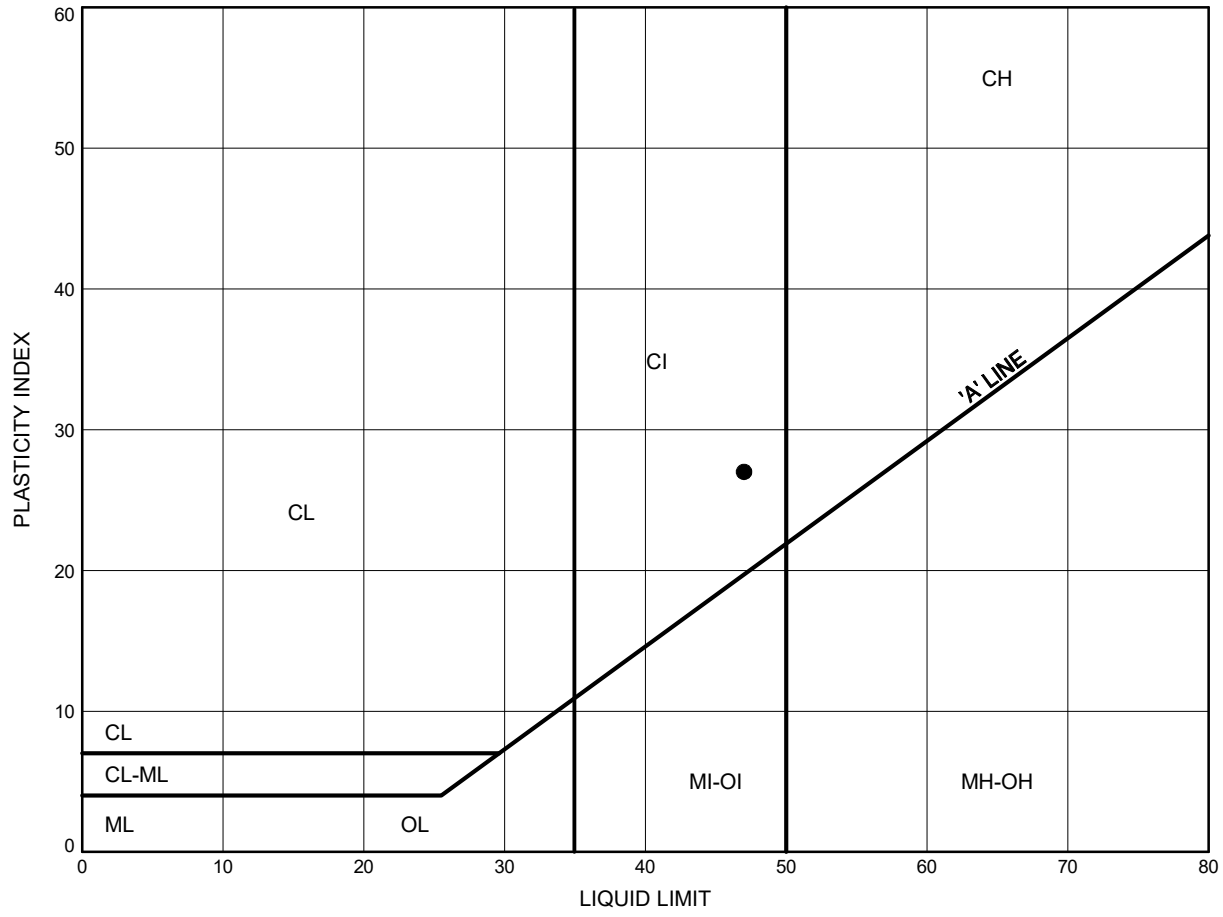
Chkd. PC

GRAIN SIZE DISTRIBUTION - THURBER RAWDON CREEK BRIDGE.GPJ 15/11/16

Site 11-134 - Highway 62 Rawdon Creek Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-1	1.07	132.82

Date November 2016

GWP# 4044-10-00

THURBER

Prep'd KCP

Chkd. PC

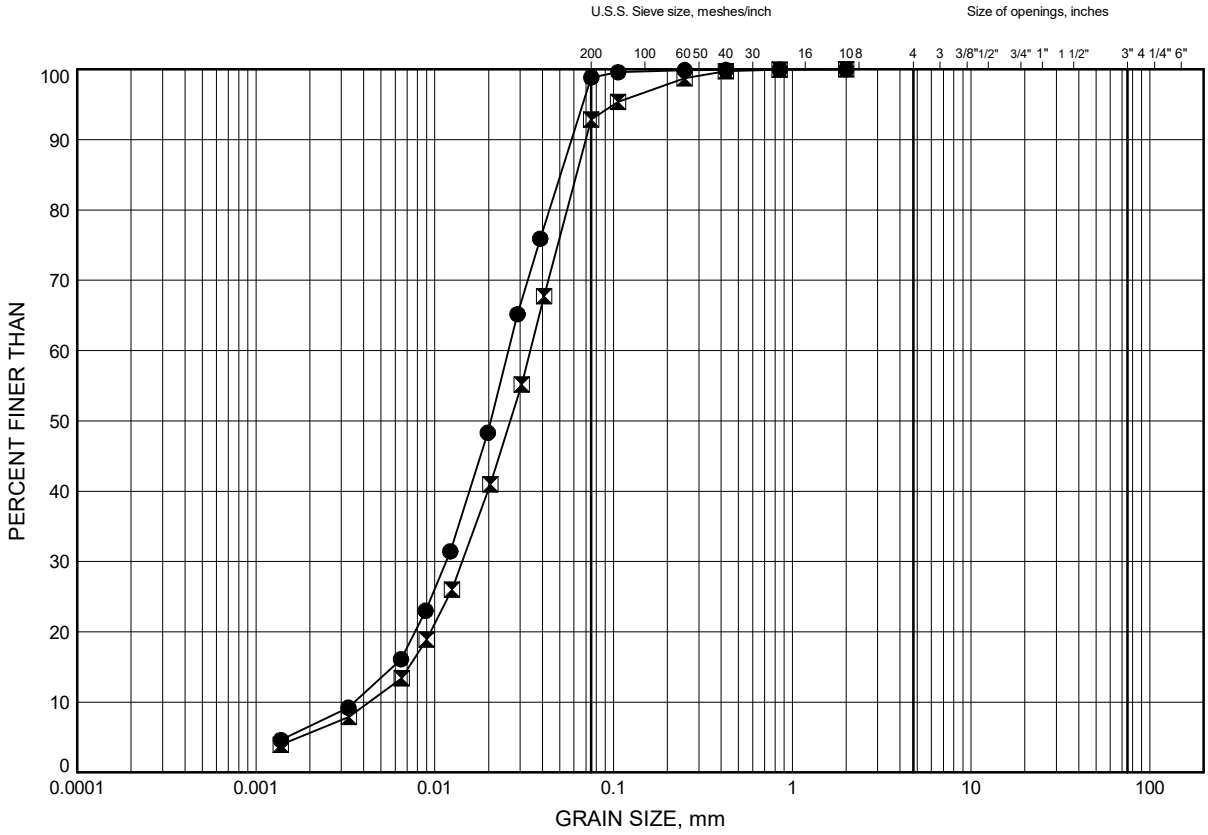
THURBALT RAWDON CREEK BRIDGE.GPJ 15/11/16

Site 11-134 - Highway 62 Rawdon Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE 3

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-1	3.35	130.54
⧓	16-2	2.59	130.48

Date November 2016

GWP# 4044-10-00

THURBER

Prep'd KCP

Chkd. PC

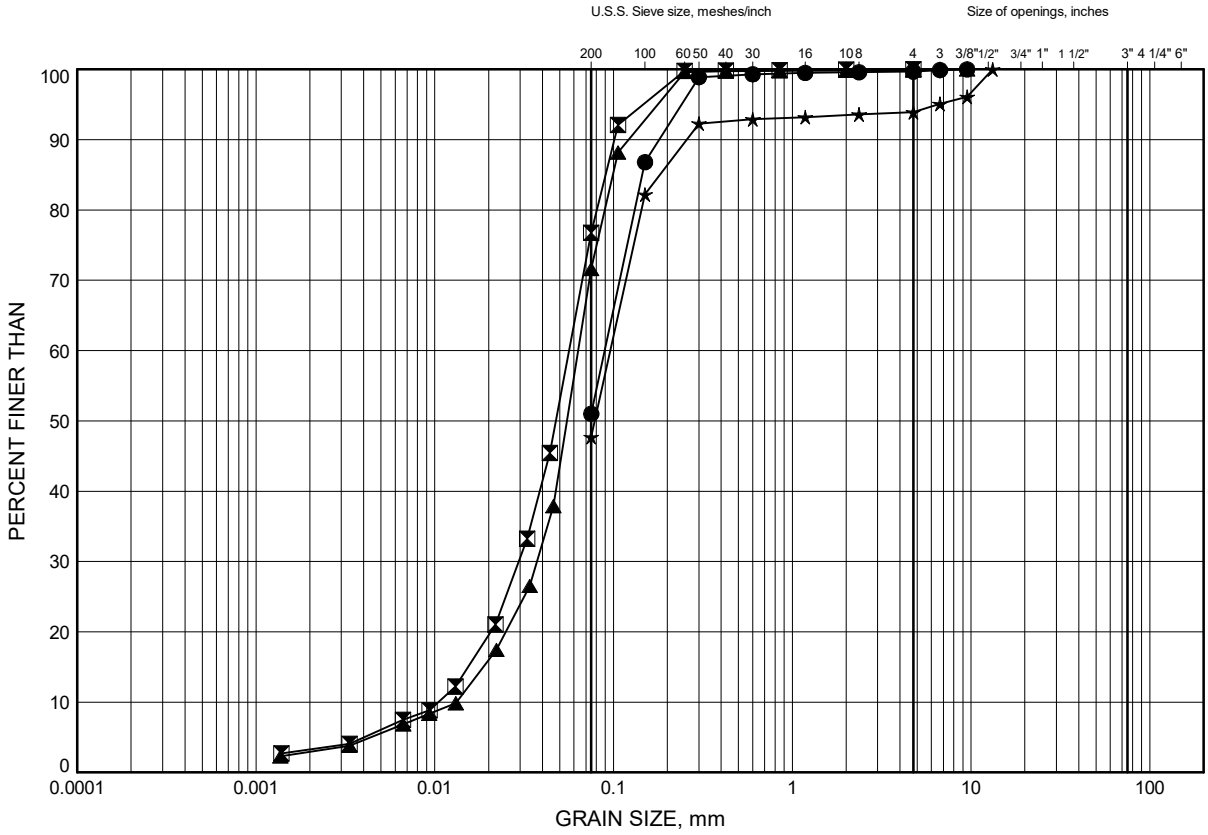
GRAIN SIZE DISTRIBUTION - THURBER RAWDON CREEK BRIDGE.GPJ 15/11/16

Site 11-134 - Highway 62 Rawdon Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE 4

Sandy Silt to Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-1	7.92	125.96
⊠	16-2	4.88	128.19
▲	16-3	3.35	128.04
★	16-4	2.59	128.84

Date November 2016

GWP# 4044-10-00

THURBER

Prep'd KCP

Chkd. PC

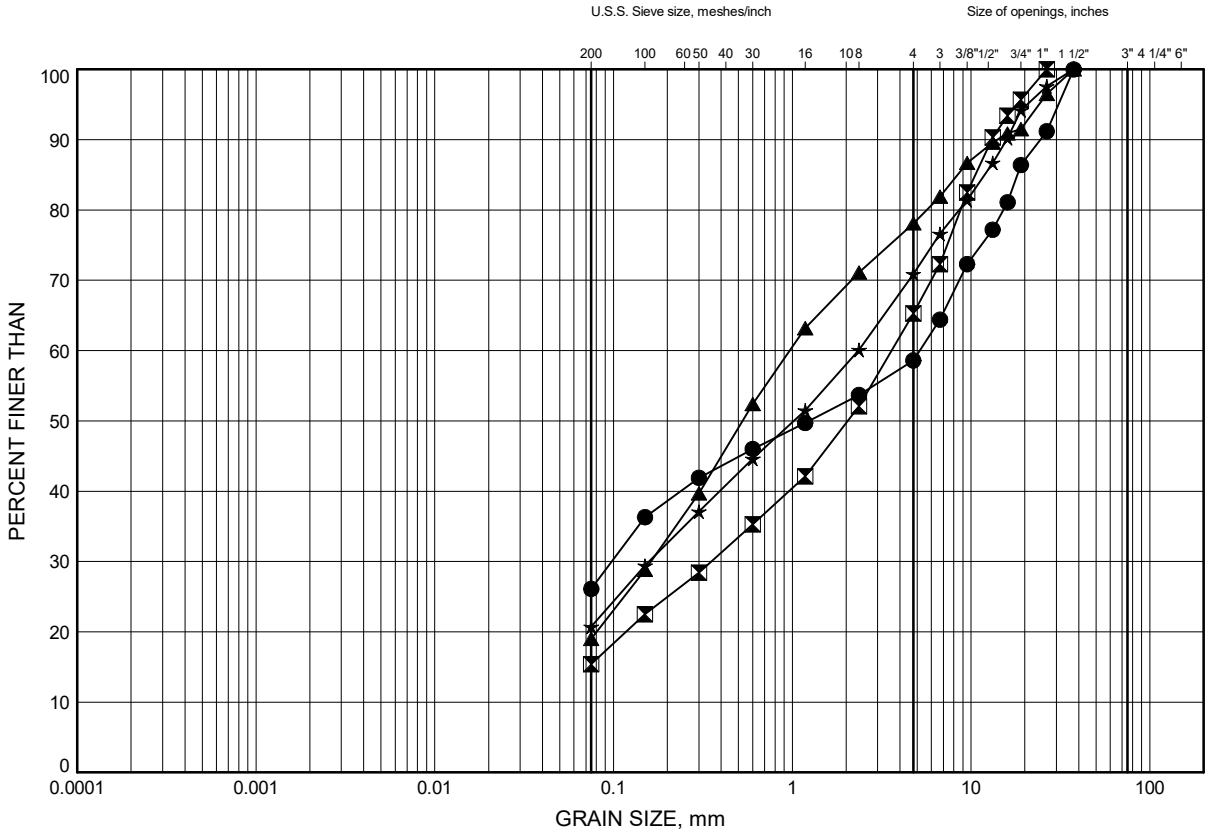
GRAIN SIZE DISTRIBUTION - THURBER RAWDON CREEK BRIDGE.GPJ 16/11/16

Site 11-134 - Highway 62 Rawdon Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE 5

Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-1	9.45	124.44
⊠	16-2	9.45	123.62
▲	16-3	7.92	123.47
★	16-4	6.40	125.03

Date November 2016

GWP# 4044-10-00

THURBER

Prep'd KCP

Chkd. PC

GRAIN SIZE DISTRIBUTION - THURBER RAWDON CREEK BRIDGE.GPJ 15/11/16

Determination of the Point Load Strength Index

THURBER

Project Name:	Site 11-134 - Highway 62 Rawdon Creek Bridge	**Client:**	MPCE-LEA
Project No:	GWP: 4044-10-00	**Date Sampled:**	October 4, 2016
Borehole No:	16-2	**Date Tested:**	November 22, 2016
Core Size:	HQ	**Lab Technician:**	CAM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	10.6	D	12.48	63.5	85.0	78.4	Limestone	Strong
2	1	10.6	A	27.84	63.5	70.0	134.5	Limestone	Very Strong
3	2	11.6	A	21.37	63.5	70.0	103.2	Limestone	Very Strong
4	2	11.4	D	9.78	63.5	85.0	61.5	Limestone	Strong
5	3	12.3	A	27.96	63.5	70.0	135.1	Limestone	Very Strong
6	3	12.4	D	24.15	63.5	95.0	151.7	Limestone	Very Strong

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
  Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have 0.7 x D on either side of test point.

APPENDIX E

SITE PHOTOGRAPHS

Figure 1: Looking north toward Rawdon Creek along the new alignment for Highway 62 from the south approach

Figure 2: Looking north along the new alignment for Highway 62 from Borehole 16-3

Figure 3: Looking south towards Rawdon Creek

Figure 4: Looking west from existing bridge towards proposed Rawdon Creek crossing