



THURBER ENGINEERING LTD.

FINAL
FOUNDATION INVESTIGATION REPORT
HIGHWAY 11 BULLEN CREEK CULVERTS, DISTRICT OF MUSKOKA
AGREEMENT NO. 5017-E-0003
Site Nos.: 42X-0034/C1 & 42X-0034/C2

G.W.P. 5138-13-00

Geocres No.: 31E-390

Report to:

McIntosh Perry Consulting Engineers Limited

Latitude: 45.251030
Longitude: -79.297444

February 2019
Thurber File: 20244

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed at the Highway 11 crossings of Bullen Creek located approximately 0.5 km south of Allensville Road within the District of Muskoka. Thurber Engineering Limited (Thurber) carried out the current field investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Assignment No. 5017-E-0003.

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 profile, laboratory test results, and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation. The following historical foundation investigation report was obtained from the online Geocres library and reviewed in preparation of this report.

Foundation Investigation Report for The Proposed Crossing at Unnamed Creek and Bullen (Lancelot) Creek, Highway 11, Line E (North Bound Lane), District 11 (Huntsville), District of Muskoka, W.P. 149-73-01, Ministry of Transportation and Communications - Ontario (1976). [Geocres 31E-33]

2 SITE DESCRIPTION

Separate culverts convey Bullen Creek from west to east beneath the Highway 11 southbound and northbound embankments.

The west culvert (Structure No. 42X-0034/C2) is located under the southbound lanes and has a span width of 6.1 m, a height of 3.6 m and a length of 33 m. The structure is understood to have been constructed in 1956. No wingwalls or headwalls are present at the culvert ends. This culvert is described in the RFP for this assignment as an open footing, rigid frame concrete culvert.

The east culvert (Structure No. 42X-0034/C1) is located under the northbound lanes and has a span width of 6.1 m, a height of 3.0 m and a length of 38.4 m. The structure is understood to have been constructed in 1978. No wingwalls or headwalls are present at the culvert ends. This culvert is described in the RFP as a rigid frame concrete box culvert. The

FINAL

historic foundation report recommends a closed box culvert or an open bottom culvert supported on piles for this site.

The creek bed elevations are 281.0 m at the inlet of the west culvert and 280.6 m at the outlet of the east culvert.

At the location of the culverts, Highway 11 is a four-lane divided highway with a rural cross-section and paved shoulders. The Highway 11 fill height above the culverts is approximately 2.8 m with the road surfaces at approximate elevations 287.4 and 287.3 m for the southbound and northbound lanes, respectively. The existing embankment slopes are inclined at approximately 2H:1V. Near the culverts, steel guiderails with steel posts are present along both the outside and median shoulders.

The land adjacent to the highway is vegetated with grasses, shrubs and trees. Traffic volumes on this section of Highway 11 are understood to be 19,700 AADT (2016).

Select photographs showing the existing conditions in the area of the culverts at the time of the field investigation are included in Appendix D for reference.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program was carried out between April 19th and April 21st, 2018. The field investigation consisted of advancing four boreholes identified as 18-1 through 18-4. The drilling was carried out using a truck mounted CME 55 drill rig. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A thin walled (Shelby) tube sample was attempted at 6.1 m depth in Borehole 18-2, however a soil sample was not recovered. The boreholes were all sampled to 18.4 m (elev. 268.7 to 269.1 m) below the existing ground surface.

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

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevation of the boreholes are provided on this drawing and on the individual Record of Borehole sheets. The northing and easting (MTM zone 10), elevation, and termination depth of the boreholes are summarized below in Table 3-1. The borehole elevations were surveyed relative to benchmark VCP 313 (elev. 285.649 m) provided by MPCE, with a Nikon-AP-8 with an accuracy of +/- 1.5 mm. Horizontal locations were measured relative to existing site features.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
18-1	SB Lane 1, north of culvert	5 012 371.2	320 684.5	287.4	18.4
18-2	SB Lane 1, south of culvert	5 012 358.9	320 682.7	287.5	18.4
18-3	NB Lane 1, north of culvert	5 012 366.0	320 714.7	287.2	18.4
18-4	NB Lane 1, south of culvert	5 012 354.2	320 713.0	287.3	18.4

Following completion of the field investigation the boreholes were backfilled in accordance with MOE requirements (O.Reg. 903 as amended). All boreholes were backfilled with granulars within the depth of pavement structure and capped with 150 mm of cold patch asphalt to reinstate the traveling surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limit testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. One sample from the native silt deposit in Borehole 18-2 was selected for organic content testing. One sample of soil recovered from within each of Boreholes 18-1 and 18-4 was selected and submitted for analytical testing of corrosivity parameters and sulphate content. All laboratory test results from the field investigation are provided in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

The historic boreholes from Geocres Report 31E-33 have also been included in Appendix B and their locations indicated on Drawing No. 1497301-B in Appendix A. The locations and ground surface elevation for these boreholes are approximate. It is expected that conditions have changed due to the roadway and culvert construction that have occurred since these holes were drilled in 1974, therefore the historic documents have not been included in the following descriptions.

In general terms, the site was found to be underlain by a pavement structure, sand or silt fill overlying, native silt and sandy silt deposits. The native silt directly below the fill was noted to contain organics. Bedrock was not encountered within the depth of the current investigation.

5.1 Fill

5.1.1 Asphalt

All boreholes were drilled through the existing Highway 11 embankment and encountered a layer of asphalt with a thickness of 200 to 210 mm.

5.1.2 Pavement Structure

Below the asphalt a layer of granular pavement material consisting of sand some gravel to gravel with sand was encountered. The underside of the pavement granular was at 0.4 to 1.5 m (elev. 285.7 to 287.0 m) below the existing roadway.

Two SPT tests were conducted in this fill with N-values of 9 and 15 blows indicating a relative density of loose to compact.

Recorded moisture contents ranged from 3 to 13%. The results of a grain size analysis conducted on a single sample of the pavement granular are summarized below and are illustrated on Figure C1 in Appendix C.

Soil Particle	Percentage (%)
Gravel	37
Sand	62
Silt	1
Clay	

5.1.3 Embankment Fill: Silt

Below the pavement structure in Boreholes 18-3 and 18-4 was a layer of fill consisting predominantly of silt some clay. The underside of the silt fill was at 3.2 and 3.5 m (elev. 283.9 and 283.8 m) below the existing roadway surface in Boreholes 18-3 and 18-4, respectively.

The SPT tests conducted in this fill gave N-values ranging from 13 to 23 blows indicating a relative density of compact.

Recorded moisture contents ranged from 14 to 23%. An Atterberg Limits test indicated that the material is non-plastic. The results of grain size analysis conducted on a single sample of the silt embankment fill are summarized below and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	1
Silt	86
Clay	13

5.1.4 Embankment Fill: Sand

Below the pavement structure in Boreholes 18-1 and 18-2 and below the silt fill in Boreholes 18-3 and 18-4 was a layer of fill consisting of sand with silt and gravel to silty sand some gravel. Occasional cobbles were noted within this layer. The fill had a thickness of 3.1 to 5.4 m and an underside depth of 4.4 to 6.6 m (elev. 280.7 to 283.0 m) below the existing roadway surface.

The SPT tests conducted in this fill gave typical N-values ranging from 2 to 30 blows indicating a relative density of very loose to compact. A single N-value equivalent to the weight of hammer was noted in Borehole 18-4.

Recorded moisture contents ranged from 4 to 16%. The results of grain size analyses conducted on four samples of the sand fill are summarized below and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	14 - 27
Sand	62 - 75
Silt	6 - 17
Clay	

5.2 Silt (ML) to Sandy Silt with Organics/Wood

Directly below the embankment fill in all boreholes was a native silt to sandy silt material. Organics and/or wood fragments were encountered within this layer. The thickness of this layer ranged from 1.1 to 2.0 m with a base elevation ranging from 279.0 to 281.4 m.

The SPT tests conducted in this layer gave N-values ranging from 1 to 13 indicating a relative density of very loose to compact.

Recorded moisture contents ranged from 22 to 55%. Organic content testing was completed on one sample of the silt from Borehole 18-2 with a result of 7.5% organic content. The Atterberg Limit testing indicated the silt with organics was non-plastic. The results of grain size analyses conducted on four samples of the silt to sandy silt are summarized below and illustrated on Figure C3 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 - 1
Sand	6 - 46
Silt	50 - 83
Clay	3 - 11

5.3 Silt (ML) to Sandy Silt (ML)

All boreholes encountered a layer of silt with varying amounts of sand below the organic silt layer. Boreholes 18-1, 18-3, and 18-4 were terminated within this layer at a depth of 18.4 m with corresponding termination elevations ranging from 268.7 to 269.1 m. The thickness of this layer in Borehole 18-2 was 11.3 m with a base elevation 270.1 m.

The SPT tests conducted in this layer gave N-values ranging from weight of hammer (WH) to 26 indicating a relative density of very loose to compact. A thin walled (Shelby) tube sample was attempted in Borehole 18-2 however no material was recovered.

Recorded moisture contents ranged from 17 to 31%. Atterberg Limit testing on seven samples all indicated the material is non-plastic. The results of grain size analyses conducted on seven samples of the silt are summarized below and illustrated on Figures C4 and C5 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 - 1
Sand	0 - 36
Silt	64 - 95
Clay	0 - 10

5.4 Sand (SP)

A 0.8 m thick deposit of sand was encountered within the silt deposit in Borehole 18-2 at an elevation of 276.2 m. Borehole 18-2 was terminated within a deeper sand layer at a termination elevation of 269.0 m.

The SPT N-values in the sand layers were 12 and 17 blows indicating a relative density of compact.

The moisture content of the samples tested was 19%.

5.5 Bedrock

Bedrock was not encountered within the depth of the current investigation. Granitic gneiss bedrock was reported in historical Borehole 4, from Geocres Report No. 31E-33, at approximate elevation 265.9 m which corresponds to an approximate depth of 21.5 m below the existing pavement surface.

5.6 Groundwater

Accurate water levels could not be recorded in the open boreholes due to water being introduced as part of the drilling operations, however an unstabilized water level was recorded in Borehole 18-4 at a depth of 4.7 m (elev. 282.6 m) prior to switching drilling methods. It is expected that the groundwater level is likely to reflect the water level in the creek. The water level of Bullen's Creek was recorded at an elevation 281.5 m on April 19th, 2018.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

5.7 Analytical Testing

Two samples of soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity, and conductivity. The analysis results are summarized in the table below:

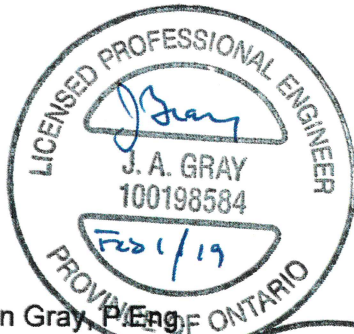
Borehole (sample)	Depth (mbgs)	Sulphate ($\mu\text{g/g}$)	pH (-)	Resistivity (Ohm-cm)	Conductivity ($\mu\text{S/cm}$)	Chloride ($\mu\text{g/g}$)	Sulphide %
18-1 (SS11)	7.1 - 7.7	200	7.44	2,500	400	23	0.40
18-4 (SS8)	5.3 - 5.9	5	6.10	2,130	469	291	<0.02

6 MISCELLANEOUS

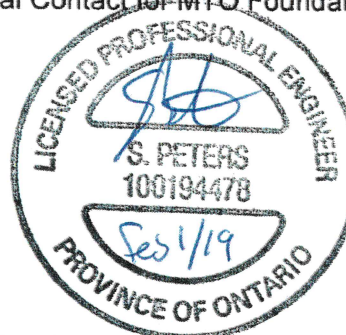
Borehole locations were selected by Thurber relative to the culvert and existing site features. The as-drilled locations and ground surface elevation of the boreholes were measured by Thurber following completion of the field program. Base plan drawings and survey benchmarks were provided by MPCE.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing and borehole decommissioning of the boreholes. The field investigation was supervised on a full-time basis by Miss Katya Edney P.Eng. of Thurber. Overall supervision of the field investigation program was provided by Mr. Stephen Peters, P.Eng.

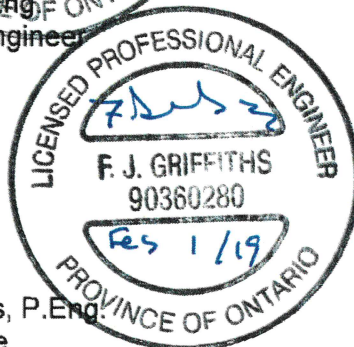
Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Organic content testing was completed by Stantec's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Justin Gray, P.Eng. and Mr. Stephen Peters P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng and Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



Justin Gray, P.Eng.
Geotechnical Engineer



Stephen Peters, P.Eng.
Associate
Geotechnical Engineer



Dr. Fred Griffiths, P.Eng.
Senior Associate
Senior Geotechnical Engineer

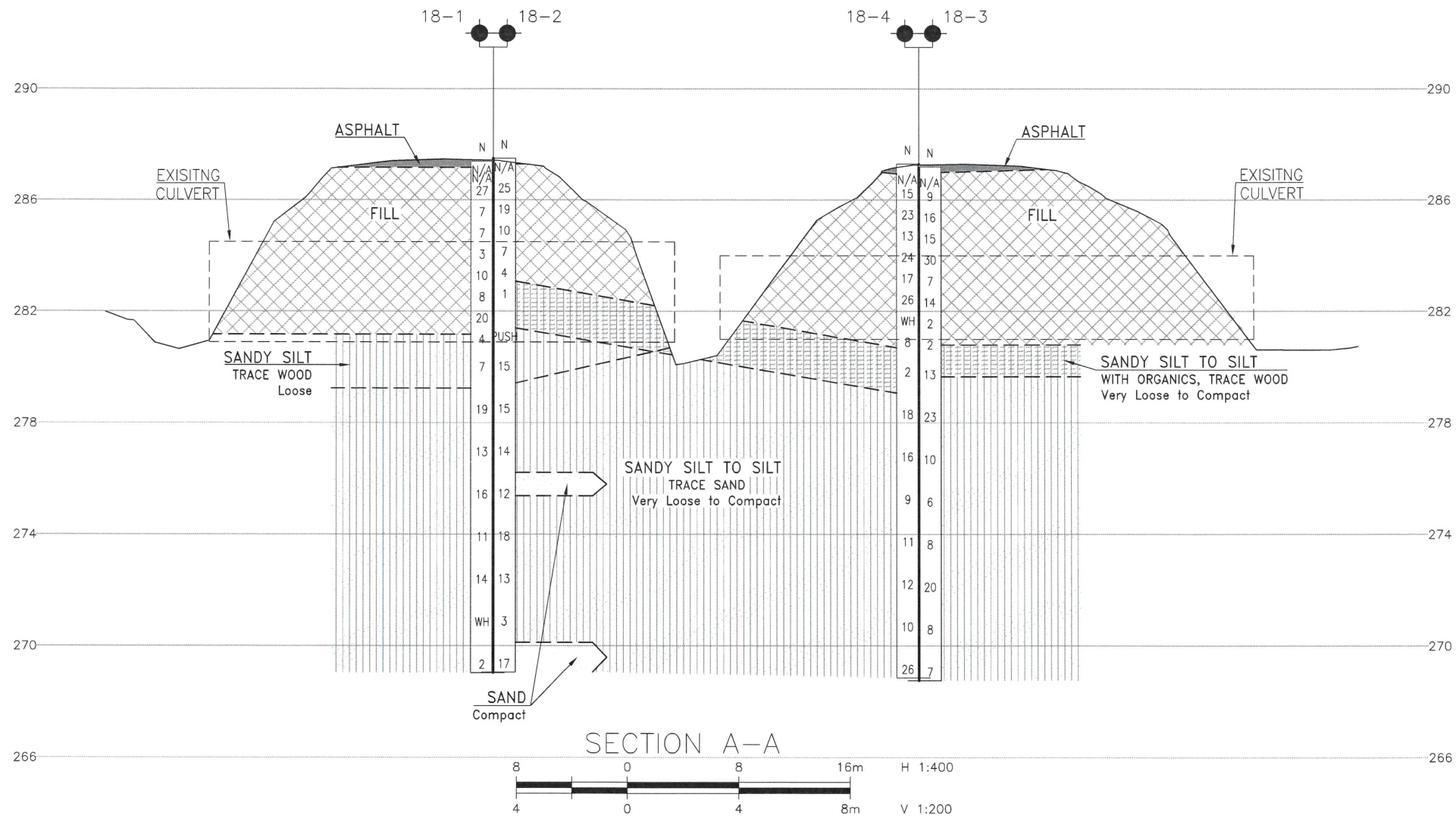
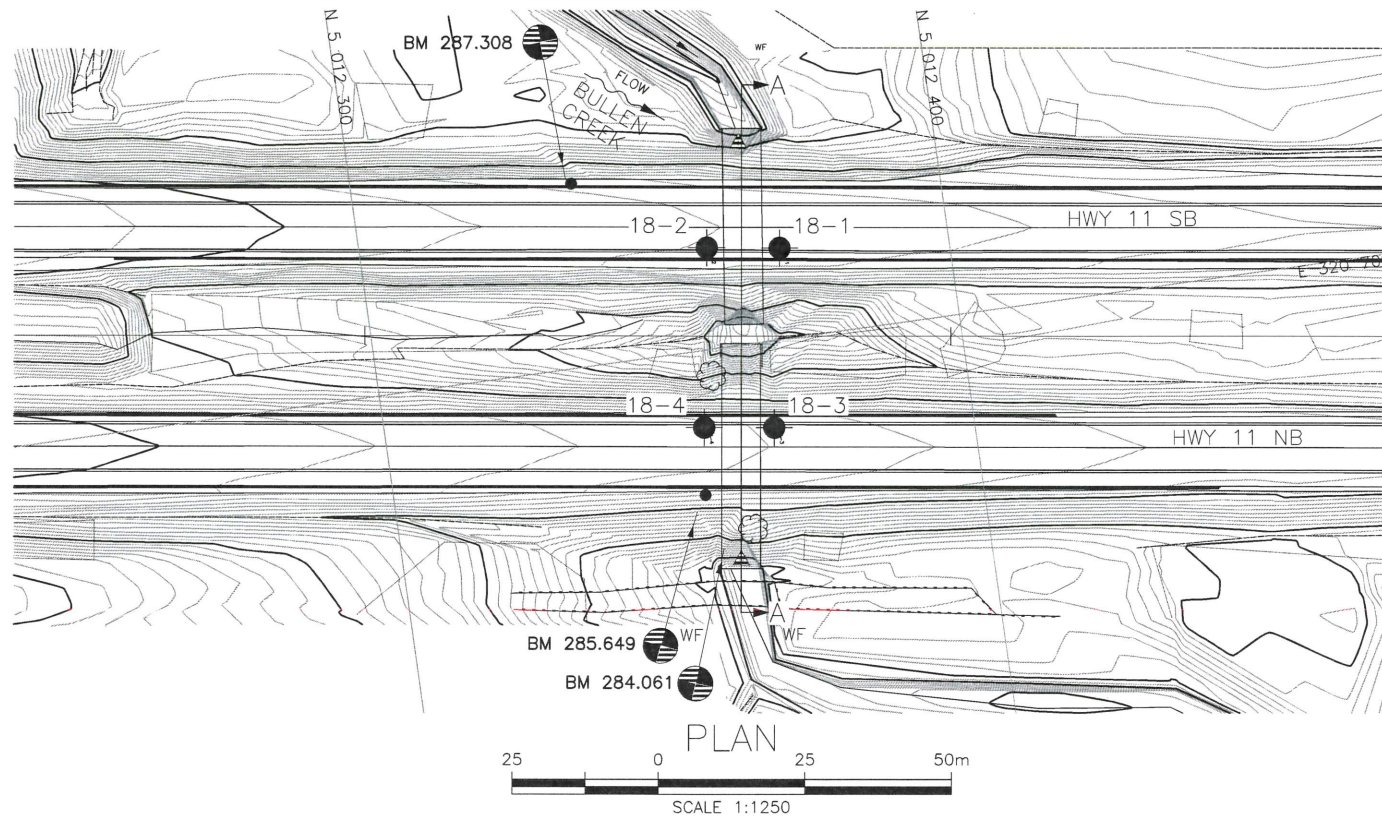


Dr. P.K. Chatterji, P.Eng.
Review Principal
Senior Geotechnical Engineer

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Appendix A.

Borehole Location Plan and Stratigraphic Drawings



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



CONT No 2019-XXXX
WP 5314-14-01, 5509-15-01

BULLEN CREEK
CULVERT REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY

SHEET
74



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

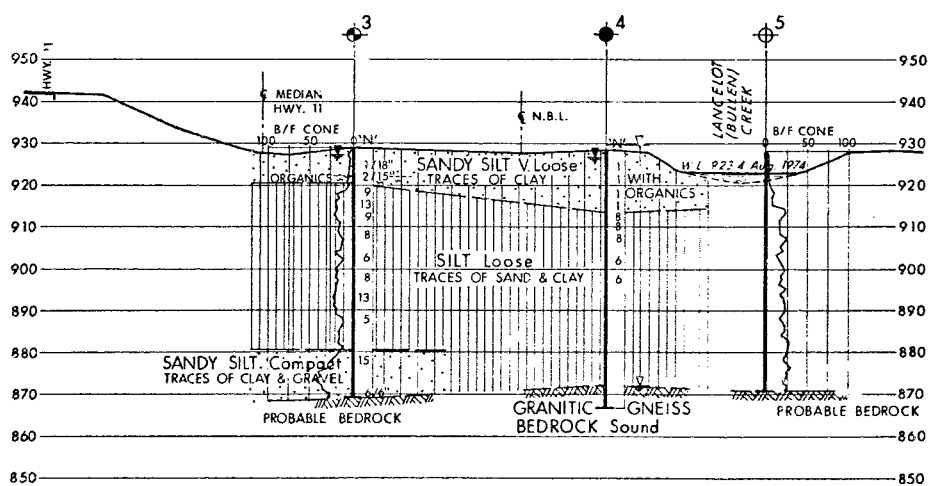
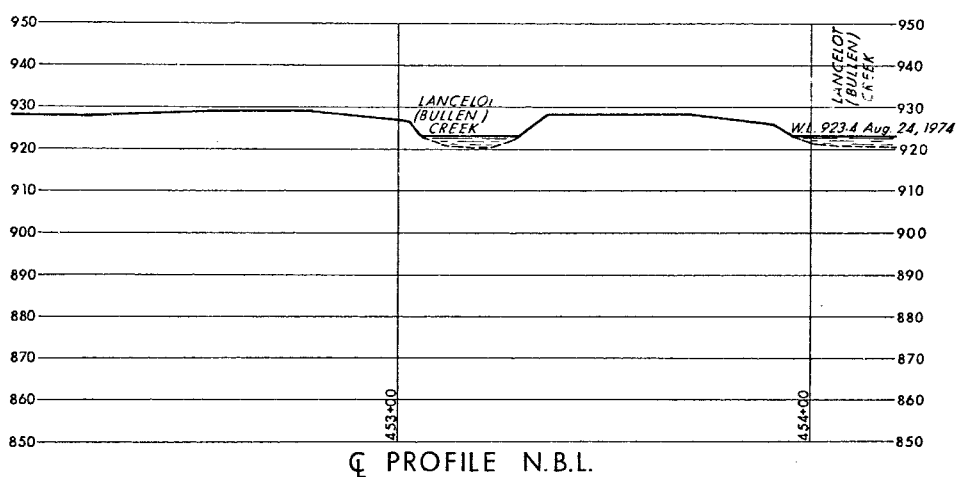
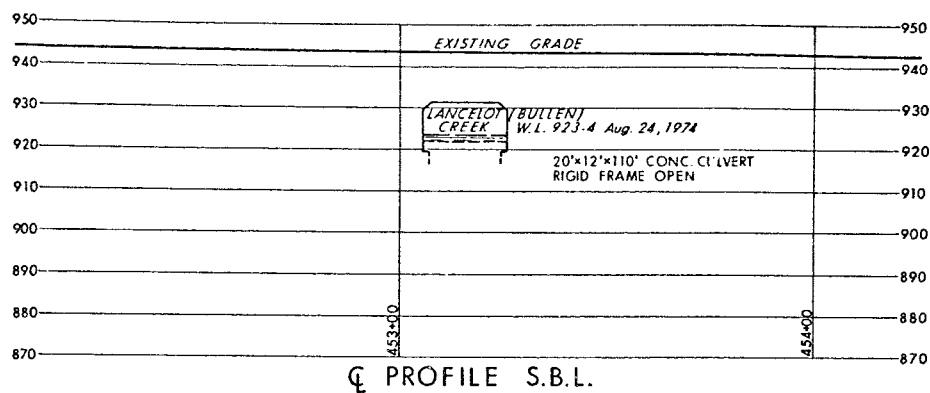
NO	ELEVATION	NORTHING	EASTING
18-1	287.4	5 012 371.2	320 684.5
18-2	287.5	5 012 358.9	320 682.7
18-3	287.2	5 012 366.0	320 714.7
18-4	287.3	5 012 354.2	320 713.0

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 31E-390

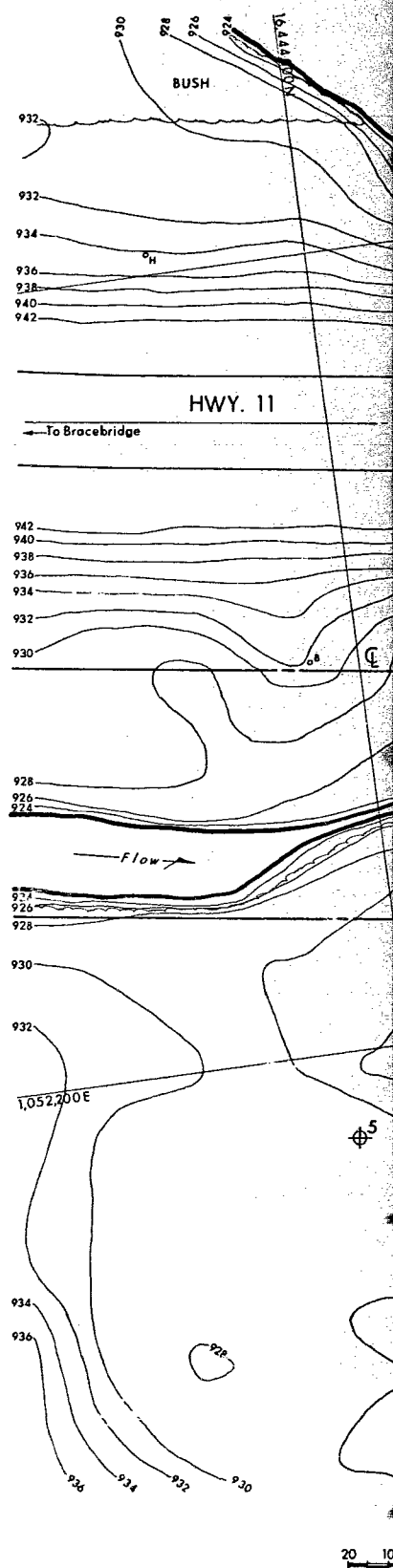
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KE	CHK SP	CODE
DRAWN	AN	CHK KE	SITE 42X-0034/C1,C2/STRUCT
			LOAD
			DATE FEB 2019
			DWG R4-02

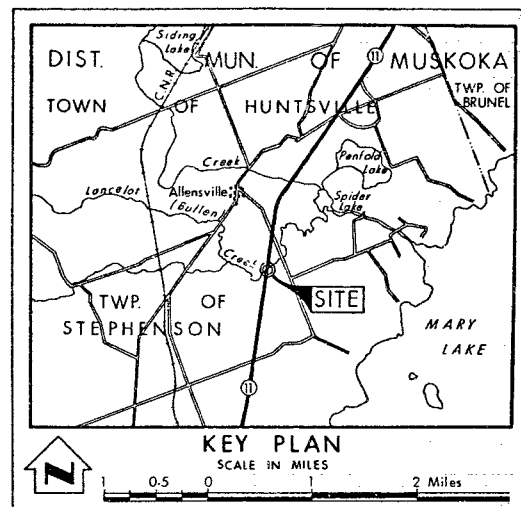
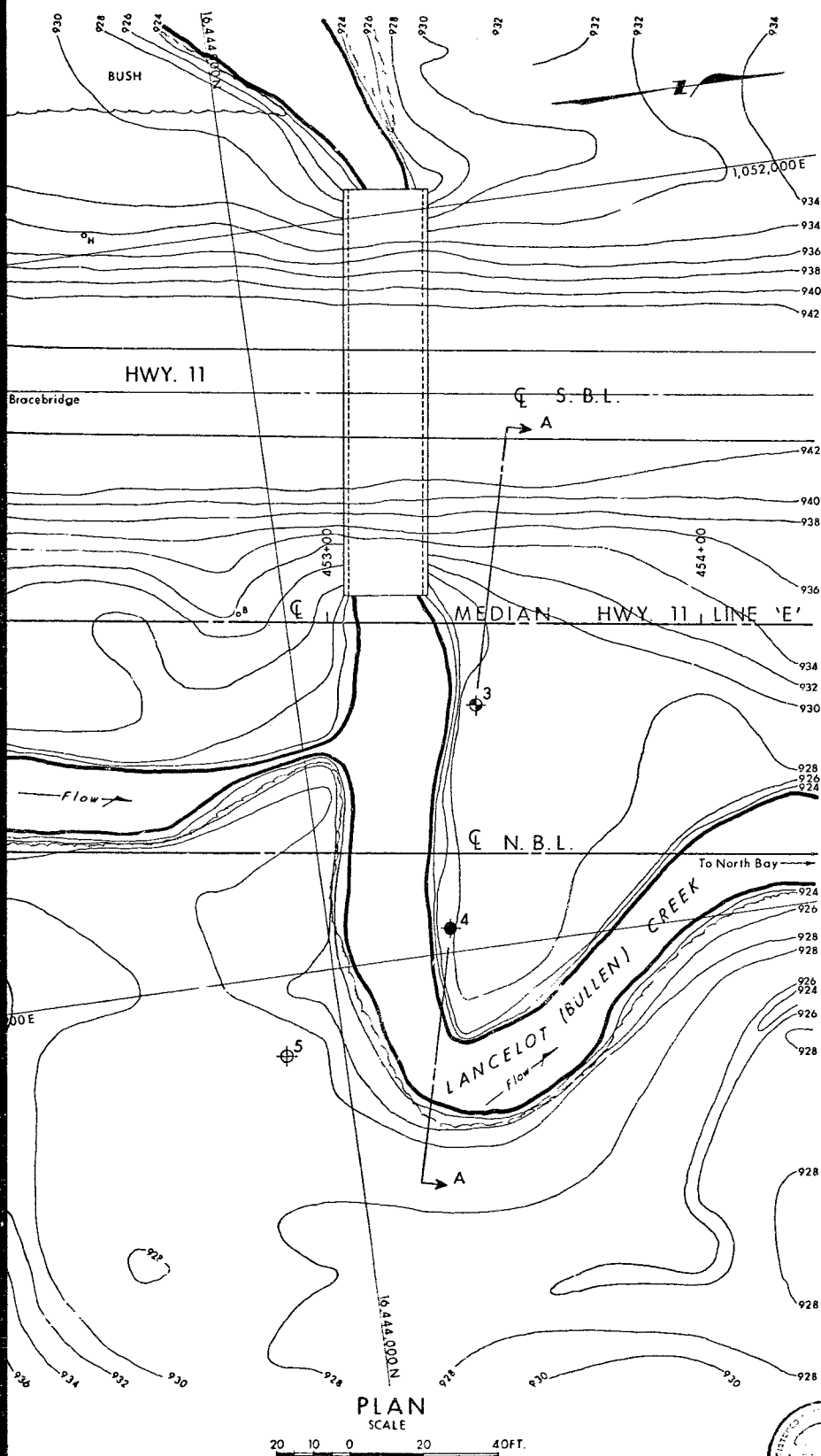


SECTION A-A

SCALE FOR SECTION & PROFILES

20 10 0 20 40 FT.





LEGEND

- Bore Hole
- ⊕ Cone Penetration Test
- ⊕ Bore Hole & Cone Test
- ⊕ Water Levels established at time of field investigation, Nov. 1974
- ⊕ Head ARTESIAN CONDITIONS Encountered

NO.	ELEVATION	STATION	OFFSET
3	929.2	453+80	22' RT.
4	928.8	453+34	82' RT.
5	928.3	452+90	117' RT.

NOTE FOR CONTRACT DOCUMENT

The complete foundation investigation report for this structure may be examined at the Structural Office and Foundations Office, Downsview, and at the HUNTSVILLE District Office.

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE

LANCELOT CREEK (BULLEN CREEK)

HIGHWAY NO. 11 LINE 'E' DIST. NO. 11
Dist. Mun. of MUSKOKA Town of HUNTSVILLE
TWP. STEPHENSON LOT 25 CON X

BORE HOLE LOCATIONS & SOIL STRATA

SUSWD A P	CHECKED	WP NO. 149-73-01	DRAWING NO.
DRAWN	CHECKED	W.O. NO.	1497301-B
DATE Dec. 18, 1974	SITE NO.	BRIDGE DRAWING NO.	
APPROVED	CON. NO.		

Appendix B.

Record of Borehole Sheets



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).

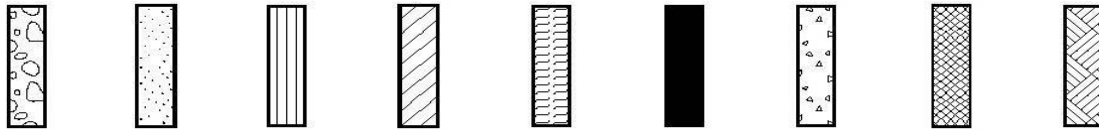
DYNAMIC CONE PENETRATION TEST (DCPT):

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.



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

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.

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 (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

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



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

RECORD OF BOREHOLE No 18-1

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251121°, Long: -79.297634° Bullen Creek, MTM Zone 10: N 5 012 371.2 E 320 684.5 ORIGINATED BY KE/RH
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2018.04.20 - 2018.04.21 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
287.4 0.0	Southbound Lane ASPHALT (200 mm)													
287.8 0.4	SAND with gravel grey, moist FILL		1	BS	N/A		287							
286.6 0.8	GRAVEL with sand grey, moist FILL		2	BS	N/A									
			3	SS	27									
			4	SS	7		286							
			5	SS	7		285							
			6	SS	3		284							
			7	SS	10		283							
			8	SS	8									
			9	SS	20		282							
281.2 6.2	wet below 6.1 m													
	SANDY SILT (ML) trace wood fragments loose, grey, wet		10	SS	4		281							
			11	SS	7		280							
279.3 8.2	SILT (ML) to SILT (ML) trace sand compact to very loose, grey, wet						279							
			12	SS	19		278							

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

DOUBLE LINE 20244_BULLEN CREEK.GPJ 2012TEMPLATE(MTO).GDT 1/2/19

RECORD OF BOREHOLE No 18-1

2 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251121°, Long: -79.297634° Bullen Creek, MTM Zone 10: N 5 012 371.2 E 320 684.5 ORIGINATED BY KE/RH
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2018.04.20 - 2018.04.21 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT			NATURAL MOISTURE CONTENT			LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P			W			W L									
	Continued From Previous Page																										
	SILT (ML) to SILT (ML) trace sand compact to very loose, grey, wet			13	SS	13		277														0 8 88 4 non-plastic					
								276																			
				14	SS	16																					
				15	SS	11		274																			

DOUBLE LINE 20244_BULLEN CREEK.GPJ 2012TEMPLATE(MTO).GDT 1/2/19

RECORD OF BOREHOLE No 18-2

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251011°, Long: -79.297658° Bullen Creek, MTM Zone 10: N 5 012 358.9 E 320 682.7 ORIGINATED BY KE/RH
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2018.04.21 - 2018.04.21 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
287.5	Southbound Lane							20	40	60	80	100									
0.0	ASPHALT (210 mm)							20	40	60	80	100									
0.2	SAND with gravel		1	BS	N/A		287													37 62 1 (SI+CL)	
287.0	brown, moist																				
0.4	FILL																				
	SAND with silt and gravel compact to loose, brown, moist occasional cobbles			2	SS	25															
	FILL																				
			3	SS	19		286														
			4	SS	10		285														
			5	SS	7		284														
			6	SS	4																
283.0																					
4.4	SILT (ML) with organics						283													0 6 83 11 non-plastic	
282.5	trace sand very loose, grey-brown, moist		7	SS	1																
5.0	SILT (ML) with organics																				
	very loose, black-brown, moist																				
							282			2.0 +											
										2.0 +											
281.4	SILT (ML)		8	ST	PUSH		281														
6.1	compact, grey, wet																				
	trace wood fragments																				
				9	SS	15		280													1 1 88 10 non-plastic
							279														
			10	SS	15		278														

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

METRIC

SOIL PROFILE						SAMPLES
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	
Continued From Previous Page						
276.2 - 275.3	SILT (ML) compact, grey, wet	[Pattern]	11	SS	14	
275.3 - 272.7	SAND (SP) compact, grey-brown, wet	[Pattern]	12	SS	12	
272.7 - 270.1	SANDY SILT (ML) compact to very loose, grey, wet	[Pattern]	14	SS	13	
270.1 - 269.0	SAND (SP) compact, grey-brown, wet	[Pattern]	16	SS	17	
269.0 - 18.4	End of Borehole					












+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 18-3

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251074°, Long: -79.297249° Bullen Creek, MTM Zone 10: N 5 012 366.0 E 320 714.7 ORIGINATED BY KE/RH
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2018.04.19 - 2018.04.20 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L				GR	SA	SI	CL
								20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%)							
287.2	Northbound Lane						287												
0.0	ASPHALT (200 mm)																		
286.8	GRAVEL with sand		1	BS	N/A														
0.4	FILL																		
	SAND, trace to some gravel		2	SS	9														
	FILL																		
285.9							286												
1.3	SILT																		
	compact, grey, moist			3	SS		16												
	FILL																		
							285												
				4	SS	15													
283.9						284													
3.2	SILTY SAND, some to with gravel			5	SS	30													
	very loose to dense, brown, moist																		
	occasional cobbles			6	SS	7													
	FILL																		
						283													
				7	SS	14													
	wet below 5.5 m					282													
				8	SS	2													
280.8						281													
6.4	SANDY SILT (ML) with organics			9	SS	2													
	with wood fragments																		
	very loose, grey, wet																		
279.6			10	SS	13		280												
7.5	SILT (ML)																		
	compact to loose, grey, wet																		
				11	SS	23		279											
							278												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-3

2 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251074°, Long: -79.297249° Bullen Creek, MTM Zone 10: N 5 012 366.0 E 320 714.7 ORIGINATED BY KE/RH
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2018.04.19 - 2018.04.20 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			
								● QUICK TRIAXIAL × LAB VANE						W P W W L			
	Continued From Previous Page																
268.7 18.4	SILT (ML) compact to loose, grey, wet		12	SS	10		277										
							276										
			13	SS	6		275										
							274										
			14	SS	8		273										
							272										
			15	SS	20		271										
							270										
			16	SS	8		269										
			17	SS	7												
	End of Borehole																

0 2 95 3
non-plastic

RECORD OF BOREHOLE No 18-4

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.250968°, Long: -79.297271° Bullen Creek, MTM Zone 10: N 5 012 354.2 E 320 713.0 ORIGINATED BY KE/RH
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2018.04.19 - 2018.04.19 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								WATER CONTENT (%)					
287.3	Northbound Lane												
0.0	ASPHALT (200 mm)												
286.9	GRAVEL with sand		1	BS	N/A								
0.4	grey FILL												
	SAND, some gravel compact, brown, moist FILL		2	SS	15								
285.7													
1.5	SILT compact, grey, moist FILL		3	SS	23								
			4	SS	13								
	- becoming sandy below 3.0 m		5	SS	24								
283.8													
3.5	SAND with silt and gravel very loose to compact, brown, moist occasional cobbles FILL		6	SS	17								
			7	SS	26								
	wet below 5.5 m		8	SS	WH								
280.7			9	SS	8								
6.6	SANDY SILT (ML) with organics trace gravel, trace wood fragments very loose, grey, wet		10	SS	2								
279.0													
8.2	SILT (ML) compact, grey, wet		11	SS	18								

DOUBLE LINE 20244_BULLEN CREEK.GPJ 2012TEMPLATE(MTO).GDT 1/2/19

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
			NUMBER	TYPE	"N" VALUES
Continued From Previous Page					
276.0	SILT (ML) compact, grey, wet		12	SS	16
11.3	SILT (ML) with sand to SANDY SILT (ML) loose to compact, grey, wet		13	SS	9
			14	SS	11
			15	SS	12
			16	SS	10
			17	SS	26
268.8	End of Borehole Water level at 4.74 mbgs during drilling operations				
18.4					

+³, ×³: Numbers refer to Sensitivity

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 3

W.P. 149-73-01

LOCATION Sta. 453+40 O/S 22' RT. & Highway 11 Line "E"
Co-ords. 16,444,048 N. 1,052,135E.

ORIGINATED BY A.P.

DIST. 11 HWY. 11

BORING DATE October 31st, and November 1st, 1974

COMPILED BY G.P.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger & Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N° VALUES		20	40	60	80	100	w_p	w	w_L		
929.2	Ground Level															
0.0	Sandy silt traces of clay very loose		1	SS	1/18"											0 41 (59)
920.7	organics		2	SS	2/15"											Org. cont. 2.78%
8.5	Silt traces of sand and clay loose		3	SS	9	920										0 0 91 9
			4	SS	13											0 3 96 1
			5	SS	9	910										
			6	SS	8											
			7	SS	6	900										0 8 91 1
			8	SS	8											
			9	SS	13	890										0 1 93 6
			10	SS	5											
880.2	Sandy silt traces of gravel and clay compact		11	SS	15	880										4 42 49 5
869.2			12	SS	6/6"	870										
60.0	End of borehole Refusal Probable bedrock										100/0" refusal					

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 4

W.P. 149-73-01

LOCATION Sta. 453+34 O/S 82' RT. 4 Highway 11 Line "E"

ORIGINATED BY A.P.

DIST. 11 HWY. 11

BORING DATE November 4th and 5th, 1974

COMPILED BY G.P.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, Axt Core

CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS Artesian Head Gr. S. CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
928.8	Ground Level															
0.0	Sandy silt with organics Traces of clay very loose		1	SS	1	920							o		0	26 13 1
			2	SS	1								o		0	49 17 4
			3	SS	1										0	39 57 4
913.8			4	SS	1								o		0	9 87 4
15.0	Silt Traces of sand and clay Loose		5	SS	8	910							o			
			6	SS	8											
			7	SS	8											
			8	SS	6	900										
			9	SS	6											
	1 ft. boulder					890										
						880										
872.3			10	Axt RC	Rec 48%	870										
56.5	Granitic Gneiss bedrock															Artesian encountered Elev. 871.3
866.6	sound		11	Axt RC	Rec 100%											
62.2	End of borehole															

Sta. 452+90 O/S 117' RT. C Highway 11 Line "E"

LOCATION Co-ords. 16.443.985 N. 1.052.222E

ORIGINATED BY A.P.

BORING DATE November 5th, 1974

COMPILED BY G.P.

BOREHOLE TYPE Dynamic Cone Penetration Test

CHECKED BY CP

20
15-0.5 % STRAIN AT FAILURE

Appendix C.

Laboratory Testing

Appendix C.1

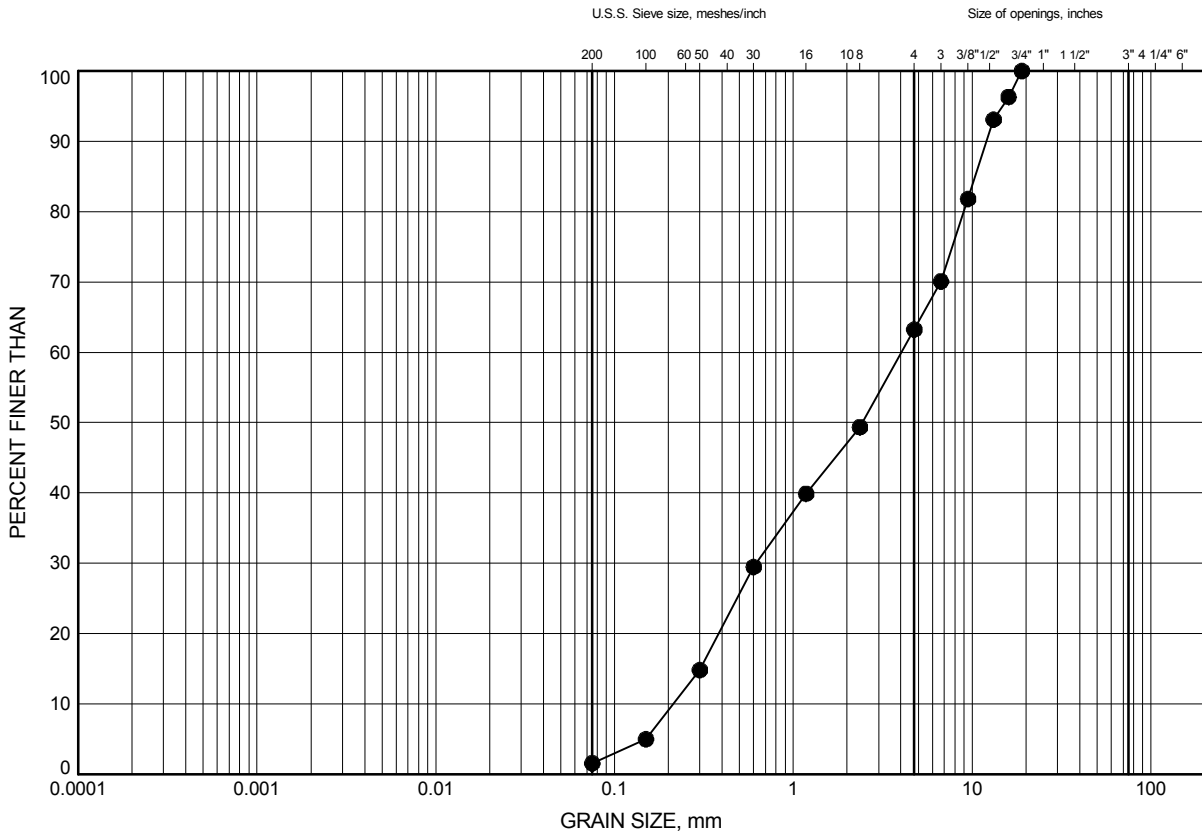
Particle Size Analysis Figures

Hwy 11 - Bullen Creek Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C1

FILL-Pavement Granular



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-2	0.3	287.1

Date January 2019
GWP# 5138-13-00



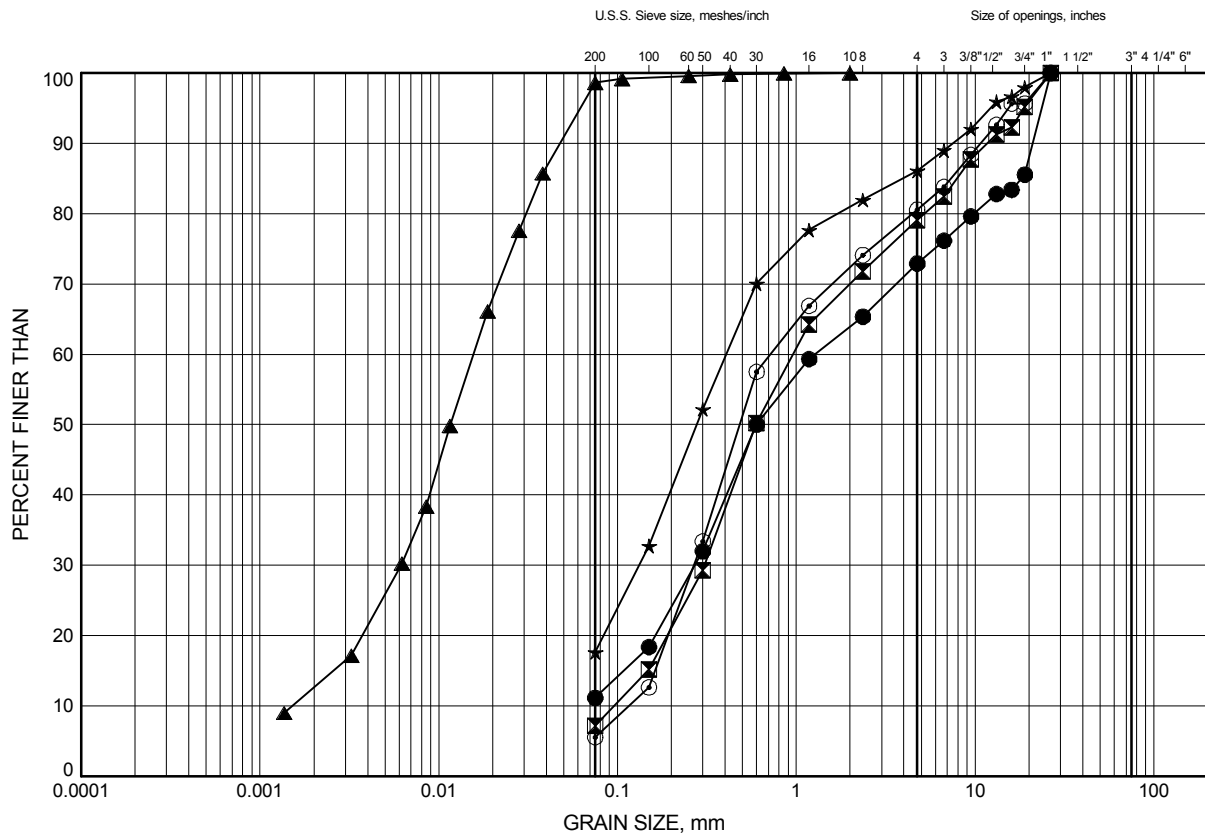
Prep'd KE
Chkd. SP

Hwy 11 - Bullen Creek Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C2

EMBANKMENT FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	1.1	286.4
⊠	18-1	4.1	283.3
▲	18-3	1.8	285.3
★	18-3	3.5	283.7
⊙	18-4	4.9	282.4

Date January 2019

GWP# 5138-13-00



Prep'd KE

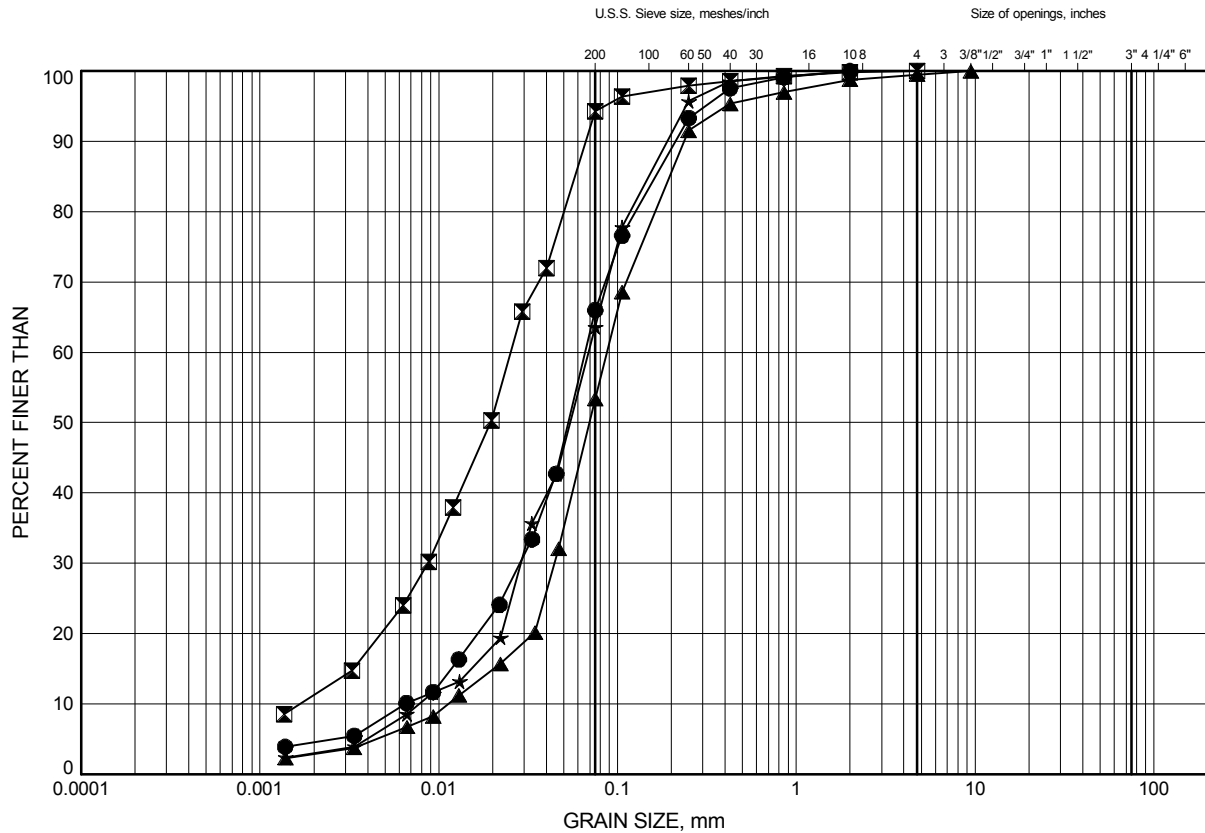
Chkd. SP

Hwy 11 - Bullen Creek Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C3

SILT (ML) with Organics



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	6.4	281.0
⊠	18-2	4.7	282.7
▲	18-3	6.6	280.6
★	18-4	7.5	279.8

Date January 2019

GWP# 5138-13-00



Prep'd KE

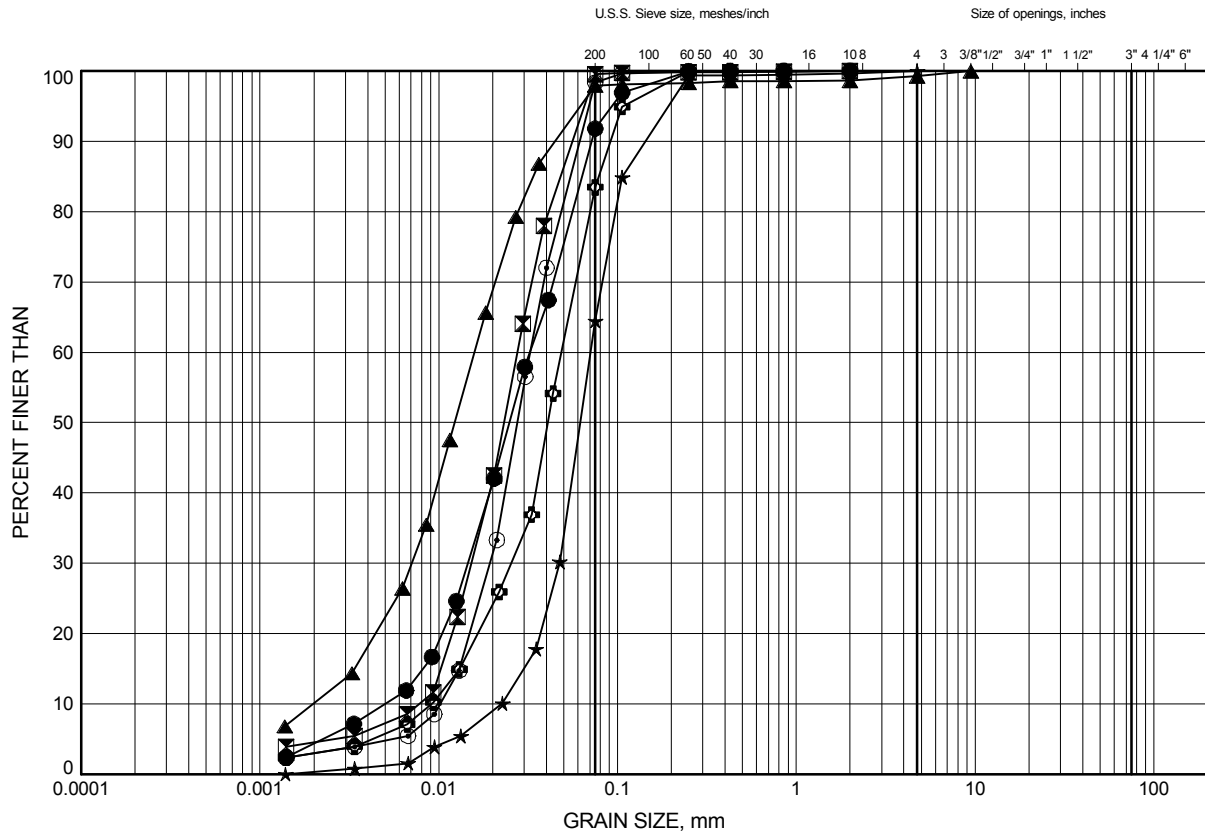
Chkd. SP

Hwy 11 - Bullen Creek Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C4

SILT (ML) to SANDY SILT (ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	12.0	275.5
⊠	18-1	15.0	272.4
▲	18-2	7.5	280.0
★	18-2	16.6	270.8
⊙	18-3	15.1	272.1
⊕	18-4	12.0	275.2

Date January 2019

GWP# 5138-13-00



Prep'd KE

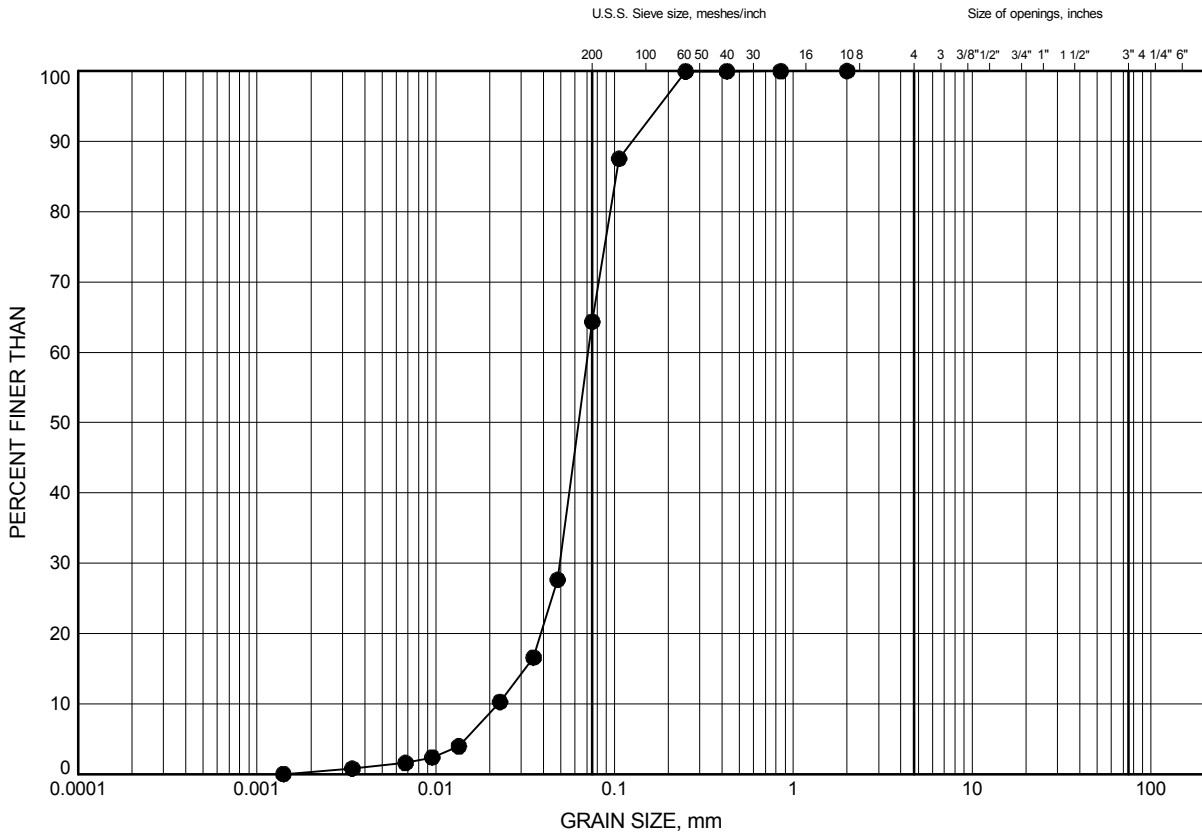
Chkd. SP

Hwy 11 - Bullen Creek Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C5

SILT (ML) to SANDY SILT (ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-4	16.6	270.6

Date January 2019

GWP# 5138-13-00



Prep'd KE

Chkd. SP

Appendix C.2
Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Katya Edney

Client PO: 20244
Project: HWY 11+118
Custody: 39844

Report Date: 1-May-2018
Order Date: 25-Apr-2018

Order #: 1817326

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID	
1817326-01	18-4 SS8 (17'6" - 19'6")	Bullen Culvert
1817326-02	18-5 SS8B (18'6" - 17')	

Approved By:

Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 01-May-2018
Order Date: 25-Apr-2018
Project Description: HWY 11+118

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	27-Apr-18	28-Apr-18
Conductivity	MOE E3138 - probe @25 °C, water ext	30-Apr-18	30-Apr-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	30-Apr-18	30-Apr-18
Resistivity	EPA 120.1 - probe, water extraction	30-Apr-18	30-Apr-18
Solids, %	Gravimetric, calculation	1-May-18	1-May-18

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 01-May-2018

Order Date: 25-Apr-2018

Project Description: HWY 11+118

Client ID:	18-4 SS8 (17'6" - 19'6")	18-3 SS8B (16'6" - 17')	-	-
Sample Date:	04/19/2018 09:00	04/22/2018 09:00	-	-
Sample ID:	1817326-01	1817326-02	-	-
MDL/Units	Soil	Soil	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	87.1	79.2	-	-
----------	--------------	------	------	---	---

General Inorganics

Conductivity	5 uS/cm	469	322	-	-
pH	0.05 pH Units	6.10	6.45	-	-
Resistivity	0.10 Ohm.m	21.3	31.1	-	-

Anions

Chloride	5 ug/g dry	291	148	-	-
Sulphate	5 ug/g dry	5	5	-	-

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 01-May-2018
Order Date: 25-Apr-2018
Project Description: HWY 11+118

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 01-May-2018
Order Date: 25-Apr-2018
Project Description: HWY 11+118

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	660	5	ug/g dry	668			1.3	20	
Sulphate	1940	5	ug/g dry	2000			3.0	20	
General Inorganics									
Conductivity	502	5	uS/cm	472			6.2	6.2	
pH	7.56	0.05	pH Units	7.57			0.1	10	
Resistivity	19.9	0.10	Ohm.m	21.2			6.2	20	
Physical Characteristics									
% Solids	89.6	0.1	% by Wt.	87.3			2.6	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 01-May-2018
Order Date: 25-Apr-2018
Project Description: HWY 11+118

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	748	5	ug/g	668	79.8	78-113			
Sulphate	103	5	ug/g		103	78-111			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 01-May-2018
Order Date: 25-Apr-2018
Project Description: HWY 11+118

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Subcontracted Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Katya Edney

Tel: (613) 247-2121
Fax: (613) 247-2185

Paracel Report No **1818495**
Client Project(s): **HWY 11+ 118**
Client PO: **20244**
Reference: **Standing Offer**
CoC Number: **39844**

Order Date: 03-May-18
Report Date: 15-May-18

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1818495-01	18-4 SS8 (17'6" - 19'6")	Sulphide, solid
1818495-02	18-5 SS8B (16'0" - 17')	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6,

Phone: 613-731-9577
Fax:613-731-9064

15-May-2018

Date Rec. : 04 May 2018
LR Report: CA15112-MAY18
Reference: Project#: 1818495

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		14-May-18
2: Analysis Start Time		13:09
3: Analysis Completed Date		14-May-18
4: Analysis Completed Time		14:54
5: QC - Blank		< 0.02
6: QC - STD % Recovery		101%
7: QC - DUP % RPD		ND
8: RL		0.02
9: 18-4 SS8 (17'6"-19'6")	19-Apr-18	< 0.02
10: 18-8 SS8D (18'0"-17")	22-Apr-18	< 0.02

RL - SGS Reporting Limit

Carrie Greenlaw
Project Specialist
Environmental Services, Analytical

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Katya Edney

Client PO:
Project: HWY 11 + 118
Custody: 39845

Report Date: 10-May-2018
Order Date: 4-May-2018

Order #: 1818669

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1818669-01	Road 117 18-1'ss13 40-42'
1818669-02	Road 117 18-2 'SS12 35-37'
1818669-03	Fraserburg '18-1SS10 22'6-24'6"
1818669-04	Fraserburg'18-2 SS12A 35-36'6"
1818669-05	Road 2 '18-1 SS9 20-22'
1818669-06	Road 2 '18-2 SS10 25-27'
1818669-07	Bullens '18-1 SS11 23'3"-25'3"
1818669-08	Road 3 18-1 SS10 25-27'
1818669-09	Road 3 18-2 SS10 25-27'
1818669-10	Siding 18-2SS5 10-12'
1818669-11	Siding 18-3 SS5 10-12'

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-May-2018
Order Date: 4-May-2018
Project Description: HWY 11 + 118

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	8-May-18	8-May-18
Conductivity	MOE E3138 - probe @25 °C, water ext	8-May-18	9-May-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	7-May-18	7-May-18
Resistivity	EPA 120.1 - probe, water extraction	8-May-18	9-May-18
Solids, %	Gravimetric, calculation	7-May-18	7-May-18

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-May-2018

Order Date: 4-May-2018

Project Description: HWY 11 + 118

Client ID:	Road 117 18-1'ss13 40-42'	Road 117 18-2 'SS12 35-37'	Fraserburg '18-1SS10 22'6-24'6"	Fraserburg'18-2 SS12A 35-36'6"
Sample Date:	04/30/2018 09:00	04/30/2018 09:00	04/29/2018 09:00	04/29/2018 09:00
Sample ID:	1818669-01	1818669-02	1818669-03	1818669-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	83.9	83.9	68.9	70.1
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General Inorganics

Conductivity	5 uS/cm	133	234	469	262
pH	0.05 pH Units	5.84	6.14	5.56	5.32
Resistivity	0.10 Ohm.m	75.0	42.7	21.3	38.1

Anions

Chloride	5 ug/g dry	82	113	246	120
Sulphate	5 ug/g dry	12	9	51	10

Client ID:	Road 2 '18-1 SS9 20-22'	Road 2 '18-2 SS10 25-27'	Bullens '18-1 SS11 23'3"-25'3"	Road 3 18-1 SS10 25-27'
Sample Date:	04/28/2018 09:00	05/01/2018 09:00	04/21/2018 09:00	04/27/2018 09:00
Sample ID:	1818669-05	1818669-06	1818669-07	1818669-08
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	87.0	72.7	77.5	80.3
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General Inorganics

Conductivity	5 uS/cm	218	1780	400	61
pH	0.05 pH Units	6.41	5.76	7.44	6.39
Resistivity	0.10 Ohm.m	45.8	5.61	25.0	164

Anions

Chloride	5 ug/g dry	124	1170	23	21
Sulphate	5 ug/g dry	7	10	200	11

Client ID:	Road 3 18-2 SS10 25-27'	Siding 18-2SS5 10-12'	Siding 18-3 SS5 10-12'	-
Sample Date:	04/27/2018 09:00	04/24/2018 09:00	04/23/2018 09:00	-
Sample ID:	1818669-09	1818669-10	1818669-11	-
MDL/Units	Soil	Soil	Soil	-

Physical Characteristics

% Solids	0.1 % by Wt.	82.5	79.5	72.3	-
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General Inorganics

Conductivity	5 uS/cm	158	2120	428	-
pH	0.05 pH Units	6.44	6.34	6.13	-
Resistivity	0.10 Ohm.m	63.1	4.71	23.4	-

Anions

Chloride	5 ug/g dry	83	1590	154	-
Sulphate	5 ug/g dry	9	19	76	-

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-May-2018
Order Date: 4-May-2018
Project Description: HWY 11 + 118

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-May-2018
Order Date: 4-May-2018
Project Description: HWY 11 + 118

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	55.9	5	ug/g dry	55.6			0.7	20	
Sulphate	23.4	5	ug/g dry	22.9			2.1	20	
General Inorganics									
Conductivity	443	5	uS/cm	424			4.4	6.2	
pH	7.77	0.05	pH Units	7.77			0.0	10	
Resistivity	22.6	0.10	Ohm.m	23.6			4.4	20	
Physical Characteristics									
% Solids	98.2	0.1	% by Wt.	98.0			0.2	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-May-2018
Order Date: 4-May-2018
Project Description: HWY 11 + 118

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	149	5	ug/g	55.6	93.2	78-113			
Sulphate	119	5	ug/g	22.9	95.8	78-111			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-May-2018
Order Date: 4-May-2018
Project Description: HWY 11 + 118

Qualifier Notes:

Login Qualifiers :

Container(s) - Bottle and COC sample ID don't match -

*Applies to samples: Road 117 18-1'ss13 40-42', Road 117 18-2 'SS12 35-37', Fraserburg '18-1SS10 22'6-24'6",
Bullens '18-1 SS11 23'3"-25'3"*

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Subcontracted Analysis

Thurber Engineering Ltd.2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Katya EdneyTel: (613) 247-2121
Fax: (613) 247-2185Paracel Report No **1818669**Client Project(s): **HWY 11 + 118**

Client PO:

Reference: **Standing Offer**CoC Number: **39845**Order Date: 04-May-18
Report Date: 15-May-18

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1818669-01	Road 117 18-1'ss13 40-42'	Sulphide, solid
1818669-02	Road 117 18-2 'SS12 35-37'	Sulphide, solid
1818669-03	Fraserburg '18-1SS10 22'6-24'6"	Sulphide, solid
1818669-04	Fraserburg'18-2 SS12A 35-36'6"	Sulphide, solid
1818669-05	Road 2 '18-1 SS9 20-22'	Sulphide, solid
1818669-06	Road 2 '18-2 SS10 25-27'	Sulphide, solid
1818669-07	Bullens '18-1 SS11 23'3"-25'3"	Sulphide, solid
1818669-08	Road 3 18-1 SS10 25-27'	Sulphide, solid
1818669-09	Road 3 18-2 SS10 25-27'	Sulphide, solid
1818669-10	Siding 18-2SS5 10-12'	Sulphide, solid
1818669-11	Siding 18-3 SS5 10-12'	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6,

Phone: 613-731-9577
Fax: 613-731-9064

15-May-2018

Date Rec. : 08 May 2018
LR Report: CA13203-MAY18
Reference: Project#: 1818669

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		14-May-18
2: Analysis Start Time		13:09
3: Analysis Completed Date		14-May-18
4: Analysis Completed Time		14:54
5: QC - Blank		< 0.02
6: QC - STD % Recovery		101%
7: QC - DUP % RPD		ND
8: RL		0.02
9: Road 117 18-1'ss13 40-42'	30-Apr-18	< 0.02
10: Road 117 18-2 'SS12 35-37'	30-Apr-18	< 0.02
11: Fraserburg '18-1SS10 22'6-24'6"	29-Apr-18	< 0.02
12: Fraserburg '18-2 SS12A 35-36'6"	29-Apr-18	< 0.02
13: Road 2 '18-1 SS9 20-22'	28-Apr-18	< 0.02
14: Road 2 '18-2 SS10 25-27'	01-May-18	< 0.02
15: Bullens '18-1 SS11 23'3"-25'3"	21-Apr-18	0.40
16: Road 3 18-1 SS10 25-27'	27-Apr-18	< 0.02
17: Road 3 18-2 SS10 25-27'	27-Apr-18	< 0.02
18: Siding 18-2SS5 10-12'	24-Apr-18	< 0.02
19: Siding 18-3 SS5 10-12'	23-Apr-18	< 0.02

RL - SGS Reporting Limit

Carrie Greenlaw
Project Specialist
Environmental Services, Analytical

Appendix D.

Site Photographs



Photo 1. Looking north along Highway 11 Northbound



Photo 2. Looking south along Highway 11 Southbound



Photo 3. Northbound outlet (42X-0034/C1) looking east



Photo 4. Looking north at culvert ends in median



Photo 5. Southbound inlet (42X-0034/C2) looking west