



**THURBER** ENGINEERING LTD.

**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
HIGHWAY 527 WABIKON CREEK CULVERT  
6 KM NORTH OF ON-811, THUNDER BAY UNORGANIZED  
SITE NO.: 48C-240/C  
ASSIGNMENT NO. 6017-E-0013**

**G.W.P. 6829-14-00**

Geocres No.: 52H-47

Report to:

**Hatch Corporation**

Latitude: 49.403053°  
Longitude: -89.352081°

December 2018  
Thurber File: 19773

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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 for the Wabikon Creek Culvert on Highway 527. The culvert is located approximately 6 km north of Tertiary Highway 811 within the Unorganized Thunder Bay District. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to Hatch Corporation (Hatch) under Assignment No. 6017-E-0013.

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. No previous foundation investigation information was available for the subject culvert site within the online Geocres Library.

**2 SITE DESCRIPTION**

The existing culvert, conveying Wabikon Creek under Highway 527, is a twin cell timber culvert with an unknown construction date. A site survey plan from Hatch indicates that the culvert is approximately 3.9 m wide, 1.9 m high and approximately 17.3 m long. The culvert alignment is generally north to south with the flow through the culvert toward the north.

At the location of the culvert, Highway 527 is a two-lane highway with a rural cross-section and gravel shoulders. The embankment fill height above the culvert is approximately 0.6 m. The elevation of the road surface at the centreline is approximately 422.1 m. The existing embankment slopes are inclined between approximately 1.9H:1V and 2.3H:1V. The land adjacent to the highway and waters edge is undeveloped and densely vegetated with trees. Traffic volumes on this section of Highway 527 are understood to be 170 AADT (2016). A sign is present at the culvert site indicating an alternate name for the creek as Cheeseman Creek.

Photographs showing the existing conditions in the area of the culvert are included in Appendix D for reference.

### 3 SITE INVESTIGATION AND FIELD TESTING

Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locate clearances in the vicinity of the intended boreholes.

The site investigation and field testing program was carried out between June 7<sup>th</sup> and June 11<sup>th</sup>, 2018. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 3-1. The site is within MTM Zone 15.

**Table 3-1: Borehole Summary**

<b>Borehole No.</b>	<b>Drilled Location</b>	<b>Northing (m)</b>	<b>Easting (m)</b>	<b>Ground Surface Elevation (m)</b>	<b>Termination Depth (m)</b>
18-401	East of culvert – NB Lane	5 474 122.2	351 844.3	422.1	8.3
18-402	West of culvert – SB Lane	5 474 121.0	351 830.4	422.2	7.6
18-403	South of culvert – culvert inlet	5 474 111.0	351 839.2	419.8	5.2
18-404	North of culvert – culvert outlet	5 474 136.8	351 838.4	419.5	5.0

The drilling was carried out using a truck mounted CME 75 drill rig for on-road Boreholes 18-401 and 18-402 and portable drilling equipment for off-road Boreholes 18-403 and 18-404. Both drills were equipped with NW casing

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Boreholes 18-403 and 18-104, which were drilled with portable equipment, also utilized a full-weight hammer for SPT testing. Bedrock was cored and collected in all boreholes using NQ coring equipment.

A 19 mm diameter standpipe piezometer was installed in Borehole 18-403 to allow for measurements of the groundwater level after completion of drilling. The piezometer installation details are illustrated on the respective Record of Borehole sheet provided in Appendix B. All other boreholes were backfilled with a low-permeability mixture of cuttings and bentonite pellets in accordance with Ontario MOE Regulation 903 as amended. Boreholes advanced within paved areas were capped with granular fill followed by 150 mm of cold patch asphalt to reinstate the travelling surface. The piezometer installed during the investigation was decommissioned in accordance with Ontario MOE Regulation 903 on August 11, 2018.

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

#### **4 LABORATORY TESTING**

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Grain size distribution testing was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. Chemical analysis for determination of pH, conductivity, resistivity, sulphate, sulphide and chloride concentrations was carried out on one soil sample.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included 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 Locations 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.

In general terms, the site was found to be underlain by a pavement structure and granular embankment fill overlying native gravel which is underlain by bedrock.

##### **5.1 Embankment Fill**

###### **5.1.1 Asphalt**

Boreholes 18-401 and 18-402 were drilled through the travelled lanes of Highway 527 and encountered a layer of asphalt with a thickness of 50 mm.

###### **5.1.2 Fill: Silty Sand with Gravel**

Below the asphalt pavement within the on-road boreholes was a layer of granular embankment fill consisting of silty sand with gravel. Occasional cobbles were encountered within this layer. The underside of the embankment fill ranged from 3.0 to 3.8 m below the existing roadway surface (elev. 418.4 to 419.1 m).

The SPT tests conducted in the fill gave N-values ranging from 29 blows for 300 mm of penetration to 100 blows for 175 mm of penetration, indicating a relative density of compact to very dense; however, the higher blow counts could represent the presence of a cobble rather than the state of packing of the soil matrix. Recorded moisture contents ranged from 6 to 10%.

Gradation analyses were completed on three samples of the granular fill. The grain size distribution curves for these samples are included in Figure C1 of Appendix C. The results of the tests are summarized in Table 5-1 below and are presented on the corresponding Record of Borehole sheets in Appendix B.

**Table 5-1: Gradation Results for Embankment Fill**

Soil Particle	Percentage (%)
Gravel	16 – 38
Sand	49 – 66
Silt and Clay	13 – 18

## **5.2 Organic Silt**

A layer of organic silt was encountered from surface in off-road Boreholes 18-403 and 18-404. The underside depth of this layer ranged from 0.3 to 1.2 m below ground surface (elev. 418.3 to 419.5 m). Two SPT tests conducted in the organic silt gave N-values of 2 and 18 blows, recognizing that correlations between SPT blow counts and relative density /consistency are not intended for organic soils. One SPT conducted in the organic silt gave an N-Value of 100 blows for 150 mm of penetration; however, this represents refusal on an underlying cobble or boulder. Very poor sample recovery within the split spoon sampler was noted within this layer. The moisture content of the organic silt was measured to range from 69 to 110%.

## **5.3 Silty Sand to Silty Gravel with Cobbles and Boulders**

A fluvial deposit of silty sand to silty gravel was encountered below the embankment fill in Boreholes 18-401 and 18-402, and below the organic silt in Boreholes 18-403 and 18-404. The composition of the deposit generally ranged from silty sand some gravel trace organics to silty gravel with sand. Occasional cobbles were encountered in this layer in Boreholes 18-401, 18-402, and 18-404. This layer consisted predominantly of cobbles and boulders in Borehole 18-403. The thickness of this layer ranged from 0.3 to 1.8 m with underside depths ranging from 1.8 to 4.4 m below ground surface (elev. 417.7 to 418.1 m).

The SPT tests conducted in this layer gave N-values ranging from 38 blows for 300 mm of penetration to 100 blows for 0 mm of penetration, indicating a dense to very dense relative density; however, the higher blow counts could represent the presence of a cobble rather than the state of packing of the soil matrix. The recorded moisture contents ranged from 8 to 32%.

A gradation analysis completed on one sample of the silty sand indicated 11% gravel, 72% sand and 17% fines. A gradation analyses completed on one sample of the silty gravel indicated 44% gravel, 27% sand and 29% fines. The gradation results are presented on the corresponding Record of Borehole sheets in Appendix B and the grain size distribution curves are included in Figures C2 and C3 of Appendix C.

#### 5.4 Bedrock

Bedrock was proven by coring in all boreholes. Information on the confirmed bedrock surface is summarized in Table 5-2 below:

**Table 5-2: Summary of Bedrock Elevation**

Borehole No.	Depth to Bedrock (mbgs)	Bedrock Surface Elevation (m)
18-401	4.4	417.7
18-402	4.1	418.1
18-403	2.1	417.7
18-404	1.8	417.7

The bedrock encountered within all boreholes consisted of fresh fine to medium grained, dark grey to black basalt. The Total Core Recovery (TCR) measured on the recovered bedrock core ranged from 88 to 100%, the Solid Core Recovery (SCR) ranged from 18 to 100% and the Rock Quality Designation (RQD) ranged from 0 to 90%. Based on the measured RQD values, the bedrock quality is classified as very poor to excellent, but typically fair to good. The basalt bedrock is estimated to be very strong. Photographs of the bedrock core are provided in Appendix C.

#### 5.5 Groundwater

The water level was measured in the piezometer installed in Borehole 18-403 and is presented in Table 5-3 below:

**Table 5-3: Groundwater Level Observations**

Borehole	Groundwater Level		Date of Measurement
	Depth (mbgs)	Elevation (m)	
18-403	0.1	419.7	June 14, 2018
	0.0	419.8	August 11, 2018

The creek water level was also surveyed at the culvert inlet and outlet and the measured elevations are provided in Table 5-4 below:

**Table 5-4: Creek Water Level Observations**

Location	Surface Water Elevation (m)	Date of Measurement
Culvert Inlet	419.8	June 18, 2018
Culvert Outlet	419.6	June 18, 2018

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

## 5.6 Analytical Testing

One sample of soil was 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 provided in Appendix C and are summarized in Table 5-5 below:

**Table 5-5: Analytical Results Summary**

Borehole	18-401
Sample	SS5
Depth (m)	3.1 – 3.7
Chloride ( $\mu\text{g/g}$ )	9
Sulphate ( $\mu\text{g/g}$ )	28
Sulphide (%)	< 0.02
pH (-)	7.56
Resistivity (Ohm-cm)	11,100
Conductivity ( $\mu\text{S/cm}$ )	90

## 6 MISCELLANEOUS

Borehole locations were selected in consultation with Hatch and the Ministry of Transportation relative to the existing culvert and the existing site features. The as-drilled locations and ground surface elevations for the boreholes were surveyed by Thurber.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario and OGS Drilling of Almonte, Ontario supplied and operated the drilling equipment for the on-road and off-road drilling, respectively, to carry out the drilling, soil sampling, in-situ testing, piezometer installation and borehole decommissioning. Traffic control was provided by NC Traffic Management Inc. of Kirkland Lake, Ontario. The field investigation was supervised on a full-time basis by Mr. Nick Weil and Mr. Sean O'Bryan, C.E.T., of Thurber. Overall supervision of the investigation program was conducted by Mr. Stephen Dunlop, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber'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 Ms. Allison Chow, E.I.T. and Mr. Stephen Dunlop, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

*Allison Chow*  
14/12/2018



Allison Chow, B.A.Sc., E.I.T.  
Geotechnical Engineering Intern

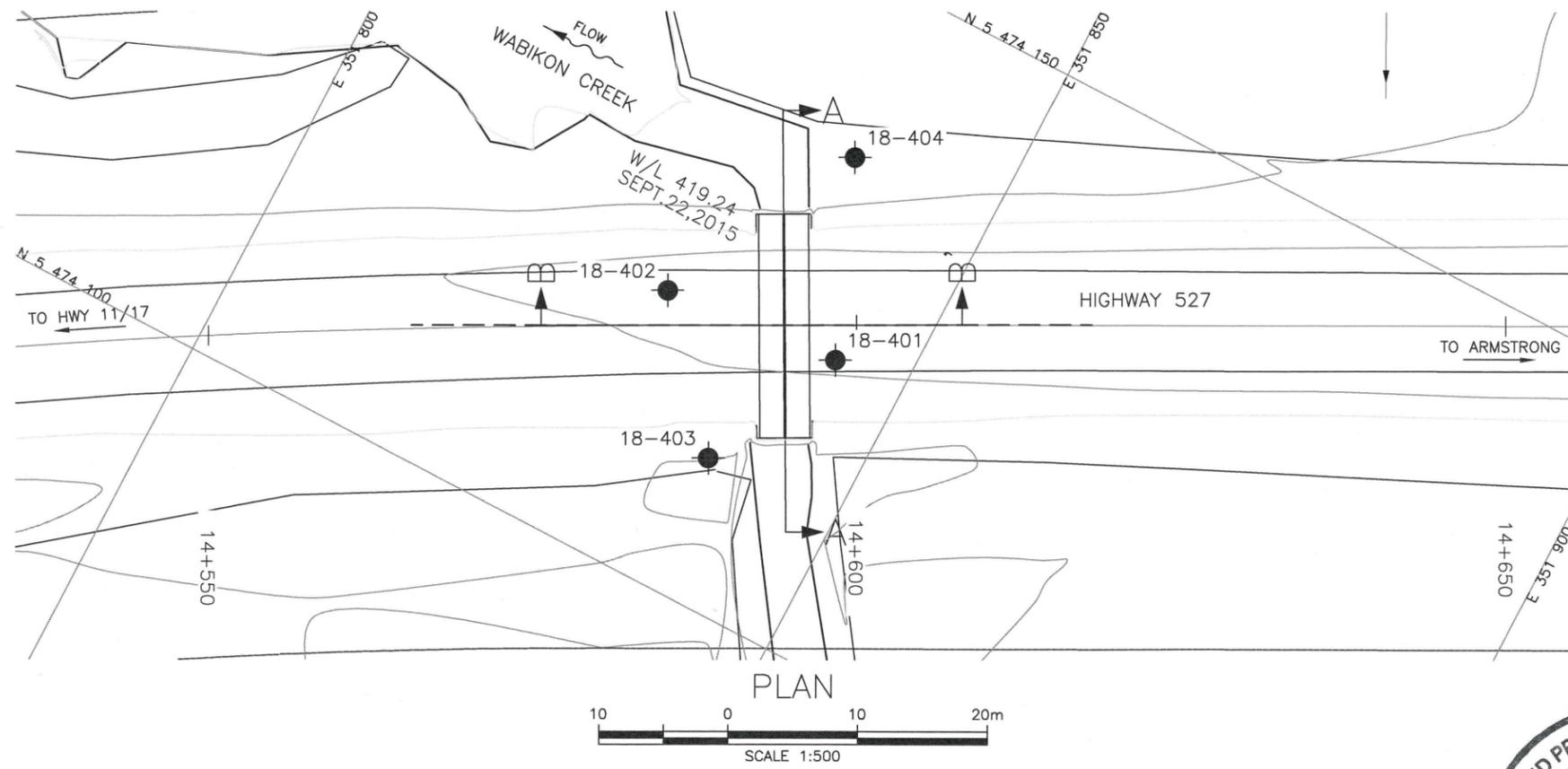
Stephen Dunlop, M.A.Sc., P.Eng.  
Senior Geotechnical Engineer



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

**Appendix A.**

**Borehole Location Plan and Stratigraphic Drawings**



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

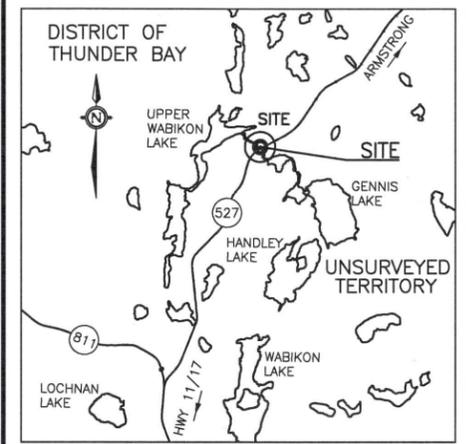
CONT No  
GWP No 6829-14-00

HIGHWAY 527  
WABIKON CREEK CULVERT  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

**HATCH**

**THURBER ENGINEERING LTD.**



KEYPLAN  
LEGEND

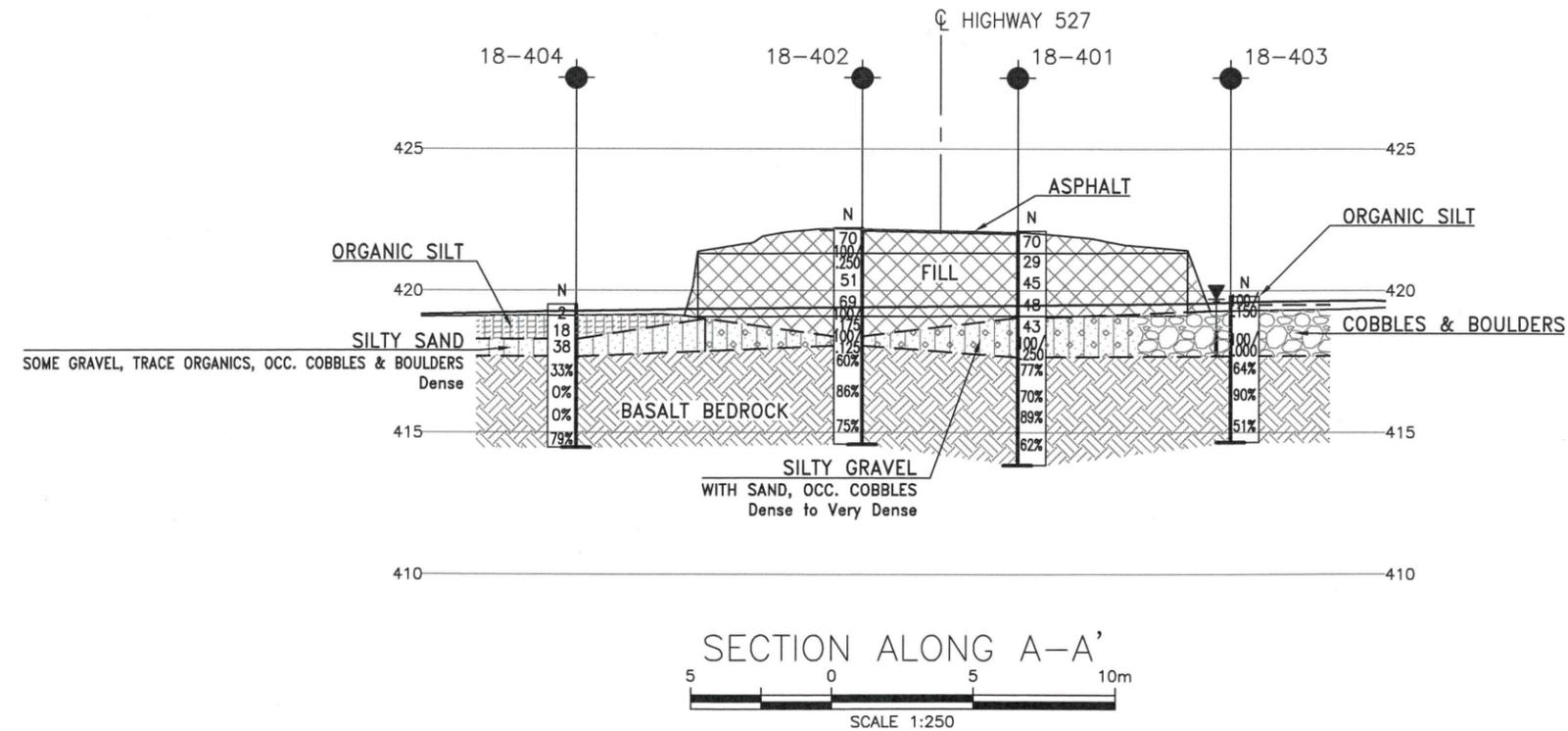
- Borehole
- ⊕ Borehole & Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- ▽ Water Level
- ⊕ Head Artesian Water
- ⊕ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
18-401	422.1	5 474 122.2	351 844.3
18-402	422.2	5 474 121.0	351 830.4
18-403	419.8	5 474 111.0	351 839.2
18-404	419.5	5 474 136.8	351 838.4

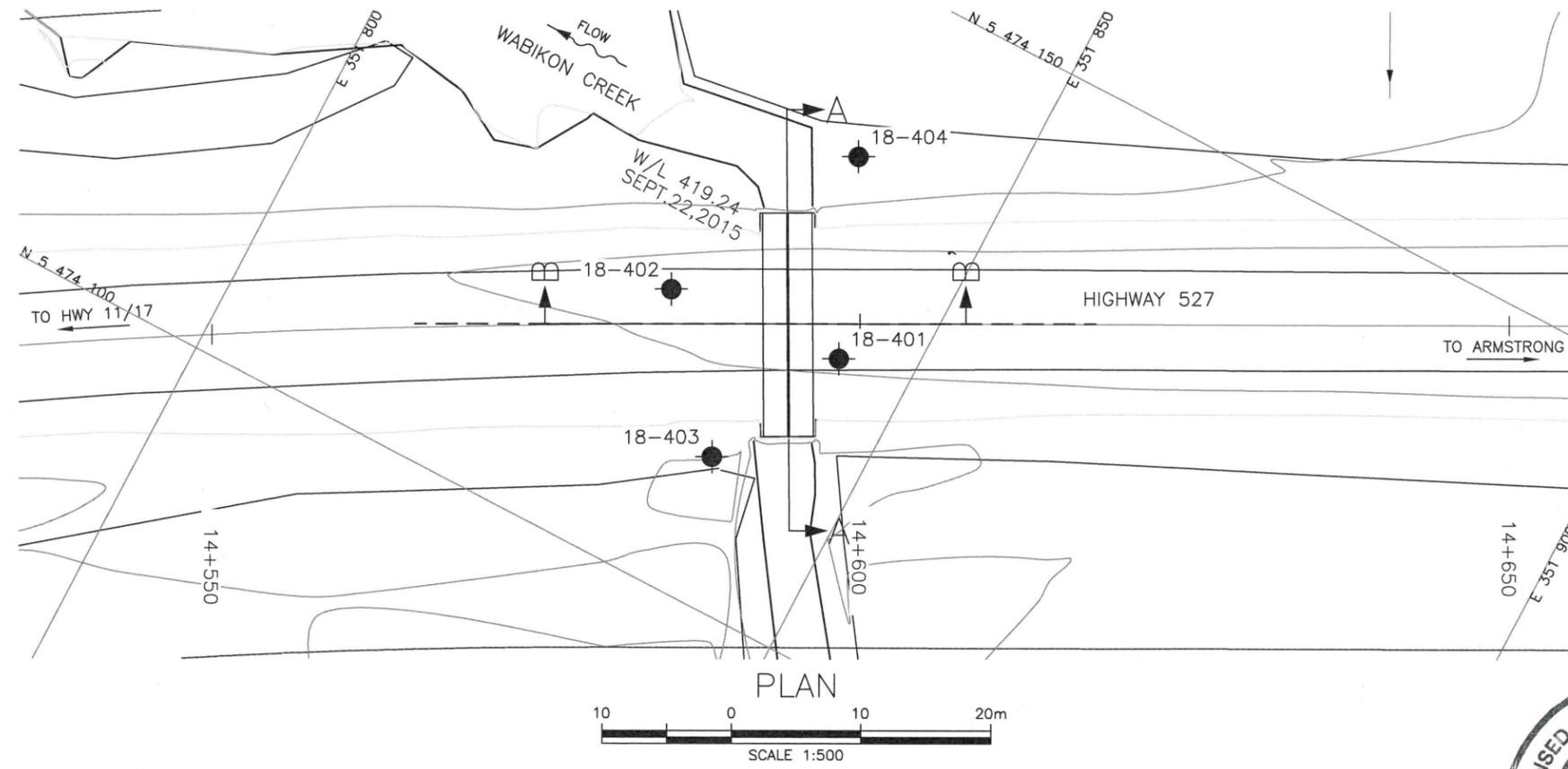
-NOTES-

- 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 15.

GEOCRES No. 52H-47



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	DP	CHK SP	CODE LOAD DATE AUG 2018
DRAWN	MFA	CHK CM	SITE STRUCT DWG 1

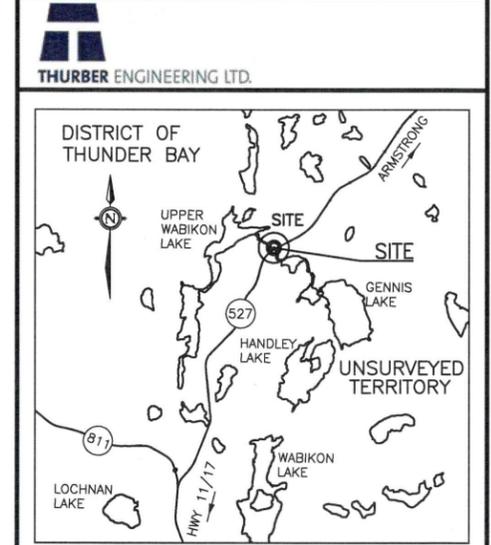


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 6829-14-00

HIGHWAY 527  
WABIKON CREEK CULVERT  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

**HATCH**



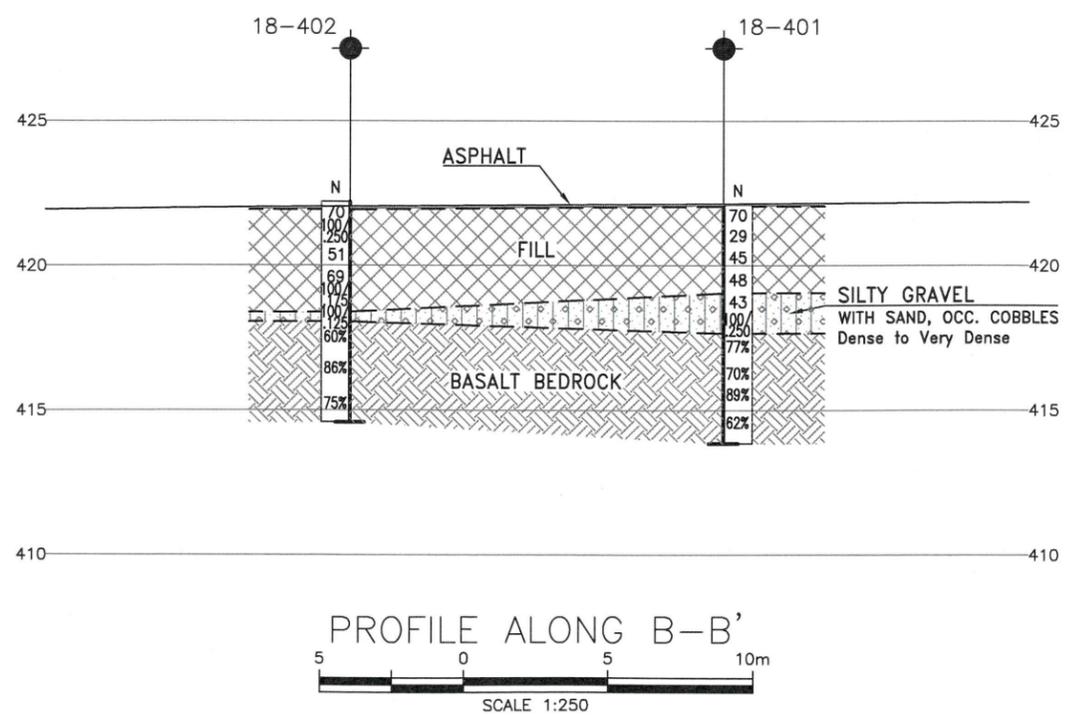
**KEYPLAN**  
**LEGEND**

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

NO	ELEVATION	NORTHING	EASTING
18-401	422.1	5 474 122.2	351 844.3
18-402	422.2	5 474 121.0	351 830.4
18-403	419.8	5 474 111.0	351 839.2
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**GEOCRES No. 52H-47**



DATE	BY	DESCRIPTION
DESIGN DP	CHK SP	CODE LOAD
DRAWN MFA	CHK CM	SITE STRUCT DWG 2

**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).

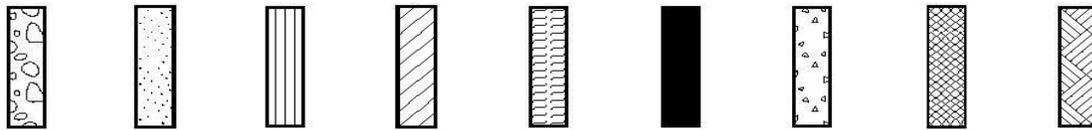
### DYNAMIC CONE PENETRATION TEST (DCPT):

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
<b>COARSE GRAINED SOIL</b>	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.
<b>FINE GRAINED SOILS</b>	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 or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
<b>HIGHLY ORGANIC SOILS</b>		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 18-401

1 OF 1

METRIC

GWP# 6829-14-00 LOCATION Wabikon Creek Culvert, MTM z15: N 5 474 122.2 E 351 844.3 ORIGINATED BY NW  
 HWY 527 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.06.07 - 2018.06.07 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20	40	60	80	100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)			
							20	40	60	80	100	20	40	60	
422.1	50mm ASPHALT	[Hatched]													
0.9	Silty SAND with Gravel, occasional Cobbles, FILL Compact to Very Dense Grey to Brown	[Cross-hatched]	1	SS	70							○			
			2	SS	29							○			
			3	SS	45							○			38 49 13 (SI+CL)
			4	SS	48							○			
419.1	Silty GRAVEL (GM) with Sand, occasional Cobbles Very Dense Grey	[Stippled]	5	SS	43							○			
			6	SS	100/250mm							○			44 27 29 (SI+CL)
417.7	BASALT BEDROCK Fresh Fine to Medium Grained Dark Grey to Black Very Strong	[Diagonal lines]	1	RUN											RUN #1 TCR=100% SCR=100% RQD=77%
			2	RUN											RUN #2 TCR=92% SCR=92% RQD=70%
			3	RUN											RUN #3 TCR=100% SCR=100% RQD=89%
			4	RUN											RUN #4 TCR=97% SCR=97% RQD=62%
413.8	End of Borehole														

ONTMT4S\_19773 WABIKON CREEK.GPJ\_2012TEMPLATE(MTO).GDT 14/12/18

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

### RECORD OF BOREHOLE No 18-402

1 OF 1

METRIC

GWP# 6829-14-00 LOCATION Wabikon Creek Culvert, MTM z15: N 5 474 121.0 E 351 830.4 ORIGINATED BY NW  
 HWY 527 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.06.08 - 2018.06.08 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
						20 40 60 80 100	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60			
422.2	50mm ASPHALT													
0.9	Silty SAND with Gravel, occasional Cobbles, FILL Very Dense Brown		1	SS	70								16 66 18 (SI+CL)	
			2	SS	100/250mm									
			3	SS	51								31 55 14 (SI+CL)	
			4	SS	69									
			5	SS	100/175mm									
418.4	Silty GRAVEL (GM) with Sand, occasional Cobbles Very Dense Grey		6	SS	100/125mm							FI		
418.1												2		
4.1	BASALT BEDROCK Fresh Fine to Medium Grained Dark Grey to Black Very Strong		1	RUN								2	RUN #1 TCR=91% SCR=91% RQD=60%	
												3		
												4		
			2	RUN								1	RUN #2 TCR=98% SCR=98% RQD=86%	
												2		
												1		
												1		
			3	RUN								2	RUN #3 TCR=98% SCR=98% RQD=75%	
												2		
												3		
414.6	End of Borehole											0		
7.6														

ONTMT4S\_19773 WABIKON CREEK.GPJ\_2012TEMPLATE(MTO).GDT 14/12/18

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

### RECORD OF BOREHOLE No 18-403

1 OF 1

METRIC

GWP# 6829-14-00 LOCATION Wabikon Creek Culvert, MTM z15: N 5 474 111.0 E 351 839.2 ORIGINATED BY SOB  
 HWY 527 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.06.10 - 2018.06.11 CHECKED BY SD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
						20 40 60 80 100											
419.8	Organic SILT		1	SS	100/												
419.5	COBBLES and BOULDERS		2	NQ	150mm												
0.3			3	NQ													
				4	NQ												
				5	NQ												
				6	NQ												
				7	SS	100/0mm											
417.7	BASALT BEDROCK Fresh Fine to Medium Grained Dark Grey to Black Very Strong		1	RUN													
2.1			2	RUN													
				3	RUN												
414.6	End of Borehole																
5.2	Standpipe Readings:																
	DATE DEPTH (m) ELEV. (m)																
	2018.06.14 0.1 419.7																
	2018.08.11 0.0 419.8																

ONTMT4S\_19773 WABIKON CREEK.GPJ\_2012TEMPLATE(MTO).GDT 14/12/18

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

### RECORD OF BOREHOLE No 18-404

1 OF 1

**METRIC**

GWP# 6829-14-00 LOCATION Wabikon Creek Culvert, MTM z15: N 5 474 136.8 E 351 838.4 ORIGINATED BY SOB  
 HWY 527 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.06.09 - 2018.06.10 CHECKED BY SD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
						20	40	60	80	100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	
419.5 0.0	<b>Organic SILT</b>		1	SS	2									
			2	SS	18									
418.3 1.2	<b>Silty SAND (SM)</b> some Gravel, trace Organics, occasional Cobbles and Boulders		3	SS	38									11 72 17 (SI+CL)
417.7 1.8	Dense Black		4	NO										
	<b>BASALT BEDROCK</b> Fresh Fine to Medium Grained Dark Grey to Black Very Strong		1	RUN										RUN #1 TCR=100% SCR=41% RQD=33%
			2	RUN										RUN #2 TCR=100% SCR=18% RQD=45%
			3	RUN										RUN #3 TCR=88% SCR=38% RQD=0%
			4	RUN										RUN #4 TCR=100% SCR=100% RQD=79%
414.5 5.0	End of Borehole													

ONTMT4S\_19773 WABIKON CREEK.GPJ\_2012TEMPLATE(MTO).GDT 14/12/18

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

**Appendix C.**

**Laboratory Testing**

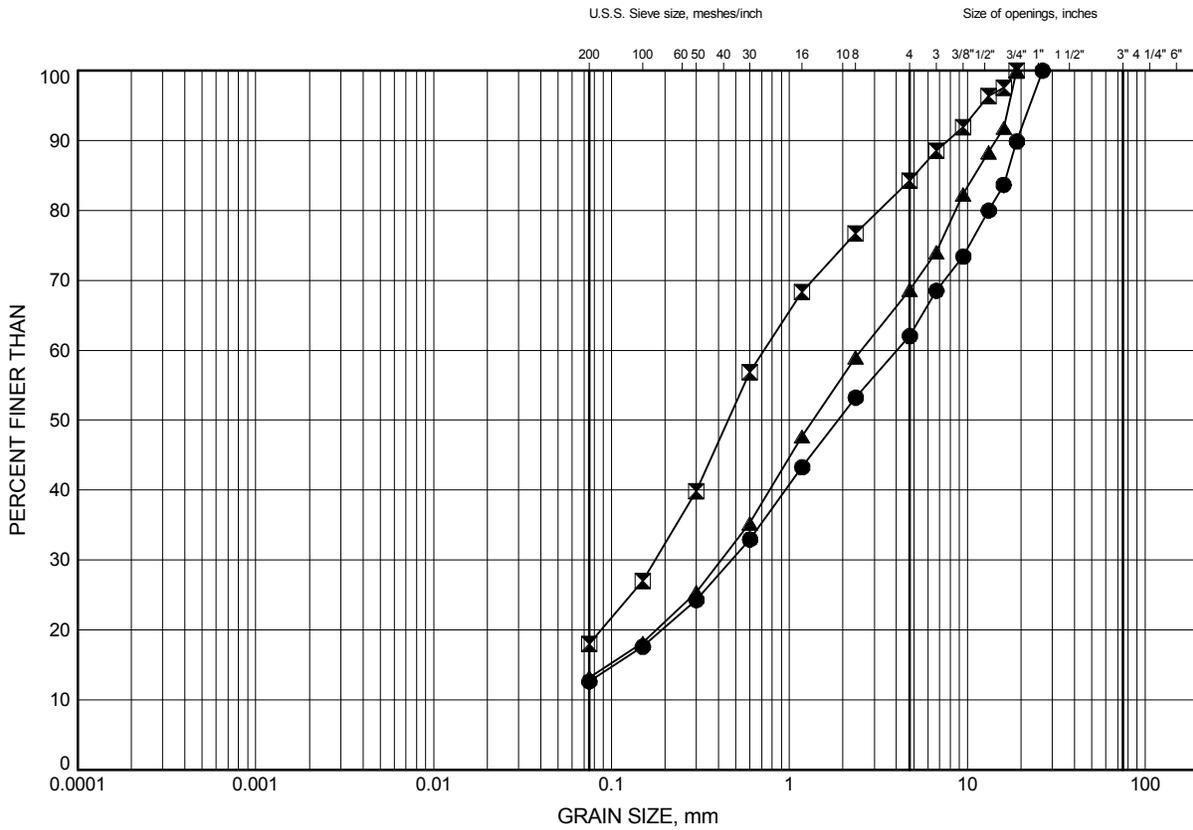
## **Appendix C.1**

### **Particle Size Analysis Figures**

Wabikon Creek Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE C1

Fill: Silty Sand with Gravel



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-401	1.83	420.27
⊠	18-402	0.36	421.84
▲	18-402	1.83	420.37

GRAIN SIZE DISTRIBUTION - THURBER - 19773 WABIKON CREEK.GPJ 9/8/18

Date .. August 2018 ..  
 GWP# .. 6829-14-00 ..

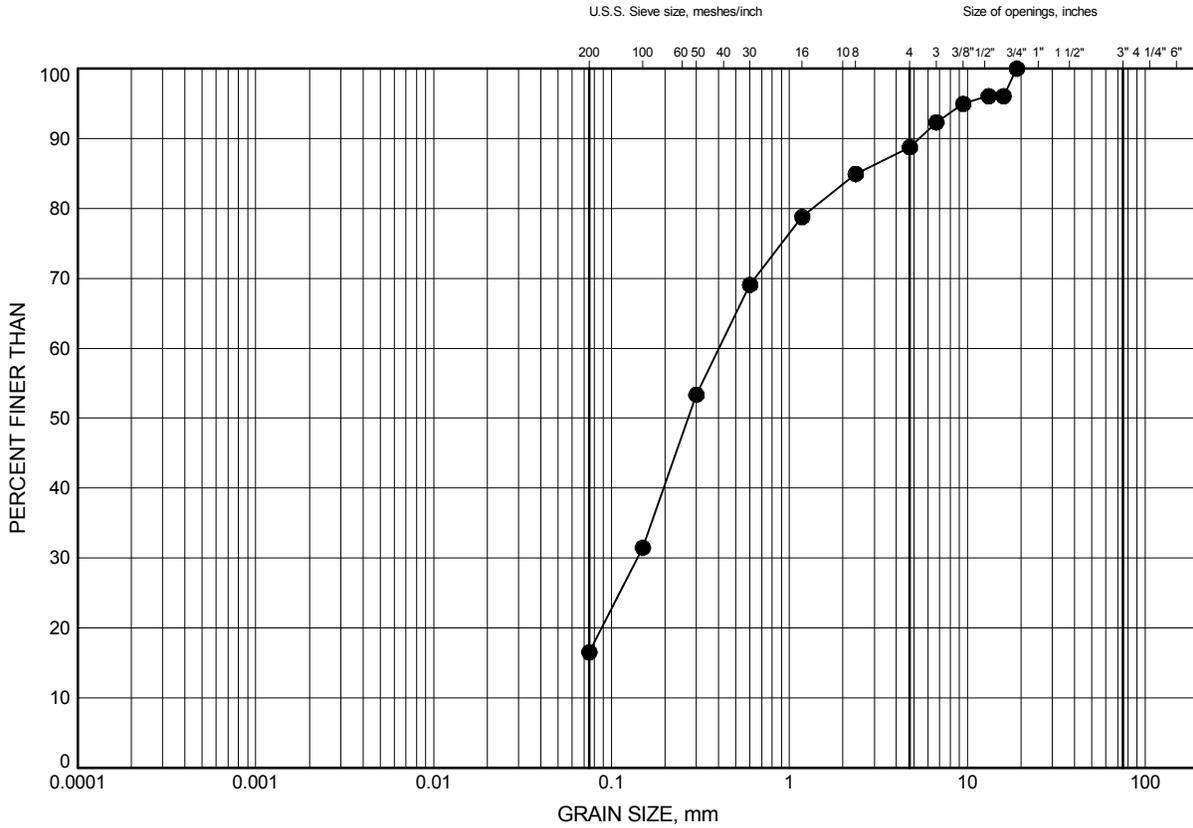


Prep'd ..... CM .....  
 Chkd. .... SD .....

Wabikon Creek Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE C2

**Silty Sand**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-404	1.49	418.01

GRAIN SIZE DISTRIBUTION - THURBER - 19773 WABIKON CREEK.GPJ 7/8/18

Date .. August 2018 ..  
 GWP# .. 6829-14-00 ..

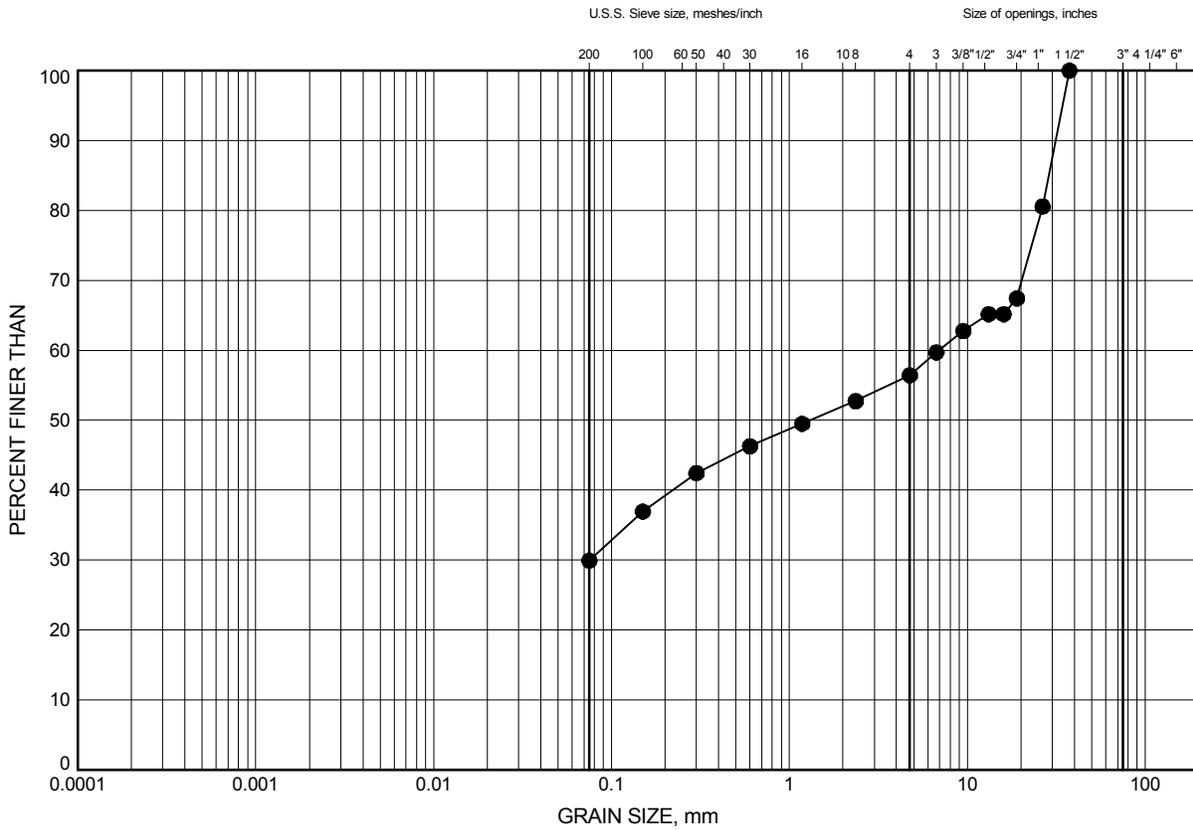


Prep'd ..... CM .....  
 Chkd. .... SD .....

Wabikon Creek Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE C3

**Silty Gravel with Sand**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-401	4.01	418.09

GRAIN SIZE DISTRIBUTION - THURBER - 19773 WABIKON CREEK.GPJ 7/8/18

Date .. August 2018 ..  
 GWP# .. 6829-14-00 ..

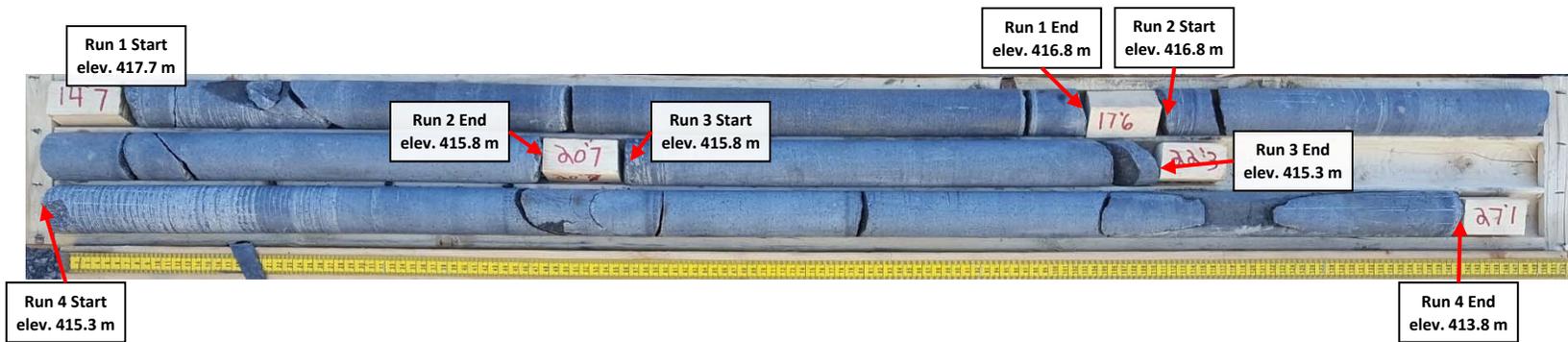


Prep'd ..... CM .....  
 Chkd. .... SD .....

## **Appendix C.2**

### **Rock Core Photos**

**Borehole 18-401**  
**Run 1 to 4 (of 4)**  
**Elevation 417.7 m to 413.8 m**



**Foundation Investigation**  
**Wabikon Creek Culvert**  
**Highway 527**

**GWP 6829-14-00**  
**Project No.: 19773**

**Borehole 18-402**  
**Run 1 to 3 (of 3)**  
**Elevation 418.1 m to 414.6 m**



**Foundation Investigation  
Wabikon Creek Culvert  
Highway 527**

**GWP 6829-14-00**  
**Project No.: 19773**

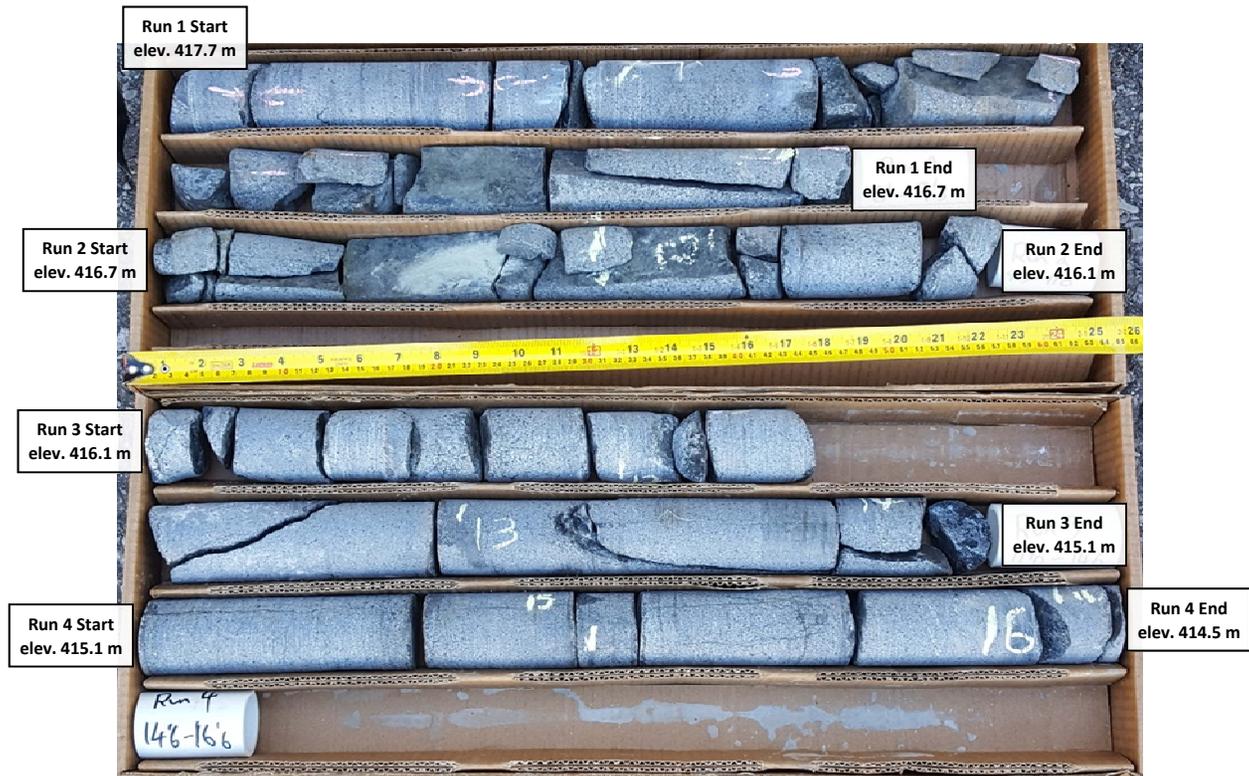
**Borehole 18-403**  
**Run 1 to 3 (of 3)**  
**Elevation 417.7 m to 414.6 m**



**Foundation Investigation**  
**Wabikon Creek Culvert**  
**Highway 527**

**GWP 6829-14-00**  
**Project No.: 19773**

**Borehole 18-404**  
**Run 1 to 4 (of 4)**  
**Elevation 417.7 m to 414.5 m**



**Foundation Investigation**  
**Wabikon Creek Culvert**  
**Highway 527**

**GWP 6829-14-00**  
**Project No.: 19773**

**Appendix C.3**  
**Analytical Testing Results**

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

Report Date: 26-Jun-2018

Order Date: 20-Jun-2018

Project Description: 19773

		Client ID:	18-101, SS6, 12'6"-14'6"	18-203, SS3, 5'10"-7'10"	18-204, SS4, 10'4"-12'4"	18-401, SS5, 10'-12'
		Sample Date:	05/30/2018 11:00	06/12/2018 14:30	06/13/2018 09:45	06/07/2018 13:30
		Sample ID:	1825441-01	1825441-02	1825441-03	1825441-04
		MDL/Units	Soil	Soil	Soil	Soil
<b>Physical Characteristics</b>						
% Solids	0.1 % by Wt.		80.0	88.0	89.3	92.4
<b>General Inorganics</b>						
Conductivity	5 uS/cm		135	156	98	90
pH	0.05 pH Units		7.81	7.76	7.76	7.56
Resistivity	0.10 Ohm.m		74.3	64.3	102	111
<b>Anions</b>						
Chloride	5 ug/g dry		9	25	29	9
Sulphate	5 ug/g dry		16	46	7	28
		Client ID:	18-502, SS8, 17'6"-19'6"	18-301, SS8A, 17'6"-19'4"	-	-
		Sample Date:	06/12/2018 11:15	06/05/2018 15:30	-	-
		Sample ID:	1825441-05	1825441-06	-	-
		MDL/Units	Soil	Soil	-	-
<b>Physical Characteristics</b>						
% Solids	0.1 % by Wt.		89.9	90.0	-	-
<b>General Inorganics</b>						
Conductivity	5 uS/cm		47	50	-	-
pH	0.05 pH Units		7.14	7.38	-	-
Resistivity	0.10 Ohm.m		213	198	-	-
<b>Anions</b>						
Chloride	5 ug/g dry		13	19	-	-
Sulphate	5 ug/g dry		10	6	-	-



**SGS Canada Inc.**

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

28-June-2018

**Paracel Laboratories**

Attn : Dale Robertson

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

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

**Date Rec. :** 22 June 2018  
**LR Report:** CA12773-JUN18  
**Reference:** Project#:1825441

**Copy:** #1

# CERTIFICATE OF ANALYSIS

## Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		28-Jun-18
2: Analysis Start Time		13:23
3: Analysis Completed Date		28-Jun-18
4: Analysis Completed Time		14:45
5: QC - Blank		< 0.02
6: QC - STD % Recovery		105%
7: QC - DUP % RPD		ND
8: RL		0.02
<del>9: 18-101,SS6, 12'6"-14'16"</del>	<del>30-May-18</del>	<del>&lt; 0.02</del>
<del>10: 18-204,SS4, 10'4"-12'4"</del>	<del>13-Jun-18</del>	<del>&lt; 0.02</del>
11: 18-401,SS5, 10'-12'	07-Jun-18	< 0.02
<del>12: 18-502,SS8, 17'6"-19'6"</del>	<del>12-Jun-18</del>	<del>&lt; 0.02</del>
<del>13: 18-301,SS8A, 17'6"-19'4"</del>	<del>05-Jun-18</del>	<del>&lt; 0.02</del>

RL - SGS Reporting Limit  
ND - Not Detected

Kimberley Didsbury  
Project Specialist  
Environmental Services, Analytical

**Appendix D.**

**Site Photographs**

HIGHWAY 527 WABIKON CREEK CULVERT  
6 KM NORTH OF ON-811, THUNDER BAY UNORGANIZED

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**Photo 1. Looking westward at north Highway 527 embankment slope (2018/06/03)**



**Photo 2. Looking eastward along Highway 527 over the culvert (2018/08/12)**



**Photo 3. Looking north downstream at culvert inlet (2018/08/12)**



**Photo 4. Looking south from BH 18-404 towards culvert outlet (2018/08/12)**