



**THURBER** ENGINEERING LTD.

**FINAL  
FOUNDATION INVESTIGATION REPORT  
HIGHWAY 523 BARK LAKE CULVERT REPLACEMENT  
7.4 KM SOUTH OF HIGHWAY 60, TOWNSHIP OF LYELL  
AGREEMENT NO. 5015-E-0043**

**W.P. 5464-15-01**

Geocres No.: 31F-198

Report to:

**McIntosh Perry Consulting Engineers Limited**

Latitude: 45.475836  
Longitude: -77.908250

April 2019  
Thurber File: 16284

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**FOUNDATION INVESTIGATION REPORT  
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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 proposed culvert replacement at the Highway 523 crossing of Bark Lake (Wolf Creek). The culvert is located approximately 7.4 km south of Highway 60 within the Township of Lyell. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Agreement No. 5015-E-0043.

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 Bark Lake under Highway 523, is a single span structural plate corrugated steel pipe culvert with an unknown construction date. A site survey plan from MPCE indicates that the culvert is 1.85 m diameter and approximately 20.70 m long. The culvert alignment is generally west to east with the flow through the culvert toward the east. A CSP overflow culvert, reported to be 1.20 m diameter and 22.80 m long, is located approximately 8.75 m to the north of the main culvert.

At the location of the culvert, Highway 523 is a two-lane highway with a rural cross-section and gravel shoulders. Lake water was present along both sides of the highway at the time of the field investigations. The culvert was nearly full and appears to operate as an equalizer pipe as flow of water was not apparent. The Highway 523 embankment fill height varies from 4.1 m on the west side to 6.4 m on the east side with the road surface at approximate elevation of 315.5 m. The existing embankment side slopes are inclined at approximately 1.5 to 2H:1V. Wooden posts with steel cable guiderails are present on both sides of the highway on each side the culvert. The land adjacent to the highway and waters edge is undeveloped and densely vegetated with trees. Traffic volumes are understood to be 520 AADT (2012).

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

**FINAL**

### **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing program was carried out between May 3<sup>rd</sup> and May 4<sup>th</sup> and between August 8<sup>th</sup> and August 10<sup>th</sup>, 2017. Drilling consisted of advancing six boreholes identified as 17-1 through 17-6. The drilling was carried out using a raft and portable equipment in the lake for Boreholes 17-3 through 17-6, and a truck mounted drill rig for on-road Boreholes 17-1 and 17-2. 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). Borehole 17-3 through 17-6 were drilled with portable equipment and a full-weight hammer for SPT testing. The boreholes were sampled to refusal which was encountered at elevations ranging from 308.0 to 306.2 m. Bedrock was cored in on-road borehole 17-2.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport for further laboratory examination and testing. Following completion of the field investigation the boreholes were backfilled in general accordance with MOEE requirements (O.Reg. 903). Boreholes 17-1 and 17-2 were capped with cold patch asphalt to reinstate the traveling surface.

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.

### **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 (sieve). The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. Two samples of soil recovered from within the boreholes were 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 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 deposits of native, non-cohesive soils over bedrock.

## 5.1 Embankment

### 5.1.1 Asphalt

Boreholes 17-1 and 17-2 were drilled through the existing Highway 523 embankment and encountered a layer of asphalt with a thickness of 80 mm.

### 5.1.2 Fill: Sand

Below the asphalt pavement within the on-road boreholes was a layer of non-cohesive embankment fill consisting of sand with silt and gravel, to sand some gravel. Cobbles and boulders were noted within the embankment fill. All four off-road boreholes also encountered a fill layer consisting of gravel with sand. The underside of the embankment fill was at 4.5 to 4.6 m (elev. 311.0 to 310.9 m) below the existing roadway surface. The underside of the fill in the off-road boreholes was encountered 0.6 to 2.7 m below lake bed surface (elev. 309.1 to 311.4 m)

The SPT tests conducted in the fill typically gave N-values ranging from 2 to 44 blows indicating a relative density of very loose to dense. Recorded moisture contents ranged from 5 to 32%.

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

Soil Particle	Percentage (%)	
	Sand with silt and gravel	Gravel with sand
Gravel	11 - 33	52 - 60
Sand	57 - 84	39 - 46
Silt and Clay	5 - 10	1 - 2

## 5.2 Silt

Below the fill in Borehole 17-3 was a native layer of silt with organics. The silt layer was 0.8 m thick with an underside depth of 2.4 m below lake bed surface (elev. 310.7 m). A single SPT test conducted in the silt gave a N-value of 3 blows indicating a very loose consistency. A moisture content of 68% was measured.

## 5.3 Sand with Silt

Below the fill was a non-cohesive layer of sand with silt which included wood fragments, cobbles and boulders. An obstruction was encountered in Borehole 17-01 which prohibited the core barrel from advancing past elevation 309.9 m and therefore the borehole was terminated at this elevation.

SPT test N-values ranging from 27 to 78 blows were recorded within the layer indicating a compact to very dense relative density. The recorded moisture contents ranged from 22 to 25%.

A gradation analysis was completed on a sample of the sand layer. The grain size distribution curve is included in Figure C2 of Appendix C. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	14
Sand	79
Silt and Clay	7

#### 5.4 Silty Sand to Gravel with Silt Till

Below the fill, silt and sand with silt layers were non-cohesive layers varying from silty sand with gravel to gravel with silt till. Boulders were noted in the till in Boreholes 17-02 and 17-06. Boreholes 17-03 through 17-06 were terminated in this layer at a base elevation of 308.0 to 306.3 m upon SPT and/or casing advancement refusal.

SPT test N-values ranging from 35 to 103 blows were recorded within the till layers indicating a dense to very dense relative density. Refusal blow counts were recorded on inferred boulders within the layer and at the borehole termination depth on inferred bedrock with N-values recorded as high as 100 blows per 100 mm of penetration. The recorded moisture contents ranged from 5 to 18%.

Gradation analyses were completed on five samples of the till layers. The grain size distribution curves are included in Figure C3 of Appendix C. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)	
	Sand with silt and gravel	Gravel/Sand
Gravel	36 - 43	43 - 66
Sand	44 - 55	28 - 44
Silt and Clay	13	6 - 13

#### 5.5 Bedrock

Bedrock was proven by coring in Borehole 17-02 and was inferred at SPT refusal in Boreholes 17-04 through 17-06. The proven and inferred bedrock surface ranged from elevation 307.9 to 306.2 m. The Total Core Recovery (TCR) was 100%, the Solid Core Recovery (SCR) ranged from 98 to 100% and the Rock Quality Designation (RQD) ranged from 93 to 97% indicating excellent rock quality.

## 5.6 Groundwater

The groundwater level was not measured in the on-road boreholes due to water being introduced into the borehole during coring operations. It is expected that, based on the foundation soils encountered at this site, the groundwater level will largely be controlled by the water level in the adjacent lake which was noted at elevation 313.8 to 313.9 m during the August 2017 field investigation.

It should be noted that the groundwater level at the time of construction may be higher 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. It is understood that the lake water level is regulated by a water control structure and will change over time.

## 5.7 Analytical Testing

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

Borehole	Sample	Depth(*) (m)	Sulphate (µg/g)	pH ( - )	Resistivity (Ohm-cm)	Chloride (µg/g)
17-3	SS3	3.0 – 3.7	176	4.9	4610	6
17-6	SS2	4.6 – 5.2	26	5.7	15800	7

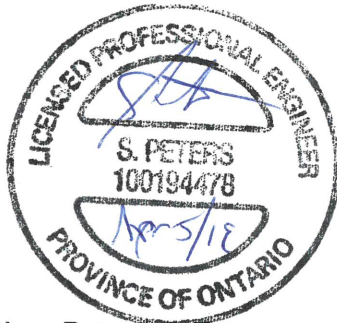
Note: (\*) depth relative to top of raft at time of drilling.

## 6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to the existing culvert and the existing site features. The as-drilled locations and ground surface elevations for the on-road boreholes were surveyed by McIntosh Perry following completion of the field program. The off-road boreholes were surveyed by Thurber.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario and Forage M3 Drilling also of Hawkesbury, Ontario supplied and operated the drilling equipment to carry out the drilling, soil sampling, in-situ testing and borehole decommissioning. The field investigation was supervised on a full time basis by Mr. Jeff Morrison, E.I.T. and Mr. Chris Murray, E.I.T., of Thurber. Overall supervision of the investigation program was conducted by Mr. Stephen Peters, 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 Dr. Fred Griffiths, P.Eng. and Mr. Stephen Peters P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



Stephen Peters, P.Eng.  
Geotechnical Engineer



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



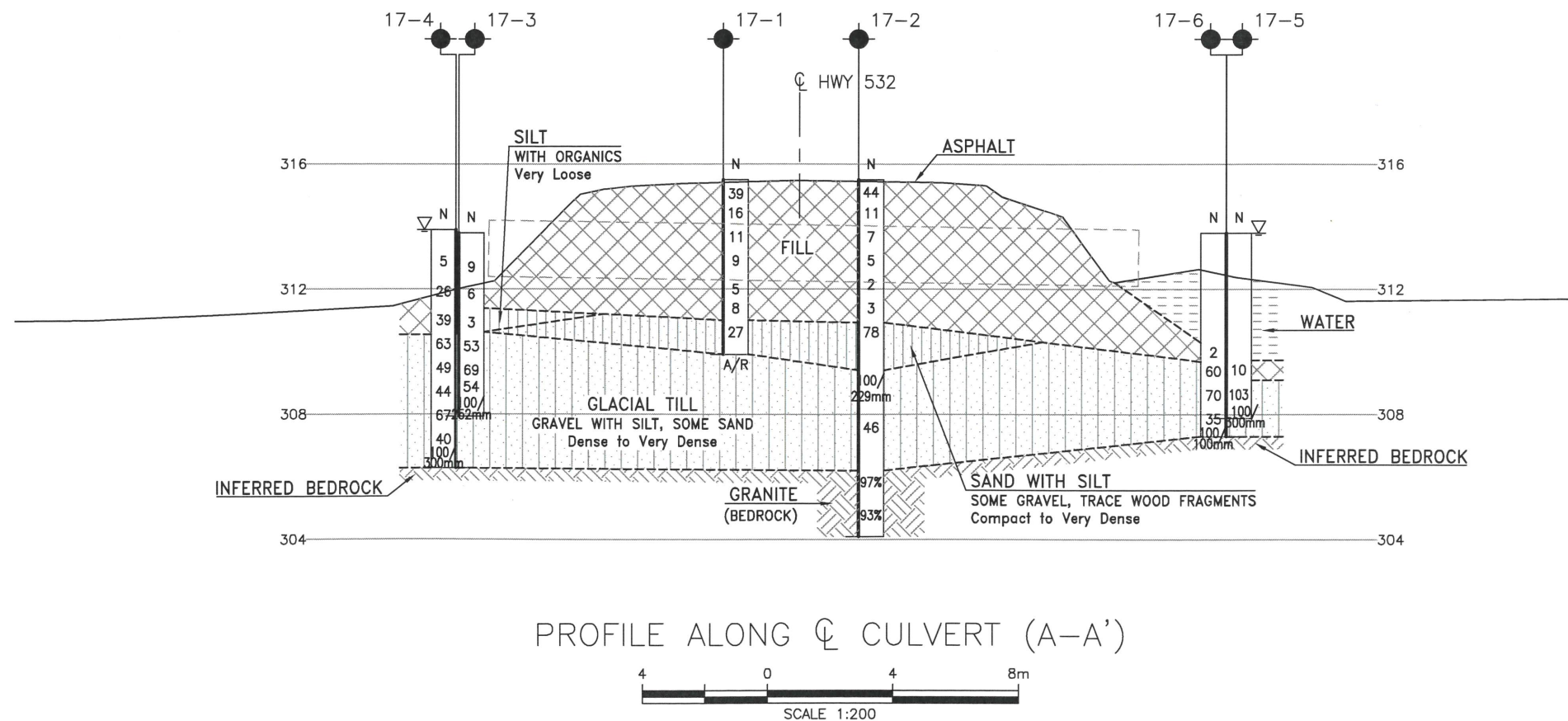
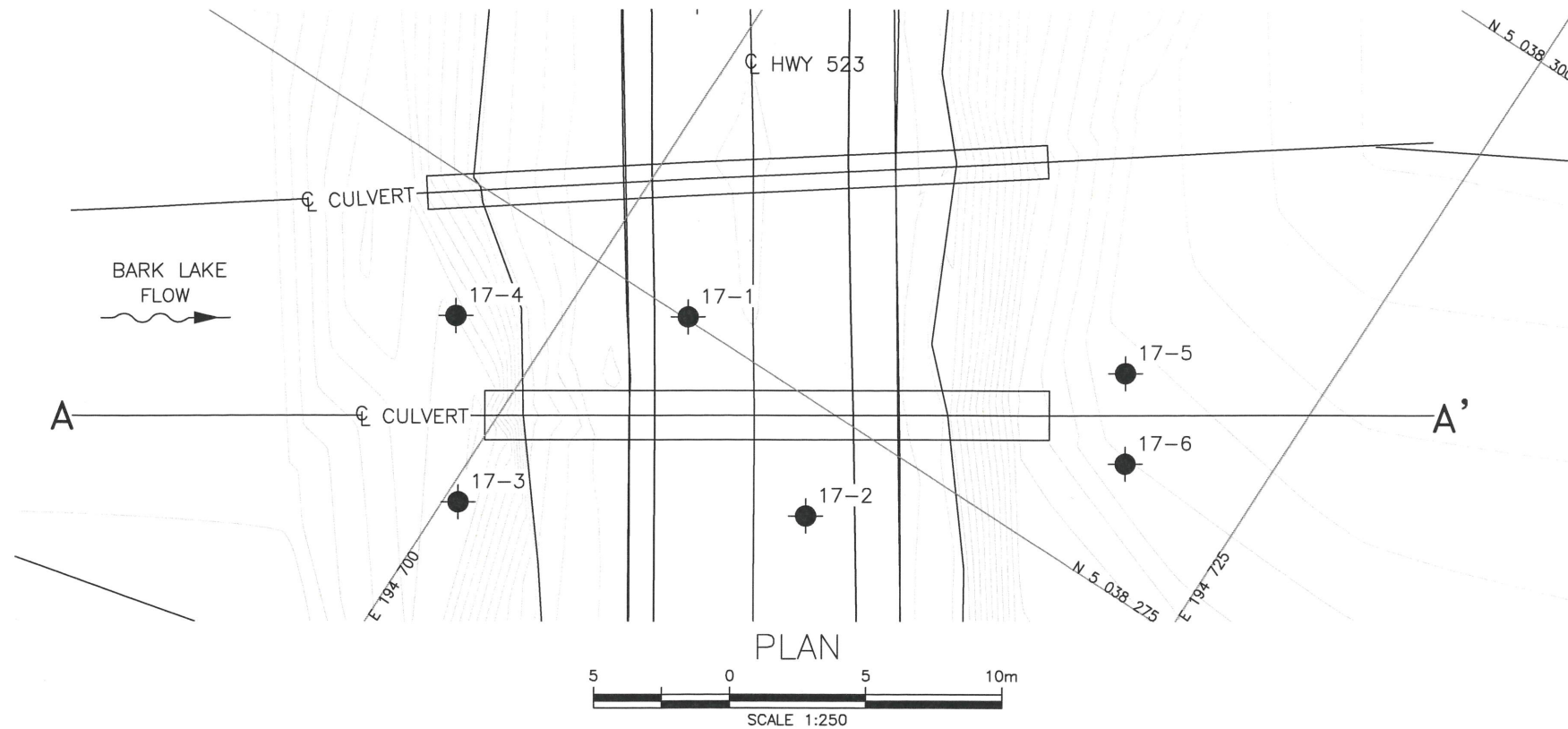
Dr. P.K. Chatterji, P.Eng.  
Review Principal  
Senior Geotechnical Engineer



HIGHWAY 523 BARK LAKE CULVERT REPLACEMENT  
7.4 KM SOUTH OF HIGHWAY 60, TOWNSHIP OF LYELL

**Appendix A.**

**Borehole Location Plan and Stratigraphic Drawings**



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



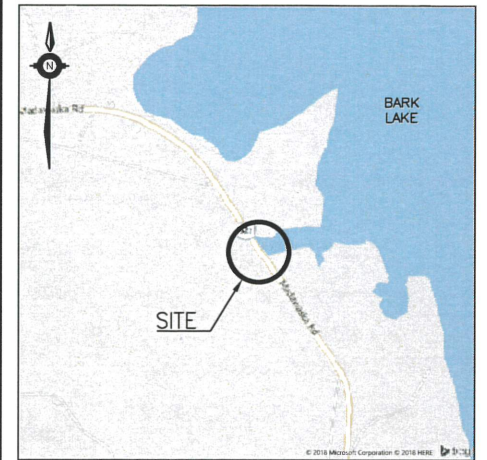
CONT No  
WP No 5464-15-01

HIGHWAY 523  
BARK LAKE CULVERT  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
17-1	315.5	5 038 275.1	194 703.9
17-2	315.5	5 038 271.3	194 711.5
17-3	313.8	5 038 264.8	194 700.5
17-4	313.9	5 038 270.5	194 696.7
17-5	313.8	5 038 282.1	194 718.5
17-6	313.8	5 038 279.3	194 720.3

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.

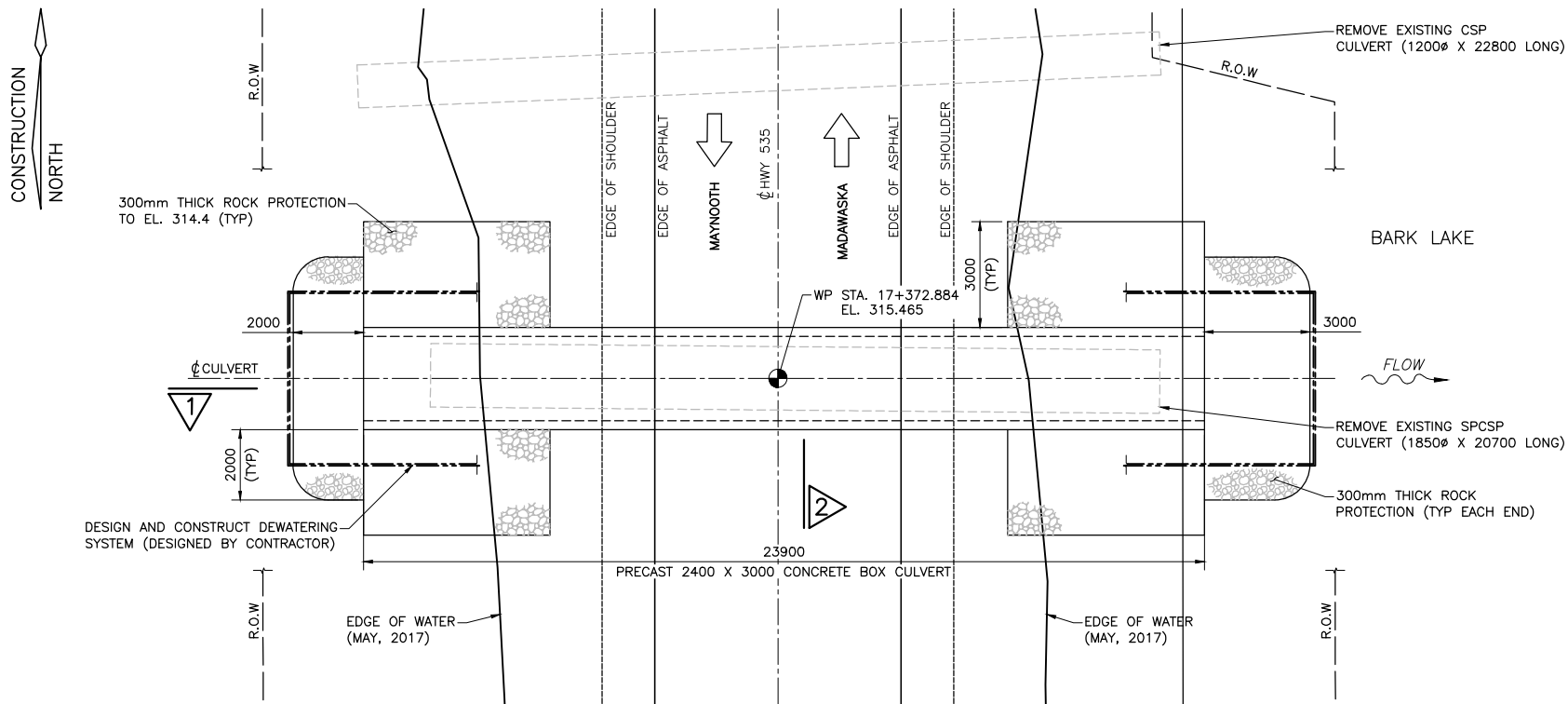
GEOCRES No. 31F-198

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DRAWN	AN	CHK	SBP
LOAD			
STRUC			
DWG			
DATE	APR 2019		

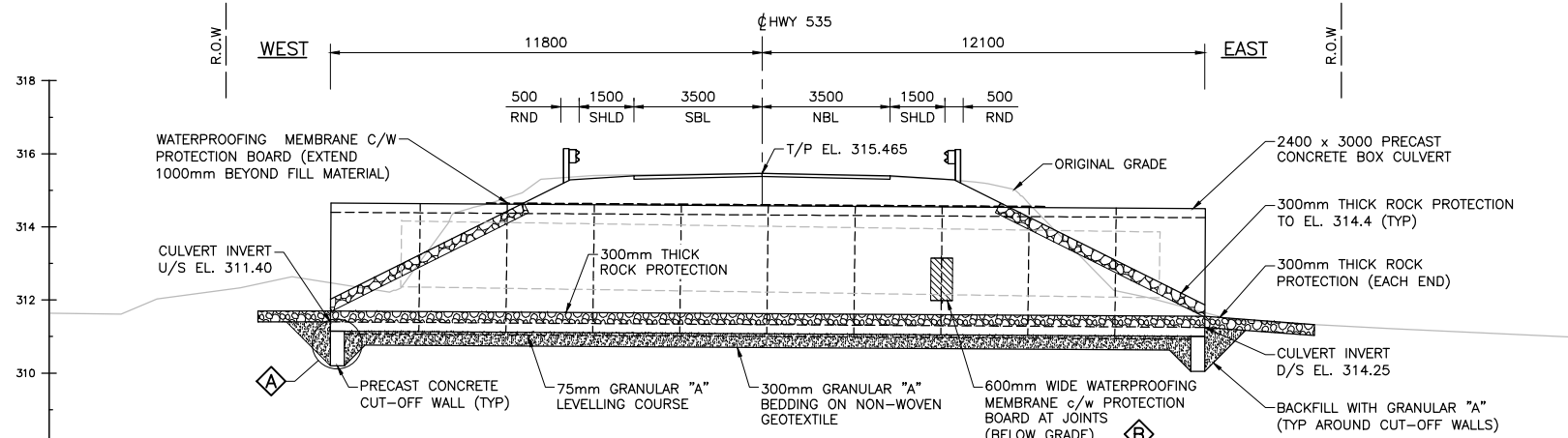
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DATE PLOTTED: 3/21/2019 11:18:45 AM BY: DEREK SIMMS

MINISTRY OF TRANSPORTATION, ONTARIO

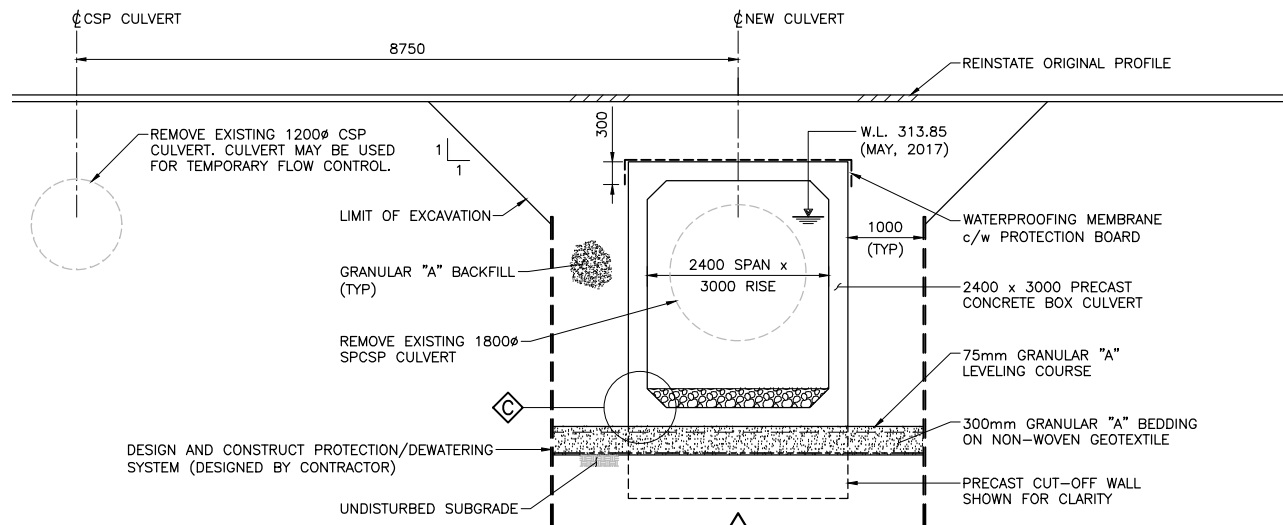
PR-D-707 8B-05



PLAN  
1:100



1  
1:100



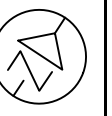
2  
1:50

LEGEND:

- GRANULAR "A" BEDDING
- GRANULAR "A" BACKFILL
- ROCK PROTECTION

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

HIGHWAY 523  
CONT. No. 2018-XXXX  
WP No. 5464-15-01



BARK LAKE  
CULVERT REPLACEMENT

SHEET

GENERAL ARRANGEMENT

18

McINTOSH PERRY

GENERAL NOTES:

- CLASS OF CONCRETE  
PRECAST 40 MPa

CLEAR COVER TO REINFORCING STEEL  
- PRECAST 50 ± 10mm

REINFORCING NOTES:

- REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
- UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES SHALL BE CLASS B.
- BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUP AND TIES SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.

GEOTEXTILE:

- NON-WOVEN, CLASS II, FOS 75 TO 150um. AND FREE OF FOLDS, TEARS AND WRINKLES.

CONSTRUCTION NOTES:

- THE CONTRACTOR SHALL CHECK AND VERIFY ALL DIMENSIONS AND SITE CONDITIONS BEFORE PROCEEDING WITH WORK AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR BEFORE COMMENCING THE WORK.
- THE TEMPORARY FLOW CONTROL SHALL BE DESIGNED FOR A TWO (2) YEAR DESIGN STORM RETURN PERIOD OF 2.74 m<sup>3</sup>/s.
- THE CONTRACTOR IS ADVISED THAT THE WATER LEVEL AT THIS SITE IS DAM CONTROLLED BY THE BARK LAKE DAM. THE NORMAL OPERATING RANGE IS 304.7m to 313.94m WITH A SUMMER MINIMUM OF 313.62m.
- LENGTH OF PRECAST UNITS MAY BE MODIFIED AS PER MANUFACTURERS REQUIREMENTS. TOTAL LENGTH OF THE CULVERT SHALL NOT BE LESS THAN WHAT IS SHOWN AND MAXIMUM LENGTH OF CULVERT WILL BE WITHIN 300mm OF WHAT IS SHOWN.
- THE CONTRACTOR SHALL ADJUST ALL NECESSARY DIMENSIONS TO ACCOMMODATE ANY CHANGES TO THE DIMENSIONS OF THE PRECAST UNITS, AT NO COST TO THE OWNER.
- THE CONTRACTOR SHALL DESIGN AND SUPPLY ANY TEMPORARY SUPPORT REQUIRED FOR THE REMOVAL OF THE EXISTING STRUCTURE IN ACCORDANCE WITH OPSS 919.
- BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH CULVERT WALLS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN THE ELEVATION BE GREATER THAN 500mm.
- LOCATION AND DESIGN FOR ALL LIFTING DEVICES SHALL BE PROVIDED BY THE PRECAST MANUFACTURER. LIFTING DEVICES SHALL BE FILLED WITH REPAIR MORTAR AND MADE TO BE FLUSH WITH THE TOP OF THE BOX CULVERT SECTION.
- PROVIDE 25x25 CHAMFER TO ALL CORNERS OF NEW CONCRETE.
- ALL AREAS AFFECTED BY CONSTRUCTION ACTIVITIES SHALL BE FULLY REINSTATED TO PRE-CONSTRUCTION OR BETTER CONDITIONS TO THE SATISFACTION OF THE CONTRACT ADMINISTRATOR INCLUDING THE REINSTATEMENT OF ALL VEGETATION, PATHWAYS, FENCES, AND AREAS USED FOR SITE ACCESS.

APPLICABLE STANDARD DRAWINGS:

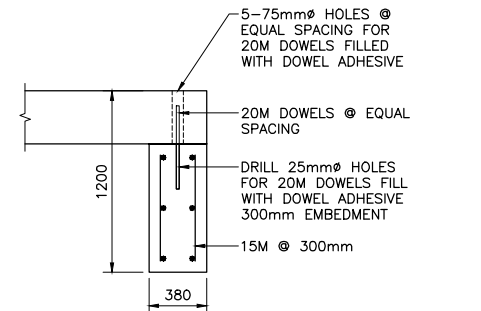
OPSD 3941.200 - FIGURES IN CONCRETE SITE NUMBER AND LAYOUT

LIST OF DRAWINGS:

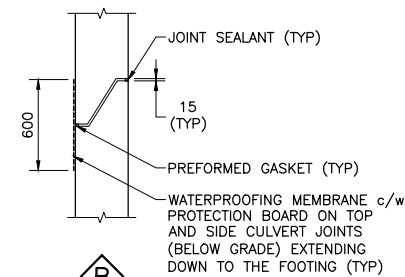
- GENERAL ARRANGEMENT
- BOREHOLE LOCATIONS AND SOIL STRATA

LIST OF ABBREVIATIONS:

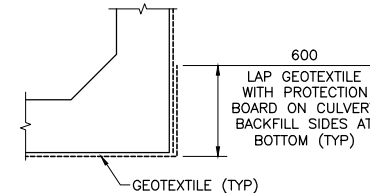
SYMBOL	ABBREVIATION	DESCRIPTION
CL	CENTRELINE	MIN. STA.
DWG.	DRAWINGS	STATION
EL.	ELEVATION (METRES)	W.L.
EX.	EXISTING	TYP
U/S	UPSTREAM	D/S
OG	ORIGINAL GROUND	R.O.W.
		MINIMUM
		STATION
		WATER LEVEL
		TYPICAL
		DOWNSTREAM
		RIGHT OF WAY



A  
N.T.S.



B  
N.T.S.



C  
N.T.S.

DRAWING NOT TO BE SCALED  
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	REV	DESCRIPTION
DESIGN	LD	CHK	QI	CODE CHBDC-14   LOAD CL-625-ONT   DATE APR/18
DRAWN	JM	CHK	LD	SITE 43-XXX/C/STRUCT   SCHEME   DWG 1

HIGHWAY 523 BARK LAKE CULVERT REPLACEMENT  
7.4 KM SOUTH OF HIGHWAY 60, TOWNSHIP OF LYELL

**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).

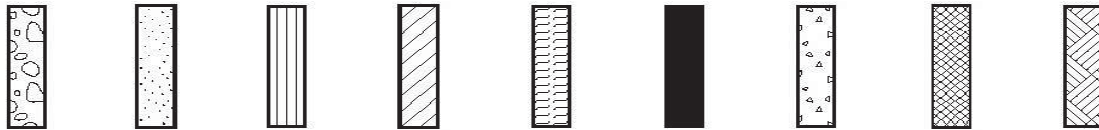
### **DYNAMIC CONE PENETRATION TEST (DCPT):**

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 17-1

1 OF 1

METRIC

WP# 5464-15-01 LOCATION Lat: 45.475720°, Long: -77.908171° Bark Lake Culvert, MTM z9: N 5 038 275.1 E 194 703.9 ORIGINATED BY JM/KE  
 HWY 523 BOREHOLE TYPE NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.05.03 - 2017.05.03 CHECKED BY SP

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 (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
315.5														
0.0	ASPHALT 80 mm													
0.1	SAND with silt and gravel Dense to loose Brown FILL		1	SS	39		315						o	33 57 10 (SI+CL)
			2	SS	16								o	
							314							
			3	SS	11									
			4	SS	9		313						o	
	- Frequent cobbles and boulders below 3.0 m, switch to coring													
			5	SS	5		312						o	
			6	SS	8								o	33 58 9 (SI+CL)
311.0							311						o	
4.5	SAND with silt and gravel frequent cobbles and boulders, trace wood fragments Compact Brown		7	SS	27									
309.9							310							
5.6	End of Borehole - obstruction encountered at 5.6 m													

DOUBLE LINE 16284 BARK LAKE CULVERT.GPJ 2012TEMPLATE(MTO).GDT 8/4/19

# RECORD OF BOREHOLE No 17-2

1 OF 2

METRIC

WP# 5464-15-01 LOCATION Lat: 45.475687°, Long: -77.908074°  
Bark Lake Culvert, MTM z9: N 5 038 271.3 E 194 711.5 ORIGINATED BY JM/KE  
HWY 523 BOREHOLE TYPE NW Casing COMPILED BY KE  
DATUM Geodetic DATE 2017.05.04 - 2017.05.04 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								WATER CONTENT (%)					
315.5													
0.0	ASPHALT 80 mm												
0.1	SAND with silt some gravel to SAND some gravel Dense to loose Brown - occasional cobbles FILL		1	SS	44								
			2	SS	11								
			3	SS	7								
			4	SS	5								
			5	SS	2								
			6	SS	3								
310.9													
4.6	SAND with silt some gravel, trace wood fragments Very dense Grey-brown  - Boulders present below 5.18 m		7	SS	78								
309.4													
6.1	GRAVELwith silt GLACIAL TILL some sand Very dense Grey Cobbles and Boulders throughout		8	S300 / 229 mm									
			9	SS	46								
306.2													
9.3	BEDROCK Granite Fresh Grey-pink		1	NQ									
												</	

DOUBLE LINE 16284 BARK LAKE CULVERT.GPJ 2012TEMPLATE(MTO).GDT 8/4/19

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10


(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 17-2

2 OF 2

METRIC

WP# 5464-15-01 LOCATION Lat: 45.475687°, Long: -77.908074° ORIGINATED BY JM/KE  
 HWY 523 BOREHOLE TYPE NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.05.04 - 2017.05.04 CHECKED BY SP

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									
							20	40	60	80	100	20	40	60			
	Continued From Previous Page																
304.1	<b>BEDROCK</b> Granite Fresh Grey-pink		2	NQ			305									RUN #2 TCR=100% SCR=98% RQD=93%	
11.4	End of Borehole																

DOUBLE LINE 16284 BARK LAKE CULVERT.GPJ 2012TEMPLATE(MTO).GDT 8/4/19

# RECORD OF BOREHOLE No 17-3

1 OF 1

METRIC

WP# 5464-15-01 LOCATION Lat: 45.475627°, Long: -77.908213° Bark Lake Culvert, MTM z9: N 5 038 264.8 E 194 700.5 ORIGINATED BY CM  
HWY 523 BOREHOLE TYPE Portable Raft / NW Casing COMPILED BY KE  
DATUM Geodetic DATE 2017.08.08 - 2017.08.08 CHECKED BY SP

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									
313.8								20	40	60	80	100					
0.0	WATER																
313.1																	
0.8	GRAVEL with sand Loose Brown FILL		1	SS	9		313										52 46 2 (SH+CL)
			2	SS	6		312										
311.4																	
2.4	SILT with Organics Very Loose Dark Brown		3	SS	3		311										
310.7																	
3.2	SILTY SAND with Gravel GLACIAL TILL Very Dense Grey		4	SS	53		310										
			5	SS	69		309										43 44 13 (SH+CL)
			6	SS	54												
308.0			7	SS	100/		308										
5.9	End of Borehole Borehole terminated within very dense Glacial Till				252 mm												

DOUBLE LINE 16284 BARK LAKE CULVERT.GPJ 2012TEMPLATE(MTO).GDT 8/4/19

# RECORD OF BOREHOLE No 17-4

1 OF 1

METRIC

WP# 5464-15-01 LOCATION Lat: 45.475678°, Long: -77.908263° Bark Lake Culvert, MTM z9: N 5 038 270.5 E 194 696.7 ORIGINATED BY CM  
HWY 523 BOREHOLE TYPE Portable Raft / NW Casing COMPILED BY KE  
DATUM Geodetic DATE 2017.08.08 - 2017.08.09 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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%) W P      W      W L						
313.9								20	40	60	80	100						
0.0	WATER																	
313.2																		
0.7	GRAVEL with sand Loose to Dense Brown FILL		1	SS	5		313							○				
			2	SS	26		312							○				
			3	SS	39		311							○				
310.5																		
3.4	SAND with silt and gravel to SILTY SAND with Gravel GLACIAL TILL Dense to Very Dense Grey		4	SS	63		310							○				36 55 9 (SI+CL)
			5	SS	49		309							○				
			6	SS	44		308							○				
			7	SS	67		307							○				26 61 13 (SI+CL)
			8	SS	40									○				
			9	SS	100/ 300 mm									○				
306.3																		
7.6	End of Borehole on inferred Bedrock																	

DOUBLE LINE 16284 BARK LAKE CULVERT GPJ 2012TEMPLATE(MTO).GDT 8/4/19

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

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 17-6

1 OF 1

METRIC

WP# 5464-15-01 LOCATION Lat: 45.475760°, Long: -77.907963° Bark Lake Culvert, MTM z9: N 5 038 279.3 E 194 720.3 ORIGINATED BY CM  
 HWY 523 BOREHOLE TYPE Portable Raft / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2017.08.09 - 2017.08.10 CHECKED BY SP

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 (%)  GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						PLASTIC LIMIT W P      NATURAL MOISTURE CONTENT W      LIQUID LIMIT W L					
313.8								20	40	60	80	100							
0.0	WATER																		
310.3	- Cobbles and Boulders on Ground Surface																		
3.5	GRAVEL with sand Compact Brown		1	SS	2														
309.7	FILL																		
4.1	GRAVEL with silt and sand GLACIAL TILL Very Dense to Dense Grey - Boulder at 4.7 m		2	SS	60														
			3	SS	70														
			4	SS	35														
307.3			5	SS	100/														
6.5	End of Borehole on inferred Bedrock				100mm														

DOUBLE LINE 16284 BARK LAKE CULVERT.GPJ 2012TEMPLATE(MTO).GDT 8/4/19

**Borehole 17-2**  
**Core Box 1 of 1**  
**Elevation 306.2 m to 304.1 m**

Run 1 Start  
elev. 306.2 m



Run 1 End  
elev. 305.5 m

Run 2 Start  
elev. 305.5 m

Run 2 End  
elev. 304.1 m



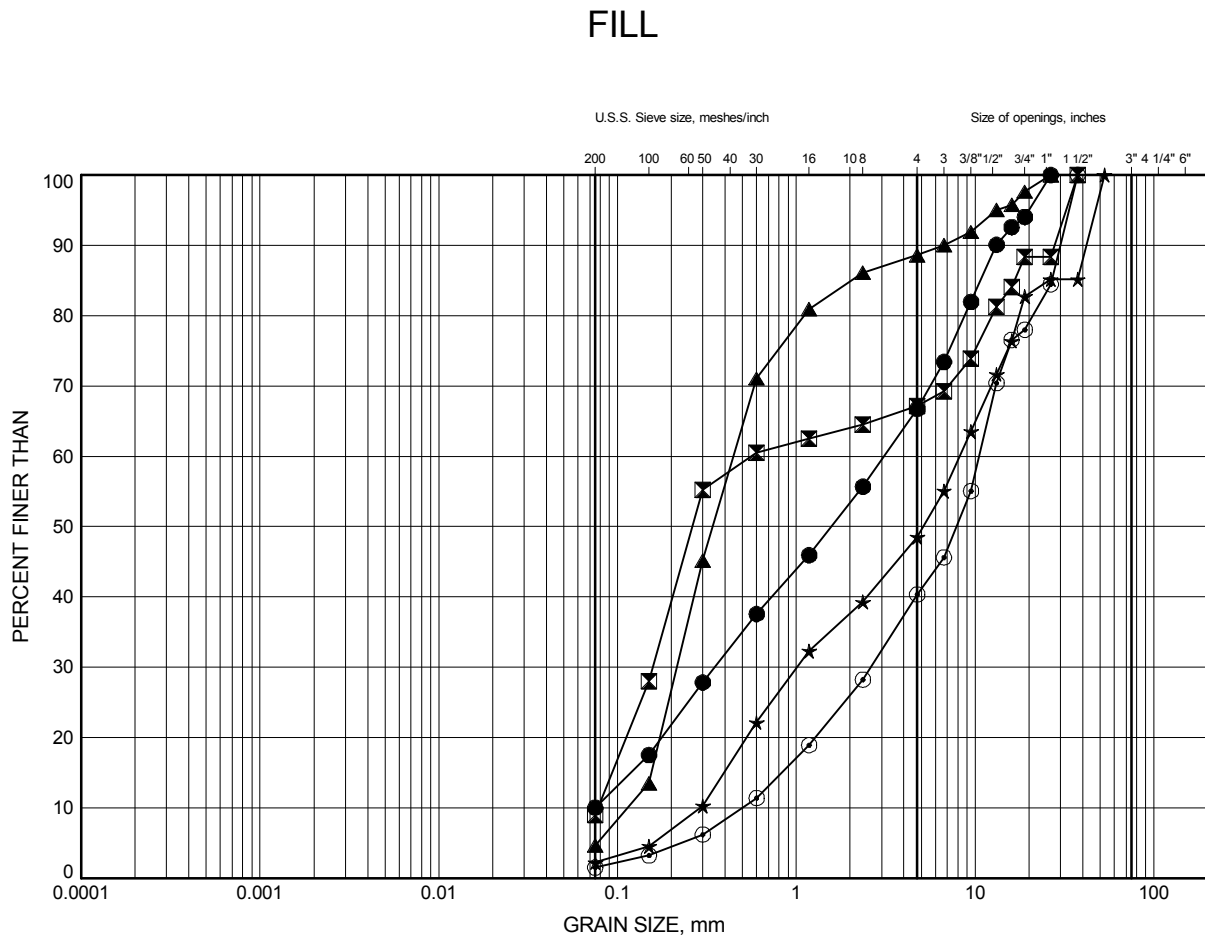
## **Appendix C.**

### **Laboratory Testing**

# Bark Lake Culvert

## GRAIN SIZE DISTRIBUTION

FIGURE C1



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	0.46	315.05
⊠	17-1	4.11	311.39
▲	17-2	1.07	314.42
★	17-3	1.09	312.76
⊙	17-5	4.37	309.47

Date April 2019  
 WP# 5464-15-01

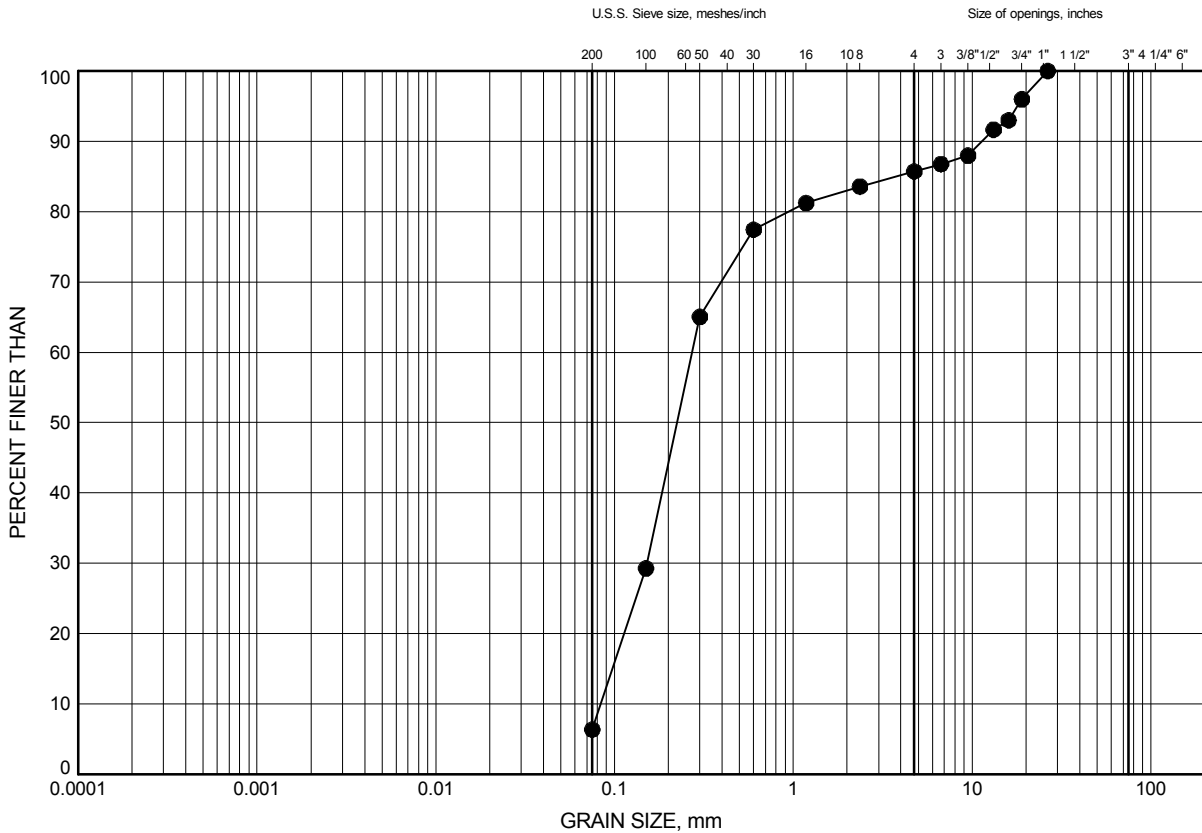


Prep'd AC  
 Chkd. SBP

# Bark Lake Culvert GRAIN SIZE DISTRIBUTION

FIGURE C2

## SAND with Silt



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-2	4.88	310.61

Date April 2019  
WP# 5464-15-01



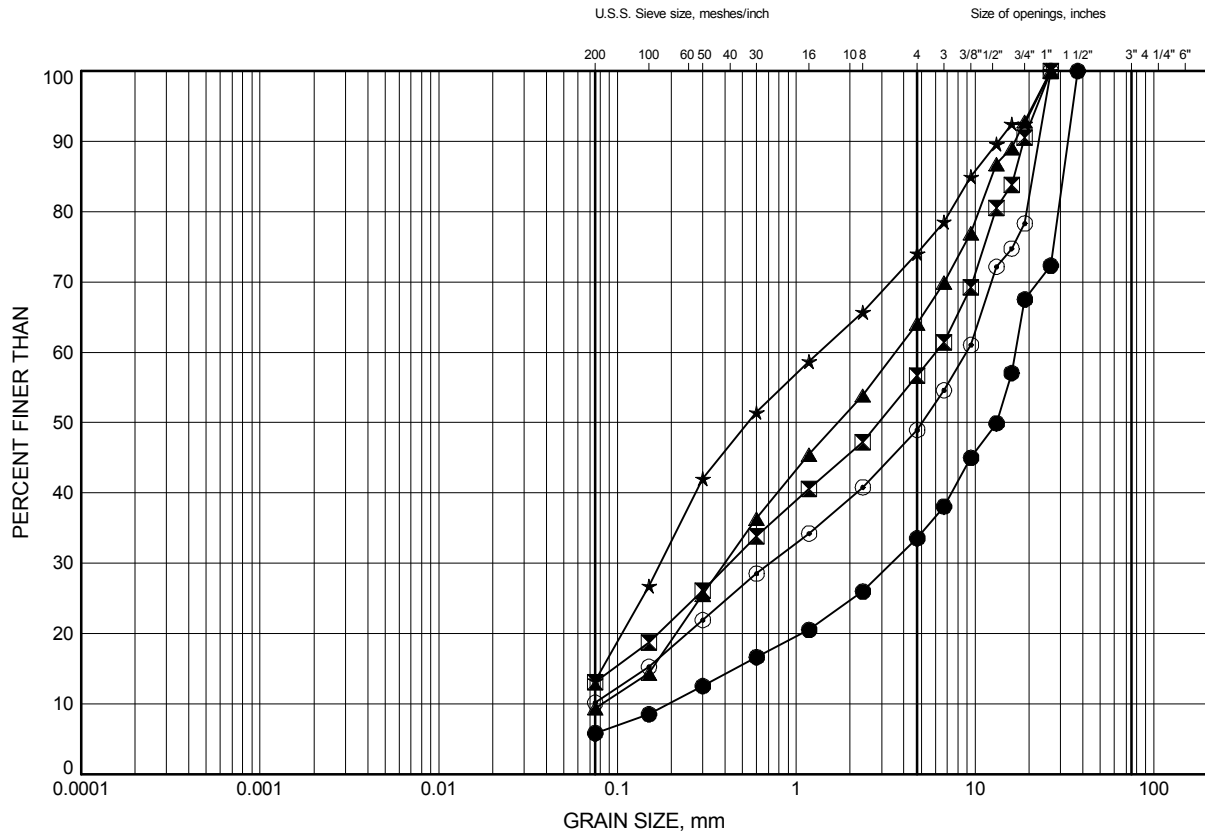
Prep'd AC  
Chkd. SBP

# Bark Lake Culvert

## GRAIN SIZE DISTRIBUTION

FIGURE C3

Silty SAND with Gravel to GRAVEL with Silt (TILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-2	6.41	309.07
⊠	17-3	4.40	309.45
▲	17-4	3.66	310.22
★	17-4	6.71	307.17
⊙	17-6	5.18	308.66

Date April 2019

WP# 5464-15-01



Prep'd AC

Chkd. SBP

## Certificate of Analysis

### Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B4S5  
Attn: Stephen Peters

Client PO: 16284  
Project: Hwy 35/523  
Custody: 38404

Report Date: 29-Aug-2017  
Order Date: 23-Aug-2017

**Order #: 1734260**

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

Parcel ID	Client ID
<del>1734260-01</del>	<del>Black Creek 17-3 SS#2 7.83-9.83'</del>
<del>1734260-02</del>	<del>Black Creek 17-5 SS#3 10.17-12.17'</del>
<del>1734260-03</del>	<del>Miner's Bay 17-3 SS#1 0-1.25'</del>
1734260-04	Bark Lake 17-3 SS#3 10-12'
1734260-05	Bark Lake 17-6 SS#2 15-17'

Approved By:



Dale Robertson, BSc  
Laboratory Director

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 16284

Report Date: 29-Aug-2017  
Order Date: 23-Aug-2017  
Project Description: Hwy 35/523

Client ID:	<del>Black Creek 17-3</del>	<del>Black Creek 17-5</del>	<del>Miner's Bay 17-3</del>	Bark Lake 17-3
Sample Date:	SS#2 7.83-9.83'	SS#3 10.17-12.17'	SS#1 0-1.25'	SS#3 10-12'
Sample ID:	14-Aug-17	16-Aug-17	10-Aug-17	08-Aug-17
	1734260-01	1734260-02	1734260-03	1734260-04
MDL/Units	Soil	Soil	Soil	Soil

#### Physical Characteristics

% Solids	0.1 % by Wt.	73.7	76.1	91.0	70.4
----------	--------------	------	------	------	------

#### General Inorganics

Conductivity	5 uS/cm	99	176	220	217
pH	0.05 pH Units	8.33	8.05	7.85	4.91
Resistivity	0.10 Ohm.m	101	56.8	45.5	46.1

#### Anions

Chloride	5 ug/g dry	11	51	8	6
Sulphate	5 ug/g dry	23	25	23	176

Client ID:	Bark Lake 17-6 SS#2	-	-	-
Sample Date:	15-17'	-	-	-
Sample ID:	09-Aug-17	-	-	-
	1734260-05	-	-	-
MDL/Units	Soil	-	-	-

#### Physical Characteristics

% Solids	0.1 % by Wt.	88.8	-	-	-
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#### General Inorganics

Conductivity	5 uS/cm	63	-	-	-
pH	0.05 pH Units	5.70	-	-	-
Resistivity	0.10 Ohm.m	158	-	-	-

#### Anions

Chloride	5 ug/g dry	7	-	-	-
Sulphate	5 ug/g dry	26	-	-	-

HIGHWAY 523 BARK LAKE CULVERT REPLACEMENT  
7.4 KM SOUTH OF HIGHWAY 60, TOWNSHIP OF LYELL

**Appendix D.**

**Site Photographs**

HIGHWAY 523 BARK LAKE CULVERT REPLACEMENT  
7.4 KM SOUTH OF HIGHWAY 60, TOWNSHIP OF LYELL



**Photo 1. Looking southward at culvert inlet (2017/08/10)**



**Photo 2. Looking southward of outlets of by-pass and main culvert (2017/08/10)**



HIGHWAY 523 BARK LAKE CULVERT REPLACEMENT  
7.4 KM SOUTH OF HIGHWAY 60, TOWNSHIP OF LYELL



**Photo 3. Looking north along Highway 523 (2017/08/10)**



**Photo 4. Looking south along Highway 523 (2017/08/10)**