



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 527 MAX CREEK CULVERT
89 KM NORTH OF HIGHWAY 11/17, THUNDER BAY UNORGANIZED
SITE NO.: 48C-222/C
ASSIGNMENT NO. 6017-E-0013**

G.W.P. 6827-14-00

Geocres No.: 52H-45

Report to:

Hatch Corporation

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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 Max Creek Culvert on Highway 527. The culvert is located approximately 89 km north of Highway 11/17 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 Max Creek under Highway 527, is a twin corrugated steel pipe (CSP) culvert constructed in 1984. A site survey plan from Hatch indicates that each CSP has a diameter of 2.4 m and is approximately 20.7 m long. The culvert alignment is generally southwest to northeast with the flow through the culvert toward the northeast.

At the location of the culvert, Highway 527 is a two-lane highway with a rural cross-section, narrow gravel shoulders and cable guiderail on both sides. The embankment fill height above the culvert is approximately 1.0 m. The elevation of the road surface at the centreline is approximately 439.1 m. The existing embankment slopes are inclined between approximately 2.4H:1V and 3.1H: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 between 170 and 420 AADT (2016).

An OSIM report for the culverts dated Friday October 30th, 2015 indicated some transverse and longitudinal cracking of the pavement north of the culverts and some longitudinal cracking south of the culverts. Further, the report commented on signs of settlement of the foundation below both culverts. Minor settlement of the north culvert barrel was also indicated. A visual inspection of the pavement in the vicinity of the culvert completed in June 2018 does not suggest poor pavement performance (i.e. no bumps or sagging of the pavement). 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 2nd and June 14th, 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

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
18-201	South of culvert – SB Lane	5448248.6	352006.3	439.0	12.3
18-202	Bypass culvert – NB Lane	5448282.5	351978.8	439.2	9.4
18-203	East end – culvert outlet	5448261.1	352014.8	436.9	5.7
18-204	West end – culvert inlet	5448246.8	351993.8	437.0	5.5

The drilling was carried out using NW casing with a truck mounted CME 75 drill rig for on-road Boreholes 18-201 and 18-202 and portable drilling equipment for off-road Boreholes 18-203 and 18-204. The off-road boreholes were advanced from the water surface on a raft.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). It is noted that the split spoon sampler has an inside diameter of 35 mm; therefore, larger size particles of gravel, cobbles and boulders, which are known to be present, were not represented in the grain size analyses. Boreholes 18-203 and 18-204, which were drilled with portable equipment, utilized a full-weight hammer for SPT testing. Bedrock was cored and collected in Boreholes 18-201 and 18-202 using NQ coring equipment.

Open-hole groundwater levels were measured within the on-road boreholes upon completion of drilling. All 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 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. Testing for grain size distribution 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 and chloride concentrations was carried out on two soil samples and one surface water sample. Chemical analysis for determination of sulphide concentration was carried out on one soil sample. Organic content testing was carried out on two samples.

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 pavement structure and granular embankment fill overlying deposits of organic silt and cohesionless till over bedrock.

5.1 Embankment Fill

5.1.1 Asphalt

Boreholes 18-201 and 18-202 were drilled through the existing Highway 527 embankment and encountered a layer of asphalt with a thickness of 75 mm.

5.1.2 Granular Fill

Below the asphalt pavement within the on-road boreholes and below the creek bed was a layer of granular fill ranging in composition from gravel with sand, to sand with gravel, to sand with silt and gravel, to silty sand with gravel, to sandy silt with gravel. The underside of the granular fill was at 4.6 to 6.1 m below the existing ground/raft surface (elev. 431.9 to 434.6 m). Cobbles ranging from 75 mm to 150 mm in size were cored in this layer in Boreholes 18-201, 18-202 and 18-203. Boulders were noted in Borehole 18-203. A 0.7 m thick layer of lumber with a creosote odor was encountered in the fill in Borehole 18-202 with an underside depth of 3.7 m (elev. 435.5 m). Given that Borehole 18-202 was drilled on what appears to be to be an old creek alignment and an old design drawing indicates an old timber culvert in this area, this lumber is suspected to be part of the old timber culvert.

The SPT tests conducted in the fill typically gave N-values ranging from 3 to 92 blows indicating a loose to very dense relative density. Higher N-values ranging from 100 blows

per 25 mm to 100 blows per 175 mm were recorded on inferred cobbles and boulders. Recorded moisture contents ranged from 2% to 22%.

Gradation analyses were completed on six 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	21 to 57
Sand	32 to 72
Silt and Clay	4 to 12

5.2 Organic Silt

A layer of organic silt was encountered below the fill in Boreholes 18-201, 18-202 and 18-204. The layer had a thickness ranging from 0.1 m to 1.5 m with an underside depth that ranged from 5.2 to 7.2 m below the existing ground/raft surface (elev. 431.8 to 433.1 m).

SPT tests conducted in the organic silt gave N-values ranging from 2 to 4 blows, recognizing that correlations to relative density are not applicable to organic soils. 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 117% to 157%. The organic content on two samples of this layer was measured to range from 13.8% to 20.8%.

5.3 Cobbles, Boulders and Gravel

A layer of cobbles and boulders with gravel to gravel with sand was encountered below the organic silt in Boreholes 18-201 and 18-204. Where fully penetrated by coring in Borehole 18-201, the thickness of this layer was 0.7 m with an underside depth of 7.9 m below the existing ground surface (elev. 431.1 m). Borehole 18-204 was terminated within this layer on inferred cobbles and boulders at a depth of 5.5 m below the raft surface (elev. 431.5 m). Cobbles and boulders cored in this layer ranged from 75 mm to 260 mm in size.

One SPT test conducted in this layer gave an N-value of 100 blows per 175 mm penetration indicating a very dense relative density; however, this blow count could represent the presence of cobbles or a boulder rather than the state of packing of the soil matrix. One recorded moisture content was 19%.

5.4 Sand with Silt and Gravel

A layer of sand with silt and gravel was encountered below the fill in Borehole 18-203. The borehole was terminated upon casing refusal on an inferred boulder in this layer at 5.7 m below the raft surface (elev. 431.2 m). This layer contained trace organics. One 50 mm particle was cored in this layer.

SPT tests conducted in this layer gave N-values ranging from 64 blows per 300 mm penetration to 100 blows per 100 mm penetration indicating a very dense relative density; however, the high blow counts could represent the presence of cobbles or a boulder rather than the state of packing of the soil matrix. The recorded moisture contents ranged from 15 to 18%.

A gradation analysis was completed on one sample of the sand layer. The grain size distribution curve is included in Figure C2 of Appendix C. The results of the test are summarized in Table 5-2 below and are presented on the corresponding Record of Borehole sheet in Appendix B.

Table 5-2: Gradation Results for Sand with Silt and Gravel

Soil Particle	Percentage (%)
Gravel	34
Sand	59
Silt and Clay	7

5.5 Silty Sand Till

A layer of silty sand till with some gravel and frequent cobbles/boulders was encountered below the layer of cobbles and boulders in Borehole 18-201. The thickness of the till was 1.0 m with an underside depth of 8.9 m below the existing ground surface (elev. 430.1 m). Cobbles cored in this layer ranged from 160 mm to 180 mm in size.

SPT tests conducted in this layer gave N-values ranging from 34 blows per 300 mm penetration to 100 blows for 25 mm of penetration indicating a dense to very dense relative density; however, the high blow counts could represent the presence of cobbles or a boulder rather than the state of packing of the soil matrix. The recorded moisture contents ranged from 9 to 11% within the till layer.

A gradation analysis was completed on one sample of the till. The grain size distribution curve is included in Figure C3 of Appendix C. The results of the test are summarized in Table 5-3 below and are presented on the corresponding Record of Borehole sheet in Appendix B.

Table 5-3: Gradation Results for Till

Soil Particle	Percentage (%)
Gravel	10
Sand	43
Silt and Clay	47

5.6 Refusal and Bedrock

Practical refusal to advancement of the portable drilling equipment was encountered at off-road Borehole 18-203 in the very dense sand with silt and gravel layer and at Borehole 18-204 within the gravel with sand layer.

Bedrock was proven by coring in on-road Boreholes 18-201 and 18-202. Information on the confirmed bedrock surface is summarized in Table 5-4 below:

Table 5-4: Summary of Bedrock Depth / Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
18-201	8.9	430.1
18-202	6.1	433.1

The bedrock encountered within Boreholes 18-201 and 18-202 consisted of fresh, banded, light to dark grey, fine to medium grained gneiss. The Total Core Recovery (TCR) measured on the recovered bedrock core was 100%, the Solid Core Recovery (SCR) ranged from 92 to 100% and the Rock Quality Designation (RQD) ranged from 57 to 100%. Based on the measured RQD values, the bedrock is classified as fair to excellent quality. The gneiss bedrock is estimated to be very strong. Photographs of the bedrock core are provided in Appendix C.

5.7 Groundwater

It is expected that the groundwater level at the site will correspond to the water level in the creek. The creek water level was surveyed at the culvert inlet and outlet and the measured elevations are provided in Table 5-5 below:

Table 5-5: Creek Water Level Observations

Location	Surface Water Elevation (m)	Date of Measurement
Culvert Inlet	436.9	June 4, 2018
	436.9	June 13, 2018
Culvert Outlet	436.9	June 4, 2018
	436.8	June 13, 2018

Water level readings were taken upon completion of drilling in Boreholes 18-201 (open borehole) and 18-202 (casing). Although water was introduced for coring, the water levels correspond relatively well to the surface water elevation at the time of drilling. A summary of the measured elevations are provided in Table 5-6 below:

Table 5-6: Open-hole Groundwater Levels

Location	Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
18-201	2.2	436.8	June 4, 2018
18-202*	2.0	437.3	June 4, 2018

Note: (*) : this borehole is located north of the existing culvert

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 level may be at a higher elevation after periods of significant and/or prolonged precipitation.

5.8 Analytical Testing

Two samples of soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. One of the submitted samples was also tested for sulphide. The analysis results are provided in Appendix C and are summarized in Table 5-7 below:

Table 5-7: Analytical Results Summary (Soil)

Borehole	18-203	18-204
Sample	SS3	SS4
Depth (m)	1.8* – 2.4*	3.1* – 3.8*
Chloride (µg/g)	25	29
Sulphate (µg/g)	46	7
Sulphide (%)	-	< 0.02
pH (-)	7.76	7.76
Resistivity (Ohm-cm)	6430	10200
Conductivity (µS/cm)	156	98

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

A surface water sample was obtained on November 30, 2018 upstream of the existing culvert and was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of conductivity, pH, resistivity, chloride and sulphate. The analysis results are provided in Appendix C and are summarized in Table 5-8 below.

Table 5-8: Analytical Results Summary (Surface Water)

Parameter	Result
Conductivity (µS/cm)	74
pH (-)	7.4
Resistivity (Ohm-cm)	13500
Chloride (mg/L)	2
Sulphate (mg/L)	1


6 MISCELLANEOUS

Borehole locations were selected by Thurber in consultation with Hatch and the Ministry 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 boreholes, respectively, to carry out the drilling, soil sampling, in-situ testing 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. Organic content testing was completed by Stantec Consulting 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. Deanna Pizycki and Mr. Stephen Dunlop, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng. a Designated Principal Contact for MTO Foundation Projects.


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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents geotechnical recommendations to assist the project team in designing a suitable foundation for the proposed replacement of the existing Max Creek culvert crossing Highway 527. The discussion and recommendations presented in this report are based on the information provided by Hatch and on the factual data obtained during the course of the investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The existing culvert, conveying Max Creek under Highway 527, is a twin corrugated steel pipe (CSP) culvert constructed in 1984. A site survey plan from Hatch indicates that each CSP has a diameter of 2.4 m and is approximately 20.7 m long. The culvert alignment is generally southwest to northeast with the flow through the culvert toward the northeast.

Creek bottom elevations of 436.0 m and 435.7 m were surveyed by Thurber at the inlet and outlet, respectively, during the field investigation. The embankment fill height above the culvert is approximately 1.0 m. The elevation of the road surface at the centreline is approximately 439.1 m. The existing embankment slopes are inclined between approximately 2.4H:1V and 3.1H:1V.

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

7.1 Preferred Structure

It is understood that the preferred replacement culvert will consist of twin 3.05 m diameter corrugated steel pipes (CSP) with a clear separation of about 1.0 m. It is also understood that the culvert will be installed on the same alignment. The proposed invert elevations are 434.8 and 434.5 m for the upstream and downstream locations, respectively.

Other potential culvert types (e.g., box culvert, steel sheet piles) are discussed in this report from a feasibility perspective.

8 DESIGN OPTIONS

8.1 Design Considerations

The records of the on-road boreholes indicate that the embankment fill is underlain by a layer of compressible organic silt extending to as deep as 7.2 m below the road surface. In contrast, the off-road boreholes, which were advanced from a raft directly in front of the ends of the existing culvert, indicated that the organic silt is absent or thin (100 mm or less). The fill overlying the organic silt is also thicker than the height of the existing embankment (i.e., it extends deeper than the surrounding ground surface). Based on these factors, it is considered possible that the organic silt layer was subexcavated during the construction of the existing culverts and replaced with compacted granular fill. However, this cannot be confirmed with the information currently available. The potential presence of the compressible organic silt layer should therefore be considered in the design of the replacement culverts. It should also be recognized that the organic silt layer has been confirmed to be present a short distance away from the existing culverts, and therefore will impact any culvert options (e.g., a box culvert) that have a greater width and/or different alignment than the existing culvert.

8.2 Culvert Type and Foundation Alternatives

In general, selection of the culvert type must consider the proposed construction procedures, staging requirement, geotechnical resistance available in the foundation soils, the depth to suitable bearing stratum and post-construction settlement criteria. At this site, a deep buried organic silt layer poses a risk of settlement if additional load is added to the existing condition. Given this constraint, the following culvert types were considered from a geotechnical perspective if the organic silt layer is left in place:

- Circular Pipes (Concrete, HDPE, Steel)

From a foundation engineering perspective, CSP culverts are a feasible culvert option provided that there is no net load increase at the site. Furthermore, CSPs offer more flexibility than concrete pipes and can accommodate some differential settlement resulting from minor variations in the subgrade. In addition, it may be possible to utilize the existing pipes for creek diversion during construction to eliminate the need for a temporary creek re-alignment through a temporary culvert. It is understood that two pipes with internal diameters of 3.05 m will be required at this site to meet the hydraulic requirements.

- Closed Bottom Culvert (Box)

A closed box culvert could be sized to ensure no net load increase. A creek diversion on a different alignment would be required. Although feasible, a closed box culvert has less flexibility than the more economical CSP alternative and is therefore not preferred at this site.

- Open Bottom Culvert (Box, Arch)

Open bottom culverts would impart additional foundation loads on the underlying organic silt layer and are therefore not considered feasible without significant sub-excavation.

- Steel Sheet Pile Walls with Precast Concrete Slab

A culvert consisting of two rows of parallel sheet pile walls supporting precast concrete slab is not considered feasible at this site because of the high risk of the sheet piles refusing at an insufficient depth on the cobbles and boulders encountered in the fill and native materials during the site investigation. The bedrock is also likely too shallow to allow for this type of culvert due to inadequate lateral support.

It is understood that a grade raise of 0.5 m may be considered at this site for a future paving project. This grade raise is expected to produce settlements in the range of 25 to 50 mm at the culvert but significantly more at locations where the organic silt has not already been removed or loaded. If it is determined that a grade raise is required at this site, the following foundation types /modifications can be considered from a geotechnical perspective:

- Culvert with Deep Sub-Excavation of Organic Silt

Any of the above culvert options (except steel sheet piles) are considered feasible from a geotechnical perspective if the deep organic silt layer is sub-excavated and replaced with compacted engineered fill or rockfill. However, this option would require a large excavation and significant dewatering efforts during construction.

- Lightweight Fill

If sub-excavation of the buried organic silt is not preferred, it may be feasible to backfill around the culvert with lightweight fill. The most common form of lightweight fill is expanded polystyrene (EPS), which has a unit weight of less than 1 kN/m³, although slag or pumice stone are also possible as backfill materials if they can be sourced. The cost of EPS lightweight fill is typically high. Detailing for the EPS will need to consider provision of adequate cover above the EPS as well as buoyancy affects under the design storm.

- Culvert on Deep Foundations

A culvert founded on deep foundations (e.g. micropiles drilled through the existing soils and socketed into bedrock) is considered feasible from a geotechnical perspective. However, it will have a significantly higher cost relative to the other options presented.

- Do Nothing

If no mitigation options are selected, settlement due to a grade raise on the deep organic silt layer must be anticipated. The selected culvert must be able to tolerate the anticipated movements while achieving the drainage objectives. From a geotechnical perspective, this would require a delay in the paving of the final asphalt surface (likely 6 to 12 months) to allow for the majority of settlement to occur in advance. Alternatively, a provision for future maintenance would be required.

A comparison of these alternatives, based on their respective advantages and disadvantages, is included in Appendix E. At present, it is understood that circular pipes (twin CSPs) will be possible; therefore, the other foundation options are not discussed further herein.

8.3 Construction Methodology Alternatives

For the proposed culvert replacement, the following construction methods were considered.

- Open Cut with Full Road Closure and Temporary Detour
Installation of a new culvert using open cut techniques and a full road closure would allow for an expedited construction schedule and could reduce costs associated with requiring roadway protection and ground/surface water control. However, it is understood that an acceptable detour route is not available and therefore this option will not be feasible.
- Open Cut with Temporary Modular Bridge Spanning Excavation
It is anticipated that it will not be feasible at this site to complete a culvert replacement within a full width open cut excavation with a single lane temporary modular bridge (TMB) spanning the excavation since the fill heights are not high enough to allow working space below the TMB.
- Open Cut with Staged Temporary Widening
Widening of the existing highway to construct a temporary detour embankment to accommodate traffic passage during construction has been considered. However, placement of fill in areas where the organic silt has not already been removed or loaded is likely to generate significant settlement under the footprint of the embankment widening and could influence the existing embankment. A review of the environmental acceptability for placing fill within the creek, the requirement for property acquisition and alteration to highway geometry is also needed to assess this option.
- Open Cut with Staged Replacement and Temporary Protection System
The use of open cut techniques in conjunction with staged culvert replacement is a potentially feasible construction option from a geotechnical perspective. This option will require roadway protection installed along the embankment centerline to maintain a single lane of traffic. Installation of sheet piles will be difficult through the cobbles and boulders. The roadway protection may require lateral support in the form of rakers, struts or deadman/bedrock anchors to reduce lateral deflections.
- Trenchless Techniques
Trenchless techniques would have the advantage of minimum disruption to traffic and would avoid a large excavation through the existing highway embankment. However, this option will be high risk due to the possibility of encountering obstructions. The low cover is also problematic and presents a significant risk. The anticipated size of replacement culvert will also limit the available installation methods. A trenchless installation is not recommended at this site due to the high risk involved.

8.4 Recommended Approach for the Culvert Replacement

From a foundation engineering perspective, the recommended culvert replacement option is a set of circular CSP pipes using open cut techniques. If a grade raise is required, sub-excavation of the buried organic silt layer, use of lightweight fill, or deep foundations could be considered. Alternatively, placement of the final lift of asphalt could be delayed to mitigate the impacts of settlement on the driving surface (i.e., the 'no-nothing' approach).

Temporary protection systems (TPS) would be needed to facilitate construction.

9 FOUNDATION DESIGN RECOMMENDATIONS

The pipe culverts should be designed and constructed in accordance with OPSS.PROV 421, OPSD 802.010 (with Granular A or Granular B Type II used as bedding, embedment, and cover material as per OPSS.PROV 401) and OPSD 803.031 (with a frost depth as noted in Section 9.2). Geotechnical resistance values are not required for pipe culverts. The culvert should be founded on a granular bedding that is constructed on the existing granular fill.

9.1 Subgrade Preparation, Bedding and Backfilling

Subgrade preparation for the culvert replacement should include excavation and removal of the existing culvert and backfill materials. All soft, loose or disturbed soils and deleterious materials must be stripped from the footprint of the foundation to expose competent subgrade at or below the desired founding elevation. It should be noted that buried organic silt was observed below the subgrade soils in Boreholes 18-201, 18-202 and 18-204 to as deep as elevation 431.8 m. This buried layer can remain in place below the fill subgrade as discussed previously.

The exposed final subgrade must be inspected to confirm that the subgrade is suitable and uniformly competent. Any soft materials at the subgrade level should be sub-excavated and backfilled with granular fill consisting of OPSS.PROV 1010 Granular A material as soon as practical to protect the subgrade from disturbance during construction. The granular fill should be compacted as per OPSS.PROV 501. In order to provide a more uniform foundation subgrade condition for the culvert, a minimum 150 mm thick layer of bedding material must be provided under the base of the culvert as per OPSD 802.010 (pipe culvert).

The subgrade may be easily disturbed when saturated and should be protected from disturbance from both construction traffic and weather. Construction equipment should not be permitted to travel on the exposed subgrade.

It is noted that construction will extend below the creek elevation. Water diversion and dewatering will be required to prepare the subgrade in the dry. Refer to Section 10.3 for additional comments on groundwater and surface water control.

Culvert backfill above the granular cover should be in accordance with OPSS 902 and consist of material meeting the requirements of OPSS Select Subgrade Material or Granular B Type I/III and should be compacted in regular lifts as per OPSS.PROV 501.

Care must be exercised when compacting the fill adjacent to and above the culvert in order not to damage the culvert. Heavy compaction equipment, used adjacent to the culvert, must be restricted in accordance with OPSS.PROV 501.

9.2 Frost Depth

The depth of frost penetration at this site is estimated to be 2.5 m (OPSD 3090.100). It is not necessary to found a pipe culvert at a depth below frost penetration. The existing granular fill that will be adjacent to the new culverts extends below the frost penetration depth and is not considered frost susceptible; therefore, a frost taper is not considered necessary at this site.

9.3 Embankment Design and Reinstatement

9.3.1 Embankment Reconstruction

Embankment reconstruction after culvert replacement should be carried out in accordance with OPSS.PROV 206. The embankment should be reinstated with side slopes of 2H:1V (or flatter) if constructed using Select Subgrade Material (SSM) or Granular B Type I (OPSS.PROV 1010). The fill should be placed and compacted in accordance with OPSS.PROV 501.

Where newly placed embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the existing slope should be carried out in accordance with OPSD 208.010.

9.3.2 Embankment Settlement and Stability

Provided the subgrade is prepared as outlined above and construction of the embankment is carried out in accordance with recommendations provided within this report, the embankment side slopes should remain stable.

Provided there is no grade raise and there is no net load increase to the site, settlement of the soils beneath the culverts are expected to be within acceptable limits. It is noted that the buried organic silt may be subject to creep settlements that are on-going (both presently and after the new construction). There is also a risk that consolidation settlement of the organic silt could occur if the loads at the site are even slightly higher than expected. Therefore, it is recommended that the final lift of pavement reinstatement be delayed as much as possible (preferably at least three months), to allow for settlement to occur in advance of the final paving.

It is understood that a future grade raise is being considered at this site. Settlements in the range of 25 to 50 mm should be expected to account for potential consolidation in the organic silt layer as a result of this net load increase. Slope stability analyses indicate that 2H:1V slopes will satisfy long-term and short-term global stability requirements.

The magnitude of the compression of the granular fill materials is in the order of 0.5% of the embankment height and is expected to occur following fill placement.

9.4 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations in soil samples of less than 1000 µg/g generally indicate a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The class of concrete selected should consider the effects of road de-icing salts.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in Section 5.8 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosion effects of road de-icing salts should also be considered.

10 CONSTRUCTION CONSIDERATIONS

10.1 Excavations

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the existing fill above the water table may be classified as Type 3 soil. The cohesionless fill below the groundwater level and the organic silt may be classified as Type 4 soils.

Excavation for the culvert replacement must be carried out in accordance with OPSS 902 and will be carried out through the existing embankment fill. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. Stockpiling or surface surcharge should not be allowed on the embankment or side slopes.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 10.2.

10.2 Temporary Protection Systems

Temporary Protection Systems may be required during various stages of construction and must be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2 (maximum 25 mm horizontal deflection). The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. The protection system near the culvert could be left in place and cut off in accordance with OPSS.PROV 539 to limit the disturbance of subgrade under the new culvert during removal of the TPS. Vibratory equipment should not be permitted at this site for installation or removal of the temporary protection systems. Otherwise, there is a risk of liquefying the organic silt layer, which could result in settlement of the newly installed culvert. Suggested wording for an NSSP is provided in Appendix F.

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design of the temporary protection system provided in Table 10-1. The lateral earth pressure coefficients assume a vertical wall and a horizontal backslope.

Table 10-1. Static Earth Pressure Coefficients

Parameter	Existing Embankment Fill	Organic Silt	Glacial Till	New Granular Fill
Unit Weight, γ (kN/m ³)	22	14	21	22.5
Active, K_A	0.31	0.39	0.31	0.27
Passive, K_P	3.3	2.6	3.3	3.7

Submerged unit weight should be used below the groundwater level.

The design of roadway protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the roadway protection system must incorporate traffic loading and surcharge loading due to construction equipment and operations.

It is recommended that an NSSP be included in the tender documents to alert the Contractor to the potential for cobbles and boulders and obstructions within the fill and native soils.

Given the obstructions present at this site, sheet piles will be difficult to install. It is anticipated that a soldier pile and lagging system will be utilized. Pre-drilling may be needed to advance the soldier piles.

Deadman or bedrock anchors, struts and/or raker supports may be required to achieve the specified performance level.

10.3 Surface and Groundwater Control

Culvert construction, subgrade preparation and placement and compaction of granular bedding must be carried out in the dry. The depth of excavations required to construct the culvert will extend below the creek level observed at the time of the investigation. Furthermore, groundwater and surface runoff will tend to seep into and accumulate into the excavations. The Contractor must control groundwater and creek/surface water flow at the site to permit the replacement of the culvert in a dry and stable excavation.

Subgrade preparation, placement and compaction of granular bedding, and culvert construction must be carried out with a properly designed dewatering system to control groundwater and creek/surface water and may include coffer dams, creek diversion, pumping etc. The dewatering system will be required to remain operational and effective until the temporary excavations are backfilled and then should be decommissioned and removed.

The dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01. It is not recommended that the design Engineer and design-checking Engineer have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work, thus Designer Fill-In ***** in SP517F01 should be "No". A preconstruction survey is not recommended, thus Designer Fill-In ***** in SP517F01 should be "NA".

The groundwater level will fluctuate and the minimum groundwater elevation at the time of the proposed work should be taken as the creek water level of the design storm return period defined by the contract documents for the temporary dewatering system.

It is anticipated that the water course diversion will be carried out with a cofferdam directing creek water through a temporary pipe culvert located to the north of the permanent alignment. The temporary pipe culvert should be supported with a bedding layer that is at least 300 mm in thickness. It should be recognized that an approximately 1.5 m thick layer of compressible organic silt is present below the anticipated founding level of the temporary culvert. For predictable performance of the temporary culvert, this organic layer could be sub-excavated down to competent soil and replaced with compacted granular fill. However, for this temporary structure it may be acceptable to allow some settlement to occur during construction provided that the contractor levels the travelled roadway surface as required to correct for the settlement. Alternatively, the Contractor could utilize one of the existing culverts as part of the creek diversion. A sand bag or sheet pile cofferdam system is anticipated to direct creek flow away from the work zone. The comments on installation and extraction of temporary protection systems are also relevant for cofferdams.

It is also anticipated that sump pumps will likely be sufficient to extract water from the excavation for the replacement culvert. Excavation below the creek level without prior dewatering is not recommended since the inflow of water will cause sloughing of the soil below the water level, making it difficult to maintain a dry, sound base on which to work. The groundwater level within the work zone should be lowered by pumping from sumps to a minimum of 500 mm below the underside of the planned excavation base prior to each stage of excavation.

Further assessment of dewatering requirements and the need for a PTTW should be carried out by specialists experienced in this field.

10.4 Scour Protection and Erosion Control

The Contractor should provide silt fences and erosion control blankets as per OPSS 805 throughout the duration of construction to prevent transport of silt/sediment. Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. Slope vegetation should be established as soon as possible after completion of the embankment fills in order to limit surficial erosion.

Particle size analyses in conjunction with the Wischmeier Nomograph indicate that the granular fill and native sand have a low erosion potential and the till has a moderate potential for soil erodibility.

Scour and erosion protection should be provided for the culvert inlet and outlet areas. Design of the scour and erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all earth surfaces subjected to flowing water in accordance with OPSS 511. Treatment at the outlet should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

It is recommended that a clay seal and/or a concrete cut-off wall be used to minimize the potential for piping and erosion around the inlet of the culvert. The clay seal must extend to approximately 300 mm above the high water level and laterally for the width of the granular material, and have a minimum thickness of 500 mm. The clay seal should also extend below the bedding and scour level if a concrete cut-off wall is not also used. The material requirements should be in accordance with OPSS.PROV 1205. A geosynthetic clay liner may be used as a clay seal. A cut-off wall should be constructed per OPSD 812.010 for CSP culverts.

11 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Disturbance of the soil subgrade due to inadequate dewatering. Construction traffic must not be allowed on the final subgrade.
- Cobbles/boulders and/or buried obstructions may be encountered in the existing embankment fill and in the native soils at this site and could interfere with installation of the roadway protection system.
- Creek water levels will fluctuate. Excavation will involve lowering the water level below the excavation base to maintain a reasonably dry excavation and stable side slopes. The dewatering scheme will be critical for culvert construction at this site.
- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structure fill (i.e., as a pad for crane support).

The successful performance of the culvert installation will depend largely upon good workmanship and quality control during construction. Subgrade examination should be carried out by qualified geotechnical personal during construction in accordance with SP109S12 to confirm that foundation recommendations are correctly implemented and material specifications are met.

12 CLOSURE

Engineering analysis and preparation of this report were carried out by Ms. Deanna Pizycki and Mr. Stephen Dunlop, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
Report Prepared By:

Deanna Pizycki
Dec 13/18



Deanna Pizycki, M.Eng.
Geotechnical EIT

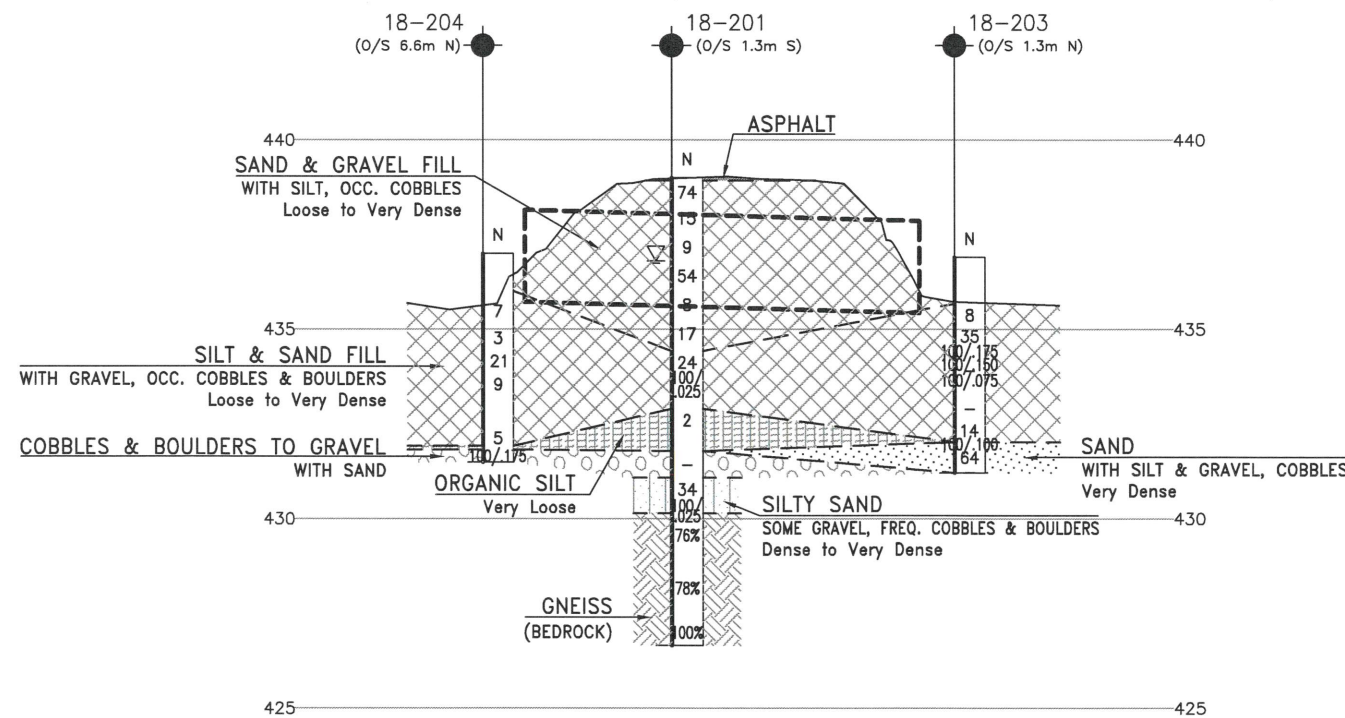
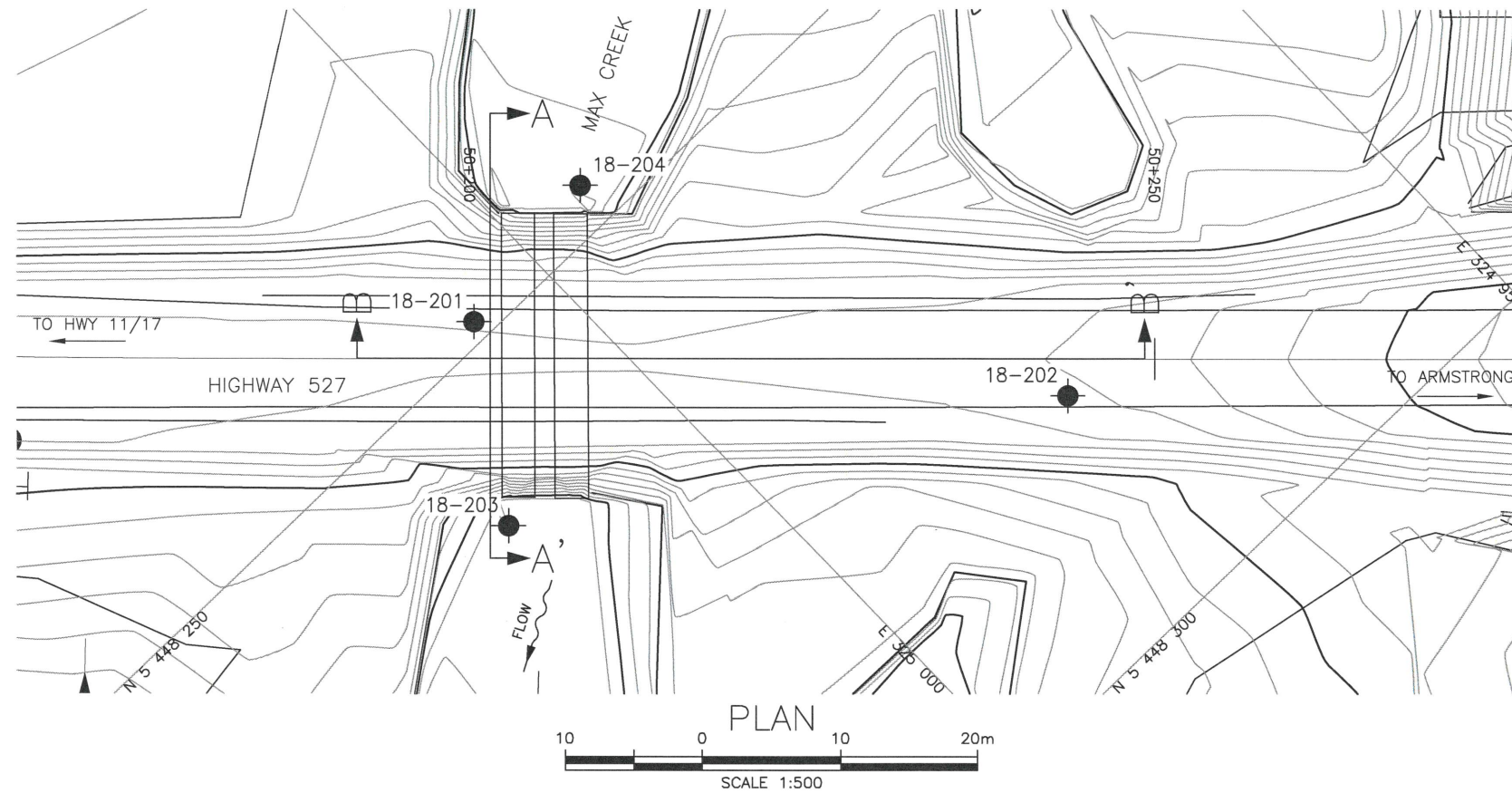
Stephen Dunlop, M.A.Sc., P.Eng.
Senior Geotechnical Engineer



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

Appendix A.

Drawings



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

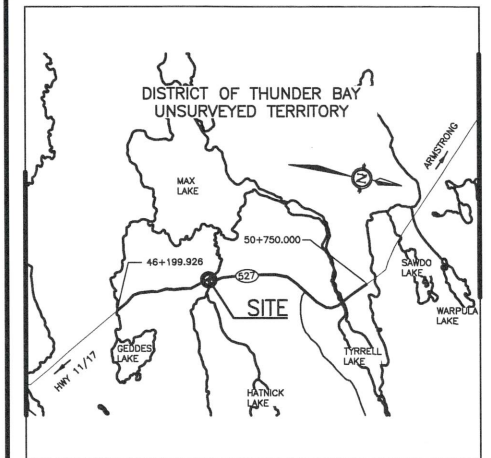
CONT No
GWP No 6827-14-00

HIGHWAY 527
MAX CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



THURBER ENGINEERING LTD.



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

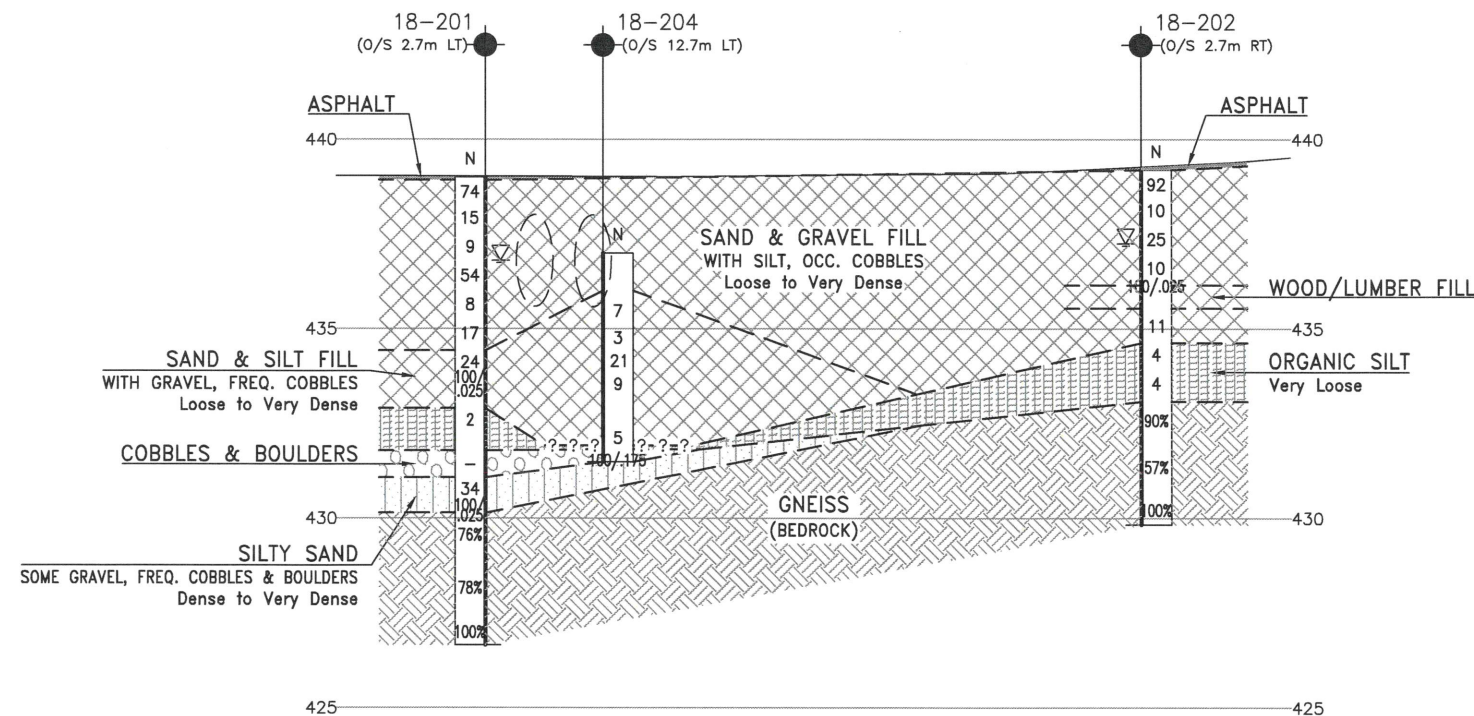
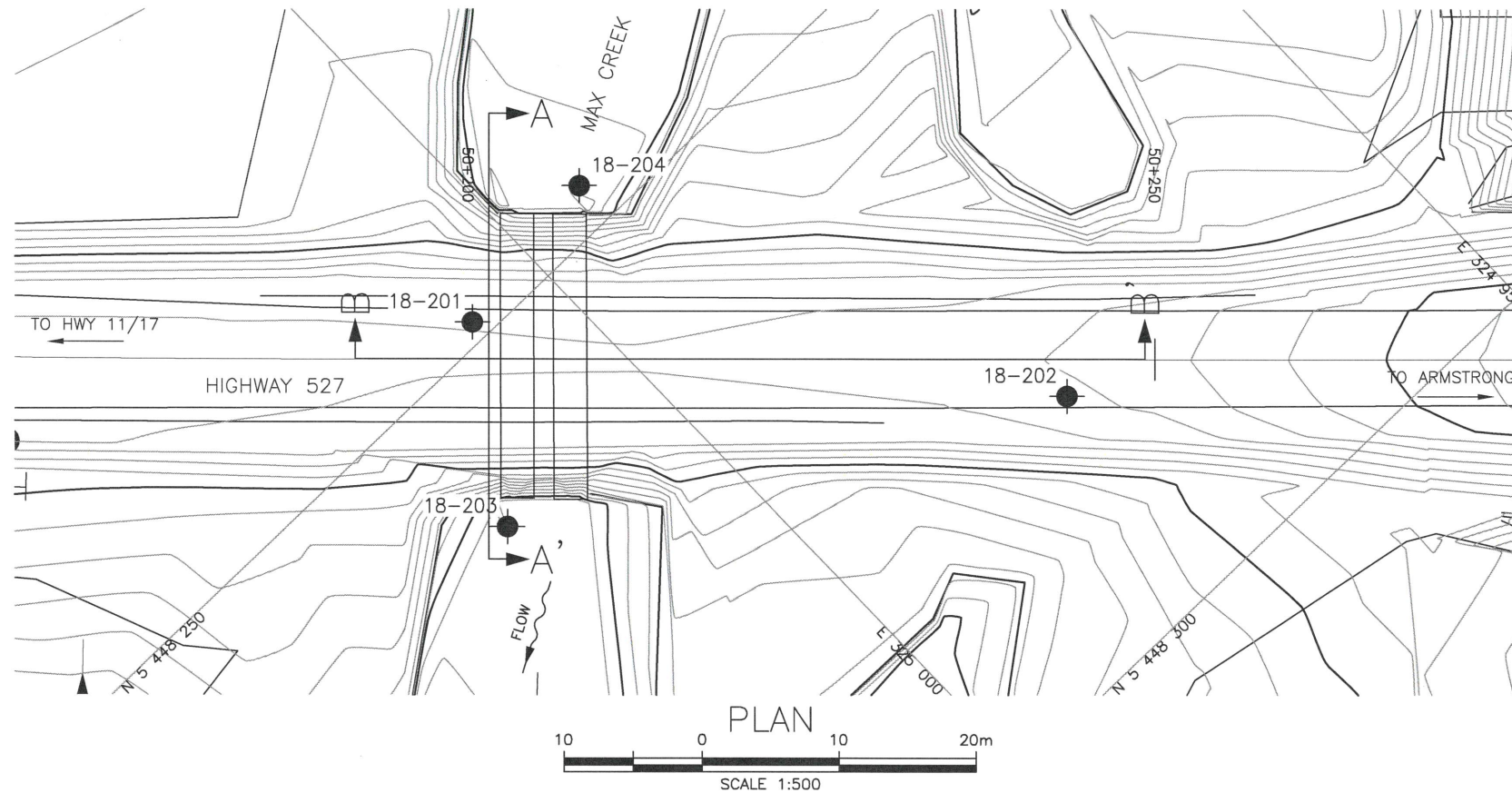
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18-201	439.0	5 448 248.6	352 006.3
18-202	439.2	5 448 282.5	351 978.8
18-203	436.9	5 448 261.1	352 014.8
18-204	437.0	5 448 246.8	351 993.8

-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-45

DATE	BY	DESCRIPTION
DESIGN DP	CHK SP	CODE
DRAWN AN	CHK DP	SITE
		LOAD
		STRUCT
		DATE DEC 2018
		DWG 1



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

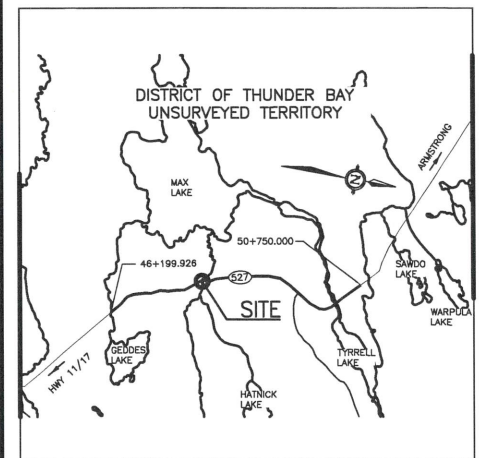
CONT No
GWP No 6827-14-00

HIGHWAY 527
MAX CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



THURBER ENGINEERING LTD.



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
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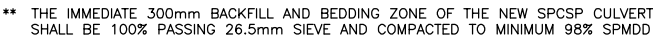
GEOCRES No. 52H-45

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	DP	CHK SP	CODE
DRAWN	AN	CHK DP	SITE
			LOAD
			STRUCT
			DWG 2
			DATE DEC 2018



MINISTRY OF TRANSPORTATION, ONTARIO

Dec 07, 2018, 9:21am Login name: REN856609
Drawing Name: C:\pwworking\hi\ren856609\d0315124\ST-356558-Max Creek Culvert-01-GA.dwg



WP	NORTHING	EASTING
#1	5 448 255.58	352 002.93
#2	5 448 252.697	352 005.929

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

MAX CREEK CULVERT
REPLACEMENT
GENERAL ARRANGEMENT



1. THE CULVERTS SHALL BE DOUBLE CORRUGATED STEEL PIPE CULVERTS EACH WITH 3050mm DIA. (MIN. WALL THICKNESS=4.0mm). CORRUGATION PROFILE IS 152mm X 51mm). CONTRACTOR IS RESPONSIBLE TO DESIGN, SUPPLY, ASSEMBLE AND ERECT THE NEW CULVERT. CULVERT DESIGN SHALL BE IN ACCORDANCE WITH CHBDC S6-14, LIVE LOAD SHALL BE CL-625-ONT.
2. DIMENSIONS AND DETAILS SHOWN ON DRAWINGS ARE BASED ON A TYPICAL MULTI-PLATE ROUND PIPE AND SHALL BE VERIFIED PRIOR TO COMMENCEMENT OF THE CONSTRUCTION.
3. PERMANENT CSP CULVERTS SHALL BE POLYMER LAMINATE COATED, CULVERTS TO BE DESIGNED FOR A 75 YEAR SERVICE LIFE. WATER RESISTIVITY AT THIS SITE IS MEASURED TO BE XXXXX $\Omega \cdot \text{cm}$. REFER TO FOUNDATION INVESTIGATION REPORT FOR MORE INFORMATION ON CHEMICAL ANALYSES.

BH	BOREHOLE
CL	CENTRELINE
ELEV.	ELEVATION
G.W.L.	GROUND WATER LEVEL
H.W.L.	HIGH WATER LEVEL
HWY	HIGHWAY
INV.	INVERT
MAX	MAXIMUM
MIN	MINIMUM
MTO	MINISTRY OF TRANSPORTATION OF ONTARIO
R.O.W.	RIGHT OF WAY
RND	ROUNDING
SHLD	SHOULDER
STA.	STATION
SPMDD	STANDARD PROCTOR MAXIMUM DRY DENSITY
SPSCP	STRUCTURAL PLATE CORRUGATED STEEL PIPE
T/P	TOP OF PAVEMENT
TYP.	TYPICAL
W.L.	WATER LEVEL
WP	WORKING POINT

OPSD 219.110	LIGHT DUTY SILT FENCE BARRIER
OPSD 219.240	SEDIMENT TRAP FOR DEWATERING
OPSD 802.010	FLEXIBLE PIPE EMBEDMENT AND BACKFILL
	EARTH EXCAVATION
OPSD 810.010	GENERAL RIP-RAP LAYOUT FOR SEWER AND
	CULVERT OUTLETS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA I
3. BOREHOLE LOCATIONS AND SOIL STRATA II
4. REMOVALS
5. CONSTRUCTION STAGING
6. GEOSYNTHETIC CLAY LINER DETAILS

PRELIMINARY
NOT FOR CONSTRUCTION

[illegible]

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).

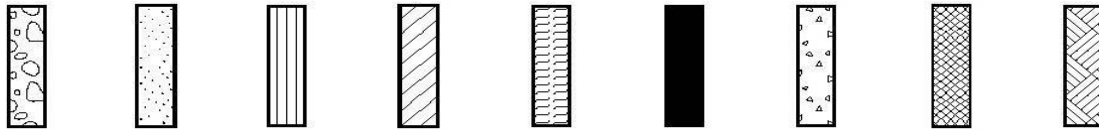
DYNAMIC CONE PENETRATION TEST (DCPT):

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 18-201

1 OF 2

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1705225°, Long: -89.3525775° Max Creek Culvert, MTM z15: N 5 448 248.6 E 352 006.3 ORIGINATED BY NW
HWY 527 BOREHOLE TYPE NW Casing/ NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.02 - 2018.06.04 CHECKED BY DJP

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						
								20 40 60 80 100						
439.0														
0.0 0.1	75 mm ASPHALT													
	GRAVEL with Sand, FILL Very Dense to Compact Brown		1	SS	74									52 44 4 (SI+CL)
			2	SS	15		438							
437.5														
1.5	SAND with Gravel to GRAVEL with Silt and Sand, Occasional Cobbles, FILL Loose to Very Dense Brown		3	SS	9		437							
			4	SS	54									
			5	SS	8		436							
	- 120 mm Cobble cored while advancing from 3.8 m to 4.6 m		6	SS	17		435							57 32 11 (SI+CL)
434.4														
4.6	Sandy SILT with Gravel, Frequent Cobbles, FILL Compact to Very Dense Brown		7	SS	24		434							
	- 100 mm and 140 mm Cobbles cored while advancing from 4.6 m to 6.1 m		8	SS	100/ 25mm									
432.9							433							
6.1	Organic SILT (OL)		9	SS	2									13.8% organic content
							432							
431.8														
7.2	Cobbles and Boulders with Gravel - 75 mm to 260 mm Cobbles / Boulders cored		9A	NQ	-									
431.1							431							
7.9	Silty SAND (SM), some Gravel, Frequent Cobbles and Boulders, TILL Dense Grey - 160 mm and 180 mm Cobbles cored while advancing from 7.9 m to 8.9 m		10	SS	34									10 43 47 (SI+CL)
			11	SS	100/ 25mm									
430.1							430							
8.9	Gneiss BEDROCK Fresh Banded Light to Dark Grey Fine to Medium Grained Verv Strong		1	RUN										RUN #1 TCR=100% SCR=100% RQD=76%

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

DOUBLE LINE 19773 MAX CREEK.GPJ 2012TEMPLATE(MTO).GDT 10/12/18

METRIC

[illegible]



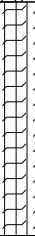

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 18-202

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1708293°, Long: -89.3529502°
Max Creek Culvert, MTM z15: N 5 448 282.5 E 351 978.8 ORIGINATED BY NW
HWY 527 BOREHOLE TYPE NW Casing/ NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.04 - 2018.06.04 CHECKED BY DJP

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									
								UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
							WATER CONTENT (%)										
							PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT W P W W L										
439.2																	
0.0	75 mm ASPHALT SAND with Silt and Gravel, FILL Very Dense to Compact Brown		1	SS	92										34 56 10 (SI+CL)		
0.1																	
			2	SS	10												
			3	SS	25												
			4	SS	10											44 48 8 (SI+CL)	
436.2			5	SS	100/25mm												
3.0	WOOD/LUMBER, Creosote Odour, FILL																
435.5																	
	SAND with Gravel, FILL Compact Brown		6	SS	11												
434.6																	
4.6	Organic SILT (OL)		7	SS	4												
			8	SS	4												
433.1																	
6.1	- 60 mm Particle cored at 6.0 m																
	Gneiss BEDROCK Fresh Banded Light to Dark Grey Fine to Medium Grained Very Strong		1	RUN													RUN #1 TCR=100% SCR=100% RQD=90%
			2	RUN													RUN #2 TCR=100% SCR=92% RQD=57%
			3	RUN													RUN #3 TCR=100% SCR=100% RQD=100%
429.8																	
9.4	End of Borehole Water level in casing at 2.0 m BGS (Elev. 437.3 m) upon completion of drilling.																

DOUBLE LINE 19773 MAX CREEK.GPJ 2012TEMPLATE(MTO).GDT 10/12/18

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

RECORD OF BOREHOLE No 18-203

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1706344° Long: -89.352459° Max Creek Culvert, MTM z15: N 5 448 261.1 E 352 014.8 ORIGINATED BY SOB
HWY 527 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.12 - 2018.06.13 CHECKED BY DJP

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						
436.9								20	40	60	80	100		
0.0	RAFT (Drilling Platform) WATER													
0.1														
435.7														
1.2	Silty SAND with Gravel, Frequent Cobbles and Boulders FILL Loose to Very Dense Grey - 150 mm Cobble cored at 1.6 m (NQ2) - 150 mm Cobble cored at 2.7 m - 50 mm Particle cored at 4.0 m		1	SS	8									
			3	SS	35									
			4	SS100/175mm										
			5	SS100/150mm										
			6	NQ	-									
			7	SS 100/75mm										
		8	NQ	-										
		9	SS	14										
432.0			10	SS100/100mm										
4.9	SAND (SP-SM) with Silt and Gravel, trace Organics, Frequent Cobbles Very Dense Brown		11	SS	64									
431.2			12	NQ	-									
5.7	- 50 mm Particle cored at 5.6 m													
	End of Borehole Casing refusal on inferred Boulder.													

DOUBLE LINE 19773 MAX CREEK.GPJ 2012TEMPLATE(MTO).GDT 10/12/18

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

RECORD OF BOREHOLE No 18-204

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1705069°, Long: -89.3527489°
Max Creek Culvert, MTM z15: N 5 448 246.8 E 351 993.8 ORIGINATED BY SOB
HWY 527 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.13 - 2018.06.14 CHECKED BY DJP

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				WATER CONTENT (%)					
437.0								20	40	60	80	100	W _p	W	W _L		
0.0																	
0.1	RAFT (Drilling Platform)																
	WATER																
436.0																	
1.0	SAND with Silt and Gravel FILL Loose to Compact Grey						436										
			1	SS	7												
			2	SS	3		435										
			3	SS	21		434										21 72 7 (SI+CL)
			4	SS	9												
							433										
			5	SS	5		432										
431.9																	
431.8	Organic SILT (OL)		6	SS100/175mm													20.8% organic content
5.2	GRAVEL with Sand																
431.5	Very Dense																
5.5	Grey																
	End of Borehole Casing refusal on inferred cobbles / boulders.																

DOUBLE LINE 19773 MAX CREEK.GPJ 2012TEMPLATE(MTO).GDT 10/12/18

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

Appendix C.

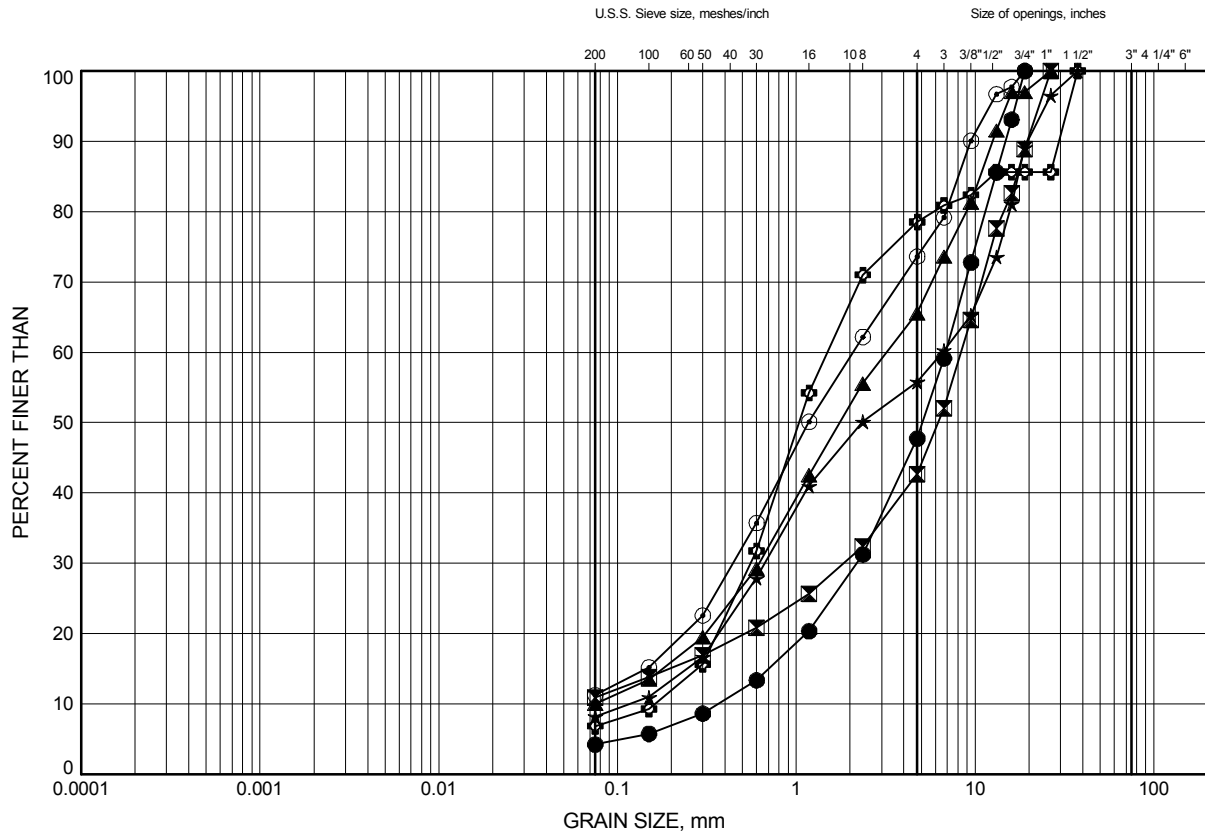
Laboratory Testing

Appendix C.1
Particle Size Analysis Figures

Max Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C1

Sand and Gravel Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-201	0.38	438.62
⊠	18-201	4.11	434.89
▲	18-202	0.38	438.82
★	18-202	2.59	436.61
⊙	18-203	2.48	434.42
⊕	18-204	2.84	434.16

Date August 2018
GWP# 6827-14-00

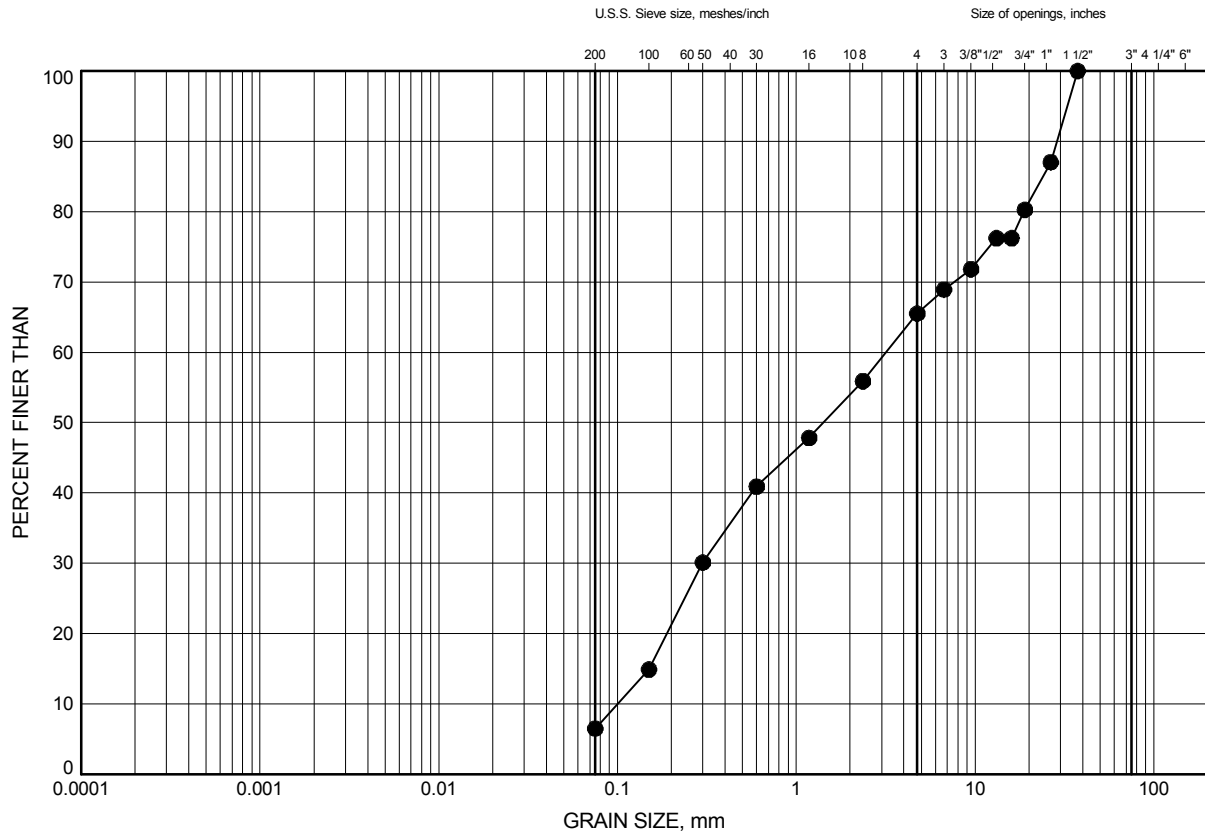


Prep'd DJP
Chkd. SD

Max Creek Culvert
GRAIN SIZE DISTRIBUTION

FIGURE C2

Sand with Silt and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-203	5.28	431.62

Date August 2018
GWP# 6827-14-00

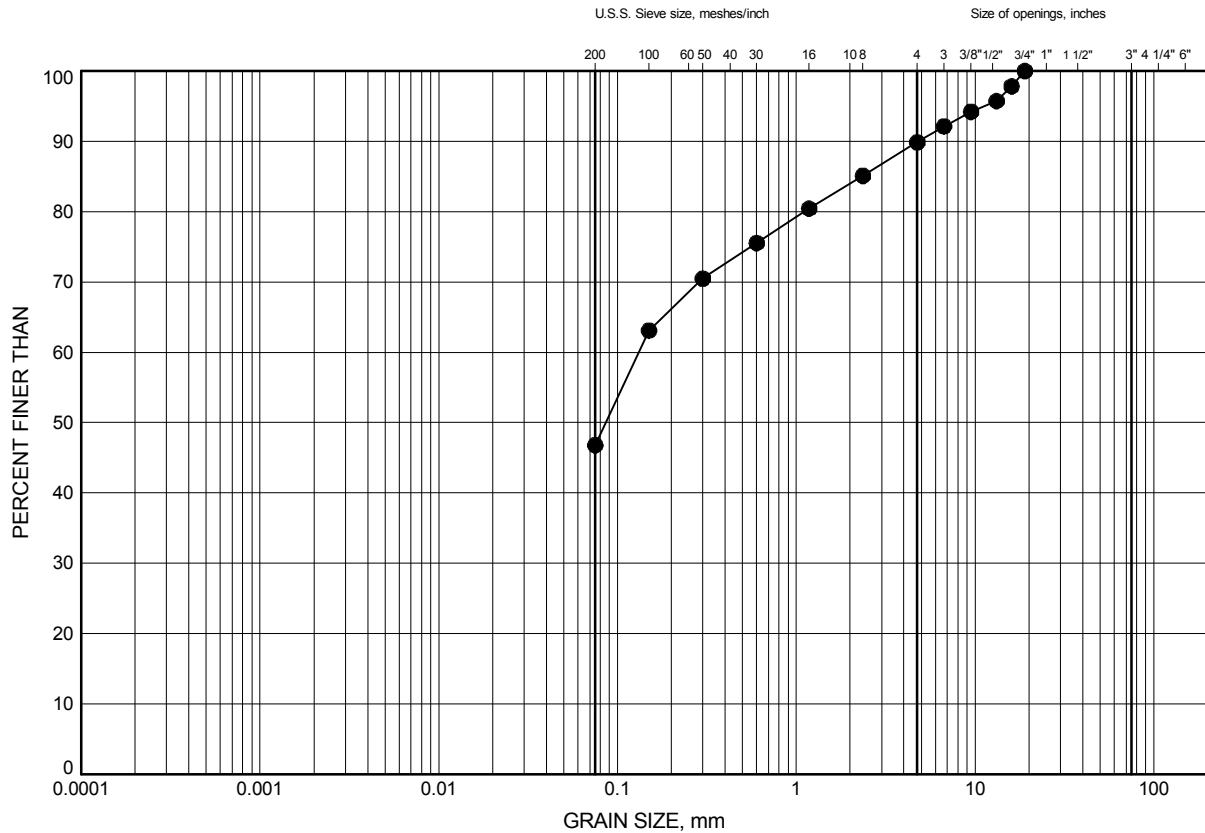


Prep'd DJP
Chkd. SD

Max Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C3

Silty Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-201	8.23	430.77

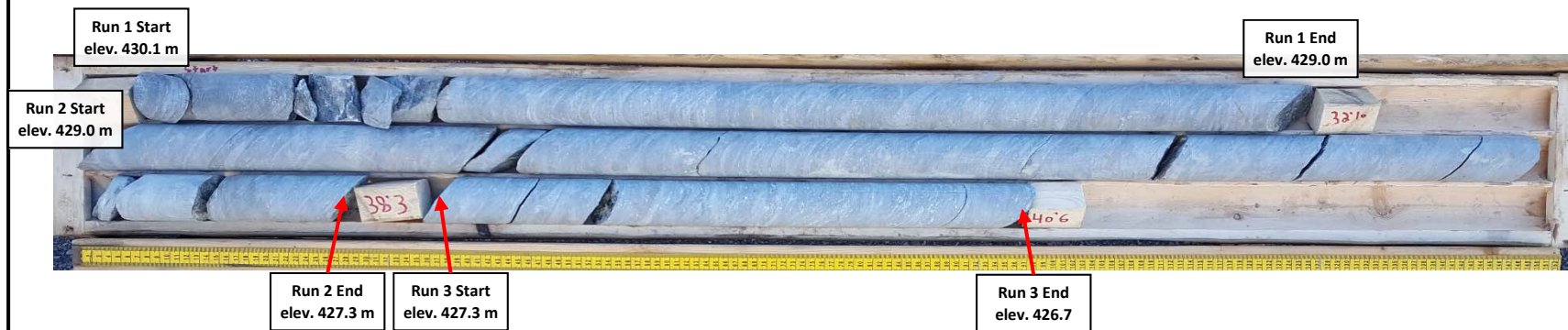
Date August 2018
GWP# 6827-14-00



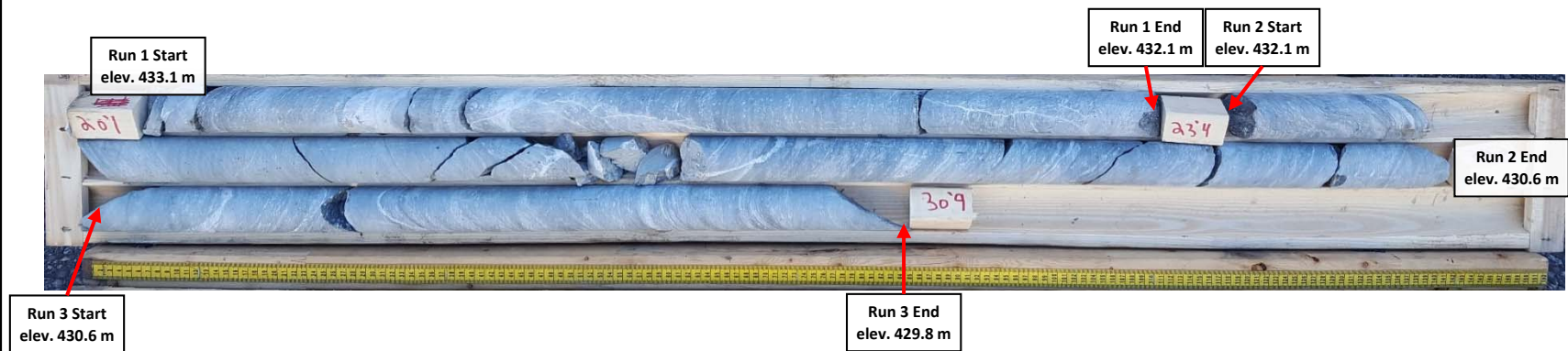
Prep'd DJP
Chkd. SD

Appendix C.2
Rock Core Photos

Borehole 18-201
Run 1 to 3 (of 3)
Elevation 430.1 to 426.7 m



Borehole 18-202
Run 1 to 3 (of 3)
Elevation 433.1 m to 429.8 m



Appendix C.3
Analytical Testing Results



Stantec

Stantec Consulting Ltd
100 A&B – 2781 Lancaster Rd
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 738-6067

June 29, 2018
File: 122410864

Attention: Thurber Engineering, File #19773

Reference: ASTM D2974 Organic Matter of Peat & Other Soils

The table below summarizes test results for Organic Matter of Peat and Other Soils.

Source	Depth	Location	Organic Content
BH18-201 SS9	20'-22'	Highway 527 Culverts	13.8%
BH18-204 SS5B	16'8"-17'	Highway 527 Culverts	20.8%
BH18-301 SS7B	15'4"-16'2"	Highway 527 Culverts	13.0%

Sincerely,

Stantec Consulting Ltd.

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-738-6067
brian.prevost@stantec.com

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

Physical Characteristics

% Solids	0.1 % by Wt.	80.0	88.0	89.3	92.4
----------	--------------	------	------	------	------

General Inorganics

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

Anions

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	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	89.9	90.0	-	-
----------	--------------	------	------	---	---

General Inorganics

Conductivity	5 uS/cm	47	50	-	-
pH	0.05 pH Units	7.14	7.38	-	-
Resistivity	0.10 Ohm.m	213	198	-	-

Anions

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 - 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

28-June-2018

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
9: 18-101,SS6, 12'6"-14'16"	30-May-18	< 0.02
10: 18-204,SS4, 10'4"-12'4"	13-Jun-18	< 0.02
11: 18-401,SS5, 10'-12'	07-Jun-18	< 0.02
12: 18-502,SS8, 17'6"-19'6"	12-Jun-18	< 0.02
13: 18-301,SS8A, 17'6"-19'4"	05-Jun-18	< 0.02

RL - SGS Reporting Limit
ND - Not Detected

Kimberley Didsbury
Project Specialist
Environmental Services, Analytical

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

Report Date: 07-Dec-2018

Order Date: 3-Dec-2018

Project Description: 19773

Client ID:	Rousseau	Max	Rinker	Wabikon
Sample Date:	11/30/2018 12:00	11/30/2018 11:45	11/30/2018 11:30	11/30/2018 11:00
Sample ID:	1849062-01	1849062-02	1849062-03	1849062-04
MDL/Units	Water	Water	Water	Water

General Inorganics

Conductivity	5 uS/cm	125	74	52	84
pH	0.1 pH Units	7.5	7.4	7.3	7.5
Resistivity	0.01 Ohm.m	79.9	135	193	119

Anions

Chloride	1 mg/L	7	2	1	4
Sulphate	1 mg/L	1	1	1	1

Client ID:	Waweig	-	-	-
Sample Date:	11/30/2018 10:00	-	-	-
Sample ID:	1849062-05	-	-	-
MDL/Units	Water	-	-	-

General Inorganics

Conductivity	5 uS/cm	56	-	-	-
pH	0.1 pH Units	7.4	-	-	-
Resistivity	0.01 Ohm.m	180	-	-	-

Anions

Chloride	1 mg/L	1	-	-	-
Sulphate	1 mg/L	<1	-	-	-

Appendix D.

Site Photographs



Photo 1. Looking northward at culvert inlets (2018/08/12)



Photo 2. Looking northward at culvert outlets (2018/08/12)



Photo 3. Looking north along Highway 527 (2018/08/12)



Photo 4. Looking south along Highway 527 (2018/08/12)



Photo 5. Looking east at Max Creek culvert outlets (2018/08/12)



Photo 6. Looking west at Max Creek culvert inlets (2018/08/12)



Photo 7. Transverse cracking near north culvert (2018/08/12)

Appendix E.

Foundation Comparison

COMPARISON OF ALTERNATIVE FOUNDATION TYPES

Type	Culvert Types				Ground Improvement Options			
	Circular CSP Pipe Culvert	Closed Box Culvert	Open Bottom Culvert	Precast Concrete Slab on Sheet Pile Culvert	Deep Foundations (Micropiles)	Sub-Excavation of Buried Organics	Lightweight Fill (EPS)	Do Nothing
Advantages	<ul style="list-style-type: none">• Can tolerate larger magnitude of settlement than concrete (rigid frame) culverts.• Relatively expedient installation.• Can be used without adding load to the existing condition, reducing the risk of settlement of the buried organic silt.• Creek diversion through existing pipes may be feasible.	<ul style="list-style-type: none">• Lower cost if precast units are used.• Relatively expedient installation if precast units are used.• Typically smaller magnitude of settlement than open footing foundation due to lower bearing stress on subgrade.• Minimized differential settlement between culvert and approach fills.	<ul style="list-style-type: none">• Limits disturbance to streambed. Typically favourable from an aquatic habitat perspective.• Relatively expedient installation if precast units are used.	<ul style="list-style-type: none">• Minimized volume of excavation compared to other options.• Allows for winter construction.• Eliminates the requirement for offline diversion channel.	<ul style="list-style-type: none">• Allows for all culvert types (except sheet piles).• Allows for a net load increase without removal of the buried organic silt layer.• Piles socketed into bedrock provide a higher geotechnical resistance• Installation equipment can also be used to install roadway protection.• Drilled micropiles can penetrate cobbles and boulders.	<ul style="list-style-type: none">• Allows for net load increase at the site.• Allows for all culvert types (except sheet piles).	<ul style="list-style-type: none">• Allows for grade raise at the site for circular pipes or closed box culvert without sub-excavating the buried organic silt.• An open bottom culvert may also be more feasible.	<ul style="list-style-type: none">• Zero to low cost• Settlements are expected to be less than 25 mm provided there is no net-load increase to the underlying organic silt layer• Settlements are expected to be manageable (25 to 50 mm) for low grade raises (<0.5 m)
Disadvantages	<ul style="list-style-type: none">• Feasibility also depends on flow capacity and other hydraulic properties. May need multiple pipes.• Requires large excavation.• Roadway protection or temporary widening will be required.• Groundwater control is required.	<ul style="list-style-type: none">• Requires large excavation.• Roadway protection or temporary widening will be required.• Groundwater control is required.• Requires creek diversion.• Less flexible than CSP.	<ul style="list-style-type: none">• Requires deeper excavation for frost protection increasing excavation volume and dewatering efforts.• Potential for post construction settlement.• Roadway protection or temporary widening will be required.• Can only be used if the buried organic silt is sub-excavated.	<ul style="list-style-type: none">• Quantity and cost of sheet piles.• Cannot penetrate obstructions.• Differential settlement will occur between non-yielding culvert and approach fills. A geogrid may be needed to strengthen the pavement structure.	<ul style="list-style-type: none">• Quantity and cost of micropiles.• Pile installation will increase the time the excavation is left open increasing groundwater control requirements• Presence of cobbles and boulders can slow production.• Differential settlement will occur between non-yielding culvert and approach fills. A geogrid may be needed to strengthen the pavement structure.	<ul style="list-style-type: none">• Requires a very deep excavation (7 to 8 m) increasing risks and costs associated with dewatering and roadway protection.• Requires a large volume of granular fill to replace the sub-excavated material.	<ul style="list-style-type: none">• Quantity and cost of EPS.• EPS floats in water. Excavation must be in the dry and buoyancy needs to be considered in design.• Differential frost movement can occur at boundary with approach fills; a frost taper may be required.	<ul style="list-style-type: none">• The final paving will need to be delayed to allow for settlement to occur in advance (3 months for no grade raise; or 6 to 12 months for a 0.5 m grade raise)• Some periodic maintenance could be required to correct for long-term settlement.
Risks/ Consequences	<ul style="list-style-type: none">• Post-construction settlement will occur if there is a net load increase to the underlying organic silt.• Cobbles and boulders present a challenge for installing roadway protection. Pre-drilling may be required to advance soldier piles.	<ul style="list-style-type: none">• Post-construction settlement will occur if there is a net load increase to the underlying organic silt.• Cobbles and boulders present a challenge for installing roadway protection. Pre-drilling may be required to advance soldier piles.	<ul style="list-style-type: none">• Increased risk of basal instability of footing excavation due to depth of excavation below water table.• Cobbles and boulders present a challenge for installing roadway protection. Pre-drilling may be required to advance soldier piles.	<ul style="list-style-type: none">• High risk of encountering obstructions and having inadequate lateral support due to a shallow refusal.	<ul style="list-style-type: none">• Equipment costs are high. Any unforeseen delays can result in high standby costs.	<ul style="list-style-type: none">• Cobbles and boulders present a challenge for installing roadway protection. Pre-drilling may be required to advance soldier piles.• Groundwater inflow could become too high to manage with sump pumps. Active pumping from well points could increase costs significantly.	<ul style="list-style-type: none">• Cobbles and boulders present a challenge for installing roadway protection. Pre-drilling may be required to advance soldier piles.	<ul style="list-style-type: none">• The final paving could be delayed longer than expected, or more maintenance could be needed, if settlements are larger than expected.
Relative Cost	Low	High	High	Moderate to High	Very High	High to Very High	High to Very High	Low
Recommendation	Feasible (Preferred)	Feasible	Not Recommended	Not Feasible	Not Recommended	Not Recommended	Not Recommended	Feasible (Preferred)

Appendix F.

List of Special Provisions and OPSS Documents Referenced in this Report

1. The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS PROV 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility and Associated Structure Excavation
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSD 208.010	Benching of Earth Slopes
OPSD 802.010	Flexible Pipe Embedment and Backfill Earth Excavation
OPSD 803.031	Frost Treatment – Pipe Culverts Frost Penetration Line Between Top of Pipe and Bedding Grade
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Depths for Northern Ontario
SP109S12	Amendment to OPSS 902 - QVE, Backfilling Compaction, and Certificate of Conformance
SP517F01	Amendment to OPSS 517 - Dewatering System
SPFOUN0003	Amendment to OPSS 902 – Dewatering Structure Excavations

2. Suggested text for a N SSP on “Installation of Temporary Protection System”

Vibratory equipment is not permitted for installation or removal of temporary protection systems and cofferdams.

3. Suggested text for a N SSP on “Obstructions”

Obstructions such as cobbles and boulders may be encountered within the existing fill and native soils. Such obstructions may impede the progress of open-cut excavations and/or installation of temporary protection systems. The contractor shall use appropriate equipment and methodologies to penetrate and/or advance past the obstructions.