



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT 44 AT STATION 15+040
HIGHWAY 17 NEAR SCHREIBER, ONTARIO
KILLRAINE TOWNSHIP
G.W.P. 6294-11-00**

GEOCRES NUMBER: 42D-42

**SUBMITTED TO
AINLEY GROUP**

**September 2016
19-6478-6**



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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for Culvert 44 located on Highway 17, within the Township of Killraine, approximately 7.6 km west of Schreiber, Ontario. Thurber carried out the investigation as a subconsultant to Ainley Group (Ainley) as part of Agreement No. 5014-E-0046.

No previous foundation investigation information for the subject culvert was available. Base plan mapping and cross section data was provided by Ainley for the preparation of this report.

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

2 SITE DESCRIPTION

Culvert 44 is located at Station 15+040 in Killraine Township on Highway 17, approximately 650 m east of Winston Lake Road, near Schreiber, Ontario. It is noted that for project orientation purposes, Highway 17 within the project limits, will be assumed to run east-west. The location of the culvert is shown on the inset Key Plan on Drawing No. 1 in Appendix A.

In the area of the culvert, Highway 17 is a two-lane, undivided highway with three cable guide rail located on both sides of the highway. Based on field measurements the roadway cross-section consists of two, 3.5 m wide lanes with approximately 3.3 m wide granular shoulders. Culvert 44 carries flow from south to north below the highway. The posted speed limit within the project limits is 90 km/hr. The 2012 AADT is reported to be 2050. The highway profile slopes down to the west at approximately 3.6%.

The available CAD drawings indicate that the existing culvert is a 1900 mm diameter, 48.0 m long corrugated steel pipe (CSP) culvert with the north/outlet end buried. The height of the fill over the culvert based on available cross sections ranges from 5.9 m to 7.2 m. The slopes of the embankment were observed to be covered with rockfill and were graded at approximately 1.3H:1V (Horizontal:Vertical). The elevation at the centreline of the roadway was approximately 319.5 m. The inlet invert elevation is 311.6 m at the south end while the north end outlet is crushed and/or buried beneath the embankment rockfill with an assumed invert elevation of approximately 310.1 m.

The lands surrounding the roadway are typically forested with little to no development in the area. The land on either side of the embankment in the vicinity of the culvert crossing is

predominantly marsh. Storm water drainage in the area is to ditches and culverts. Typical site photographs are presented in Appendix D.

3 SITE INVESTIGATION AND FIELD TESTING

As a component of our standard procedures and due diligence, Thurber contacted Ontario One Call to provide utility locate clearances for the intended borehole locations. The results of the utility locates indicated that there were no buried utilities in the area of the proposed test holes at the time of the field investigation. It should be noted that utility locate clearances will be required for any future excavations.

The field investigation for this site included advancing four boreholes drilled between November 7 and November 27, 2015. 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.

Table 3-1: Borehole Summary

Borehole	Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Depth (m)
15-1	Culvert Outlet	5 409 540.6	277 855.4	311.9	10.1
15-2	Highway 17 Westbound	5 409 519.5	277 855.4	319.8	17.0
15-3	Highway 17 Eastbound	5 409 509.1	277 833.8	319.4	14.7
15-4	Culvert Inlet	5 409 492.6	277 828.2	311.9	2.6

The boreholes through the roadway embankment were advanced with a CME track mounted drill rig equipped with NW size casing. The inlet and outlet boreholes were advanced with portable drilling equipment. The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the boreholes via the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. All soil samples recovered from the boreholes were placed in moisture-proof containers and the samples were transported to Thurber's Ottawa geotechnical laboratory for further examination and testing. Bedrock was cored in both embankment boreholes using NQ size coring equipment following ASTM Standard D6032-08. Bedrock core samples were stored in core boxes for transport.

The boreholes were backfilled with a low-permeability mixture of auger cuttings and bentonite pellets in general accordance with the intent of Ontario MOE Regulation 903 and where required topped with asphalt patch.

The as-drilled locations of the boreholes were measured by Thurber personnel on November 30, 2015 and elevations were obtained from CAD drawings and cross sections provided by Ainley.

4 LABORATORY TESTING

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all soil samples in accordance with the current MTO standards. Grain size distribution analyses testing was also carried out on selected samples to MTO and ASTM standards.

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

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 Overview / General

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

For reference, the stratigraphy in the area of the boreholes through the embankment is generally characterized by asphalt overlying sand with gravel fill overlying rockfill overlying silt and sand deposits and underlain by granite bedrock.

More detailed descriptions of the individual strata are presented below.

5.2 Pavement Structure

Surface Treatment:

An asphalt layer with a thickness of 50 mm was encountered in both embankment boreholes which were advanced through the partially paved shoulders.

Base Materials:

A granular fill layer consisting predominantly of sand with gravel with varying amounts of cobbles was encountered below the asphalt in the embankment boreholes. This layer has a top elevation ranging from 319.3 m to 319.7 m and a thickness ranging from 0.8 m to 0.9 m in Boreholes 15-2 and 15-3. The SPT 'N' values ranged from 8 blows to greater than 100 blows for 0.3 m of penetration; indicating a loose to very dense condition, although typically compact.

The moisture content of the samples tested ranged between 3% and 8%. The results of a grain size analysis conducted on one sample of the granular fill material is summarized in Table 5-1 and illustrated on Figure 1 in Appendix C.

Table 5-1: Gradation Results for Granular Fill

Soil Particles	%
Gravel	33
Sand	58
Silt and Clay	9

5.3 Embankment Fill (Rockfill)

A fill layer consisting predominantly of rockfill with frequent cobbles and boulders was encountered beneath the pavement structure fill in both embankment boreholes. This layer has a top elevation of 318.4 m to 318.9 m, and a thickness ranging from 7.8 m to 8.5 m in Boreholes 15-2 and 15-3. The SPT 'N' values ranged from 20 blows to greater than 100 blows for 0.3 m of penetration; indicating a compact to very dense condition, although typically very dense. Due to the nature of this material, no split spoon samples were recovered within this layer as the borehole had to be advanced using casing and coring techniques. Boulders were cored over lengths ranging from 300 mm to 750 mm and were noted to be the main constituent in this rockfill. Boulders estimated as large as 1.5 m in diameter were observed on the side slopes of the embankment in the area of the culvert.

5.4 Rootmat

A rootmat layer with a thickness of 50 mm was found at ground surface in Borehole 15-1.

5.5 Sand with Organics

Underlying the rootmat in Borehole 15-1, a deposit of sand with organics was encountered. This layer was observed to be 1.7 m in thickness with an elevation of the base of the unit of 310.2 m. This material contained occasional cobbles near surface and frequent cobbles and boulders from 0.5 m to 1.7 m. The boulders and cobbles within this layer are likely part of the rockfill discussed in Section 5.3.

The SPT N-value for this deposit was 7 blows per 0.3 m penetration, indicating a very loose state. The water content of the recovered sample was 18%. The colour of this deposit is brown.

5.6 Silty Sand to Sandy Silt

A native soil deposit ranging from silty sand to sandy silt was encountered in Boreholes 15-1, 15-2 and 15-4. This layer was inferred in Borehole 15-3 using visual changes in the wash boring flush return and casing advancement progress. This soil was found at surface in Borehole 15-4, just below the rockfill in Boreholes 15-2 and 15-3 and just below the sand with organics in Borehole 15-1. In Borehole 15-4 this soil was noted to contain organics. The thickness was observed to range from 0.3 m to 6.5 m with the surface elevation ranging from 310.2 m to 311.9 m.

The SPT N-values for this deposit varied from 4 blows to 35 blows per 0.3 m penetration; indicating a very loose to dense state, typically loose to compact. The water content of the recovered samples ranged between 21% and 32%. The colour of this deposit is brown to grey.

Grain size analyses conducted on three samples of the soil are presented on Figure 2 in Appendix C. These results are summarized in the following table.

Table 5-2: Gradation Results for Silty Sand to Sandy Silt

Soil Particles	%
Gravel	0 to 3
Sand	29 to 57
Silt	42 to 70
Clay	1

5.7 Sand with Gravel

A layer of sand to sand with gravel was encountered in Boreholes 15-1, 15-2, and 15-4. In Borehole 15-3 a thin gravel with sand layer was inferred using visual changes in the wash boring flush return and casing advancement progress. This soil was found just below the silty sand to sandy silt layer. Borehole 15-1 was terminated in this material. The thickness where fully penetrated was observed to range from 1.0 m to 2.3 m with the surface elevation ranging from 303.7 m to 311.6 m.

The SPT N-values for this deposit varied from 22 blows to greater than 100 blows per 0.3 m penetration, indicating a compact to very dense state. The water content of the recovered samples ranged between 8% and 20%. The colour of this deposit is brown.

Grain size analyses conducted on three samples of the soil are presented on Figure 3 in Appendix C. These results are summarized in the following table.

Table 5-3: Gradation Results for Granular Fill

Soil Particles	%
Gravel	4 to 45
Sand	45 to 88
Silt and Clay	4 to 10

5.8 Bedrock

Granitic bedrock was encountered in both the embankment boreholes; as identified by visual inspection of NQ coring. Borehole 15-4 was terminated at refusal on inferred bedrock. The bedrock surface where observed or inferred, ranged in elevation from 307.4 m to 309.3 m. Bedrock total core recovery ranged from 82% to 100% in both cored boreholes, solid core recovery ranged from 24% to 100% and the RQD values ranged from 0% to 98%. Based on the RQD values the rock mass quality ranges from poor to excellent. The bedrock fractures had a horizontal to inclined orientation. The fracture index ranged from 0 to 6 fractures per 0.3 m. Photographs of the bedrock cores are provided in Appendix B.

5.9 Groundwater Conditions

Groundwater levels were measured on completion of drilling in the open boreholes prior to backfilling. Groundwater was observed at ground surface in Borehole 15-1 and 0.3 m below surface in Borehole 15-4 corresponding to elevations of 311.9 m and 311.6 m respectively. Due to the use of water during coring in Boreholes 15-2 and 15-3 the groundwater levels could not be determined accurately upon completion of drilling.

There was no water flowing through the culvert at the time of Thurber's field investigation.

The groundwater level in the area of the culvert is expected to reflect the water level in the stream flowing through the culvert. These observations are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber measured the borehole locations, and determined the coordinates and ground surface elevations based on contract drawings provided by Ainley. RPM Drilling of Thunder Bay, Ontario supplied and operated the track mount CME drill rig to carry out the drilling, sampling, and in-situ testing operations on the existing highway platform. Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario, supplied and operated the portable drilling equipment. The drilling, and sampling operations in the field were supervised on a full time basis by Mr. Christopher Murray, E.I.T. of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Dr. Fred Griffiths, P.Eng. Interpretation of the field data and preparation of this report was completed by Mr. Justin Gray, E.I.T. The report was reviewed by Dr. Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.

Justin A. Gray
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Fred J. Griffiths, P.Eng.
Senior Associate, Senior Geotechnical Engineer



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Review Principal, Designated MTO Contact

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents a foundation assessment and evaluation of the proposed method for partial replacement of a culvert under Highway 17 near Schreiber, Ontario, approximately 650 metres east of the intersection of Winston Lake Road and Highway 17 in the Township of Killraine.

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 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.

A 1.9 m diameter by 48 m long corrugated steel pipe culvert (CSP) is present at the site. Water at the site flows from south to north. The invert elevation is 311.6 m at the south end while the north end is crushed and/or buried beneath the embankment rockfill. It is understood that the damaged section is approximately 7 m in length.

The grade of the existing Highway 17 in the vicinity of the culvert is at 319.5 m geodetic. The embankment is constructed with side slopes approximately 1.3H:1V. Selected photographs showing the existing conditions at the culvert site are included in Appendix D for reference.

It is understood that the culvert is to be lined however a portion of the north end will require replacement due to the damage.

The borehole information indicates that the base of the embankment fill ranges from 310.4 m to 310.6 m. The majority of the excavation for the replacement section of culvert would therefore be within the rockfill. The native material observed immediately beneath the fill consisted of silty sand to sandy silt. It was typically loose to compact.

This report presents an evaluation of the methods for the replacement of the damaged culvert section. The discussions and recommendations presented in this report are based on information provided by Ainley and on the factual data obtained during the course of this investigation.

8 CULVERT FOUNDATIONS

8.1 General

It was determined by Ainley that installing a culvert liner is sufficient to meet project needs provided the damaged culvert section at the north end is replaced. The following sections address replacement of the culvert section. It is noted that the existing culvert is considered a non-structural culvert.

8.2 Proposed Approach

It is our understanding that open cut techniques will be utilized to replace the 7 m long damaged culvert section. It is anticipated that two lanes of traffic can be maintained during the replacement.

Temporary protection systems were considered initially but were determined not to be feasible due to the nature of the rockfill and the fact that the 7 m length of damaged culvert can be replaced with open cut techniques while maintaining two lanes of traffic.

9 RECOMMENDATIONS

9.1 Excavation and Water Control

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment rock fill and native soil at this site are classified as Type 3 soil above the water level and Type 4 soil below the water level.

Temporary excavations in Type 3 soils may be carried out with side slopes as steep as 1H:1V from the base of the excavation.

Culvert construction and subgrade preparation must be carried out in the dry. This work should be carried out in accordance with OPSS 421. The ground water levels observed in the boreholes were at or above the anticipated base of the excavation. It is noted however that ground water levels do fluctuate and it is expected that groundwater and surface water will accumulate in the excavations during culvert construction. The groundwater level is expected to be largely governed by the water level in the stream and seasonal weather.

The Contractor must make provisions to control any groundwater seepage, surface runoff and ponding by measures including the use of sump pumps, cofferdams, and/or creek diversion and protection systems to maintain dry and stable excavations during the course of construction. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor.

9.2 Subgrade Preparation

After removal of the existing culvert and excavation to the design founding elevation (underside of bedding), the exposed surface must be inspected to confirm that the subgrade is suitable and uniformly competent. Any remaining fill, topsoil, organics, creek bed deposits, soft/loose areas, disturbed soils and any deleterious materials within the culvert replacement footprint must be further sub-excavated to undisturbed, competent native soils. The sub-excavated area should be replaced with well compacted granular fill consisting of OPSS Granular A material as soon as practicable and the subgrade protected from disturbance during construction.

Culvert construction and subgrade preparation must be carried out in the dry. This work should be carried out in accordance with OPSS 421.

9.3 Culvert Bedding and Cover

It is recommended that the limits of excavation and backfill be in accordance with OPSD 802.014.

Culvert bedding and cover material should consist of free-draining granular material conforming to OPSS Granular A specifications.

The cover should be placed and compacted in simultaneous, equal lifts on both sides of the culvert. Heavy compaction equipment should not be used adjacent to or over the culvert. Compaction should be carried out in accordance with OPSS 501.

9.4 Embankment Reinstatement

The existing rock embankment is sloped at approximately 1.3H:1V and exhibits no signs of instability.

Embankment reconstruction, after culvert replacement, should be carried out in accordance with OPSS 206. The excavated rock fill embankment material may be reused as backfill provided there is no organic material in the excavated fill and there is sufficient space to stockpile on site and the material is in accordance with OPSS 206. The embankment reconstruction should be constructed with side slopes no steeper than 1.25H:1V. The top of the rock fill should be chinked to prevent the migration of roadway granular into voids. The pavement structure should be reinstated as described in the Pavement Design Report.

9.5 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field. Typically, rock protection should be provided over all surfaces with which flowing surface water is likely to be in contact. Treatment at the outlet should be in accordance with OPSD 810.010.

9.6 Cement Type and Corrosion Potential

Two samples of the native silty sand to sandy silt were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis was completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in the following table.

Results of Chemical Analysis

Borehole	Sample	Depth (m)	pH	Resistivity (Ohm-cm)	Chloride (µg/g)	Sulphate (µg/g)
15-1	SS2	2.0	6.3	1770	226	15
15-2	SS5	10.2	5.4	2860	15	<5

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 less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU Portland Cement should therefore be suitable for use in concrete at this site. The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH measured was within or slightly below what is considered the normal range for soil pH of 5.5 to 9.0. The test results provided may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

10 CONSTRUCTION CONCERNS

The planned construction methodology includes staged construction in order to maintain both traffic flow and water flow through the culvert area. Potential construction concerns include, but are not necessarily limited to, the following:

- Impact of excavation on the existing pavement surface. Daily visual inspection of the pavement surface must be carried out in the vicinity of the culvert construction. If cracks form in the pavement or settlement is observed to occur, these matters must immediately be brought to the attention of the C.A. for determining the level of remedial action that is required.
- Implementation of an adequate and effective surface water management and dewatering plan to construct the replacement culvert segment and subgrade in the dry.
- Removal of organics and soft soils from the culvert subgrade.
- The base of excavations for the culvert must be protected from disturbance since the base will be within soils that are easily disturbed.
- Confirmation that the culvert backfill is adequately placed and compacted to specifications.

During construction, the Contract Administrator should employ experienced geotechnical staff to observe construction activities related to foundation construction.

The successful performance of the culvert will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations by the QVE will be required during construction to confirm that the foundation recommendations are correctly implemented and material specifications are met.

11 CLOSURE

Preparation of this foundation design report was carried out by Mr. Justin Gray, and Dr. Fred Griffiths P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng.

Justin A. Gray
for
Justin A. Gray
Geotechnical E.I.T.

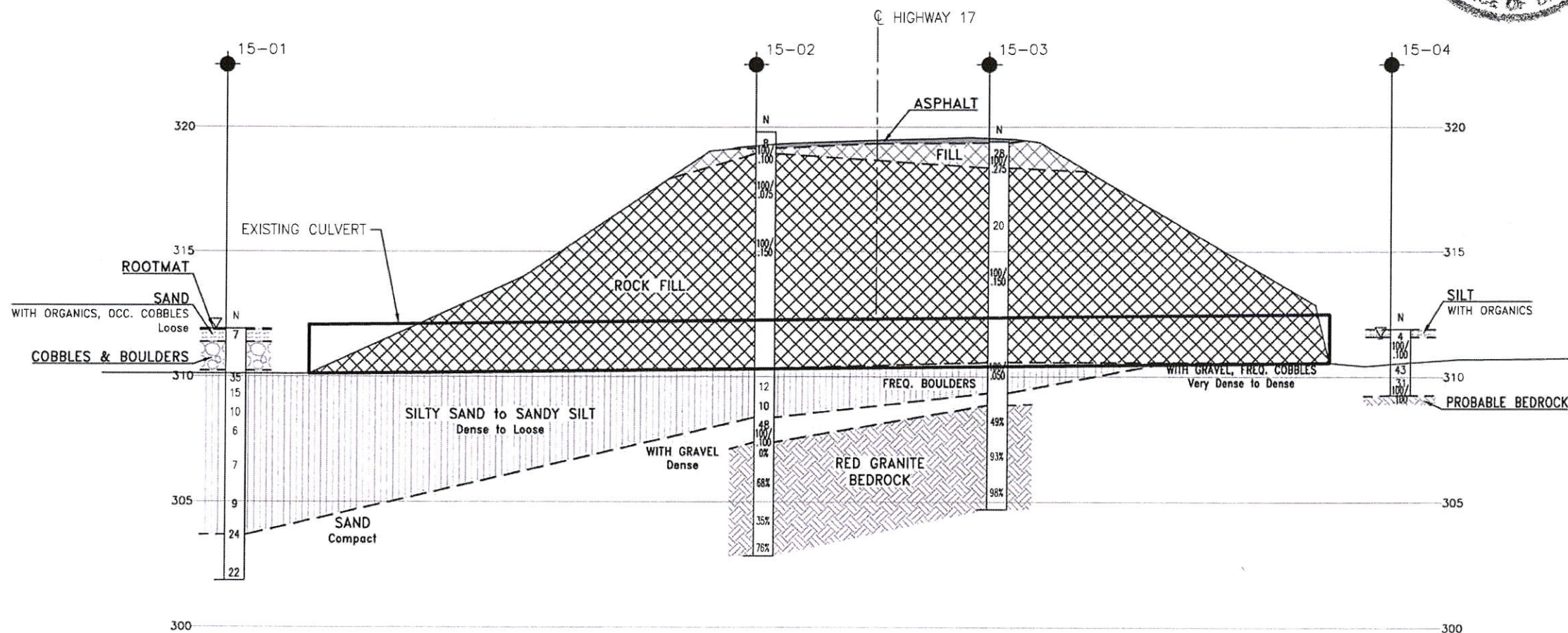
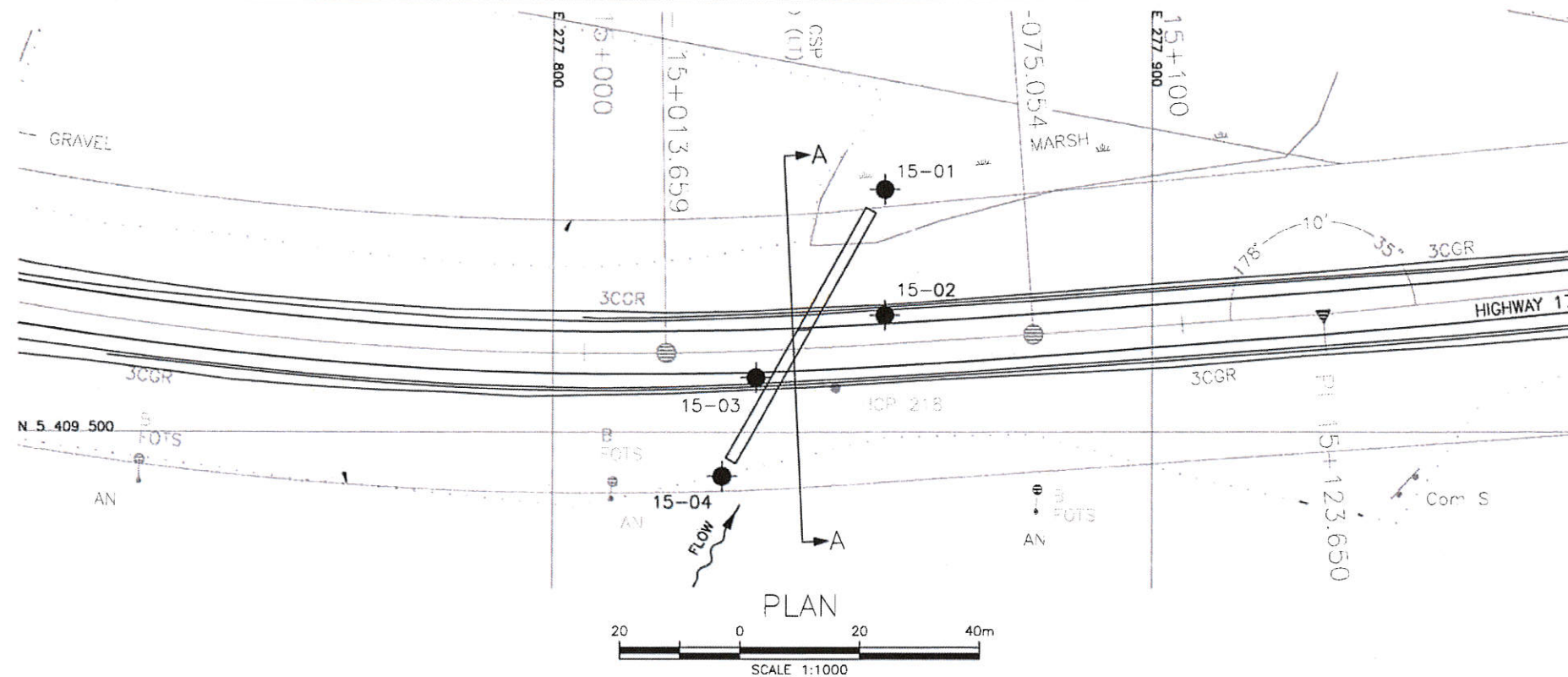


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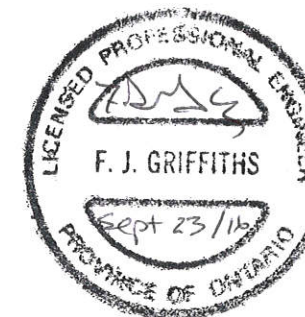


P.K. Chatterji, P.Eng.
Principal, Designated MTO Contact

APPENDIX A
BOREHOLE LOCATIONS AND SOIL STRATA DRAWINGS



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

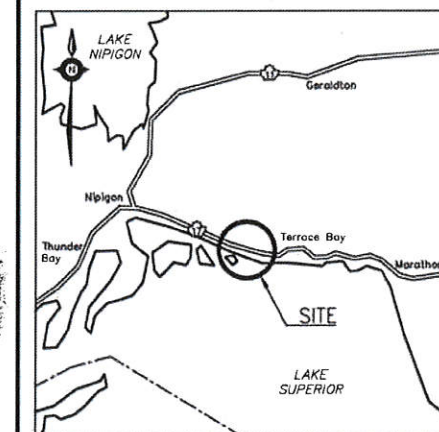


CONT No
GWP No 6294-11-00

HIGHWAY 17
CULVERT REPLACEMENT
CULVERT 44
BOREHOLE LOCATIONS AND SOIL STRATA

Ainley CONSULTING
ENGINEERS
PLANNERS

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
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
15-01	311.9	5 409 540.6	277 855.4
15-02	319.8	5 409 519.5	277 855.4
15-03	319.4	5 409 509.1	277 833.8
15-04	311.9	5 409 492.6	277 828.2

-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.
- Borehole locations are shown in MTM Zone 14 coordinates.

GEOCRES No. 42D-42

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CM	CHK -	CODE
DRAWN	MFA	CHK CM	SITE
			LOAD
			STRUCT
			DWG 1

FILENAME: I:\Drawing\15\GWP\15-035\15-035-PLR-Culvert44.dwg
PLOT DATE: 9/27/2016 2:56 PM

APPENDIX B

RECORD OF BOREHOLE SHEETS PHOTOGRAPHS OF ROCK CORE



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.

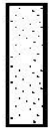


STRATA PLOT:

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



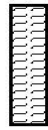
Sand



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

SAMPLE TYPES

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

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

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 15-01

1 OF 2

METRIC

GWP# 6294-11-00 LOCATION Culvert Site 44 N 5 409 540.6 E 277 855.4 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable / Casing COMPILED BY CAM
 DATUM Geodetic DATE 2015.11.24 - 2015.11.27 CHECKED BY FJG

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					
311.9								20 40 60 80 100					
0.0	ROOTMAT (50mm)		1	SS	7		311						
	SAND (SP) with Organics, occasional Cobbles Loose Brown												
	- Frequent Cobbles and Boulders 0.5 m to 1.7 m												
310.2													
1.7	SILTY SAND (SM) to Sandy SILT (ML) Dense to Loose Brown to Grey		2	SS	35		310						
			3	SS	15								0 57 42 1
			4	SS	10								
			5	SS	6								
			6	SS	7								
			7	SS	9								3 33 63 1
303.7			8	SS	24								
8.2	SAND (SW-SM) Compact Brown												
			9	SS	22								4 88 8 (SI+CL)

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-01

2 OF 2

METRIC

GWP# 6294-11-00 LOCATION Culvert Site 44 N 5 409 540.6 E 277 855.4 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable / Casing COMPILED BY CAM
 DATUM Geodetic DATE 2015.11.24 - 2015.11.27 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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									
301.8 10.1	Continued From Previous Page End of Borehole at 10.1 m Water table at ground surface on completion of drilling																

RECORD OF BOREHOLE No 15-02

1 OF 2

METRIC

GWP# 6294-11-00 LOCATION Culvert Site 44 N 5 409 519.5 E 277 855.4 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Solid Stem Auger / Casing / NQ Coring COMPILED BY CAM
 DATUM Geodetic DATE 2015.11.07 - 2015.11.08 CHECKED BY FJG

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				
								20 40 60 80 100	PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W		
319.8												
0.0	ASPHALT (50mm)											
0.2	SAND with Gravel Compact Dark Brown FILL		1	SS	8							
318.9			2	SS	100/ 100mm		319					
0.9	SAND, some Gravel Loose Brown FILL frequent cobbles below 0.75 m ROCK FILL - Borehole advanced by casing from 0.9 m to 9.4 m - Boulders ranging from 0.3 m to 0.75 m penetrated											
			3	SS	100/ 75mm		318					
			4	SS	100/ 150mm		317					
							316					
							315					
							314					
							313					
							312					
							311					
310.4												
9.4	Sandy SILT (ML) Compact Grey						310					

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 15-03

1 OF 2

METRIC

GWP# 6294-11-00 LOCATION Culvert Site 44 N 5 409 509.1 E 277 833.8 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Solid Stem Auger / Casing / NQ Coring COMPILED BY CAM
 DATUM Geodetic DATE 2015.11.09 - 2015.11.10 CHECKED BY FJG

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					
319.4								20 40 60 80 100					
0.0	ASPHALT (50mm)							○ UNCONFINED + FIELD VANE					
0.2	SAND with gravel Compact Dark Brown FILL		1	SS	28		319						33 58 9 (SI+CL)
318.4	SAND, some gravel, frequent cobbles Compact Brown FILL		2	SS	100/ 275mm								
1.0	ROCK FILL - Borehole advanced by casing from 1.0 m to 8.8 m - Boulders ranging from 0.3 m to 0.75 m penetrated						318						
							317						
			3	SS	20		316						
							315						
							314						
			4	SS	100/ 150mm		313						
							312						
							311						
310.6	Inferred Sandy SILT, frequent Boulders		5	SS	100/ 50mm		310						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-03

2 OF 2

METRIC

GWP# 6294-11-00 LOCATION Culvert Site 44 N 5 409 509.1 E 277 833.8 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Solid Stem Auger / Casing / NQ Coring COMPILED BY CAM
 DATUM Geodetic DATE 2015.11.09 - 2015.11.10 CHECKED BY FJG

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					
								20 40 60 80 100					
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W P W W L						
							WATER CONTENT (%) 20 40 60						
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
309.3	Continued From Previous Page												
10.1	Inferred GRAVEL with Sand, frequent Cobbles						309						
308.9	RED GRANITE BEDROCK Faintly Weathered to Fresh		1	RUN			308						RUN #1 TCR=100% SCR=76% RQD=49%
10.5			2	RUN			307						RUN #2 TCR=100% SCR=100% RQD=93%
			3	RUN			306						RUN #3 TCR=100% SCR=98% RQD=98%
304.7							305						
14.7	End of Borehole at 14.7 m												



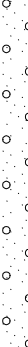
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RECORD OF BOREHOLE No 15-04

1 OF 1

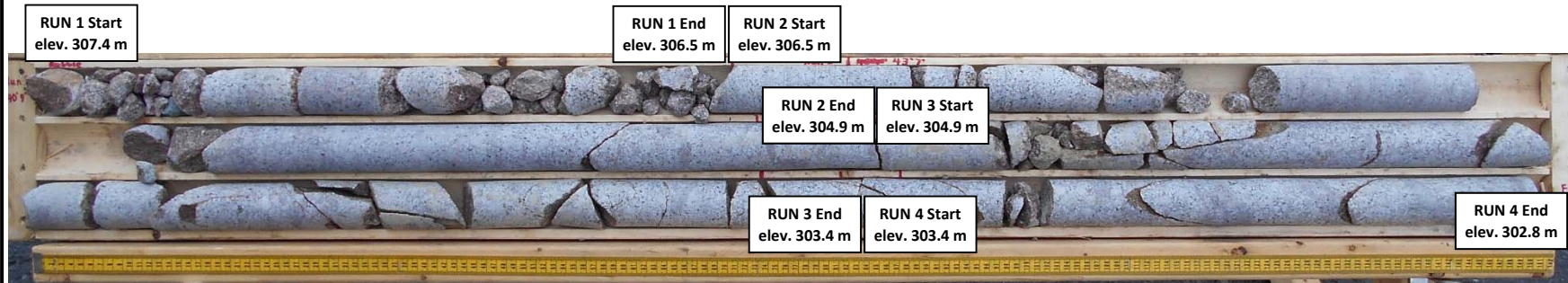
METRIC

GWP# 6294-11-00 LOCATION Culvert Site 44 N 5 409 492.6 E 277 828.2 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable / Casing COMPILED BY CAM
 DATUM Geodetic DATE 2015.11.27 - 2015.11.28 CHECKED BY FJG

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											
311.9								20	40	60	80	100							
0.0	Sandy SILT (ML) with Organics		1	SS	4		311												
311.6																			
0.3	SAND (SW) with Gravel, frequent Cobbles Very Dense to Dense Brown		2	SS	100/ 100mm														
			3	SS	43														
							310												
			4	SS	31														
			5	SS	100/ 100mm														
309.3																			
2.6	End of Borehole on probable bedrock at 2.6 m Water table at 0.3 m below ground surface on completion of drilling																		

ONTMT4S 19-6478-6.GPJ 2012TEMPLATE(MTO).GDT 9/16/16

Borehole 15-2
RUN 1 to 4 (of 4)
Elevation 307.4 m to 302.8 m



Borehole 15-3
RUN 1 to 3 (of 3)
Elevation 308.9 m to 304.7 m

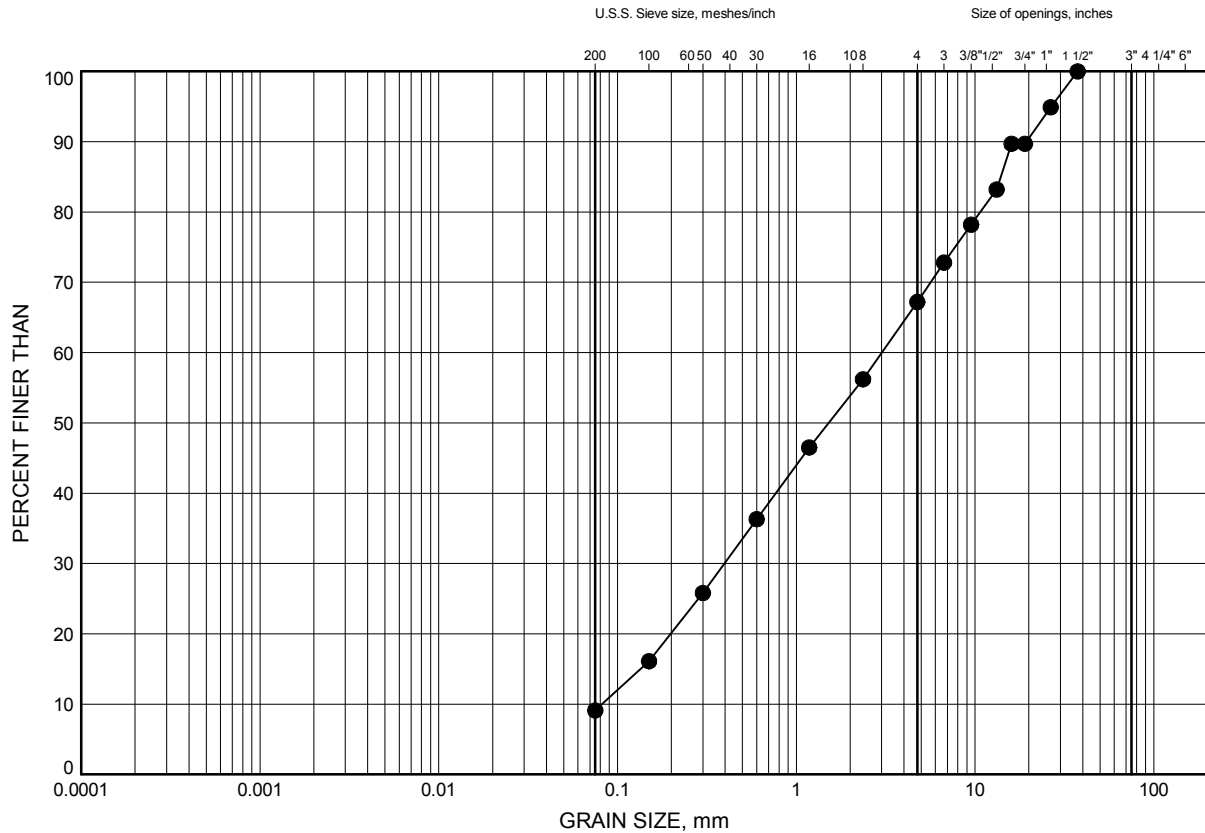


APPENDIX C
LABORATORY TEST RESULTS

Highway 17 GRAIN SIZE DISTRIBUTION

FIGURE 1

Granular Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-03	0.38	319.02

Date June 2016
GWP# 6294-11-00

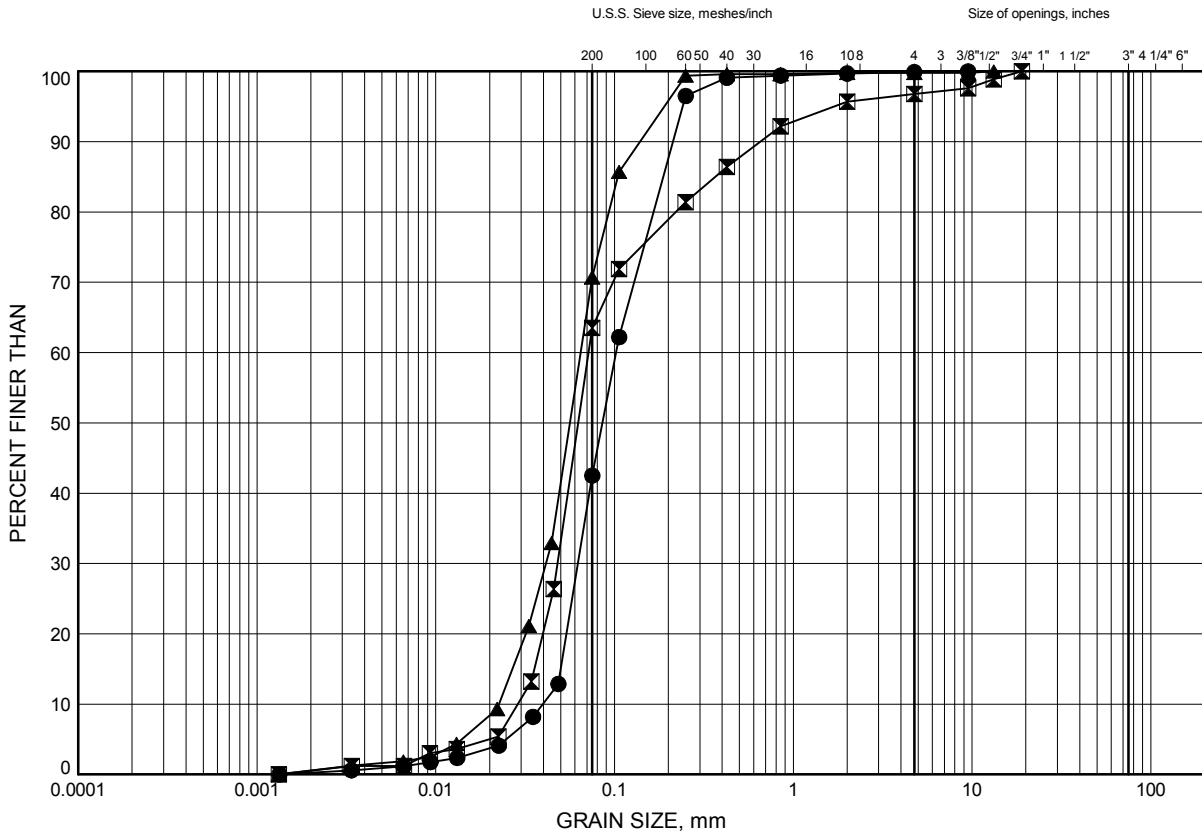


Prep'd CAM
Chkd. FJG

Highway 17 GRAIN SIZE DISTRIBUTION

FIGURE 2

Silty Sand to Sandy Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	2.59	309.31
⊠	15-01	7.01	304.89
▲	15-02	10.97	308.83

Date June 2016
GWP# 6294-11-00

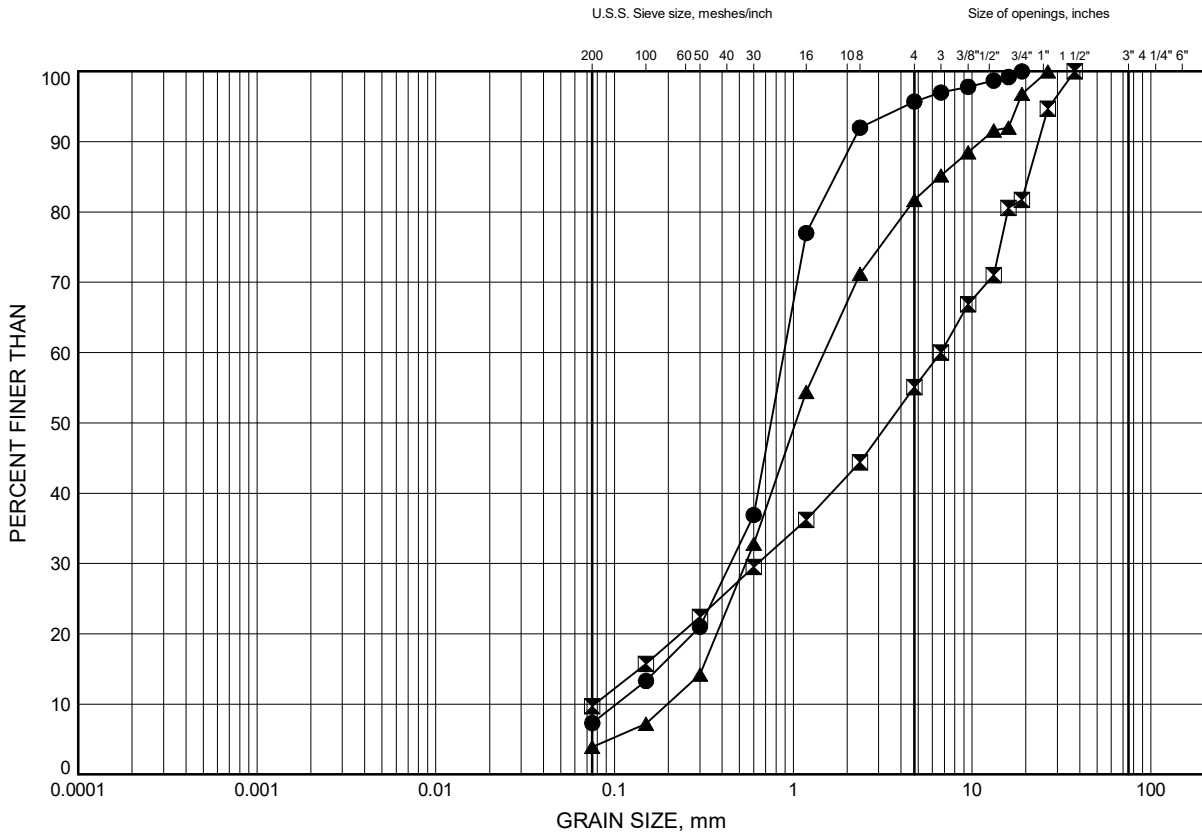


Prep'd CAM
Chkd. FJG

Highway 17 GRAIN SIZE DISTRIBUTION

FIGURE 3

Glacial Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	9.75	302.15
⊠	15-02	11.73	308.07
▲	15-04	2.13	309.77

Date August 2016

GWP# 6294-11-00



Prep'd JM

Chkd. FJG

APPENDIX D
SELECTED PHOTOGRAPHS



Figure 1: Roadway Platform at Culvert 44 Looking West



Figure 2: Culvert 44 inlet looking North, BH 15-04 location is staked



Figure 3: Roadway Platform at Culvert 44 Looking East



Figure 4: North side slope looking East



Figure 5: South side slope looking East