Foundation Investigation Report

Highway 28, Eel's Creek Bridge Replacement, North Kawartha, Ontario
MTO Agreement No. 4014-E-0012, Assignment No. 15

Submitted to:

Ministry of Transportation, Ontario - Foundations Section
145 Sir William Hearst Avenue, Building C, Room 223
Downsview, Ontario
M3M 0B6

Submitted by:

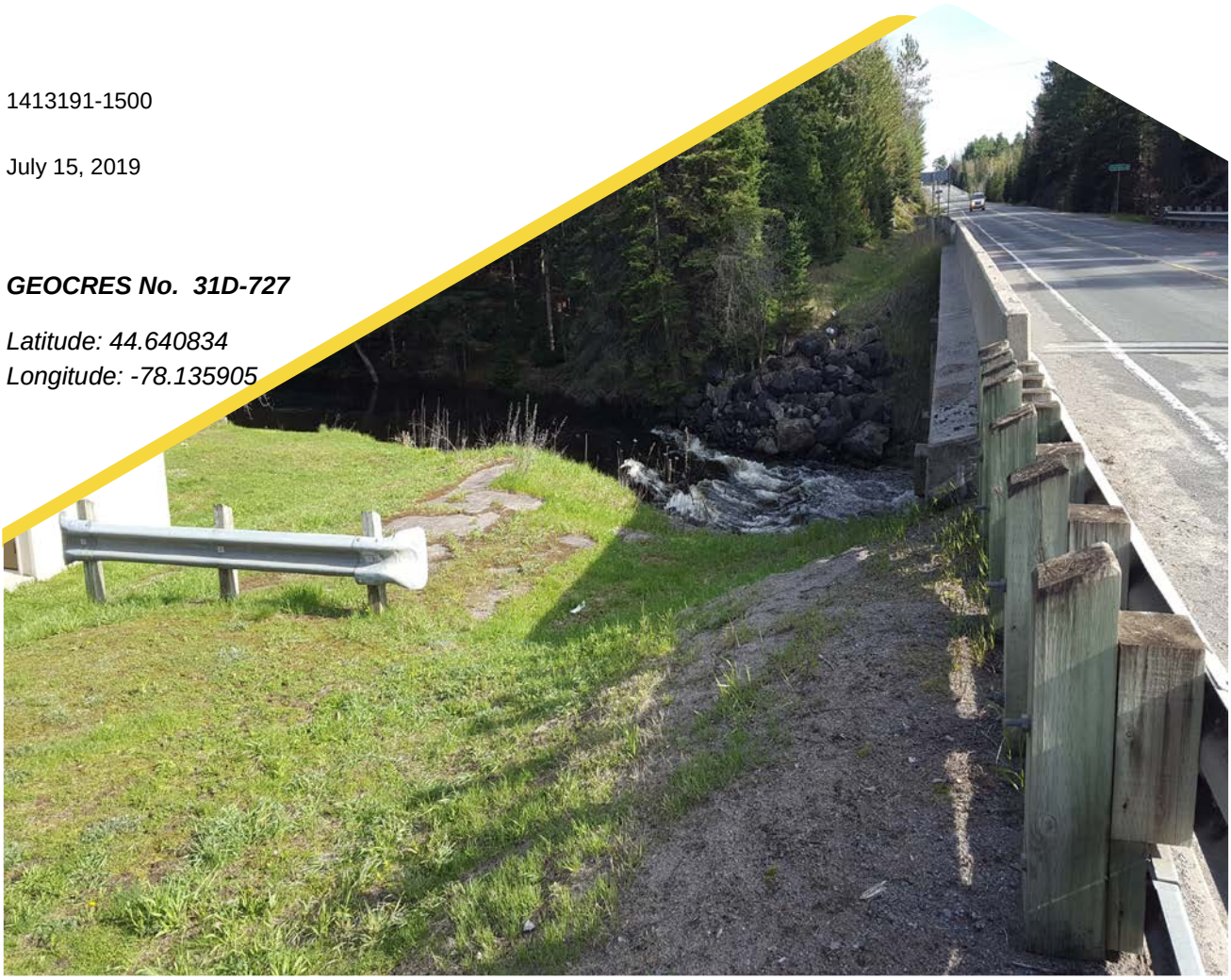
Golder Associates Ltd.
6925 Century Avenue, Suite #100, Mississauga, Ontario, L5N 7K2, Canada
+1 905 567 4444

1413191-1500

July 15, 2019

GEOCRES No. 31D-727

Latitude: 44.640834
Longitude: -78.135905



Distribution List

1 PDF and 1 Hard Copy - Ministry of Transportation, Ontario Eastern Region

1 PDF and 1 Hard Copy - Ministry of Transportation, Ontario Foundations Section

1 PDF - Golder Associates Ltd.

Table of Contents

1.0 INTRODUCTION 1

2.0 SITE DESCRIPTION 1

3.0 FIELD INVESTIGATION PROCEDURES 4

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS 8

4.1 Regional Geology 8

4.2 Subsurface Conditions 8

4.2.1 Topsoil 9

4.2.2 Asphalt 9

4.2.3 Non-Cohesive Embankment Fill 9

4.2.4 Silty Sand and Gravel to Sand to Silty Sand (Containing Organics) 9

4.2.5 Bedrock 10

4.2.6 Groundwater Conditions 12

4.3 Analytical Testing of Soil 13

5.0 CLOSURE 14

DRAWINGS

Drawing 1 – Borehole Location and Soil Strata
Drawing 2 – Soil Strata

APPENDICES

APPENDIX A - RECORD OF BOREHOLES, PROBEHOLES AND DRILLHOLES

List of Symbols
List of Abbreviations
Lithological and Geotechnical Rock Description Terminology
Records of Boreholes 16-1, 16-2, 16-6, 17-3, 17-4, 17-5, 17-7, 17-8, 17-9, 17-10, 18-1, 18-2, 18-6, 18-8, 18-10
Records of Probeholes 18-3, 18-5, 18-9, 18-11
Records of Drillholes 16-1, 16-2, 17-7, 18-1, 18-2, 18-6, 18-8, 18-10

APPENDIX B - LABORATORY TEST RESULTS

Figure B1A - B1B Grain Size Distribution – Gravelly Sand to Sand and Gravel (Fill)
Figure B2A - B2C Grain Size Distribution – Sand (Fill)
Figure B3 Grain Size Distribution – Silt and Sand (Fill)

Figure B4	Grain Size Distribution – Sand
Figure B5	Unconfined Compression (UC) Test – Borehole 16-1, Run No. 1
Figure B6	Unconfined Compression (UC) Test – Borehole 16-2, Run No. 1
Figure B7	Unconfined Compression (UC) Test – Borehole 17-7, Run No. 2
Figure B8	Unconfined Compression (UC) Test – Borehole 17-7, Run No. 3
Figure B9	Bedrock Core Photographs – Borehole 16-1 (10.29 m to 13.30 m)
Figure B10	Bedrock Core Photographs – Borehole 16-2 (6.48 m to 11.76 m)
Figure B11	Bedrock Core Photographs – Borehole 17-7 (5.13 m to 8.79 m)
Figure B12	Bedrock Core Photographs – Borehole 18-1 (1.75 m to 5.73 m) and Borehole 18-2 (2.96 m to 6.59 m)
Figure B13	Bedrock Core Photographs – Borehole 18-6 (7.65 m to 8.55 m) and Borehole 18-8 (5.33 m to 8.84 m)
Figure B14	Bedrock Core Photographs – Borehole 18-10 (2.59 m to 6.19 m)

APPENDIX C - VERTICAL SEISMIC PROFILING TEST RESULTS

Technical Memorandum titled “Vertical Seismic Profiling Test Results, Eel’s Creek Bridge and Highway 28, North Kawartha, Ontario”, prepared by Golder Associates Ltd., dated July 4, 2017

APPENDIX D - ROCK LABORATORY TEST RESULTS

Rock Laboratory Test Results Report, prepared by Geomechanica Inc., dated December 14, 2018

APPENDIX E - ANALYTICAL LABORATORY TEST RESULTS

Certificate of Analysis- Revised Report, prepared by Maxxam Analytics, dated August 23, 2017

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detail design of the Eel's Creek Bridge replacement project (Site No. 26-117) located on Highway 28, approximately 200 m south of Eel's Creek Park Road in North Kawartha, Ontario.

The purpose of this investigation is to establish subsurface soil, bedrock and groundwater conditions at the proposed structure replacement by borehole/probehole drilling, vertical seismic profiling (VSP) and geotechnical/analytical laboratory testing on selected soil and bedrock samples.

The Terms of Reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal titled "To Provide Foundations Engineering Services on Retainer, Various Locations, Assignment No. 4014-E-0012 & 4014-E-0013, Eastern Region" dated October 2014 and associated clarifications. The detailed Scope of Work for this assignment is presented in the Golder's *Understanding of Scope* documents for Assignment Number 4014-E-0012, Work Item No. 15 and the associated Work Item Quote Form. Supplementary foundation investigation services were provided under a similar understanding of scope document prepared for Assignment Number 4017-E-0048, Work Item No. 003. Authorization to proceed with both work order assignments was provided by MTO via signed Work Item Quote Forms for each assignment.

2.0 SITE DESCRIPTION

The site of the bridge structure to be replaced is located on Highway 28 in North Kawartha, Ontario. Highway 28 is currently an undivided two-lane highway with northbound and southbound traffic at this location. Eel's Creek flows in an east to west direction below the existing bridge. Bedrock outcrops were observed in the vicinity of the bridge during visits to the site in 2017 and 2018 (see Drawing 1).

Based on the General Plan drawing (Dwg. No. 320-2-1 prepared by DHO, dated December 3, 1952), the existing Eel's Creek Bridge is slightly skewed from the highway alignment and is a 17.8 m long single-span structure (as measured parallel to highway alignment). Based on the General Plan drawing, the north abutment is shown to be supported on a stepped shallow footing (about 13.5 m long by 1.8 m wide) founded below the existing stream bed on sand and gravel between about Elevation 254.6 m and 252.8 m. The south abutment footing (about 12.8 m long by 1.8 m wide) is shown to have been founded on bedrock, after removal / excavation of a minimum 0.3 m of the surficial rock within the foundation footprint. Within the south abutment foundation footprint, the bedrock surface is shown to be sloping from about Elevation 258.8 m on the east side to about Elevation 256.4 m on the west side, with a similar slope from the south side to the north side.

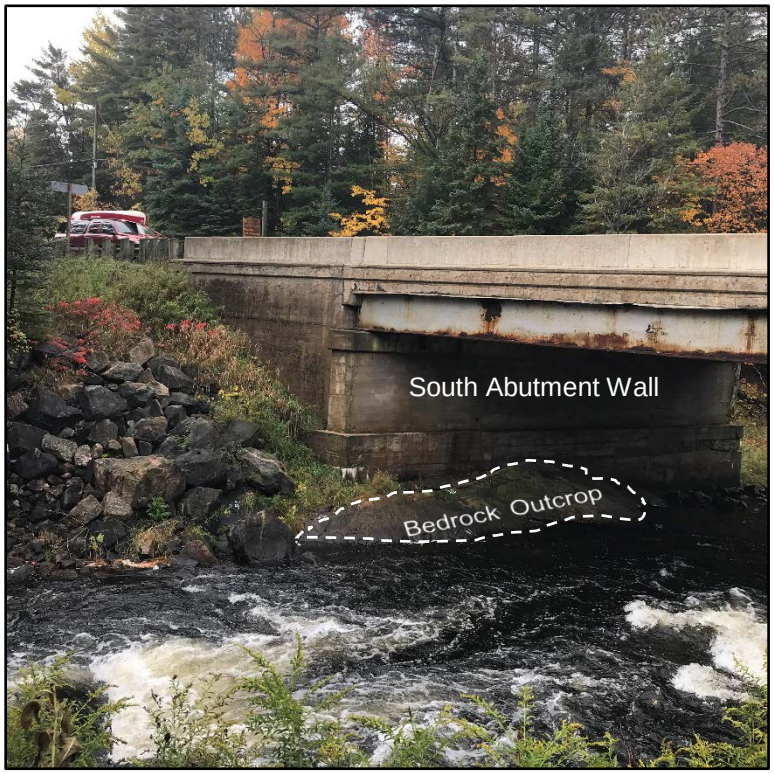
Concrete wingwalls are shown to be present each at each quadrant of the abutments, with wingwall foundations shown to match the founding level of the adjacent abutment wall at each location. The wing wall foundations are shown to extend about 5 m to 6 m back from the face of the abutment walls and range from about 2 m to 3 m wide. Cantilevered portions of the wingwalls extend back from the foundations and are shown to terminate about 7 m to 9 m back from the face of the existing abutment walls.

During the investigations performed in 2017 and 2018, the existing bridge abutments and approach embankments were observed and showed no visual signs of major distress or movement. The side slopes of the approach embankment were observed to be covered in rock fill in some areas, especially near the creek. Photographs taken of the bridge from Highway 28 and near the creek level are provided below.

Photograph 1 – Looking at bridge skew from Highway 28 – looking south

Photograph 2 – Looking at face of south abutment from north side of creek (photo courtesy of MTO, 2016)

Photograph 3 – Looking at face of north abutment from south side of creek (photo courtesy of MTO, 2016)



Photograph 4 – South abutment and bedrock outcrop – looking southwest from north side of creek

Photograph 5 – West side of Highway 28 looking north. Rock fill observed on surface of northwest approach embankment side slope.

The water level of Eel's Creek upstream and east of the existing bridge structure, as measured by Golder in June 2017, was at about Elevation 257.9 m. The water level shown on the General Plan (Dwg. No. 320-2-1) at the Eel's Creek structure was at Elevation 257.0 m and a high-water level at Elevation 258.5 m is also shown on the 1952 drawing.

3.0 FIELD INVESTIGATION PROCEDURES

The subsurface investigation for the proposed bridge replacement was carried out in three phases. The first phase was carried out between December 10 and 15, 2016, at which time three boreholes (designated as Boreholes 16-1, 16-2 and 16-6) were advanced at the locations shown on Drawing 1. A second phase of investigation was carried out between June 19 and 21, 2017 during which time a total of seven boreholes (designated as Boreholes 17-3, 17-4, 17-5, 17-7, 17-8, 17-9 and 17-10) were advanced at the locations shown on Drawing 1. A third investigation phase was carried out between November 12 and 15, 2018 to provide additional information to address alternate skews for the abutment foundations, during which time a total of five boreholes (designated as Boreholes 18-1, 18-2, 18-6, 18-8 and 18-10) and four probeholes (designated as Probeholes 18-3, 18-5, 18-9 and 18-11) were advanced at the locations shown on Drawing 1.

The boreholes and probeholes were advanced near the proposed replacement structure foundation elements as described below:

Proposed Foundation Element	Nearest Relevant Borehole / Probehole
South Approach Embankment	17-10, 18-1
South Abutment Foundations	16-6, 17-7, 17-8, 17-9, 18-2, 18-3
South Approach Temporary Protection System	16-6, 17-8, 17-10, 18-1
North Approach Embankment	17-5, 18-8
North Abutment Foundations	16-1, 16-2, 17-3, 17-4, 18-5, 18-6, 18-9, 18-10, 18-11
North Approach Temporary Protection System	16-2, 17-4, 17-5, 18-8

The location of the boreholes and probeholes are shown on Drawing 1 and the borehole, probehole and drillhole records are presented in Appendix A. Lists of abbreviations and symbols and rock descriptions are also provided in Appendix A to assist in the interpretation of the borehole, probehole and drillhole records.

The boreholes completed in 2016 and 2017 (Boreholes 16-1, 16-2, 16-6, 17-3, 17-4, 17-5, 17-7, 17-8, 17-9 and 17-10) were advanced using a CME-55 track-mounted drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville-sur-la-Rouge, Quebec. The boreholes and probeholes completed in 2018 were advanced using an Acker Renegade track-mounted drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario (Boreholes 18-1, 18-2, and 18-10 and Probeholes 18-3, 18-9 and 18-11); and using a CME-55 truck mounted drill rig supplied and operated by Geo-Environmental Drilling Inc. of Acton, Ontario (Boreholes 18-6 and 18-8 and Probehole 18-5).

The boreholes from the 2016 investigation were generally advanced through the overburden using 114 mm outer diameter (O.D.) HW casing with wash boring techniques. The boreholes from the 2017 investigation, and Boreholes 18-1, 18-2, 18-6, 18-8 and 18-10 were advanced through the overburden using 203 mm O.D. and 108 mm inner diameter (I.D.) hollow-stem augers. Probeholes 18-3, 18-9 and 18-11 were advanced using 102 mm O.D. solid-stem augers and Probehole 18-5 was advanced using 152 mm O.D. and 57 mm I.D. hollow-stem augers. Core samples of the bedrock in Boreholes 16-1, 16-2, 17-7, 18-1, 18-2, 18-6, 18-8 and 18-10 were obtained using either an ‘HQ’ or ‘NQ’ size rock core barrel, as noted on the drillhole records.

The boreholes and probeholes were advanced to depths between approximately 2.0 m and 13.3 m below existing ground surface, including coring of bedrock for core lengths of between 0.9 m and 5.2 m in select boreholes. Photographs of the recovered bedrock core samples are provided in Appendix B.

At borehole locations, soil samples were generally obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler advanced by an automatic hammer mounted on the drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586[1]). Bedrock quality and discontinuity data were recorded in the field based on visual inspection of the recovered bedrock core extracted from the core

[1] ASTM D1586-11 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils, ASTM International, West Conshohocken, PA, 2011

barrel. Probeholes were advanced by continuously drilling from ground surface, without sampling, until auger refusal was reached. At each probehole location, a split-spoon sample was attempted at the auger refusal depth with limited to no penetration observed / measured.

The groundwater conditions in the open boreholes / probeholes were observed during drilling operations and prior to wash boring / rock coring and are noted on the borehole and probehole records in Appendix A. All boreholes were backfilled upon completion of drilling / coring in accordance with Ontario Regulation 903 (Wells) (as amended).

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and the soil and bedrock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination. Geotechnical classification testing (i.e. water content, Atterberg limits and grain size distribution) was carried out on selected soil samples. Uniaxial Compressive Strength (UCS) tests were carried out on selected rock core samples. All the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Higher complexity Unconfined Compressive Strength (UCS) tests including measurement of Young's modulus were carried out on two selected specimens of the bedrock core samples by Geomechanica Inc., a specialist rock testing company, on behalf of Golder. The results of the geotechnical laboratory testing on the soil and rock core samples are included in Appendices B and D.

Borehole 16-2 was grouted and cased with a PVC pipe after completion of geotechnical drilling to allow for Vertical Seismic Profile (VSP) testing, which was carried out on June 20, 2017. Details of the VSP investigation methodology and results are outlined in the Technical Memorandum titled "Vertical Seismic Profiling Test Results – Eels Creek Bridge and Highway 28, North Kawartha, Ontario", dated July 4, 2017 and attached in Appendix C, following the text of this report.

Two selected soil samples were submitted, under chain-of-custody procedures, to Maxxam Analytics of Mississauga, Ontario (a Standards Council of Canada accredited laboratory) for corrosivity testing. The soil samples were analyzed for a suite of parameters, including conductivity, resistivity, soluble chloride, soluble sulphate and pH. The testing procedures and results of the analytical tests are presented in Appendix E.

The as-drilled locations and ground surface elevations at Boreholes 16-2, 17-3, 17-4, 17-5, 17-7, 17-8, 17-9 and 17-10 were established on-site by Golder personnel using a Global Positioning System unit (i.e. Trimble Geo7 GPS unit) with a horizontal accuracy of 2 cm or less, and a vertical accuracy of 4 cm or less. The remainder of the borehole and probehole locations were measured in the field relative to existing site features, and the ground surface elevations and coordinates were generated from the digital terrain model / CAD files provided by MTO. The locations provided on the borehole and probehole records and shown on Drawings 1 and 2 are positioned relative to the MTM NAD 83 (Zone 10) coordinate system, and the ground surface elevations are referenced to Geodetic datum. The as-drilled borehole/probehole locations, coordinates, ground surface elevations and drilled depths/elevations are summarized below.

Borehole / Probehole Designation	Coordinates, MTM NAD83 Zone 10 (Geographic)		Ground Surface Elevation (m)	Borehole / Probehole Termination Depth (m)	Borehole / Probehole Termination Elevation (m)
	Northing (Latitude, °)	Easting (Longitude, °)			
16-1	4,945,466.9 (44.641072)	413,005.0 (-78.136013)	262.0	13.3*	248.7
16-2	4,945,465.5 (44.641058)	413,010.4 (-78.135945)	262.0	11.8*	250.2
16-6	4,945,440.7 (44.604834)	413,014.0 (-78.135905)	262.4	4.3	258.1
17-3	4,945,468.7 (44.641087)	413,011.5 (-78.135930)	262.0	5.6	256.4
17-4	4,945,470.1 (44.641100)	413,006.4 (-78.135995)	262.0	9.3	252.7
17-5	4,945,475.9 (44.640847)	413,008.9 (-78.135962)	261.9	5.2	256.7
17-7	4,945,442.0 (44.640847)	413,008.9 (-78.135969)	262.4	8.8*	253.6
17-8	4,945,438.9 (44.640890)	413,009.7 (-78.135960)	262.4	3.9	258.5
17-9	4,945,435.3 (44.640786)	413,015.5 (-78.135884)	262.5	3.1	259.4
17-10	4,945,431.5 (44.640752)	413,012.8 (-78.135921)	262.5	2.0	260.5
18-1	4,945,424.4 (44.640688)	413,010.4 (-78.135953)	262.6	5.7*	256.9
18-2	4,945,432.7 (44.640763)	413,008.9 (-78.135971)	262.2	6.6*	255.6
18-3	4,945,437.1 (44.640803)	413,009.6 (-78.135961)	262.3	3.6	258.7
18-5	4,945,470.5 (44.641104)	413,003.4 (-78.136032)	261.9	9.8	252.2
18-6	4,945,475.5 (44.641149)	413,002.8 (-78.136038)	261.8	8.6*	253.3
18-8	4,945,479.4 (44.641148)	413,006.6 (-78.133599)	261.8	8.8*	253.0
18-9	4,945,470.6	413,016.9	260.7	2.9	257.8

Borehole / Probehole Designation	Coordinates, MTM NAD83 Zone 10 (Geographic)		Ground Surface Elevation (m)	Borehole / Probehole Termination Depth (m)	Borehole / Probehole Termination Elevation (m)
	Northing (Latitude, °)	Easting (Longitude, °)			
	(44.641103)	(-78.135862)			
18-10	4,945,473.4 (44.641128)	413,017.6 (-78.135852)	260.7	6.2*	254.5
18-11	4,945,478.3 (44.641173)	413,015.9 (-78.135873)	261.0	3.2	257.8

*Includes coring of bedrock for core lengths of between 0.9 m and 5.2 m

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*[2] (Chapman and Putnam, 1984), this site lies within the physiographic region known as Georgian Bay Fringe, located north of the Drummer moraines.

The Georgian Bay Fringe is characterized by shallow deposits of glacial till and bare rock knobs and ridges. The underlying bedrock in this physiographic region is typically Precambrian igneous and metamorphic rock.

4.2 Subsurface Conditions

The subsurface and groundwater conditions encountered in the boreholes advanced at this site as part of the foundation investigation together with the results of in-situ and geotechnical and analytical laboratory testing, are presented on the borehole records (provided in Appendix A) and laboratory test figures / tables (provided in Appendices B and D). The results of the in-situ field tests (i.e., SPT 'N'-values) as presented on the borehole records are uncorrected, and are based on sampling procedures carried out with an automatic hammer.

The stratigraphic boundaries shown on the borehole/probehole records and on the stratigraphic profiles on Drawings 1 and 2 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented in the borehole records governs any interpretation of the site conditions. It should be noted that the interpreted stratigraphic profiles shown on Drawings 1 and 2 represent a simplification of the subsurface conditions.

The subsurface conditions encountered at the Site generally consist of the highway pavement structure underlain by non-cohesive embankment fill underlain by bedrock comprised of a combination of granite and migmatite gneiss. Interlayers of silty sand to silty sand and gravel were encountered between the fill and bedrock interface at some

[2] Chapman, L.J. and D.F. Putnam. The Physiography of Southern Ontario. Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

locations. A more detailed description of the subsurface conditions encountered in the boreholes from the current investigation is provided in the following sections.

4.2.1 Topsoil

A 100 mm thick layer of topsoil was encountered at the ground surface in Borehole 18-10. Topsoil was observed at the ground surface in Probeholes 18-9 and 18-11.

4.2.2 Asphalt

All boreholes, with the exception of Borehole 18-10 and Probeholes 18-9 and 18-11, were advanced from within the travelled lanes of Highway 28 and through the pavement structure. Asphalt ranging in thickness between approximately 100 mm and 200 mm was encountered at ground (roadway) surface.

4.2.3 Non-Cohesive Embankment Fill

The asphalt and topsoil are underlain by deposits of non-cohesive fill extending to depths ranging from 1.5 m to 9.3 m below existing ground surface (Elevation 261.1 m to 252.7 m) in all boreholes. The upper 0.3 m to 0.7 m of fill is generally comprised of sand and gravel to gravelly sand (i.e. pavement structure) at most borehole locations. The lower portions of the fill range in composition from silt and sand to sand to gravelly sand to sand and gravel containing trace to some clay and trace to some organics. The presence of cobbles and potentially boulders within the fill at some borehole locations was inferred based on auger grinding during borehole advancement at varying depths/elevations as noted on the borehole records. The cobble to boulder sized fragments could potentially be rock fill that was previously used for embankment construction. Boreholes 16-6, 17-3, 17-4, 17-5, 17-8 and 17-9 were terminated after encountering auger refusal and split-spoon refusal on the inferred fill/bedrock interface.

Standard Penetration Test (SPT) ‘N’ values measured in the fill range from 2 blows per 0.3 m of penetration to 50 blows for 0.05 m of penetration, but generally less than 20 blows per 0.3 m of penetration, indicating a very loose to very dense, but generally loose to compact state of compactness.

The results of grain size distribution testing carried out on 25 samples of the fill are provided on Figures B1A-B, B2A-C and B3 in Appendix B. It should be noted that the grain size results do not reflect the cobble or boulder content of the fill material due to the 50 mm outer diameter sampler used to retrieve the samples. An Atterberg Limits test was carried out on one sample of the fill deposit from Borehole 18-10 and returned a result of non-plastic. The natural water content measured on selected samples of the fill ranges between 2 per cent and 26 per cent.

4.2.4 Silty Sand and Gravel to Sand to Silty Sand (Containing Organics)

The fill soils were underlain by a deposit of silty sand and gravel to sand to silty sand in Boreholes 16-1, 16-2, 17-10 and 18-6 at depths between 1.5 m and 7.5 m below ground surface (Elevation 261.1 m and 254.5 m). Variable amounts of organics were encountered within the deposit in Borehole 16-1, 16-2 and 17-10. In Borehole 16-1, wood fragments were observed in the upper portion of the deposit and the laboratory organic content measured on one sample was approximately 10 per cent.

Standard Penetration Test (SPT) ‘N’ values measured within the deposit range from 1 blow to 5 blows per 0.3 m of penetration, indicating very loose to loose compactness condition. Higher SPT ‘N’ values ranging from 50 blows for no penetration to 50 blows for 0.13 m of penetration were recorded at the bottom of the deposit in Borehole 16-1, 17-10 and 18-6, but are indicative of sampler refusal on the underlying bedrock interface.

The results of grain size distribution testing carried out on three samples of this deposit are provided on Figure B4 in Appendix B. The natural water content typically measured on selected samples of the deposit range between 12

per cent and 34 per cent, with one higher value of 58 per cent measured in the upper portion of the deposit in Borehole 16-1 where significant organics were present.

4.2.5 Bedrock

Bedrock was inferred and/or confirmed to be encountered underlying the fill and sandy deposits in all boreholes / probeholes advanced during the current investigation. Bedrock was confirmed by core samples recovered from Boreholes 16-1, 16-2, 17-7, 18-1, 18-2, 18-6, 18-8 and 18-10 where bedrock was encountered at depths ranging between 1.8 m and 10.3 m below ground surface. Auger and split-spoon refusal on inferred bedrock was encountered in all of the remaining boreholes and probeholes between a depth of 2.0 m and 9.8 m below ground surface. The approximate depths to the top of bedrock below ground surface and corresponding top of bedrock surface elevation are summarized below and shown on the borehole / probehole / drillhole records in Appendix A.

Borehole / Probehole Designation	Existing Ground Surface Elevation (m)	Approximate Depth to Bedrock Surface (m)	Approximate Bedrock Surface Elevation (m)	Notes
16-1	262.0	10.3	251.7	Bedrock cored
16-2	262.0	6.5	255.5	Bedrock cored
16-6	262.4	4.3	258.1	Auger / split-spoon refusal on inferred bedrock
17-3	262.0	5.6	256.4	Auger / split-spoon refusal on inferred bedrock
17-4	262.0	9.3	252.7	Auger / split-spoon refusal on inferred bedrock
17-5	261.9	5.2	256.7	Auger / split-spoon refusal on inferred bedrock
17-7	262.4	5.1	257.3	Bedrock cored
17-8	262.4	3.9	258.5	Auger / split-spoon refusal on inferred bedrock
17-9	262.5	3.1	259.4	Auger / split-spoon refusal on inferred bedrock
17-10	262.5	2.0	260.5	Auger / split-spoon refusal on inferred bedrock
18-1	262.6	1.8	260.9	Bedrock cored
18-2	262.2	2.6	259.6	Bedrock cored
18-3	262.3	3.6	258.7	Auger / split-spoon refusal on inferred bedrock
18-5	261.9	9.8	252.2	Auger / split-spoon refusal on inferred bedrock

Borehole / Probehole Designation	Existing Ground Surface Elevation (m)	Approximate Depth to Bedrock Surface (m)	Approximate Bedrock Surface Elevation (m)	Notes
18-6	261.8	7.7	254.2	Bedrock cored
18-8	261.8	5.3	256.5	Bedrock cored
18-9	260.7	2.9	257.8	Auger / split-spoon refusal on inferred bedrock
18-10	260.7	2.6	258.1	Bedrock cored
18-11	261.0	3.2	257.8	Auger / split-spoon refusal on inferred bedrock

Based on the review of the recovered bedrock core samples, the bedrock consists predominantly of black and grey gneiss, pink granite and black and red migmatite bedrock. The bedrock is generally fresh, fine to medium grained and non-porous. Photographs of the bedrock cores are shown on Figures B9 to B14 in Appendix B.

The Rock Quality Designation (RQD) measured on the core samples generally ranges from about 58 per cent to 100 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM), 2006[3]. At Boreholes 18-1 and 18-8, RQD values of 30 per cent to 40 per cent were measured near the bedrock surface at depths between 1.8 m to 4.4 m (Elevation 260.8 m to 258.2 m) and 5.3 m to 5.7 m (Elevation 256.5 m to 256.1 m) below ground surface respectively, indicating that this portion is a rock mass of poor quality (CFEM), 2006[3].

The Total Core Recovery (TCR) ranges from about 48 per cent to 100 per cent and the Solid Core Recovery (SCR) ranges from about 32 per cent to 100 per cent.

Uniaxial Compressive Strength (UCS) tests (including assessment of Young's modulus) were carried out on two selected specimens of the bedrock core samples by Geomechanica Inc. on behalf of Golder and the detailed test report is included in Appendix D. UCS tests were also carried out on four samples of the bedrock core by Golder and the laboratory test results and photographs of the condition of the tested specimens are summarized in Figures B5, B6, B7 and B8 in Appendix B. The results of the rock core strength testing are summarised below:

Borehole No.	Sample Depth (m)	Sample Elevation (m)	Bedrock Type	Bulk Unit Weight (kN/m^3)	UCS (MPa)	Young's Modulus (GPa)
16-1	10.47 – 10.75	251.5 – 251.2	Migmatite	27.0	47.0	not measured
16-2	6.48 – 6.75	255.5 – 255.2	Migmatite	25.5	99.4	not measured
17-7	5.87 – 6.00	256.5 – 256.4	Migmatite	25.8	45.5	not measured

[3] Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

Borehole No.	Sample Depth (m)	Sample Elevation (m)	Bedrock Type	Bulk Unit Weight (kN/m^3)	UCS (MPa)	Young's Modulus (GPa)
17-7	8.62 – 8.80	253.8 – 253.6	Migmatite	27.3	55.1	not measured
18-1	3.79 – 3.93	258.8 – 258.7	Migmatite	28.2	149.1	78.3
18-8	5.76 – 5.99	256.0 – 255.8	Gneiss	27.4	93.0	42.8

Based on the laboratory testing results, the intact strength of the migmatite (granite and gneiss) bedrock varies from medium strong (25 MPa < UCS < 50 MPa) to strong (50 MPa < UCS < 100 MPa) to very strong (100 MPa < UCS < 250 MPa) in accordance with Table 3.5 in CFEM (2006).

4.2.6 Groundwater Conditions

The groundwater level, if present, in the open boreholes or within the drilling casing was typically measured upon completion of drilling operations and / or prior to rock coring. In some boreholes, drilling mud / water was added during drilling operations and groundwater levels were not recorded in these boreholes. The details of the groundwater level measurements are shown on the borehole records contained in Appendix A; however, it is noted that these measurements may not represent the long-term, stabilized groundwater levels at the site.

The measured groundwater levels in the open boreholes upon completion of drilling operations are summarized below:

Borehole / Probehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date (dd/mm/yyyy)
16-1	262.0	3.3	258.7	10/12/2016
17-3	262.0	Dry	N/A	20/06/2017
17-4	262.0	6.1	255.9	20/06/2017
17-5	261.9	Dry	N/A	20/06/2017
17-7	262.4	Dry	N/A	21/06/2017
17-8	262.4	Dry	N/A	21/06/2017
17-9	262.5	Dry	N/A	20/06/2017
17-10	262.5	Dry	N/A	20/06/2017
18-1	262.6	Dry	N/A	14/11/2018
18-2	262.2	1.6	260.6	15/11/2018
18-3	262.3	Dry	N/A	14/11/2018
18-5	261.9	7.6	254.3	14/11/2018

Borehole / Probehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date (dd/mm/yyyy)
18-6	261.8	5.2	256.6	15/11/2018
18-8	261.8	5.1	256.7	14/11/2018
18-9	260.7	Dry	N/A	15/11/2018
18-11	261.0	2.7	258.3	15/11/2018

Note: Water levels were not recorded in boreholes 16-2, 16-6 and 18-10

Based on the General Arrangement (GA) drawing provided by MTO and dated April 2016, the Eel's Creek water level is at about Elevation 257.0 m and the high-water level (HWL) is shown to be at Elevation 258.5 m. It is noted that the same creek water levels are shown on the original 1952 design drawing. In June 2017, the Eel's Creek water level east of the bridge site was measured to be at Elevation 257.9 m during the foundation investigation. It is noted that the Eel's Creek streambed gradient within this reach is significant based on the observed fast flowing water and rapids observed during the investigation in June 2017.

It should be noted that groundwater levels and the Eel's Creek water level are subject to seasonal fluctuations and precipitation events and are expected to be higher during wet seasons and sustained periods of precipitation. Perched groundwater conditions are anticipated to be present at / near the overburden / bedrock interface when this interface is located above the creek water level.

4.3 Analytical Testing of Soil

A soil sample from each of Boreholes 16-1 and 17-7 was selected during the field investigation programs and submitted to Maxxam Analytics of Mississauga, Ontario for analysis of parameters used to assess the potential corrosivity of the site soils to steel and concrete. The analytical laboratory test results are provided on the Certificate of Analysis presented in Appendix E and summarized below.

Borehole No.	Sample ID.	Depth (m)	Elevation	Material Type	Parameters				
					Resistivity (ohm·cm)	Electrical Conductivity (µmho/cm)	pH	Chloride (Cl) Content (µg/g)	Soluble Sulphate (SO4) Content (µg/g)
16-1	SS 12	8.4 – 9.0	253.6 – 253.0	Sand	3,200	312	5.85	45	200
17-7	SS 5 & SS 6	3.0 – 4.4	259.4 – 258.0	Sand and Gravel (Fill)	1,600	621	7.72	250	140

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Katelyn Nero, and was reviewed by Mr. Matthew Kelly, P.Eng. Kevin Bentley, M.E.Sc., P.Eng., an Associate and MTO Designated Foundations Contact of Golder, and Lisa Coyne, P.Eng., a Principal and MTO Designated Foundations Contact of Golder, conducted a technical and quality control review of the report.

Golder Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
M. W. KELLY
100125796
July 15, 2019
PROVINCE OF ONTARIO

Mathew Kelly, P.Eng.
Geotechnical Engineer

Kevin J. Bentley, M.E.Sc., P.Eng.
MTO Designated Foundations Contact, Associate

LICENSED PROFESSIONAL ENGINEER
L. C. COYNE
15 JUL 2019
PROVINCE OF ONTARIO

Lisa Coyne, P.Eng.
Principal, MTO Designated Foundations Contact

KN/MK/KJB/LCC/rb

Golder and the G logo are trademarks of Golder Associates Corporation

MINISTRY OF TRANSPORTATION, ONTARIO

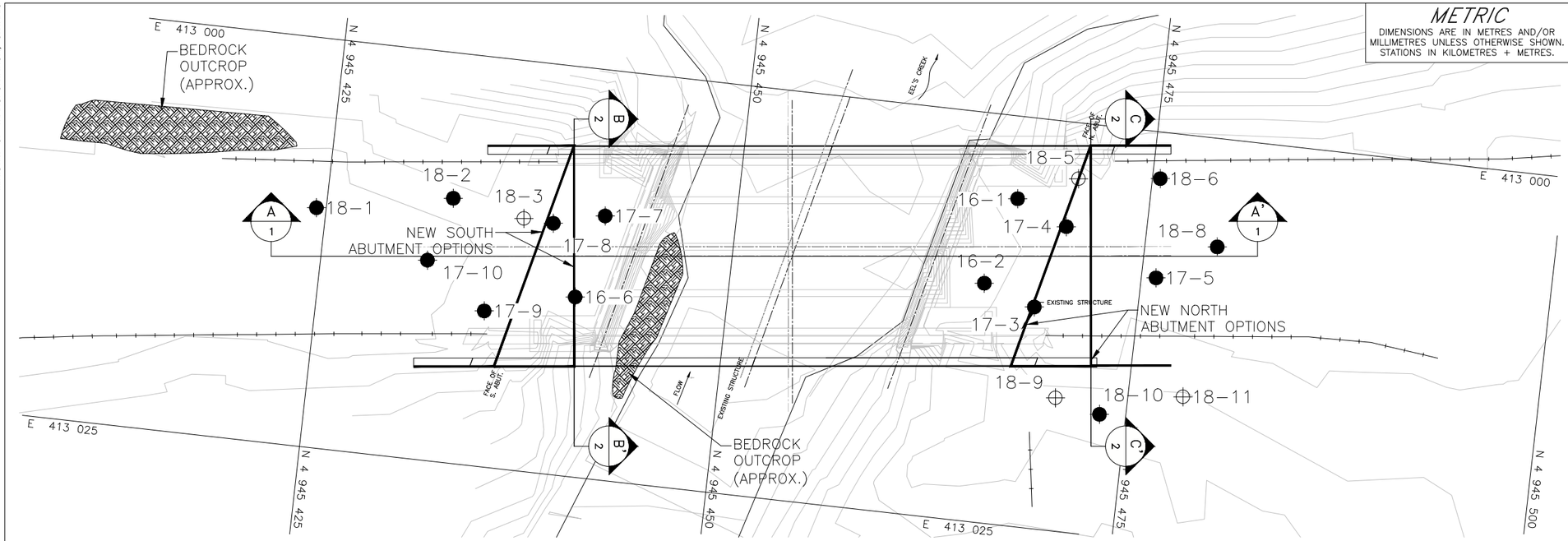
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

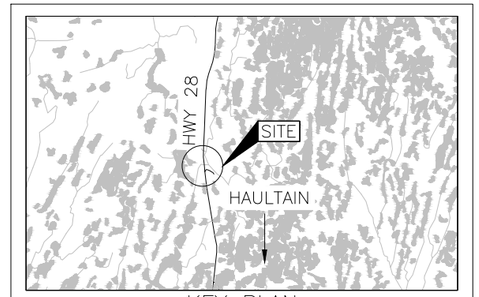
HWY 28
EEL'S CREEK BRIDGE REPLACEMENT
BOREHOLE LOCATION AND SOIL STRATA

SHEET

GOLDER



PLAN
SCALE
3 0 3 6 m



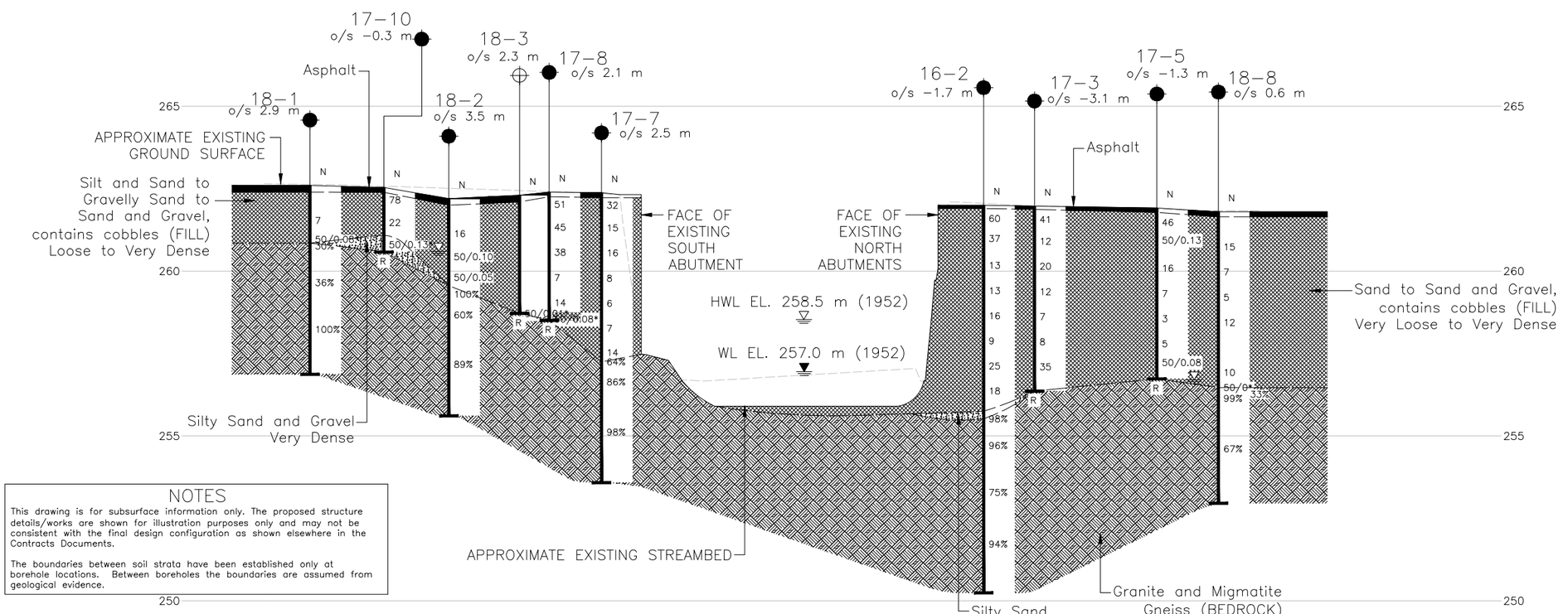
KEY PLAN
SCALE
1 0 1 2 km

LEGEND

- Borehole – Current Investigation
- Probehole – Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling
- R Auger refusal on inferred bedrock

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
16-6	262.4	4945440.7	413014.0
16-1	262.0	4945466.9	413005.0
16-2	262.0	4945465.5	413010.4
17-10	262.5	4945431.5	413012.8
17-9	262.5	4945435.3	413015.5
17-8	262.4	4945438.9	413009.7
17-7	262.4	4945442.0	413008.9
17-5	261.9	4945475.9	413008.9
17-4	262.0	4945470.1	413006.4
17-3	262.0	4945468.7	413011.5
18-5	261.9	4945470.5	413003.4
18-3	262.3	4945437.1	413009.6
18-9	260.7	4945470.6	413016.9
18-11	261.0	4945478.3	413015.9
18-10	260.7	4945473.4	413017.6
18-8	261.8	4945479.4	413006.6
18-6	261.8	4945475.5	413002.8
18-2	262.2	4945432.7	413008.9
18-1	262.6	4945424.4	413010.4



CROSS-SECTION A-A'

VERTICAL SCALE
3 0 3 6 m

HORIZONTAL SCALE
3 0 3 6 m

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by MTO, drawing file no. BC320281.dwg, received October 31, 2018.
General arrangement plan provided in digital format by MTO, drawing file no. 26-117 GENERAL ARRANGEMENT.DWG, received October 22, 2018.
General arrangement plan provided by MTO, DWG NO. 1, SITE 26-117 EEL'S CREEK BRIDGE GENERAL ARRANGEMENT, HWY 28, dated April 2016.

LICENSED PROFESSIONAL ENGINEER M.W.KELLY May 10, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER K. J. BENTLEY May 10, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D-727

HWY. 28	PROJECT NO. 1413191/1895756		DIST. EASTERN
SUBM'D. KN	CHKD. MWK	DATE: 05/10/2019	SITE: 26-117
DRAWN: DD	CHKD. MWK	APPD. KJB	DWG. 1

PLOT DATE: May 10, 2019
FILENAME: S:\Clients\MTO\Hwy_28_Eels_Creek\99_PROJ\1413191\10_PROD\0001_Bridge _Replacement\1413191-0001-BD-0001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

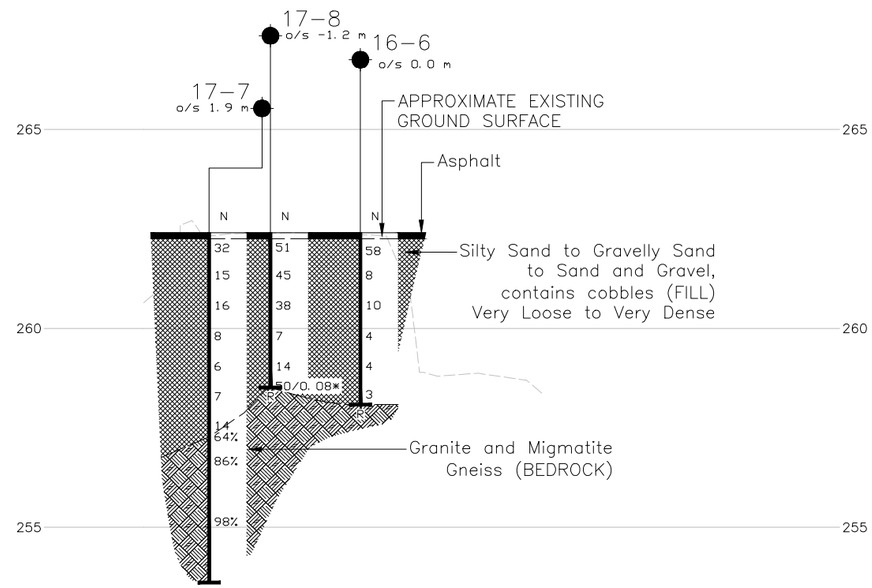
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

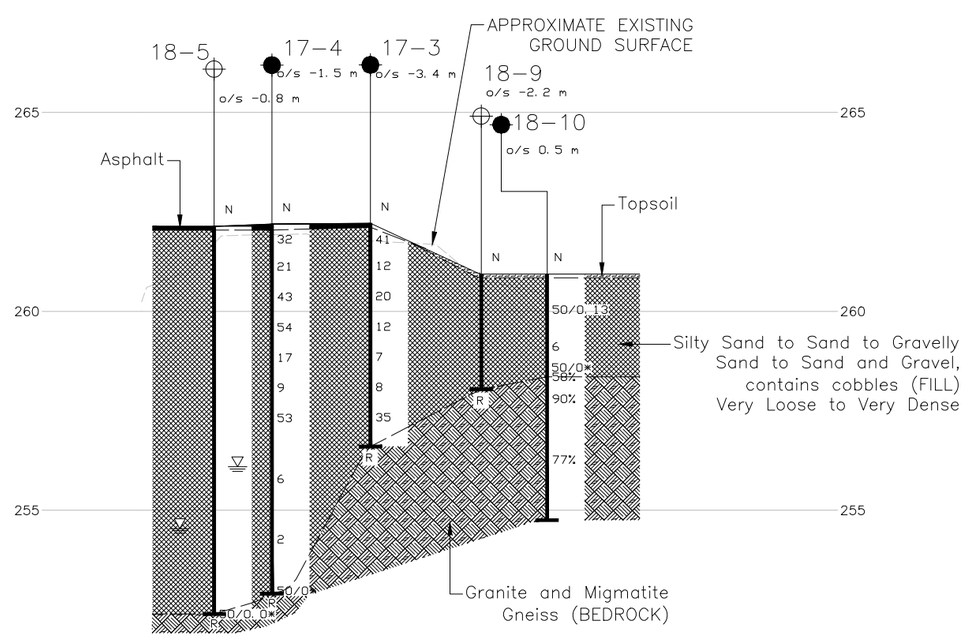
HWY 28
EEL'S CREEK BRIDGE REPLACEMENT
SOIL STRATA

SHEET

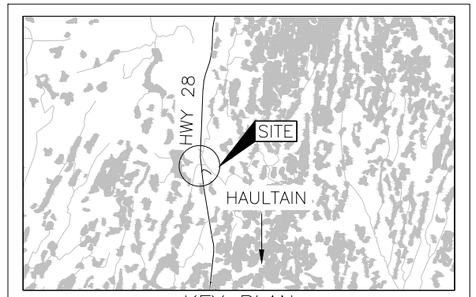
GOLDER



CROSS–SECTION B–B' – SOUTH ABUTMENT



CROSS–SECTION C–C' – NORTH ABUTMENT



KEY PLAN
SCALE
3 0 3 6 m

LEGEND

- Borehole – Current Investigation
- Probehole – Current Investigation
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- WL upon completion of drilling
- R — Auger refusal on inferred bedrock

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
16–6	262.4	4945440.7	413014.0
16–1	262.0	4945466.9	413005.0
16–2	262.0	4945465.5	413010.4
17–10	262.5	4945431.5	413012.8
17–9	262.5	4945435.3	413015.5
17–8	262.4	4945438.9	413009.7
17–7	262.4	4945442.0	413008.9
17–5	261.9	4945475.9	413008.9
17–4	262.0	4945470.1	413006.4
17–3	262.0	4945468.7	413011.5
18–10	260.7	4945473.4	413017.6
18–8	261.8	4945479.4	413006.6
18–6	261.8	4945475.5	413002.8
18–2	262.2	4945432.7	413008.9
18–1	262.6	4945424.4	413010.4
18–5	261.9	4945470.5	413003.4
18–3	262.3	4945437.1	413009.6
18–9	260.7	4945470.6	413016.9
18–11	261.0	4945478.3	413015.9

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by MTO, drawing file no. BC320281.dwg, received October 31, 2018.
General arrangement plan provided in digital format by MTO, drawing file no. 26–117 GENERAL ARRANGEMENT.DWG, received October 22, 2018.

VERTICAL SCALE
3 0 3 6 m

HORIZONTAL SCALE
3 0 3 6 m

LICENSED PROFESSIONAL ENGINEER M.W.KELLY May 10, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER K. J. BENTLEY May 10, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D–727

HWY. 28		PROJECT NO. 1413191/1895756	DIST. EASTERN
SUBM'D. KN	CHKD. MWK	DATE: 05/10/2019	SITE: 26–117
DRAWN: DD/SW	CHKD. MWK	APPD. KJB	DWG. 2

PLOT DATE: May 10, 2019
FILENAME: S:\Clients\MTO\Hwy_28_Eels_Creek\99_PROJ\1413191\10_PROD\0001_Bridge _Replacement\1413191-0001-BC-0002.dwg

APPENDIX A

Record of Boreholes

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I.	**GENERAL**
π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety
II.	**STRESS AND STRAIN**
γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility
III.	**SOIL PROPERTIES**
(a)	**Index Properties**
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a)	**Index Properties (continued)**
w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)
(b)	**Hydraulic Properties**
h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume
(c)	**Consolidation (one-dimensional)**
C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}
(d)	**Shear Strength**
τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan\delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or	Sand and Gravel
	With (cohesive)	Silty Clay with sand / Clayey Silt with sand

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

RECORD OF BOREHOLE No 16-1

SHEET 1 OF 2

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945466.9; E 413005.0 MTM NAD 83 ZONE 10 (LAT. 44.641072; LONG. -78.136013)

ORIGINATED BY DG

DIST Eastern HWY 28

BOREHOLE TYPE 114 mm O.D. HW Casing and Wash Boring

COMPILED BY AK

DATUM Geodetic

DATE December 10, 2016

CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
262.0	GROUND SURFACE							
0.0	ASPHALT (150 mm)							
261.5 / 0.5	Sand and gravel, trace to some silt (FILL) Grey Moist	1A 1B	SS	60				
	Sand, some gravel, some silt (FILL) Compact Brown Moist	2	SS	28				
259.8		3	SS	18	16	70	13	1
2.2	Sandy gravel, some silt to silty, trace clay (FILL) Compact to dense Brown Moist to wet	4	SS	18				
		5	SS	17				
		6	SS	35				
256.7		7	SS	12				
5.3	Sand, some silt, trace gravel, trace clay (FILL) Loose Brown Moist	8	SS	5	5	80	14	1
		9	SS	8				
254.5		10	SS	5				
7.5	SAND, trace to some silt, trace gravel, trace clay, contains organics matter including wood fragments to 9 m depth Very loose to loose Brown to dark brown Moist to wet	11	SS	5	2	91	6	1
		12	SS	2				
		13	SS	3	0	95	5	0
251.7		14	SS	54/0.23				
10.3	MIGMATITE (BEDROCK) Rock cored between depths of 10.29 m to 13.30 m below ground surface. See Record of Drillhole 16-1 for details.	1	RC	REC 100%	RQD = 80%			
		2	RC	REC 100%	RQD = 100%			
248.7								
13.3								

GROUND WATER CONDITIONS: ∇

ELEVATION SCALE: 261, 260, 259, 258, 257, 256, 255, 254, 253, 252, 251, 250, 249

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

57.8 (unit weight, 7.5 m)

OC=9.9%

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-1

SHEET 2 OF 2

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945466.9; E 413005.0 MTM NAD 83 ZONE 10 (LAT. 44.641072; LONG. -78.136013)

ORIGINATED BY DG

DIST Eastern HWY 28

BOREHOLE TYPE 114 mm O.D. HW Casing and Wash Boring

COMPILED BY AK

DATUM Geodetic

DATE December 10, 2016

CHECKED BY MWK

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	w_P — w — w_L WATER CONTENT (%) (10 20 30)	γ kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE										
	NOTES:										
	1. Water level in casing measured at a depth of about 3.3 m below ground surface (Elev. 258.7 m) on completion of drilling.										
	2. * N-value not representative of soil due to bedrock contact.										

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 1413191 (1150)

RECORD OF DRILLHOLE: 16-1

SHEET 1 OF 1

LOCATION: N 4945466.9 ;E 413005.0

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track Mount

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate
BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage
PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular
PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES PIEZOMETER OR STANDPIPE INSTALLATION
		Continued from Record of Borehole 16-1		251.71															
		Slightly weathered to fresh, crystalline / foliated, black and red, fine to medium grained, non-porous, medium strong MIGMATITE (Granite and gneiss)		10.29															
11					1							FR,IR,RO Sa He							UCS = 47.0 MPa
												FR,PL,RO Sa He, Fe CO,IR,RO							γ = 27.0 KN/m³
												FR,CU,RO PC, Fe							
												FR,PL,RO							
												FO,PL,RO Sa He, Fe FR,IR,RO							
12					2							FR,PL,RO Sa He, Fe CO,PL,RO							
13				248.70								FR,UN,RO							
		END OF DRILLHOLE		13.30															
14																			
15																			
16																			
17																			
18																			
19																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: AK

GTA-RCK 054 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-MISS.GDT 19-7-17

RECORD OF BOREHOLE No 16-2

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945465.5; E 413010.4 MTM NAD 83 ZONE 10 (LAT. 44.641058; LONG. -78.135945)

ORIGINATED BY DG

DIST Eastern HWY 28

BOREHOLE TYPE 114 mm O.D. HW Casing and Wash Boring

COMPILED BY AK

DATUM Geodetic

DATE December 10-11, 2016

CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.0	GROUND SURFACE								
0.0	ASPHALT (100 mm)								
0.1	Sand and gravel (FILL) Very dense Grey Moist		1A 1B	SS	60				
261.4 / 0.6	Sand, trace to some silt, trace clay, trace gravel (FILL) Dense Brown Moist - Contains 25 mm thick silt pocket		2	SS	37		261		3 89 7 1
260.6 / 1.5	Sand and gravel, trace to some silt, trace clay (FILL) Loose to compact Brown Moist to wet - Contains cobbles/rock fragments from 3.0 m to 6.4 m depth		3	SS	13		260		
			4	SS	13				
			5	SS	16		259		
			6	SS	9		258		
			7	SS	25		257		34 57 8 1
			8	SS	18				
255.8			9A 9B	SS	36		256		
6.5	Silty SAND, contains organic matter Loose Brown to dark brown Wet		1	RC	REC 100%		255		RQD = 98%
	MIGMATITE (BEDROCK) Rock cored between depths of 6.48 m to 11.76 m below ground surface. See Record of Drillhole 16-2 for details.		2	RC	REC 100%		254		RQD = 96%
			3	RC	REC 100%		253 252		RQD = 75%
			4	RC	REC 100%		251		RQD = 94%
250.2 / 11.8	END OF BOREHOLE								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

NOTE:

1. PVC pipe (63 mm diameter) installed and grouted in place from ground surface to 10.8 m depth for future VSP testing.

2. Water level not measured due to influence of using wash boring methods.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 1413191 (1150)

RECORD OF DRILLHOLE: 16-2

SHEET 1 OF 1

LOCATION: N 4945465.5 ;E 413010.4

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track Mount

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate
BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage
PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular
PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES PIEZOMETER OR STANDPIPE INSTALLATION
		Continued from Record of Borehole 16-2		255.52															
		Fresh, crystalline/ foliated, black and red, fine to coarse grained, non-porous, strong MIGMATITE (Granite and gneiss)		6.48															UCS = 99.4 MPa; γ = 25.5 KN/m³
7					1							FR,IR,RO							
8					2							VN,UN,RO Sa Bt							
												VN,PL,RO Sa							
												CO,IR,RO Sa Bt							
												CO,PL,RO Sa Bt							
												FR,PL,RO Sa Bt							
9												FR,PL,RO							
												FR,IR,RO							
												JN,IR,RO Sa Bt							
					3							FR,IR,RO Sa Bt							
												FR,PL,RO							
10												FR,PL,RO Sa Fe							
												FR,IR,RO Sa Bt							
												FR,PL,RO Sa							
												FR,PL,RO Sa Bt							
												FR,IR,RO							
11					4							FR,IR,RO							
												FR,UN,RO							
				250.24															
		END OF DRILLHOLE		11.76															
12																			
13																			
14																			
15																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: AK

GTA-RCK 054 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-MISS.GDT 19-7-17

RECORD OF BOREHOLE No 16-6

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945440.7; E 413014.0 MTM NAD 83 ZONE 10 (LAT. 44.604834; LONG. -78.135905)

ORIGINATED BY DG

DIST Eastern HWY 28

BOREHOLE TYPE 114 mm O.D. HW Casing and Wash Boring

COMPILED BY AK

DATUM Geodetic

DATE December 14-15, 2016

CHECKED BY MWK

SOIL PROFILE			SAMPLES													
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.4	GROUND SURFACE										
0.0	ASPHALT (150 mm)										
0.2	Sand and gravel, trace to some silt, trace clay (FILL) Very dense Grey Moist		1	SS	58		262		○		40 50 7 3
261.8 / 0.6	Silty sand, some gravel, containing silt pockets, trace clay (FILL) Loose to very loose Brown Moist to wet		2	SS	8		261		○		
	- Gravelly between depths of 1.5 m and 3.0 m below ground surface		3	SS	10		260				
	- Wet below 2.3 m depth (Elev. 260.1 m)		4	SS	4		259		○		
258.1			5	SS	4						
4.3	END OF BOREHOLE - AUGER AND SPOON REFUSAL Possible Bedrock		6	SS	3						

NOTE:

1. Sample 3 had no sample recovery when split-spoon retrieved.

2. Split-spoon measured >50 blows/0.05 m of penetration at a depth of 4.3 m (Elev. 258.1 m).

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-3

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945468.7; E 413011.5 MTM NAD 83 ZONE 10 (LAT. 44.641087; LONG. -78.135930)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY KN

DATUM Geodetic

DATE June 20, 2017

CHECKED BY MWK

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.0	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.1 / 261.3	Sand and gravel, trace silt (FILL) Dense Brown Moist		1	SS	41				○		
0.7 / 259.8	Sand, some gravel, some silt, trace clay (FILL) Compact Brown Moist		2	SS	12		261				
			3	SS	20		260		○		16 67 13 4
2.2 / 259.0	Sand and gravel, some silt (FILL) Compact Brown Moist		4	SS	12						
3.0 / 256.4	Sand, some gravel, trace to some silt, trace clay (FILL) Loose to dense Brown Moist		5	SS	7		259		○		18 70 8 4
			6	SS	8		258				
			7	SS	35		257		○		
5.6	END OF BOREHOLE - AUGER AND SPOON REFUSAL Possible Bedrock										

NOTE:

1. Borehole caved to 4.1 m depth (Elev. 257.9 m) below ground surface upon completion of drilling.

2.. Caved borehole dry upon completion of drilling.

3. SPT 'N' value measured 50 blows for no observable penetration at a depth of 5.6 m (Elev. 256.4 m) below ground surface.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-4

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945470.1; E 413006.4 MTM NAD 83 ZONE 10 (LAT. 44.641100; LONG. -78.135995)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY KN

DATUM Geodetic

DATE June 20, 2017

CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
262.0	GROUND SURFACE									
0.0	ASPHALT (150 mm)									
0.2	Sand and gravel, some silt (FILL) Dense Grey Moist	1	SS	32						
261.3 / 0.7	Silty sand, trace gravel (FILL) Compact Brown Moist	2	SS	21	261					
260.6 / 1.5	Gravelly sand, some silt, trace clay, contains cobbles (FILL) Compact to very dense Brown Moist - Grinding of augers from depth of 1.5 m to 2.2 m	3	SS	43	260					
		4	SS	54						
		5	SS	17	259					
258.3 / 3.7	Sand, some gravel, trace to some silt, trace clay, contains cobbles (FILL) Loose to very dense Brown Moist - Grinding of augers from depth of 3 m to 4 m	6	SS	9	258		14	73	9	4
		7	SS	53	257					
256.4 / 5.6	Gravelly sand, some silt, contains cobbles (FILL) Loose Brown Wet - Grinding of augers from depth of 6.5 m to 7.5 m	8	SS	6	256					
254.8 / 7.2	Sand, trace silt, trace clay, some organics at a depth of 7.9 m (FILL) Very loose Grey-brown to brown Wet	9	SS	2	255 / 254		0	93	5	2
252.7 / 9.3	END OF BOREHOLE - AUGER AND SPOON REFUSAL Possible Bedrock	10	SS	50/0*	253					

NOTE:

1. Water level measured at a depth of about 6.1 m below ground surface (Elev. 255.9) upon completion of drilling.

2. * N-value not representative of soil due to assumed bedrock contact.

3. Sample 4 had zero sample recovery in split-spoon.

4. Limited sample recovery in sample 7.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) 10 20 30

GROUND WATER CONDITIONS: ▽

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-GTA.GDT 19-5-10

RECORD OF BOREHOLE No 17-5

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945475.9; E 413008.9 MTM NAD 83 ZONE 10 (LAT. 44.640847; LONG. -78.135962)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY KN

DATUM Geodetic

DATE June 20, 2017

CHECKED BY MWK

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.9	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.1	Sand and gravel, trace to some silt, trace to some clay (FILL) Dense Brown Moist		1	SS	46				○		34 53 6 7
261.1											
0.8	Sand, some silt, trace gravel, trace clay, contains cobbles (FILL) Very loose to very dense Brown Moist		2	SS	50/0.13		261				
			3	SS	16		260		○		
	- Auger grinding from depth of 4.6 m to 5.2 m		4	SS	7		259				
			5	SS	3				○		2 81 14 3
			6	SS	5		258				
			7	SS	50/0.08		257		○		
256.7											
5.2	END OF BOREHOLE - AUGER AND SPOON REFUSAL Possible Bedrock										

NOTES:

1. Borehole caved to a depth of about 4.3 m below ground surface on removal of augers.

2. Borehole dry upon completion of drilling.

3. SPT 'N' value measured 50 blows with zero penetration at a depth of 5.2 m (Elev. 256.7 m) below ground surface.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-7

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945442.0; E 413008.9 MTM NAD 83 ZONE 10 (LAT. 44.640847; LONG. -78.135969)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY KN

DATUM Geodetic

DATE June 21, 2017

CHECKED BY MWK

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.4	GROUND SURFACE										
0.0	ASPHALT (150 mm)										
0.2	Sand and gravel to gravelly sand, trace to some silt, trace clay, contains cobbles (FILL) Loose to dense Brown Moist		1	SS	32		262				
			2	SS	15		261		○		30 58 7 5
			3	SS	16						
	- Auger grinding between depths of 0.9 m and 1.5 m		4	SS	8		260		○		
	- Auger grinding between depths of 2.3 m and 3.7 m										
	- Split-spoon refusal at 5.1 m depth below ground surface		5	SS	6		259				23 69 4 4
			6	SS	7				○		
							258				
257.3			7	SS	14						
5.1	MIGMATITE (BEDROCK) Rock cored between depths of 5.10 m to 8.8 m below ground surface. See Record of Drillhole 17-7 for details.		1	RC	REC 95%		257				RQD = 64%
			2	RC	REC 100%		256				RQD = 86%
							255				
			3	RC	REC 98%						RQD = 98%
253.6							254				
8.8	END OF BOREHOLE										

NOTES:

1. Borehole dry upon completion of drilling.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 1413191 (1150)

RECORD OF DRILLHOLE: 17-7

SHEET 1 OF 1

LOCATION: N 4945442.0 ;E 413008.9

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track Mount

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate
BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage
PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular
PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES PIEZOMETER OR STANDPIPE INSTALLATION
		Continued from Record of Borehole 16-7		257.25															
		Fresh, crystalline/ foliated, black and red, fine to medium grained, non-porous, medium strong to strong MIGMATITE (Granite and gneiss)		5.13	1														
												FR,CU,RO Sa Fe							
6																			UCS = 45.5 MPa; γ = 25.8 KN/m³
												FR,PL,RO							
												FR,PL,RO							
												FR,IR,RO							
					2							FR,PL,RO Sa Bt							
												FR,PL,RO Sa Bt							
												FR,PL,RO							
7																			
												FR,PL,RO Sa Bt							
												FO,PL,RO Sa Bt							
												FO,PL,RO Sa Bt							
8					3														
				253.59															γ = 27.3 KN/m³; UCS = 55.1 MPa
		END OF DRILLHOLE		8.79															
9																			
10																			
11																			
12																			
13																			
14																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: BC
CHECKED: AK

GTA-RCK 054 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-MISS.GDT 19-7-17

RECORD OF BOREHOLE No 17-8

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945438.9; E 413009.7 MTM NAD 83 ZONE 10 (LAT. 44.640890; LONG. -78.135960)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY KN

DATUM Geodetic

DATE June 21, 2017

CHECKED BY MWK

SOIL PROFILE			SAMPLES													
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
262.4	GROUND SURFACE													
0.0	ASPHALT (150 mm)													
0.1	Sand and gravel, trace to some silt, trace to some clay, contains cobbles (FILL) Loose to very dense Brown Moist		1	SS	51		262		○		39	47	6	8
			2	SS	45									
	- Auger grinding between depths of 0.8 m and 1.5 m		3	SS	38		261		○					
	- Fresh broken rock/gravel fragments observed in sample 3		4	SS	7		260							
			5	SS	14		259		○					
258.5			6	SS	50/0.08*									
3.9	END OF BOREHOLE - AUGER AND SPOON REFUSAL Possible Bedrock													

NOTES:

1. Borehole caved to a depth of about 3.6 m below ground surface on removal of augers.

2. Borehole dry upon completion of drilling.

3. *N-value not representative of soil due to bedrock contact.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-9

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945435.3; E 413015.5 MTM NAD 83 ZONE 10 (LAT. 44.640786; LONG. -78.135884)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY KN

DATUM Geodetic

DATE June 20, 2017

CHECKED BY MWK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
262.5	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.1	Sand and gravel to sand, some gravel, trace to some silt, trace clay (FILL) Compact to very dense Grey to brown Moist		1	SS	69		262				
			2	SS	16				○		19 69 7 5
			3	SS	14		261				
260.3											
2.2	Sandy gravel, some silt (FILL) Compact Brown Wet		4	SS	11		260		○		
259.4			5	SS	50/0.02*						
3.1	END OF BOREHOLE - AUGER AND SPOON REFUSAL Possible Bedrock										

NOTES:

1. Borehole caved to a depth of about 1.5 m below ground surface.

2. Borehole dry upon completion of drilling.

3. *N-value not representative of soil due to bedrock contact.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No 17-10

SHEET 1 OF 1

METRIC

PROJECT 1413191 (1150)

G.W.P.

LOCATION N 4945431.5; E 413012.8 MTM NAD 83 ZONE 10 (LAT. 44.640752; LONG. -78.135921)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY KN

DATUM Geodetic

DATE June 20, 2017

CHECKED BY MWK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
262.5	GROUND SURFACE										
0.0	ASPHALT (150 mm)										
0.2	Sand and gravel, trace to some silt, trace to some clay (FILL) Compact to very dense Grey to brown Moist		1	SS	78		262		○		35 50 8 7
			2	SS	22						
261.1											
1.5	Silty SAND and GRAVEL, trace organics Very dense		3	SS	50/0.13*		261		○		
260.5											
2.0	Brown to dark brown Wet										
	END OF BOREHOLE - AUGER REFUSAL Possible Bedrock										

NOTE:

1. Borehole dry upon completion of drilling.

2. *N-value not representative of soil due to assumed bedrock contact.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-1

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945424.4; E 413010.4 MTM NAD 83 ZONE 10 (LAT. 44.640688; LONG. -78.135953)

ORIGINATED BY SK

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY AK

DATUM Geodetic

DATE November 14, 2018

CHECKED BY MWK

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.6	GROUND SURFACE										
0.0	ASPHALT (200 mm)										
0.2	Silt and sand, some gravel, trace clay (FILL) Loose Brown Moist						262				
			1	SS	7				○		12 55 31 2
260.9			2	SS	50/0.08*		261				
1.8	MIGMATITE (BEDROCK)										
	Rock cored between depths of 1.8 m to 5.7 m below ground surface.		1	RC	REC 69%		260				RQD = 30%
	See Record of Drillhole 18-1 for details.		2	RC	REC 77%		259				RQD = 36%
			3	RC	REC 94%		258				RQD = 100%
256.9							257				
5.7	END OF BOREHOLE										

NOTES:

1. Borehole dry in hollow stem augers upon completion of drilling, prior to rock coring.

2. *N-value not representative of soil due to bedrock contact.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 1895756

RECORD OF DRILLHOLE: 18-1

SHEET 1 OF 1

LOCATION: N 4945424.40 ;E 413010.40

DRILLING DATE: November 14, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Acker Renegade Track Mount

DRILLING CONTRACTOR: Walker Drilling Ltd.

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATHERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole 18-1		260.85															
2		Fresh, crystalline, foliated, black and red, fine to medium grained, non-porous, very strong MIGMATITE		1.75	1							FR,PL,RO,Sa FR,IR,RO,Sa FR,UN,RO,Sa						Lost Core Broken Core	
3					2							FR,PL,RO,Sa FR,PL,RO,Sa FR,IR,RO FR,IR,RO,Sa						Broken Core Broken Core Lost Core	γ = 28.8 KN/m³ UCS=149.1 MPa E = 78.3 GPa
4																			
5					3							FR,PL,RO,Sa FO,PL,RO,Sa FO,CU,RO,Sa FO,IR,RO,Sa JN,IR,RO,Sa							
				256.87															
		END OF DRILLHOLE		5.73															
6																			
7																			
8																			
9																			
10																			
11																			

DEPTH SCALE

1 : 50

GOLDER

LOGGED: BC

CHECKED: AK

GTA-RCK 046 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-MISS.GDT 19-5-10

RECORD OF BOREHOLE No 18-2

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945432.7; E 413008.9 MTM NAD 83 ZONE 10 (LAT. 44.640763; LONG. -78.135971)

ORIGINATED BY SK

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY AK

DATUM Geodetic

DATE November 15, 2018

CHECKED BY MWK

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.2	GROUND SURFACE										
0.0	ASPHALT (200 mm)						262				
0.2	Gravelly sand to sand, some gravel, trace to some silt, trace clay (FILL) Compact to very dense Brown Moist to wet - Auger grinding at a depth of 1.1 m		1	SS	16	▽	261		○		17 72 8 3
			2	SS	50/0.10						
	- Wet below a depth of 2.1 m		3	SS	50/0.05		260		○		28 56 13 3
259.6	- Auger grinding/refusal at a depth of 2.6 m below ground surface										
2.6	MIGMATITE (BEDROCK)		1	RC	REC 100%		259				RQD = 100%
	Rock cored between depths of 2.90 m to 6.59 m below ground surface. See Record of Drillhole 18-2 for details.		2	RC	REC 100%		258				RQD = 60%
			3	RC	REC 100%		257				RQD = 89%
							256				
255.6											
6.6	END OF BOREHOLE										

NOTES:

1. Water level in hollow stem augers measured at a depth of about 1.6 m below ground surface (Elev. 260.6 m) prior to rock coring.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 1895756

RECORD OF DRILLHOLE: 18-2

SHEET 1 OF 1

LOCATION: N 4945432.70 ;E 413008.90

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Acker Renegade Track Mount

DRILLING CONTRACTOR: Walker Drilling Ltd.

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jconn	WEATH-ERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole 18-2		259.30															
3		Fresh, crystalline / foliated, black and red, fine to medium grained, non-porous, strong MIGMATITE (Granite and banded gneiss)		2.90	1							FR,,							
												FR,,							
												CO,,							
4					2							FR,PL,RO,SA, He	1.5	2	16				
												CO,CU,RO,SA, He	3	2	20				
												FO,CU,RO,SA, He	3	2	20				
												FR,CU,RO,SA, He	3	2	20				
												FO,CU,RO,SA, He	3	2	20				
												FO,CU,RO,SA, He	3	1	22				
												FO,CU,RO	3	4	12				
												FO,CU,RO,CC, Sa							
												FR,CU,RO,SA, Bt	3	2	20				
5					3							FR,PL,RO,SA	1.5	2	16				
												FR,CU,RO,SA	3	2	20				
6												FR,IR,RO,SA	3	2	20				
												FR,IR,RO,SA	3	2	20				
												FR,UN,RO,SA	3	2	20				
				255.61															
		END OF DRILLHOLE		6.59															
7																			
8																			
9																			
10																			
11																			
12																			

DEPTH SCALE

1 : 50

GOLDER

LOGGED: SK

CHECKED: AK

GTA-RCK 046 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-MISS.GDT 19-5-10

GOLDER

RECORD OF BOREHOLE No 18-3

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945437.1; E 413009.6 MTM NAD 83 ZONE 10 (LAT. 44.640803; LONG. -78.135961)

ORIGINATED BY SK

DIST Eastern HWY 28

BOREHOLE TYPE 102 mm O.D. Solid Stem

COMPILED BY AK

DATUM Geodetic

DATE November 14, 2018

CHECKED BY MWK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
262.3	GROUND SURFACE										
0.0	ASPHALT (200 mm)										
0.2	- Continuous auger drilling from ground surface-no sampling						262				
							261				
							260				
							259				
258.7											
3.6	END OF PROBEHOLE - AUGER REFUSAL Possible Bedrock NOTES: 1. Borehole dry upon completion of drilling. 2. SPT 'N' value measured >50 blows for 0.01 m of penetration on possible bedrock. A small piece of granite was retrieved from tip of split-spoon.		1	SS	50/0.01						

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-5

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945470.5; E 413003.4 MTM NAD 83 ZONE 10 (LAT. 44.641104; LONG. -78.136032)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 152 mm O.D. Hollow Stem Power Augers

COMPILED BY AK

DATUM Geodetic

DATE November 14, 2018

CHECKED BY MWK

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	w_P	w	w_L	γ kN/m³	GR SA SI CL
261.9	GROUND SURFACE												
0.0	- Continuous auger drilling from ground surface-no sampling												
							261						
							260						
							259						
							258						
							257						
							256						
							255						
						▽	254						
							253						
252.2													
9.8	END OF PROBEHOLE - AUGER AND SPOON REFUSAL Possible Bedrock		1	SS	50/0.0*								

NOTES:

1. Flowing sands encountered during borehole advancement below a depth of 7 m (Elev. 254.9 m).

2. SPT 'N' value measured >50 blows for zero observable penetration on possible bedrock.

3. Water level measured at a depth of 7.6 m below ground surface (Elev. 254.3 m) upon completion of drilling.

WATER CONTENT (%) 10 20 30

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-6

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945475.5; E 413002.8 MTM NAD 83 ZONE 10 (LAT. 44.641149; LONG. -78.136038)

ORIGINATED BY BC

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY AK

DATUM Geodetic

DATE November 15, 2018

CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.8	GROUND SURFACE								
0.0	ASPHALT (150 mm)								
0.2	Gravelly sand, trace to some silt (FILL) Compact Brown Moist	1	SS	11	261				
260.4									
1.5	Sand, trace to some gravel, trace to some silt, trace clay (FILL) Very loose to compact Brown Moist	2	SS	8	260				
		3	SS	6	259		○		14 72 11 3
		4	SS	13					
	- Auger grinding at a depth of 3.7 m				258				
		5	SS	4	257		○		7 79 12 2
256.2									
5.6	SAND, trace silt, trace clay Very loose Brown Wet				256				
	- Possible blowing sand condition in Sample 6	6	SS	1*				○	0 97 1 2
	- Auger and spoon refusal at a depth of 7.7 m below ground surface				255				
254.2		~~7~~	~~SS~~	~~50/0*~~					
7.7	GNEISS (BEDROCK)				254				
	Rock cored between depths of 7.7 m to 8.6 m below ground surface.	1	RC	REC 100%					RQD = 70%
253.3									
8.6	See Record of Drillhole 18-6 for details.								

END OF BOREHOLE

NOTES:

1. * N-value not representative of soil due to bedrock contact.

2. Water level measured at a depth of 5.2 m below ground surface on completion of drilling (Elev. 256.6 m).

$+^3, \times^3$: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 1895756

RECORD OF DRILLHOLE: 18-6

SHEET 1 OF 1

LOCATION: N 4945475.50 ;E 413002.80

DRILLING DATE: November 15, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track Mount

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATHERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole 18-6		254.15															
8		Fresh, foliated, black and grey, fine grained, non-porous, strong GNEISS		7.65	1						0	JN,CU,RO	3	1	22			LC	
											30	JN,IR,RO,Sa	3	2	20			LC	
											90	JN,IR,RO,Sa	3	2	20				
				253.25															
		END OF DRILLHOLE		8.55															
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			

DEPTH SCALE
1 : 50

GOLDER

LOGGED: BC
CHECKED: AK

GTA-RCK 046 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-MISS.GDT 19-5-10

RECORD OF BOREHOLE No 18-8

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945479.4; E 413006.6 MTM NAD 83 ZONE 10 (LAT. 44.641148; LONG. -78.133599)

ORIGINATED BY SK

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY AK

DATUM Geodetic

DATE November 14, 2018

CHECKED BY MWK

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.8	GROUND SURFACE										
0.0	ASPHALT (150 mm)										
0.2	Gravelly sand, some silt (FILL) Compact Brown Moist		1	SS	15		261				
260.4											
1.5	Sand, trace to some gravel, trace to some silt, trace clay (FILL) Loose to compact Brown Moist to wet		2	SS	7		260		○		8 78 12 2
			3	SS	5		259				
			4	SS	12		258				
	- Auger and spoon refusal at a depth of 5.3 m		5	SS	10	▽	257		○		0 92 6 2
256.5			6	SS	50/0*						
5.3	GNEISS and GRANITE (BEDROCK)		1	RC	REC 48%						RQD = 33%
	Rock cored between depths of 5.3 m to 8.8 m below ground surface. See Record of Drillhole 18-8 for details.		2	RC	REC 100%		256				RQD = 99%
			3	RC	REC 100%		254				RQD = 67%
253.0							253				
8.8	END OF BOREHOLE										

NOTES:

1. * N-value not representative of soil due to bedrock contact.

2. Water level measured in hollow stem augers at a depth of 5.1 m below ground surface (Elev. 256.7 m) prior to rock coring.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 1895756

RECORD OF DRILLHOLE: 18-8

SHEET 1 OF 1

LOCATION: N 4945479.4 ;E 413006.6

DRILLING DATE: November 14, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track Mount

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate
BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage
PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular
PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES PIEZOMETER OR STANDPIPE INSTALLATION
		Continued from Record of Borehole 18-8		256.47															
		Fresh, foliated, black and grey, fine grained, non-porous, strong GNEISS		5.33	1							FR,IR,RO	3	1					γ = 27.4 KN/m³
6												JN,PL,RO Sa JN,CU,RO	1.5 3	2 1					UCS=93.0 MPa E = 42.8 GPa
					2							FR,PL,RO Sa	1.5	2					
7				254.61															
		Fresh, crystalline, pink, medium to coarse grained, non-porous, strong GRANITE (Pegmatite)		7.19								CO,IR,SM FR,IR,RO Sa CO,PL,RO Sa FR,CU,RO FR,IR,RO Sa Bt JN,IR,RO Sa Ht JN,IR,RO Sa Ht JN,IR,RO Sa Ht	2 3 1.5 3 3 3 3 3	1 2 2 2 2 2 2 2					
8					3							JN,CU,RO Sa JN,PL,RO Sa Fe	3 1.5	2 2					
				252.96								JN,UN,RO Sa	3	2					
		END OF BOREHOLE		8.84															
9																			
10																			
11																			
12																			
13																			
14																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: BC
CHECKED: AK

GTA-RCK 054 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-MISS.GDT 19-7-17

RECORD OF BOREHOLE No 18-9

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945470.6; E 413016.9 MTM NAD 83 ZONE 10 (LAT. 44.641103; LONG. -78.135862)

ORIGINATED BY SK

DIST Eastern HWY 28

BOREHOLE TYPE 102 mm O.D. Solid Stem Power Augers

COMPILED BY AK

DATUM Geodetic

DATE November 15, 2018

CHECKED BY MWK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
260.7	GROUND SURFACE										
0.0	- Continuous auger drilling from ground surface-no sampling - Auger grinding encountered at a depth of 2 m						260 259 258				
257.8											
2.9	END OF PROBEHOLE - AUGER AND SPOON REFUSAL Bedrock		1	SS	50/0*						

NOTES:

1. SPT 'N' value measured >50 blows for zero penetration on possible bedrock.
2. Open borehole dry upon completion of drilling.
3. Topsoil observed at ground surface.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-10

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945473.4; E 413017.6 MTM NAD 83 ZONE 10 (LAT. 44.641128; LONG. -78.135852)

ORIGINATED BY SK

DIST Eastern HWY 28

BOREHOLE TYPE 203 mm O.D. Hollow Stem Power Augers

COMPILED BY AK

DATUM Geodetic

DATE November 15, 2018

CHECKED BY MWK

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.7	GROUND SURFACE										
0.0	TOPSOIL (100 mm)										
0.1	Gravelly sand to sand, trace gravel, some silt, trace clay, trace organics, some silty sand pockets (FILL) Loose to very dense Brown Moist - Auger grinding between depths of 1.0 m and 1.2 m		1	SS	50/0.13		260				23 64 11 2
			2	SS	6		259			NP	3 77 17 3
258.1	- Auger grinding below depth of 2.1 m and auger refusal 2.6 m										
2.6	GNEISS (BEDROCK) Rock cored between depths of 2.6 m to 6.2 m below ground surface. See Record of Drillhole 18-10 for details.		1	RC	REC 98%		258				RQD = 58%
			2	RC	REC 100%		257				RQD = 90%
			3	RC	REC 93%		256				RQD = 77%
254.5							255				
6.2	END OF BOREHOLE										

NOTES:

1. Water level not recorded prior to rock coring.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 1895756

RECORD OF DRILLHOLE: 18-10

SHEET 1 OF 1

LOCATION: N 4945473.40 ;E 413017.60

DRILLING DATE: November 15, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Acker Renegade Track Mount

DRILLING CONTRACTOR: Walker Drilling Ltd.

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATHERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole 18-10		258.11															
		Fresh, foliated, black and grey, fine grained, non-porous, strin GNEISS		2.59															Broken Core
					1							SA,IR,RO	3	2	20				
												,,							Broken Core
3												SA,IR,RO,BE	3	1	22				
												SA,PL,RO,BE	1.5	2	16				
												SA,CU,RO,BE	3	2	20				
					2							SA,CU,RO	3	2	20				
4												SA,IR,RO	3	1	20				
												,IR,RO	3	1	22				
												SA,IR,RO	3	2	20				
												SA,IR,RO,BE	3	2	20				
												SA,IR,RO,BE	3	2	20				
												SA,CU,RO	3	2	20				
5																			
												SA,PL,RO,SA	1.5	3	16				
												SA,PL,RO	1.5	2	16				
												SA,PL,RO	1.5	2	16				
					3							SA,IR,RO,BE	3	2	20				
												,PL,RO	1.5	1	20				
												,PL,RO	1.5	1	20				
												,PL,RO	1.5	1	20				
6				254.51															Lost Core
		END OF DRILLHOLE		6.19															
7																			
8																			
9																			
10																			
11																			
12																			

DEPTH SCALE

1 : 50

GOLDER

LOGGED: BC

CHECKED: AK

GTA-RCK 046 S:\CLIENTS\MTO\HWY_28_EELS_CREEK\02_DATA\GINT\HWY_28_EELS_CREEK.GPJ GAL-MISS.GDT 19-5-10

RECORD OF BOREHOLE No 18-11

SHEET 1 OF 1

METRIC

PROJECT 1895756

G.W.P.

LOCATION N 4945478.3; E 413015.9 MTM NAD 83 ZONE 10 (LAT. 44.641173; LONG. -78.135873)

ORIGINATED BY SK

DIST Eastern HWY 28

BOREHOLE TYPE 102 mm O.D. Solid Stem Power Augers

COMPILED BY AK

DATUM Geodetic

DATE November 15, 2018

CHECKED BY MWK

SOIL PROFILE: ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.0	GROUND SURFACE										
0.0	- Continuous auger drilling from ground surface-no sampling - Auger grinding between depths of 2.1 m and 2.9 m					▽	260 259 258				
257.8			1	SS	50/0.0*						
3.2	END OF PROBEHOLE - AUGER AND SPOON REFUSAL Possible Bedrock										

NOTES:

1. SPT 'N' value measured >50 blows for 0.01 m of penetration on possible bedrock.

2. Water level measured in open borehole at a depth of 2.7 m below ground surface (Elev. 258.3 m) upon completion of drilling.

3. Topsoil observed at ground surface.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

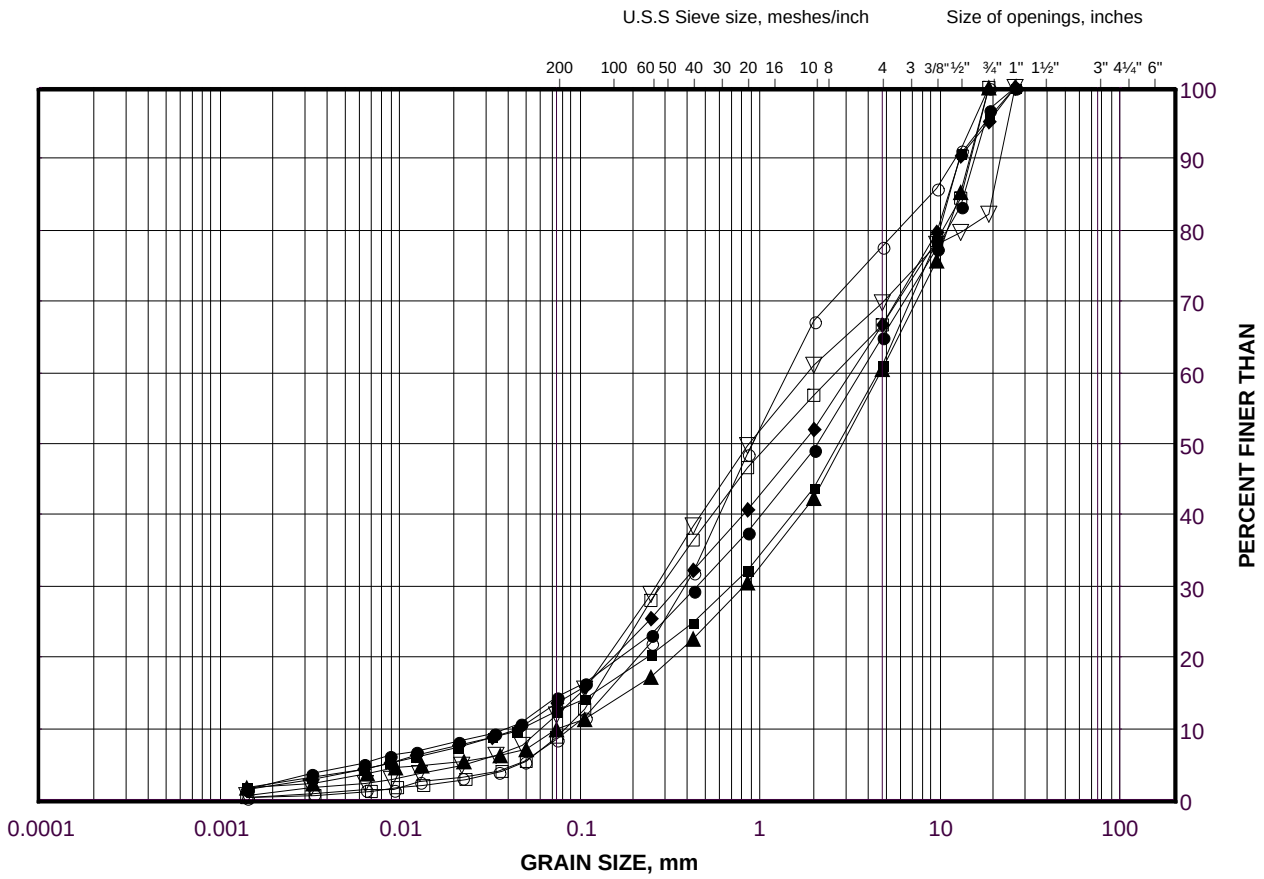
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Gravelly Sand to Sand and Gravel (FILL)

FIGURE B1 A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	17-10	SS1	262.1
■	17-8	SS1	261.9
◆	17-5	SS1	261.5
▲	16-6	SS1	261.9
▽	17-7	SS2	261.3
○	17-7	SS5	259.0
□	16-2	SS7	257.1

Project Number: 1895756,1413191

Checked By: MWK

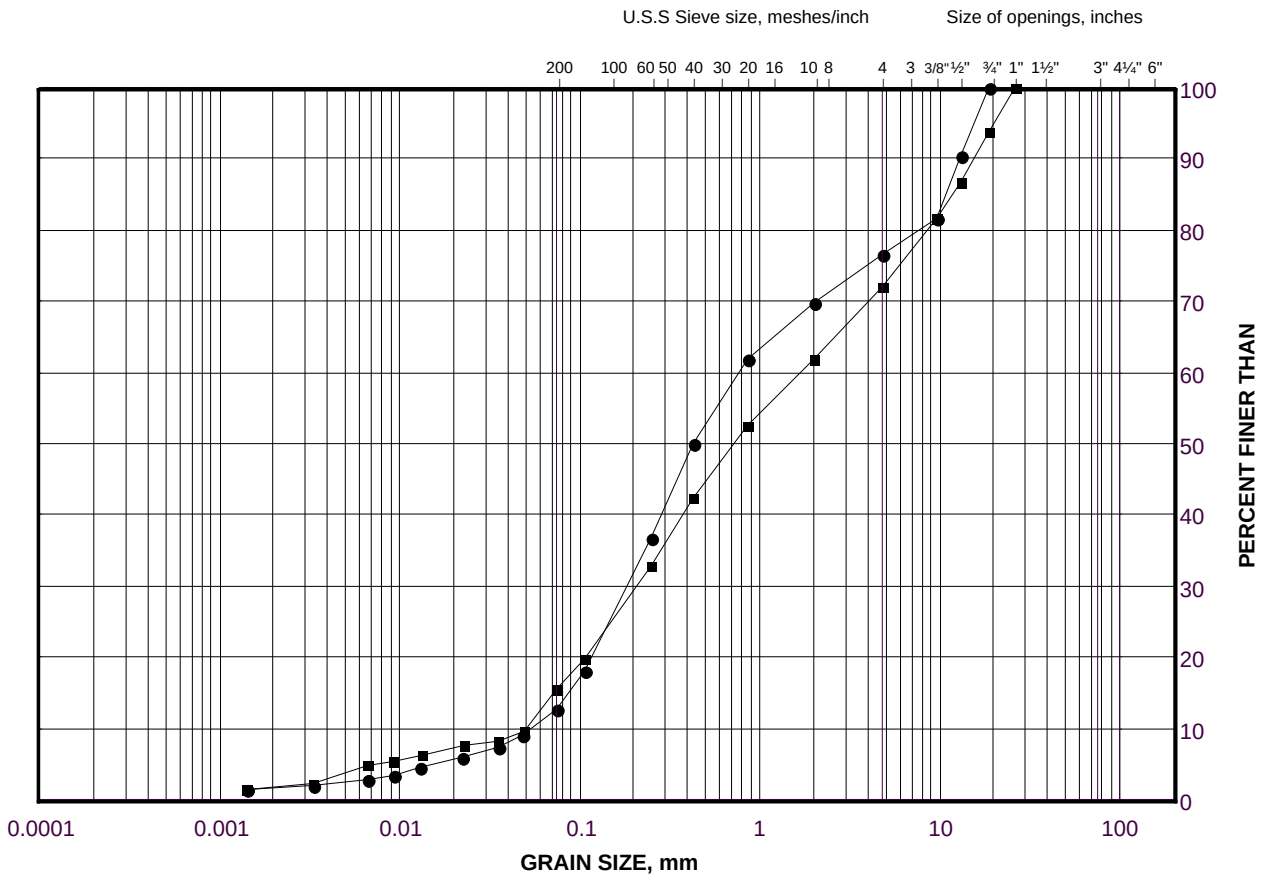
Golder Associates

Date: 08-Mar-19

GRAIN SIZE DISTRIBUTION

Gravelly Sand to Sand and Gravel (FILL)

FIGURE B1 B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	18-10	SS1	259.8
■	18-2	SS3	259.8

Project Number: 1895756,1413191

Checked By: MWK

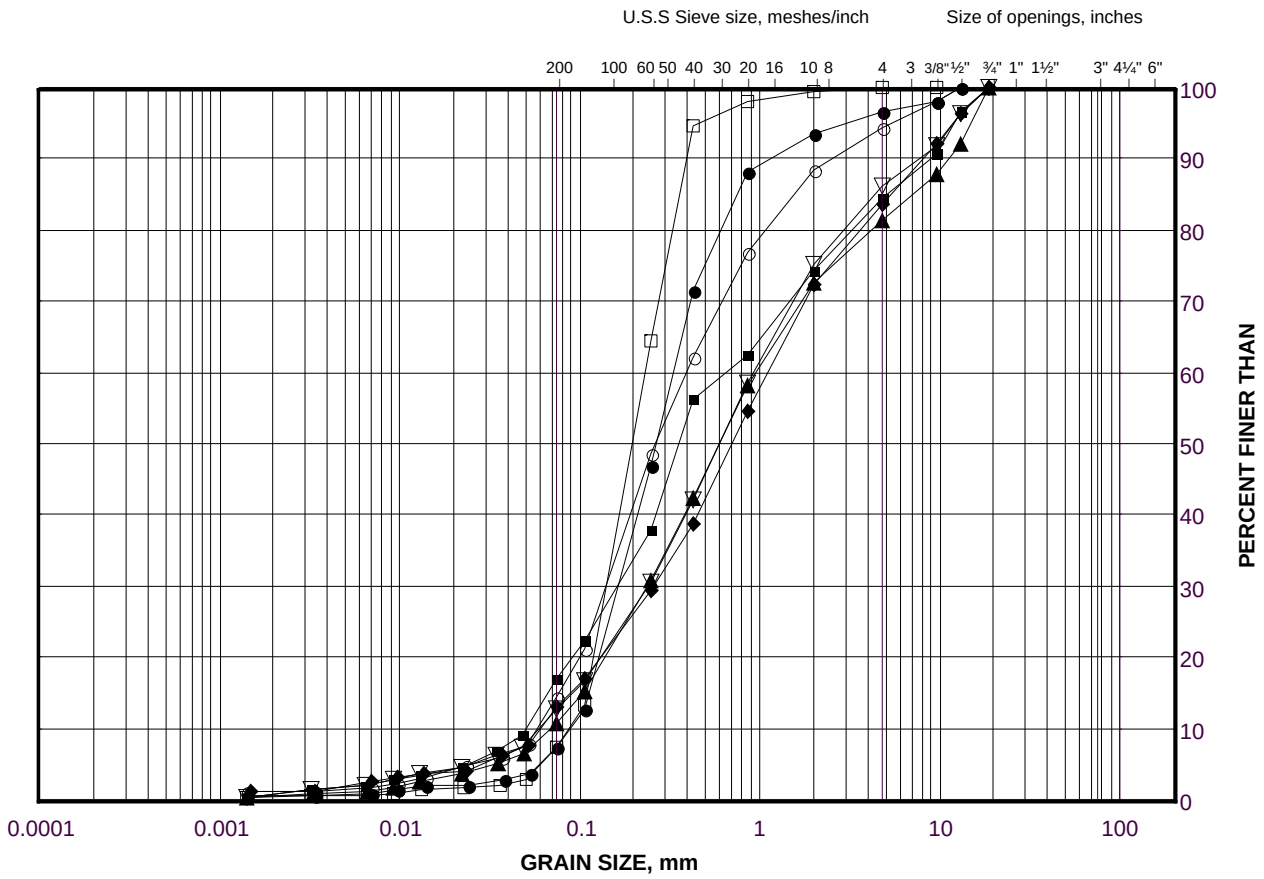
Golder Associates

Date: 08-Mar-19

GRAIN SIZE DISTRIBUTION

Sand (Fill)

FIGURE B2 A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	16-2	SS2	261.0
■	17-3	SS3	260.2
◆	16-1	SS3	260.2
▲	17-3	SS5	258.6
▽	17-4	SS6	257.9
○	16-1	SS8	256.4
□	17-4	SS9	254.1

Project Number: 1895756,1413191

Checked By: MWK

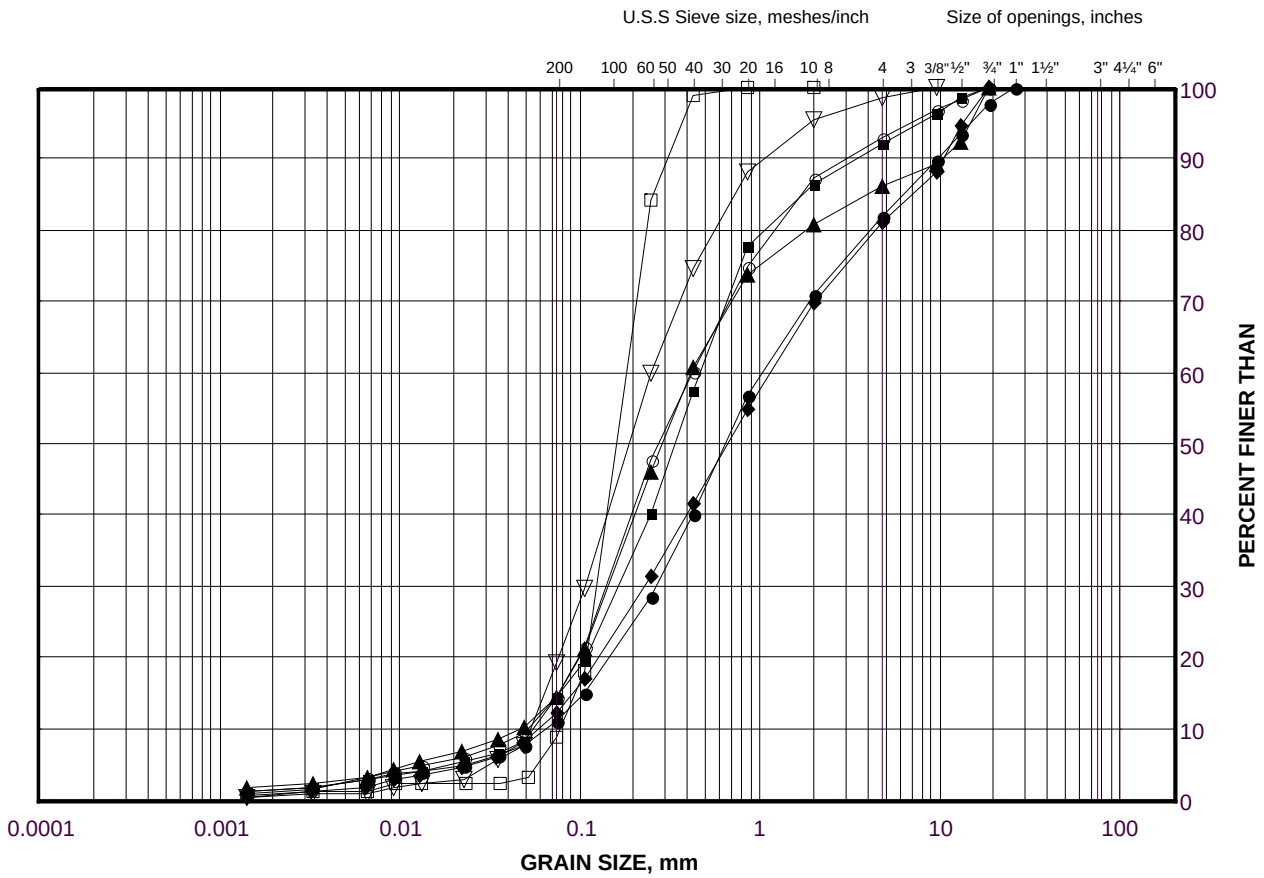
Golder Associates

Date: 08-Mar-19

GRAIN SIZE DISTRIBUTION

Sand (Fill)

FIGURE B2 B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	18-2	SS1	261.1
■	18-8	SS2	260.0
◆	17-9	SS2	261.4
▲	18-6	SS3	259.2
▽	17-5	SS5	258.5
○	18-6	SS5	256.9
□	18-8	SS5	256.9

Project Number: 1895756,1413191

Checked By: MWK

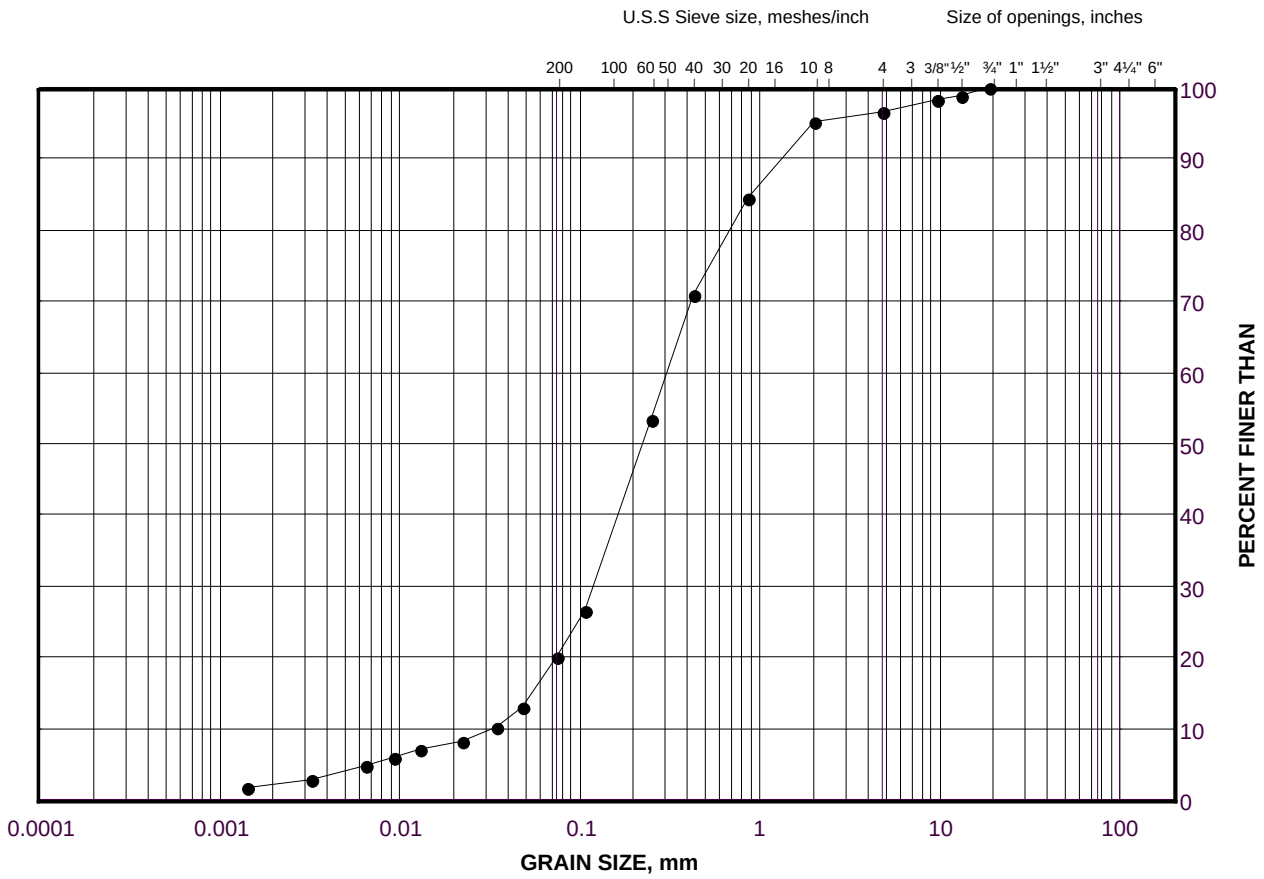
Golder Associates

Date: 08-Mar-19

GRAIN SIZE DISTRIBUTION

Sand (Fill)

FIGURE B2 C



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	18-10	SS2	258.9

Project Number: 1895756,1413191

Checked By: MWK

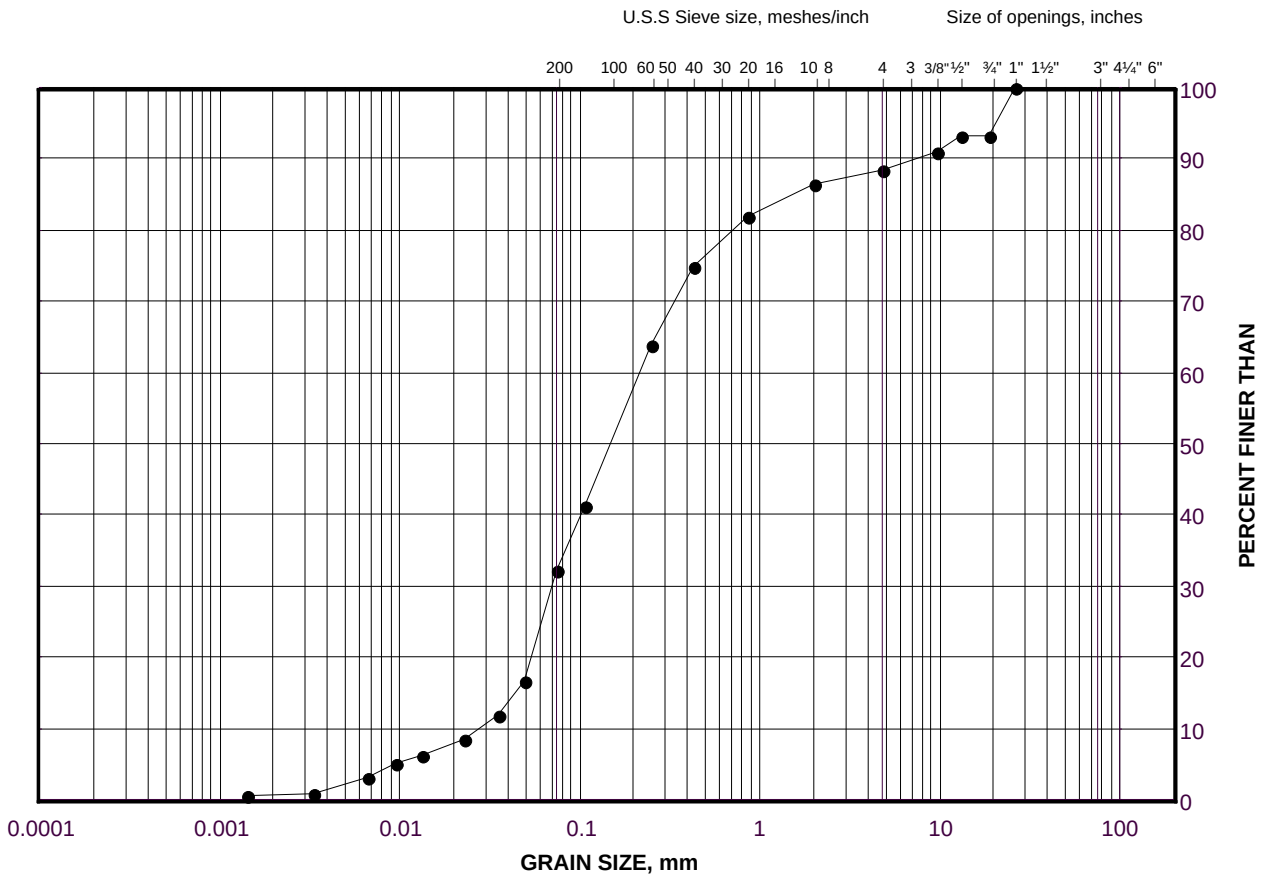
Golder Associates

Date: 08-Mar-19

GRAIN SIZE DISTRIBUTION

Silt and Sand (Fill)

FIGURE B3



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	18-1	SS1	261.5

Project Number: 1895756,1413191

Checked By: MWK

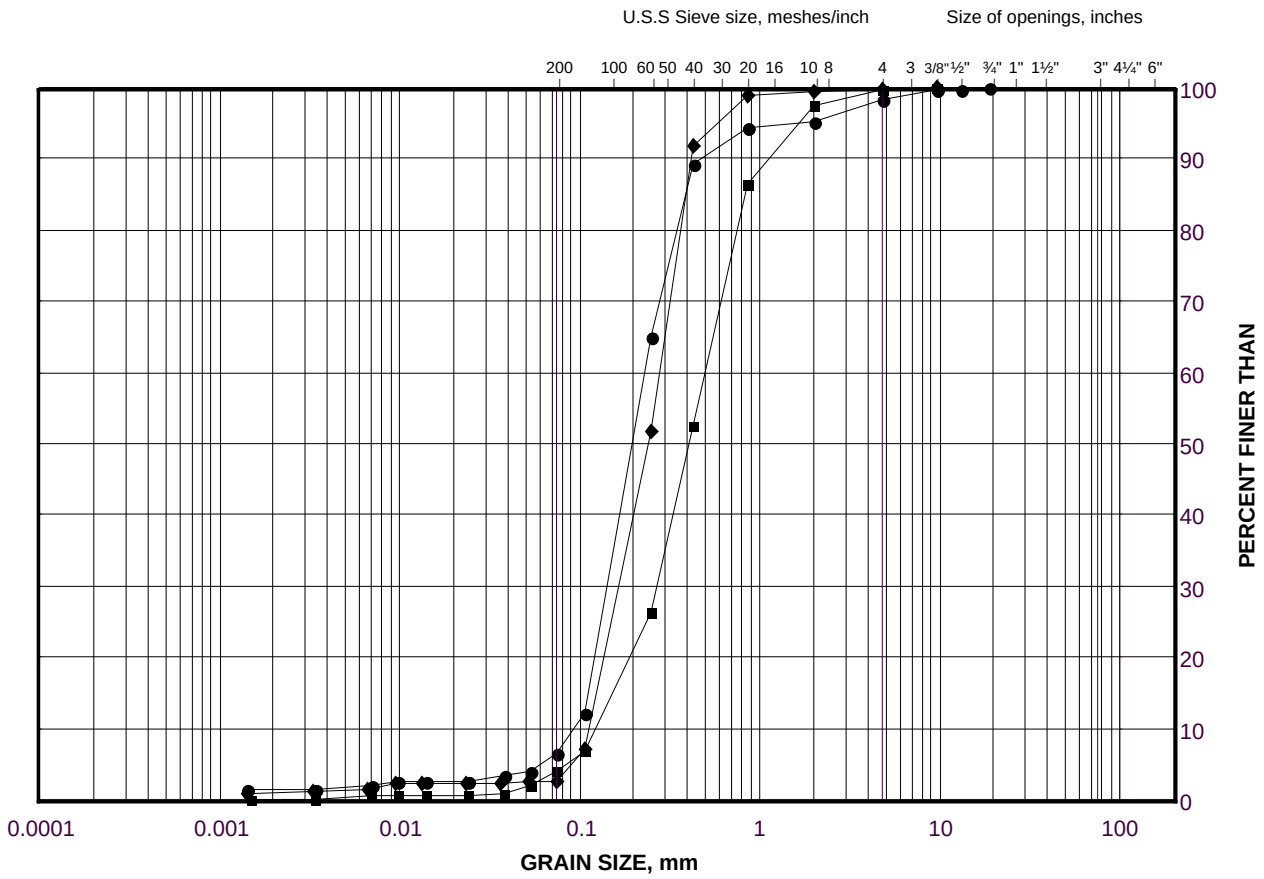
Golder Associates

Date: 08-Mar-19

GRAIN SIZE DISTRIBUTION

SAND

FIGURE B4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	16-1	SS11	254.1
■	16-1	SS13	252.6
◆	18-6	SS6	255.4

Project Number: 1895756,1413191

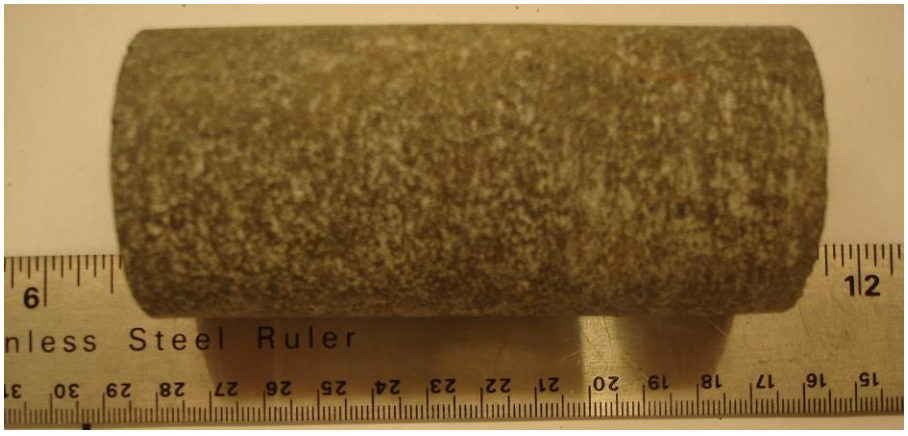
Checked By: MWK

Golder Associates

Date: 08-Mar-19

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE B5



Project No.: 1413191/1150
Borehole No.: 16-1
Sample No.: RC 1
Depth: 10.47-10.75m

BEFORE COMPRESSION

Project No.: 1413191/1150
Borehole No.: 16-1
Sample No.: RC 1
Depth: 10.47-10.75m

AFTER COMPRESSION

Date Aug. 22, 2017
Project 1413191

Golder Associates

Drawn Frank
Chkd. MM

FORM PRODUCED JUNE 1986

Form G.A.-D-4 (imperial)

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE B6

Project No.: 1413191/1150
Borehole No.: 16-2
Sample No.: RC 1
Depth: 6.48-6.75m

BEFORE COMPRESSION

Project No.: 1413191/1150
Borehole No.: 16-2
Sample No.: RC 1
Depth: 6.48-6.75m

AFTER COMPRESSION

Date Aug. 22, 2017
Project 1413191

Golder Associates

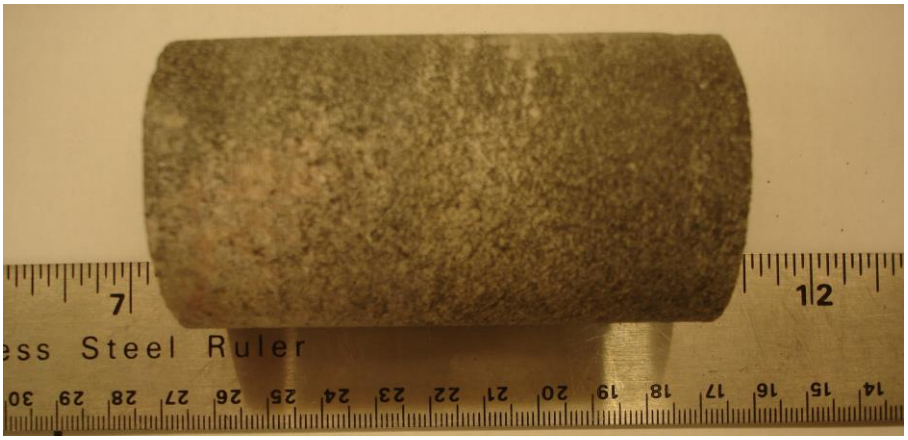
Drawn Frank
Chkd. MM

FORM PRODUCED JUNE 1986

Form G.A.-D-4 (imperial)

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE B7



Project No.: 1413191/1150
Borehole No.: 17-7
Sample No.: RC 2
Depth: 5.87-6.0m

BEFORE COMPRESSION

Project No.: 1413191/1150
Borehole No.: 17-7
Sample No.: RC 2
Depth: 5.87-6.0m

AFTER COMPRESSION

Date Aug. 22, 2017
Project 1413191

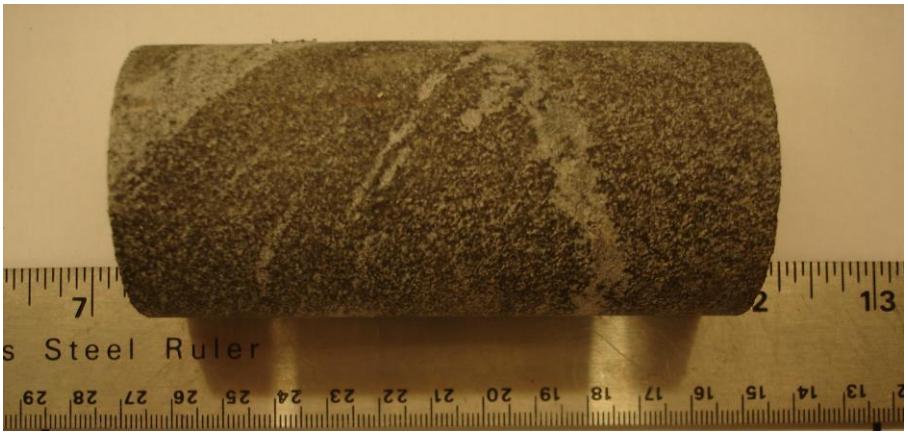
Golder Associates

Drawn Frank
Chkd. MM

FORM PRODUCED JUNE 1986
Form GA-D-4 (imperial)

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE B8



Project No.: 1413191/1150
Borehole No.: 17-7
Sample No.: RC 3
Depth: 8.62-8.8m

BEFORE COMPRESSION

Project No.: 1413191/1150
Borehole No.: 17-7
Sample No.: RC 3
Depth: 8.62-8.8m

AFTER COMPRESSION

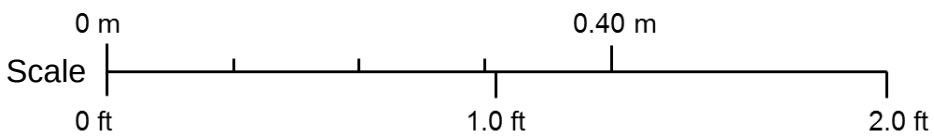
Date Aug. 22, 2017
Project 1413191

Golder Associates

Drawn Frank
Chkd. MM

FORM PRODUCED JUNE 1986
Form GA-D-4 (imperial)

Borehole 16-1: Bedrock cored between depths of about 10.29 m to 13.30 m



PROJECT	Highway 28 Eel's Creek Bridge Replacement (Site No. 26-117) North Kawartha, Ontario				
TITLE	BEDROCK CORE PHOTOGRAPHS BOREHOLE 16-1				
GOLDER	PROJECT No.1413191 /1895756		FILE No. ----		
	DESIGN	AK	20181126	SCALE NTS	VER. 1.
	CADD	--		FIGURE B9	
	CHECK	MWK	20171214		
	REVIEW	KJB	20180209		

BY: AK Project: 1895756

Borehole 16-2: Rock fragment and cobbles cored between depths of about 3.05 m and 6.48 m and Bedrock cored between depths of about 6.48 m to 8.92 m

Borehole 16-2: Bedrock cored between depths of about 8.92 m to 11.76 m

Scale

0 m — 0.40 m

0 ft — 1.0 ft — 2.0 ft

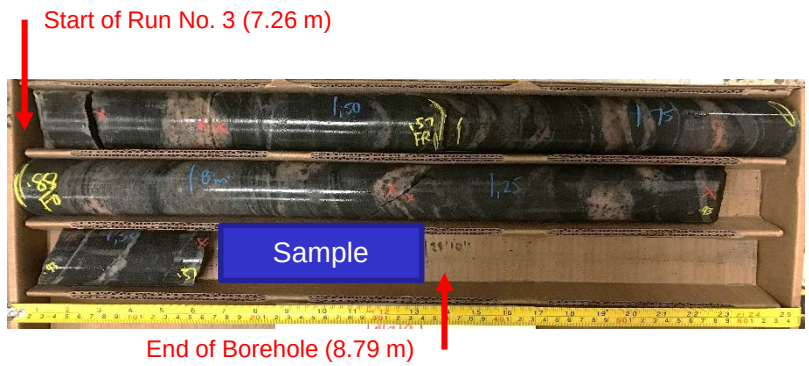
PROJECT	Highway 28 Eel's Creek Bridge Replacement (Site No. 26-117) North Kawartha, Ontario
TITLE	BEDROCK CORE PHOTOGRAPHS BOREHOLE 16-2

GOLDER

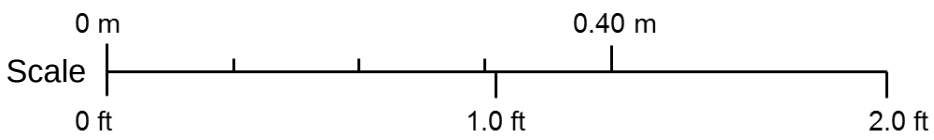
PROJECT No.	1413191 /1895756		FILE No.	----	
DESIGN	AK	20181126	SCALE	NTS	VER. 1.
CADD	--		FIGURE B10		
CHECK	MWK	20171214			
REVIEW	KJB	20180209			

BY: AK Project: 1895756

Borehole 17-7: Bedrock cored between depths of about 5.13 m to 7.26 m

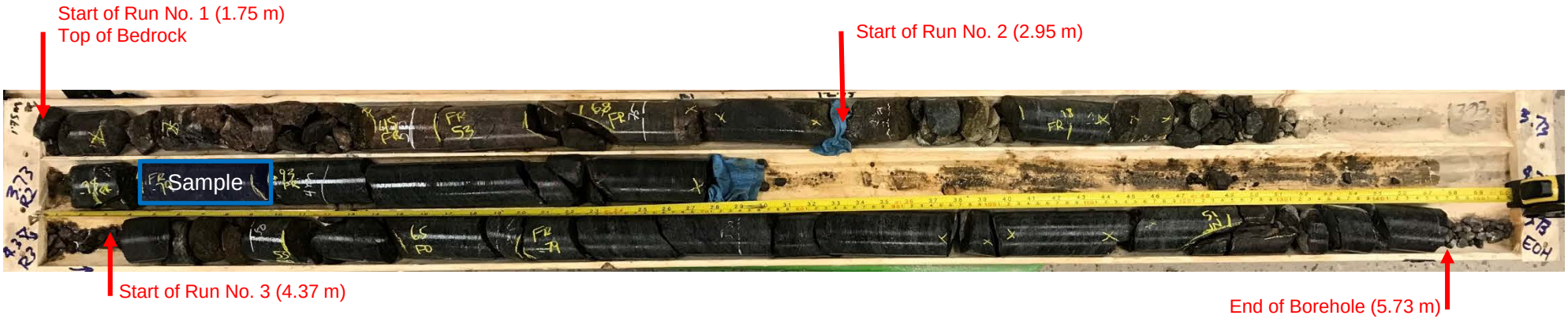


Borehole 17-7: Bedrock cored between depths of about 7.26 m to 8.79 m

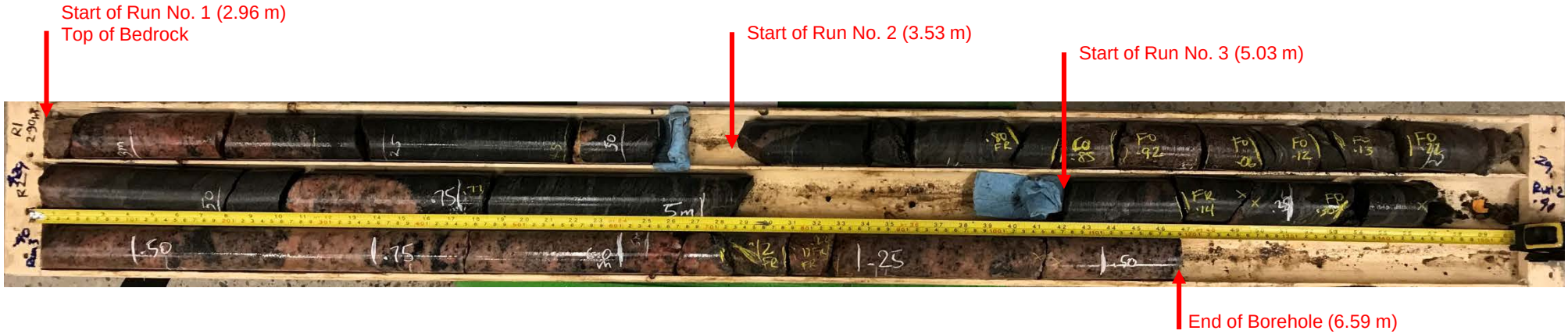


PROJECT	Highway 28 Eel's Creek Bridge Replacement (Site No. 26-117) North Kawartha, Ontario				
TITLE	BEDROCK CORE PHOTOGRAPHS BOREHOLE 17-7				
GOLDER	PROJECT No.1413191 /1895756		FILE No. ----		
	DESIGN	AK	20181126	SCALE NTS	VER. 1.
	CADD	--		FIGURE B11	
	CHECK	MWK	20171214		
	REVIEW	KJB	20180209		

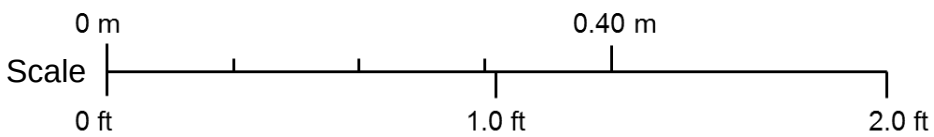
BY: AK Project: 1895756



Borehole 18-1: Bedrock cored between depths of about 1.75 m to 5.73 m



Borehole 18-2: Bedrock cored between depths of about 2.96 m to 6.59 m



PROJECT	Highway 28 Eel's Creek Bridge Replacement (Site No. 26-117) North Kawartha, Ontario
TITLE	BEDROCK CORE PHOTOGRAPHS BOREHOLES 18-1 AND 18-2

GOLDER

PROJECT No.	1413191 /1895756		FILE No.	----	
DESIGN	AK	20181126	SCALE	NTS	VER. 1.
CADD	--		FIGURE B12		
CHECK	MWK	20171214			
REVIEW	KJB	20180209			

BY: AK Project: 1895756

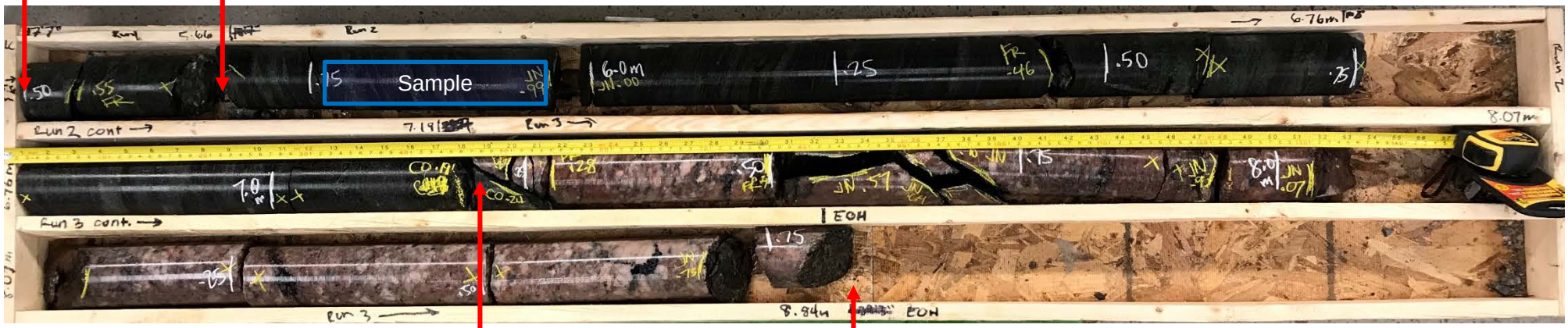
Start of Run No. 1 (7.65 m)
Top of Bedrock

End of Borehole (8.55 m)

Borehole 18-6: Bedrock cored between depths of about 7.65 m to 8.55 m

Start of Run No. 1 (5.50 m) – Lost core from 5.33 m to 5.50 m

Start of Run No. 2 (5.66 m)



Start of Run No. 3 (7.19 m)

End of Borehole (8.84 m)

Borehole 18-8: Bedrock cored between depths of about 5.50 m to 8.84 m

Scale

0 m — 0.40 m

0 ft — 1.0 ft — 2.0 ft

PROJECT	Highway 28 Eel's Creek Bridge Replacement (Site No. 26-117) North Kawartha, Ontario
TITLE	BEDROCK CORE PHOTOGRAPHS BOREHOLES 18-6 AND 18-8

GOLDER

PROJECT No.	1413191 /1895756		FILE No.	----	
DESIGN	AK	20181126	SCALE	NTS	VER. 1.
CADD	--		FIGURE B13		
CHECK	MWK	20171214			
REVIEW	KJB	20180209			

BY: AK Project: 1895756

Start of Run No. 1 (2.59 m)
Top of Bedrock

End of Borehole (6.19 m)

Start of Run No. 3 (4.67 m)

Start of Run No. 2 (3.14 m)

Borehole 18-10: Bedrock cored between depths of about 2.59 m to 6.09 m

Scale

0 m — 0.40 m

0 ft — 1.0 ft — 2.0 ft

PROJECT	Highway 28 Eel's Creek Bridge Replacement (Site No. 26-117) North Kawartha, Ontario				
TITLE	BEDROCK CORE PHOTOGRAPHS BOREHOLE 18-10				
GOLDER	PROJECT No.1413191 /1895756		FILE No. ----		
	DESIGN	AK	20181126	SCALE NTS	VER. 1.
	CADD	--		FIGURE B14	
	CHECK	MWK	20171214		
	REVIEW	KJB	20180209		

BY: AK Project: 1895756

APPENDIX C

Vertical Seismic Profiling Test Results

TECHNICAL MEMORANDUM

DATE July 04, 2017 **PROJECT No.** 1413191 - 1150

TO Kevin Bentley
Golder Associates

FROM Stephane Sol, Christopher Phillips **EMAIL** ssol@golder.com, cphillips@golder.com

VERTICAL SEISMIC PROFILING TEST RESULTS
EELS CREEK BRIDGE AND HIGHWAY 28, NORTH KAWARTHA, ONTARIO

This memorandum presents the results of the Vertical Seismic Profiling (VSP) testing carried out at the Eels Creek Bridge located along Highway 28 in North Kawartha, Ontario. VSP testing was carried out on June 20, 2017. Borehole 16-2 was drilled to an approximate depth of 11.8 m below the existing pavement surface and then cased with a PVC pipe grouted in place. Borehole 16-2 was located at the center of the northbound lane. The borehole consisted of approximately 6.6 m of silty sand fill over granite bedrock.

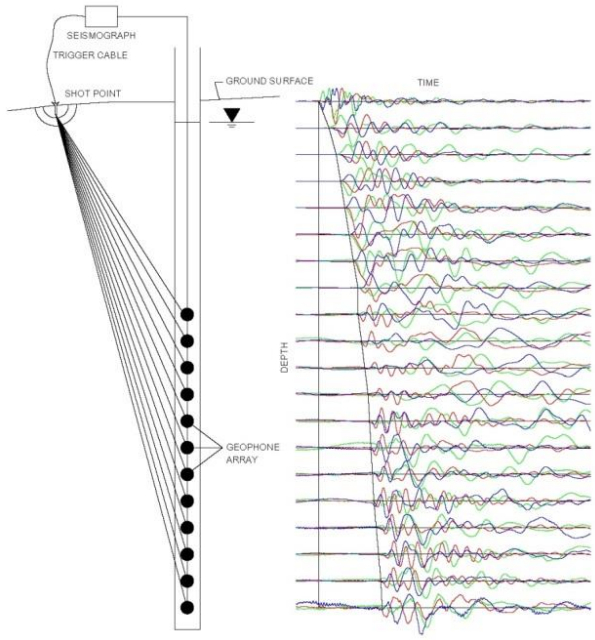
Methodology

For the VSP method, seismic energy is generated at the ground surface by an active seismic source and recorded by a geophone located in a nearby borehole at a known depth. The active seismic source can be either compression or shear wave. The time required for the energy to travel from the source to the receiver (geophone) provides a measurement of the average compression or shear-wave seismic velocity of the medium between the source and the receiver. Data obtained from different geophone depths are used to calculate a detailed vertical seismic velocity profile of the subsurface in the immediate vicinity of the test borehole.

The high resolution results of a VSP survey are often used for earthquake engineering site classification, as per the 2010 National Building Code of Canada.

CANADA'S BEST MANAGED COMPANIES Platinum member

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.



Example 1: Layout and resulting time traces from a VSP survey.

Fieldwork

The fieldwork was carried out on June 20, 2017, by personnel from the Golder Mississauga office.

Both compression and shear-wave seismic sources were used and both were located 2 m from the borehole. The seismic source for the compression wave test consisted of a 9.9 kilogram sledge hammer vertically impacted on a metal plate. The seismic source for the shear-wave test consisted of a 2.4 metre long, 150 millimetre by 150 millimetre wooden beam, weighted by a vehicle and horizontally struck with a 9.9 kilogram sledge hammer on alternate ends of the beam to induce polarized shear waves. The shear source was coupled to the ground surface by parking a vehicle on top of it. Test measurements started at ground surface and were recorded in the borehole with a 3-component receiver spaced at 0.5-metre intervals below the ground surface to a maximum depth of the casing (10.3 m).

The seismic records collected for each source location were stacked a minimum of five times to minimize the effects of ambient background seismic noise on the collected data. The data was sampled at 0.020833 millisecond intervals and a total time window of 0.341 seconds was collected for each seismic shot.

Data Processing

Processing of the VSP test results consisted of the following main steps:

1) Combination of seismic records to present seismic traces for all depth intervals on a single plot for each seismic source and for each component;

2) Low Pass Filtering of data to remove spurious high frequency noise;

3) First break picking of the compression and shear-wave arrivals; and,

4) Calculation of the average compression and shear-wave velocity to each tested depth interval.

Processing of the VSP data was completed using the SeisImager/SW software package (Geometrics Inc.). The seismic records are presented on the following four plots and show the first break picks of the compression wave (Figure 1) and shear wave arrivals (Figure 2) overlaid on the seismic waveform traces recorded at the different geophone depths for Borehole 16-2. The arrivals were picked on the vertical component for the compression source and on the two horizontal components for the shear source.

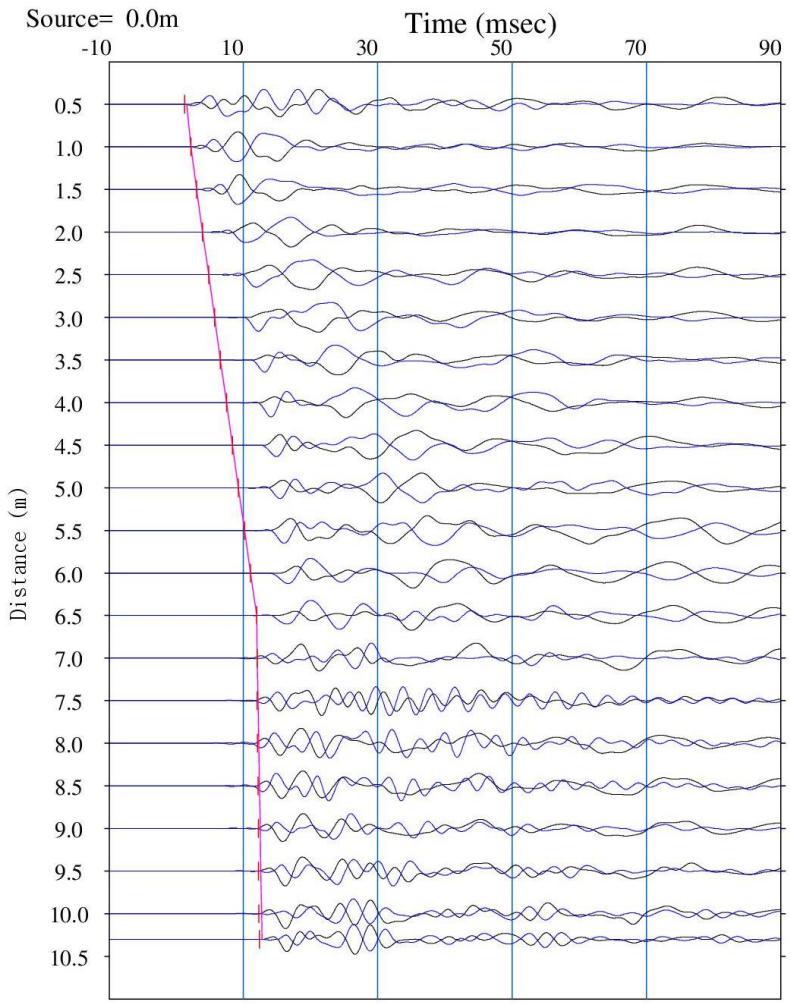


Figure 1: First break picking of compression wave arrivals (red) along the seismic traces recorded at each receiver depth of Borehole 16-2.

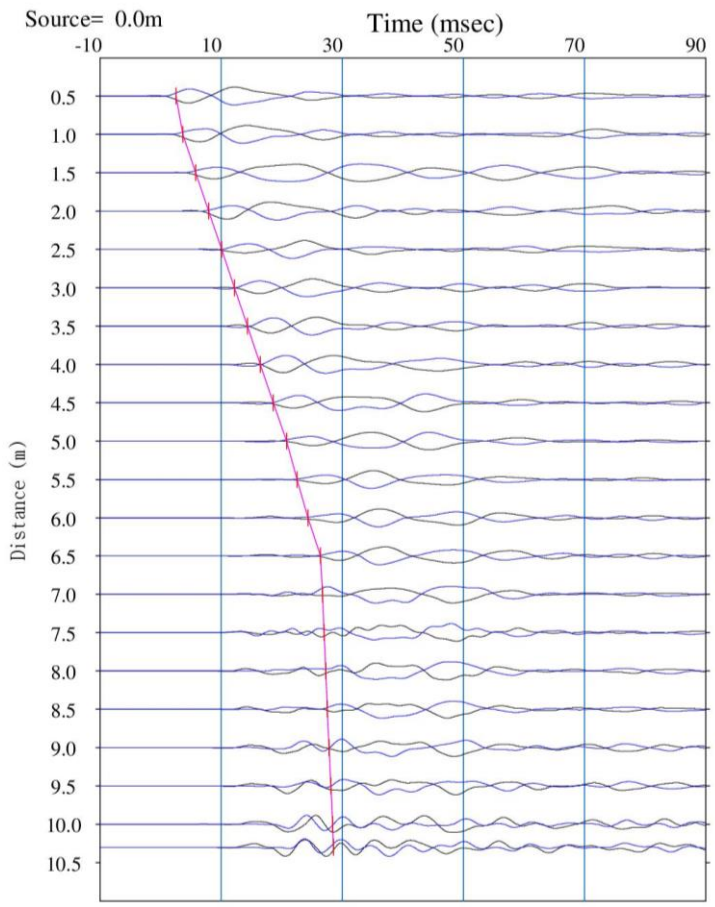


Figure 2: First break picking of shear wave arrivals (red) along the seismic traces recorded at each receiver depth of Borehole 16-2.

Results

The VSP results are summarized in Table 1. The shear wave and compression wave layer velocities were calculated by best fitting a theoretical travel time model to the field data. The depths presented on the table are relative to ground surface.

The estimated dynamic engineering moduli, based on the calculated wave velocities, are also presented in Table 1. The engineering moduli were calculated using an estimated bulk density, based on the borehole log. For the overburden a bulk density of 1,650 kg/m^3 was used. For the granite bedrock down to the bottom of the borehole at 10.3 metres, a bulk density of 2,600 kilogram per cubic metre was used.

The average shear wave velocity from ground surface to a depth of 30 metres was measured to be 729 metres per second. The average velocity was calculated assuming that the velocity from 10.3 metres to a depth of 30 metres was constant with an average shear-wave velocity value of 1,500 m/s which is equal to the velocity of the granite bedrock at the bottom of the borehole.

Limitations

This technical memorandum, which specifically includes all tables, figures and attachments, is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this memo.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this memo, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this memo.

The findings and conclusions of this memo are valid only as of the date of this memo. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this memo, and to provide amendments as required.

Closure

We trust that these results meet your current needs. If you have any questions or require clarification, please contact the undersigned at your convenience.

GOLDER ASSOCIATES LTD.

Stephane Sol, Ph.D., P.Geo
Senior Geophysicist

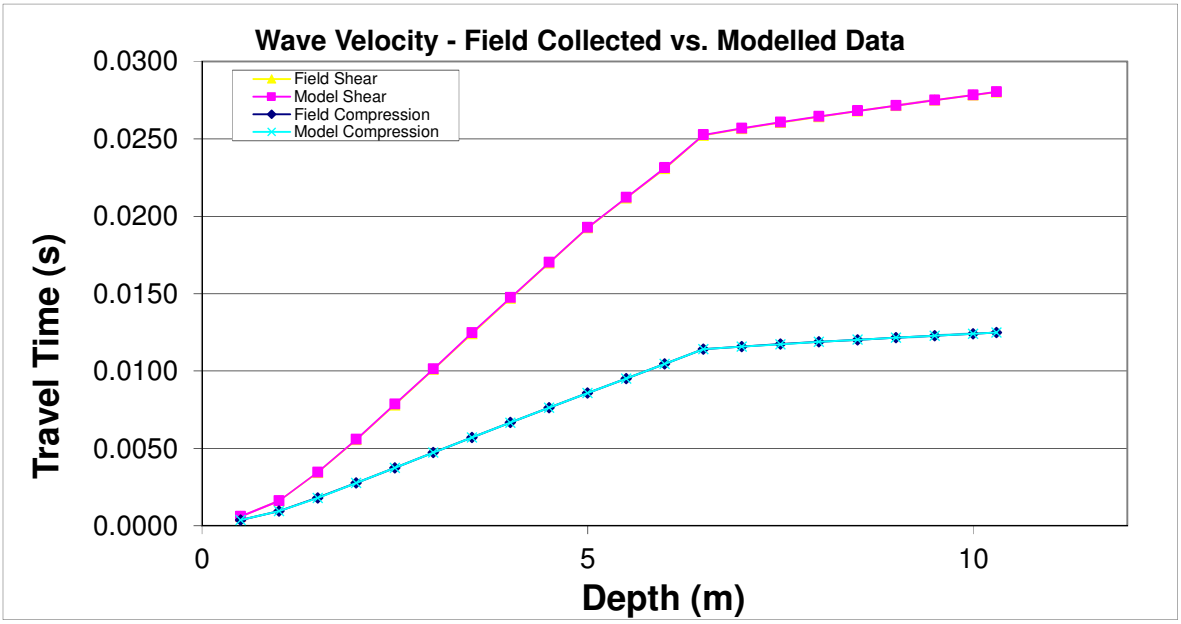
Christopher Phillips, M.Sc., P.Geo
Principal, Senior Geophysicist

SS/CRP/jl
\\golder.gds\gal\mississauga\active\2014\1111\1413191 mto - foundations eng retainer - east on\15 - hwy 28 eels creek\3 - field work management\geophysics\report final\1413191 tech memo 2017july04 vsp.docx

Attachment: Table 1 – Shear Wave Velocity Profile at BH-16-2

TABLE 1
SHEAR WAVE VELOCITY PROFILE AT BH-16-2

Layer Depth (m)		Velocities (m/s)		Estimated Bulk Density (kg/m^3)	Dynamic Engineering Properties			
Top	Bottom	Compressional Wave	Shear Wave		Poissons Ratio	Shear Modulus (MPa)	Deformation Modulus (MPa)	Bulk Modulus (MPa)
0.0	0.5	1350	835	1650	0.19	1150	2738	1473
0.5	1.0	850	495	1650	0.24	404	1005	653
1.0	1.5	590	270	1650	0.37	120	329	414
1.5	2.0	520	235	1650	0.37	91	250	325
2.0	2.5	510	220	1650	0.39	80	221	323
2.5	3.0	510	220	1650	0.39	80	221	323
3.0	3.5	510	215	1650	0.39	76	212	327
3.5	4.0	520	220	1650	0.39	80	222	340
4.0	4.5	520	220	1650	0.39	80	222	340
4.5	5.0	525	220	1650	0.39	80	223	348
5.0	5.5	535	260	1650	0.35	112	300	324
5.5	6.0	535	260	1650	0.35	112	300	324
6.0	6.5	525	235	1650	0.37	91	251	333
6.5	7.0	3000	1200	2600	0.40	3744	10519	18408
7.0	7.5	3200	1270	2600	0.41	4194	11797	21033
7.5	8.0	3200	1300	2600	0.40	4394	12313	20765
8.0	8.5	3600	1400	2600	0.41	5096	14380	26901
8.5	9.0	3700	1450	2600	0.41	5467	15408	28305
9.0	9.5	3800	1450	2600	0.41	5467	15468	30255
9.5	10.0	4000	1500	2600	0.42	5850	16593	33800
10.0	10.3	4000	1500	2600	0.42	5850	16593	33800



Notes
1. Depth Presented relative to ground surface.
2. This Table to be analyzed in conjunction with the accompanying report.

APPENDIX D

Rock Laboratory Test Results

Geomechanica Inc.
Suite 900 – 390 Bay St.
Toronto Ontario
Canada M5H 2Y2

December 14, 2018

Ms. Alysha Kobylinski
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Re: UCS+E testing
(Golder Project No. 1895756)

Dear Ms. Kobylinski:

On Novemebr 30, 2018, one (1) HQ-sized and one (1) NQ-sized core samples were received by Geomechanica Inc. via drop-off by Golder Personnel. These samples were identified as being from Golder project 1895756 (Eel's Creek) From these samples, two (2) UCS tests were completed.

Details regarding the steps of specimen preparation and testing along with the test results and photographs of the test specimens before and after testing are presented in the accompanying laboratory report and spreadsheet.

Sincerely,

Bryan Tatone Ph.D., P. Eng.

Geomechanica Inc.
Tel: (647) 478-9767
Email: bryan.tatone@geomechanica.com

Rock Laboratory Testing Results

A report submitted to:

Alysha Kobylinski
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Prepared by:

Bryan Tatone, PhD, PEng
Omid Mahabadi, PhD, PEng
Geomechanica Inc.
#900-390 Bay St.
Toronto ON
M5H 2Y2 Canada
Tel: +1-647-478-9767
lab@geomechanica.com

December 14, 2018
Project number: 1895756

Abstract

This document summarizes the results of rock laboratory testing, including the result of uniaxial compressive strength (UCS) tests. Results including the uniaxial compressive strength (UCS) and Young's modulus along with photographs of test specimens before and after testing are presented herein.

In this document:

1 Uniaxial Compressive Strength Tests 1
Appendices 4

Disclaimer: This report was prepared by Geomechanica Inc. for Golder Associates Ltd.. The material herein reflects Geomechanica Inc.'s best judgment given the information available at the time of preparation. Any use which a third party makes of this report, any reliance on or decision to be made based on it, are the responsibility of such third parties. Geomechanica Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

1 Uniaxial Compressive Strength Tests

1.1 Overview

This section summarizes the results of uniaxial compressive strength testing of an NQ- and HQ-sized specimen. The testing was performed in Geomechanica's rock testing laboratory using a 150 ton (1.3 MN) Forney loading frame equipped with pressure-compensated control valve to maintain an axial strain rate of approximately 0.050 mm/min (Figure 1). The specimen preparation and testing procedure included the following:

1. Unwrapping of the core sample and inspecting it for damage.
2. Diamond cutting of core samples to obtain cylindrical specimens with an appropriate length (length:diameter = 2:1) and nearly parallel end faces.
3. Diamond grinding of specimens to obtain flat (within ± 0.025 mm) and parallel end faces (within 0.25°).
4. Placement of the specimens into the loading frame and axially loading them to rupture while continuously recording the axial force and axial deformation to determine the peak strength (UCS) and tangent Young's modulus.

Figure 1: Forney loading frame setup for uniaxial compressive strength testing.

Using a precision V-block mounted on the magnetic chuck of the surface grinder, test specimens met the end flatness, end parallelism, and perpendicularity criteria set out in ASTM D4543-08. The side straightness

criteria, as checked with a feeler gauge, was met for all samples and the minimum length:diameter criteria was met for all specimens unless noted otherwise in Table 1. Testing of the specimens followed ASTM D7012-14 with the following exceptions:

- Rather than a spherical seat diameter equal to 1 to 2 times the specimen diameter, the setup used here employed a 25.4 mm diameter high precision ball bearing and seat. Despite the smaller diameter, this seat could move freely to accommodate small angular rotations in any direction, as needed, and therefore did not appreciably influence the results.
- The tests reported herein included the measurement of the UCS and elastic modulus, but not the Poisson's ratio. This represents a hybrid between Methods C and D of ASTM D7012-14.

1.2 Results

The results of the tests are summarized in Table 1. Additional specimens measurements and details are provided in the summary spreadsheet that accompanies this report. The corresponding stress-strain curves for the uniaxial compression tests are presented in Figure 2. Young's modulus is the tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 50.0% of the peak strength.

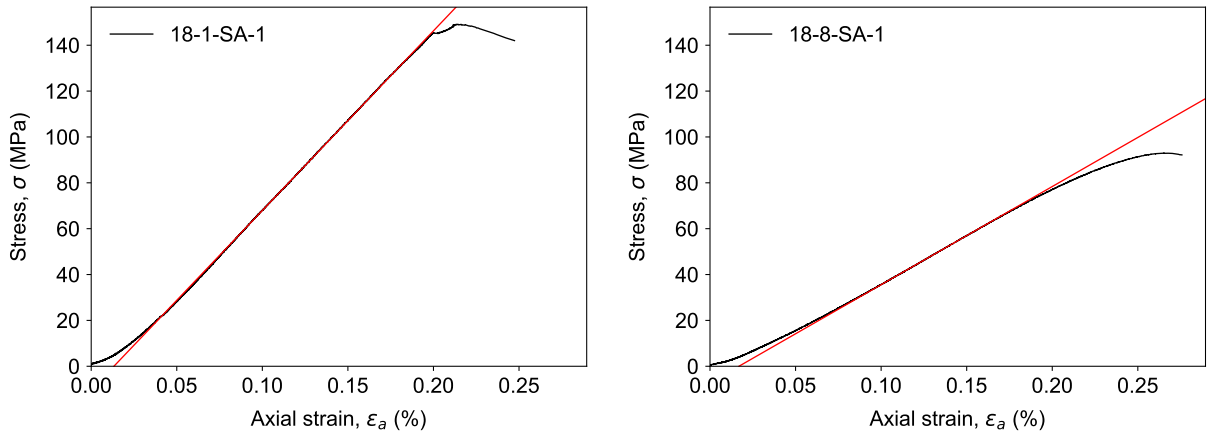
Table 1: Summary of Uniaxial Compression test results.

Sample	Depth (m)	Bulk density ρ (g/cm^3)	UCS (MPa)	Young's modulus E (GPa)	Lithology	Failure description
18-1-SA-1	3.79 - 3.93	2.877	149.1	78.3	Biotite-hornblende gneiss	1
18-8-SA-1	5.76 - 5.99	2.794	93.0	42.8	Biotite-hornblende gneiss	2
	Average	2.836	121.1	60.6		
	Standard deviation	0.041	28.1	17.8		

[1] Inclined shear failure
[2] Partial hourglass failure

1.3 Specimen photographs

Photographs of the specimens prior to and after testing are presented in the Appendix of this report.



(a) 18-1-SA-1

(b) 18-8-SA-1

Figure 2: Measured stress-strain curves.

Appendices

Specimen sheets

- 18-1-SA-1
- 18-8-SA-1

GEOMECHANICA

Uniaxial Compression Test

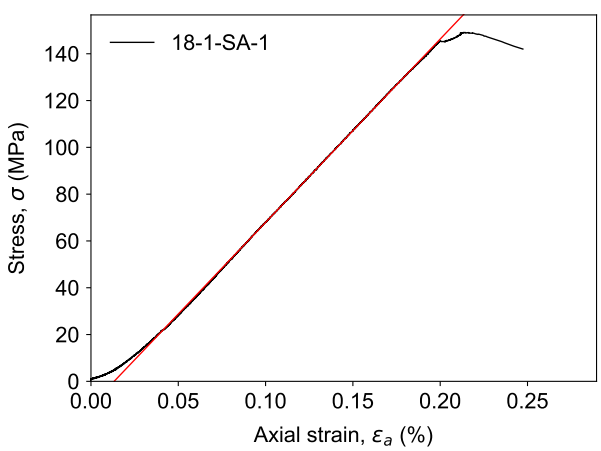
Client	Golder Associates Ltd.	**Project**	1895756
Sample	18-1-SA-1	**Depth**	3.79 - 3.93

Specimen parameters	
Diameter (mm) [a]	47.10
Length (mm) [a]	98.04
Bulk density ρ (g/cm^3)	2.877
UCS (MPa)	149.1
Young's modulus E (GPa) [b]	78.3
Lithology	Biotite-hornblende gneiss
Failure description [c]	1

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 50.0% of the peak strength.
[c] Failure description: [1] Inclined shear failure;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2018-12-14

GEOMECHANICA

Uniaxial Compression Test

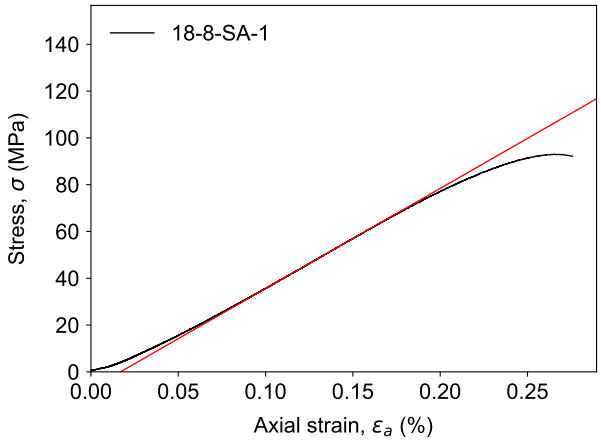
Client	Golder Associates Ltd.	**Project**	1895756
Sample	18-8-SA-1	**Depth**	5.76 - 5.99

Specimen parameters	
Diameter (mm) [a]	63.15
Length (mm) [a]	128.82
Bulk density ρ (g/cm^3)	2.794
UCS (MPa)	93.0
Young's modulus E (GPa) [b]	42.8
Lithology	Biotite-hornblende gneiss
Failure description [c]	2

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 50.0% of the peak strength.
[c] Failure description: [2] Partial hourglass failure;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2018-12-14

APPENDIX E

Analytical Laboratory Test Results

Maxxam
A Bureau Veritas Group Company

Your Project #: 1413191-1150
Site Location: EEL'S CREEK
Your C.O.C. #: na

Attention:Kevin Bentley

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2017/08/23
Report #: R4671474
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B7H5074
Received: 2017/08/15, 14:16

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	2	N/A	2017/08/21	CAM SOP-00463	EPA 325.2 m
Conductivity	2	N/A	2017/08/21	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	2	2017/08/18	2017/08/18	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2017/08/15	2017/08/21	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	2	N/A	2017/08/21	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Your Project #: 1413191-1150
Site Location: EEL'S CREEK
Your C.O.C. #: na

Attention:Kevin Bentley

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2017/08/23
Report #: R4671474
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B7H5074
Received: 2017/08/15, 14:16

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829
==========
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B7H5074
Report Date: 2017/08/23

Golder Associates Ltd
Client Project #: 1413191-1150
Site Location: EEL'S CREEK
Sampler Initials: DG

RESULTS OF ANALYSES OF SOIL

Maxxam ID		EYD320	EYD321		
Sampling Date		2016/12/10	2017/06/21		
COC Number		na	na		
	UNITS	**BH16-1**	**BH17-7**	**RDL**	**QC Batch**
Calculated Parameters					
Resistivity	ohm-cm	3200	1600		5119234
Inorganics					
Soluble (20:1) Chloride (Cl)	ug/g	45	250	20	5127419
Conductivity	umho/cm	312	621	2	5127604
Available (CaCl2) pH	pH	5.85	7.72		5124333
Soluble (20:1) Sulphate (SO4)	ug/g	200	140	20	5127430

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B7H5074
Report Date: 2017/08/23

Golder Associates Ltd
Client Project #: 1413191-1150
Site Location: EEL'S CREEK
Sampler Initials: DG

TEST SUMMARY

Maxxam ID: EYD320
Sample ID: BH16-1
Matrix: Soil

Collected: 2016/12/10
Shipped:
Received: 2017/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5127419	N/A	2017/08/21	Deonarine Ramnarine
Conductivity	AT	5127604	N/A	2017/08/21	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5124333	2017/08/18	2017/08/18	Tahir Anwar
Resistivity of Soil		5119234	2017/08/21	2017/08/21	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5127430	N/A	2017/08/21	Deonarine Ramnarine

Maxxam ID: EYD321
Sample ID: BH17-7
Matrix: Soil

Collected: 2017/06/21
Shipped:
Received: 2017/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5127419	N/A	2017/08/21	Deonarine Ramnarine
Conductivity	AT	5127604	N/A	2017/08/21	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5124333	2017/08/18	2017/08/18	Tahir Anwar
Resistivity of Soil		5119234	2017/08/21	2017/08/21	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5127430	N/A	2017/08/21	Deonarine Ramnarine

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B7H5074
Report Date: 2017/08/23

Golder Associates Ltd
Client Project #: 1413191-1150
Site Location: EEL'S CREEK
Sampler Initials: DG

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	3.3°C

Revised report (2017/08/23): Sample ID updated as requested.

Sample EYD320 [BH16-1] : Sample submitted and analyzed past the recommended hold time as per client consent.

Results relate only to the items tested.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B7H5074
Report Date: 2017/08/23

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1413191-1150
Site Location: EEL'S CREEK
Sampler Initials: DG

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5124333	Available (CaCl2) pH	2017/08/18			99	97 - 103			0.99	N/A
5127419	Soluble (20:1) Chloride (Cl)	2017/08/21	111	70 - 130	103	70 - 130	<20	ug/g	NC	35
5127430	Soluble (20:1) Sulphate (SO4)	2017/08/21	124	70 - 130	109	70 - 130	<20	ug/g	NC	35
5127604	Conductivity	2017/08/21			100	90 - 110	<2	umho/cm	1.5	10

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B7H5074
Report Date: 2017/08/23

Golder Associates Ltd
Client Project #: 1413191-1150
Site Location: EEL'S CREEK
Sampler Initials: DG

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/2

CHAIN OF CUSTODY RECORD 76787

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required
Company Name:	Golder Associates Ltd.	Company Name:		Quotation #:		[X] Regular TAT (5-7 days) Most analyses
Contact Name:	Kevin Bentley	Contact Name:		P.O. #/ AFE#:		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address:	6925 Century Ave. Suite #100, Mississauga ON	Address:		Project #:	1413191-1150	Rush TAT (Surcharges will be applied)
				Site Location:	Eel's Creek	[ ] 1 Day [ ] 2 Days [ ] 3-4 Days
Phone	(905) 567 4444 Fax: (905) 567 6561	Phone:	Fax:	Site #:		
Email:	kevin_Bentley@golder.com	Email:		Sampled By:	DG and BC	Date Required:

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Rush Confirmation #:

Regulation 153	Other Regulations
[ ] Table 1 [ ] Res/Park [ ] Med/ Fine	[ ] CCME [ ] Sanitary Sewer Bylaw
[ ] Table 2 [ ] Ind/Comm [ ] Coarse	[ ] MISA [ ] Storm Sewer Bylaw
[ ] Table 3 [x] Agri/ Other	[ ] PWQO Region
[ ] Table ____	[ ] Other (Specify)
FOR RSC (PLEASE CIRCLE) Y / N	[ ] REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

Analysis Requested

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS (REFER TO BACK OF COC)	REG 153 ICPMS METALS (REFER TO BACK OF COC)	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B) (REFER TO BACK OF COC)	Corrosivity							HOLD- DO NOT ANALYZE
1	BH16-1	2016/12/10	—	Soil	1								X							
2	BH16-5/6	~~2017/21~~	—		1															
3		2017/06/21		Soil	1								X							
4																				
5																				
6																				
7																				
8																				
9																				
10																				

LABORATORY USE ONLY

CUSTODY SEAL Y / N		COOLER TEMPERATURES
Present	Intact	
		4.1 / 3

COOLING MEDIA PRESENT: (Y) / N TS

COMMENTS 2017/08/15

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
Katie Nen.	2017/08/15	2:15 PM	Tawnia Tawnisam	2017/08/15	14:16

15-Aug-17 14:16
Ema Gitej
B7H5074
MNI ENV-871

COC-1004 (10/14) - ENV. ENG.

White: Maxxam - Yellow: Client

GOLDER

golder.com