REPORT

**February 26, 2018**

# FOUNDATION INVESTIGATION REPORT

## Temporary Protection System for Culvert STA 11+622, Highway 11, Blythe Township North Bay, Ontario GWP 5186-14-00

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**Geocres No.:** 31L-209

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# PART A

## FOUNDATION INVESTIGATION REPORT
## TEMPORARY PROTECTION SYSTEM FOR CULVERT
## STA 11+622, HIGHWAY 11, BLYTHE TOWNSHIP
## NORTH BAY, ONTARIO
## GWP 5186-14-00

**February 26, 2018**
**Report No.** 1671122.2000-R5

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# 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morison Hershfield Ltd. (MH), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering data for the contractor's design of temporary protection systems required for the replacement of the non-structural culvert located at STA 11+622 on Highway 11 in Blythe Township north of North Bay. The key plan showing the general location of this section of Highway 11 and the location of the investigated area and boreholes are shown on Drawing 1.

# 2.0 SITE DESCRIPTION

The existing culvert at STA 11+622 on Highway 11 consists of a single, 910 mm by 910 mm non-rigid frame box (NRFB) with 1200 mm diameter corrugated steel pipe (CSP) extensions. The invert of this culvert is at approximately Elevation 356.5 m.

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is referenced to project north and therefore may differ from magnetic north shown on the drawing. For the purpose of this report, Highway 11 is oriented in a north-south direction (for this section of roadway) with the culvert perpendicular to the highway in a west-east orientation.

In general, the topography in the area of the culvert is relatively flat with moderate to dense tree cover along the highway right-of-way. At the culvert location, the highway grade is at Elevation 360.4 m. The highway embankment appears to be approximately 3 m to 4 m in height, relative to the surrounding natural ground surface.

# 3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on August 23 and 24, 2017, during which time two boreholes (Boreholes 17-12 and 17-13) were advanced at the locations shown on Drawing 1.

Boreholes 17-12 and 17-13 were advanced through the roadway embankment, down chainage and up chainage of the culvert, respectively. Both boreholes were advanced using an ATV-mounted CME 550 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. All boreholes were advanced using NW casing with wash boring techniques, and NQ coring, as required.

Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures[1]. NQ rock coring was carried out in each of the boreholes, to penetrate cobbles/boulders encountered within the overburden and to core the bedrock. The groundwater level in the open boreholes was observed during the drilling operations as described on the borehole records in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 (Wells, as amended).

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, arranged for the clearance of underground services, supervised the drilling and sampling operations, logged the boreholes, and examined and took custody of the soil samples and rock core. The soil and rock core samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Mississauga for further examination and laboratory testing. Index and classification testing consisting of water content determinations and grain size distributions were carried out on selected soil

[1] ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

samples. The geotechnical laboratory testing was completed according to MTO LS standards. Unconfined compressive strength tests were carried out on selected bedrock samples.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by members of Golder's technical staff, referenced to the highway centreline and the existing culvert and converted into northing/easting coordinates on the plan drawing. The ground surface elevation of the highway centreline was obtained from the profile drawing provided by MH (Drawing B0351144001.dwg). The MTM NAD83 Zone 10 northing and easting coordinates and geographical coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the borehole records in Appendix A and summarized below.

| Borehole Number | MTM NAD83 Northing (Latitude) | MTM NAD83 Easting (Longitude) | Ground Surface Elevation (m) | Borehole Depth (m), including Rock Coring (Base Elevation, m) |
|---|---|---|---|---|
| 17-12 | 5151637.2 (46.504392) | 303091.3 (-79.522263) | 360.3 | 8.0 (352.3) |
| 17-13 | 5151650.1 (46.504507) | 303078.7 (-79.522427) | 360.5 | 9.2 (351.3) |

# 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

## 4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Mapping (NOEGTS)[2] mapping, the culvert site is located within an outwash plain deposit consisting primarily of sand and gravel soils, bordered by bedrock knobs. The area is generally described as undulating to rolling.

Based on geological mapping by the Ontario Ministry of Northern Development and Mines (Map 2543)[3], the site is underlain by strong bedrock consisting of layered biotite gneisses and migmatites, locally including quartzofeldsparic gneisses, orthogneisses and paragneisses.

## 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records contained in Appendix A. The detailed results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values) as presented on the borehole records and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (sand to sand and gravel) underlain by a native deposit of sand to gravelly sand to silt and sand, containing cobbles and boulders.

[2] Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52KSW.

[3] Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543.

Gneiss bedrock was encountered below the native deposits. A more detailed description of the soil deposits, bedrock, and groundwater conditions encountered in the boreholes is provided below.

### 4.2.1 Asphalt

An approximately 150 mm to 200 mm thick layer of asphalt was encountered at the surface in Boreholes 17-13 and 17-12, respectively, as advanced through Highway 11.

### 4.2.2 Fill

A layer of fill described as sand to sand and gravel was encountered below the asphalt in Boreholes 17-12 and 17-13 and extended to depths of 2.9 m and 3.7 m. The thickness of this layer in Boreholes 17-12 and 17-13 is 2.7 m to 3.5 m, with the base of the fill at Elevation 357.4 m and 356.8 m, respectively.

In general, the SPT 'N'-values measured in the upper approximately 2 m to 3 m of the fill are between 32 blows and 78 blows per 0.3 m of penetration indicating a dense to very dense relative density, while the lowermost 'N'-values within the fill and above the native deposits are 6 blows and 8 blows per 0.3 m of penetration, indicating a loose relative density. One SPT 'N'-value measured within the upper portion of the fill is 100 blows per 0.1 m of penetration which could be indicative of the presence of gravel, cobble(s) or an obstruction.

The results of grain size distribution tests carried out on two samples of this fill are shown on Figure B1 and Figure B2 in Appendix B. The natural water contents measured on samples of this fill range between about 6 per cent and 9 per cent.

### 4.2.3 Sand/Gravelly Sand to Silt and Sand Containing Cobbles and Boulders

A non-cohesive deposit was encountered below the fill in Boreholes 17-12 and 17-13 at Elevations of 357.4 m and 356.8 m, respectively. The deposit varies in composition from sand, some gravel to gravelly, trace to some silt, trace clay, trace organics, to silt and sand, trace gravel, trace clay. The deposit extends to depths of 4.8 m and 6.2 m below ground surface in Boreholes 17-12 and 17-13, respectively. Two cobbles and a boulder were cored through and recovered from this deposit, with cored lengths ranging from approximately 200 mm to 540 mm. The thickness of the deposit in Boreholes 17-12 and 17-13 is about 1.9 m and 2.5 m, respectively. This granular deposit immediately overlies the bedrock in both boreholes.

The SPT 'N'-values vary from 11 blows to 39 blows per 0.3 m of penetration, indicating a compact to dense relative density. One SPT 'N'-value of 100 blows for 0.05 m of penetration was measured in both boreholes at the interface of this deposit and the bedrock; however, these values are not considered representative of the relative density of the deposit.

The results of grain size distribution tests carried out on one sample of the sand deposit and one sample of the silt and sand deposit are shown on Figures B3 and B4 in Appendix B. The natural water contents range between about 10 per cent and 18 per cent, with one sample containing trace organics measuring a water content of about 96 per cent. An organic content test carried out on one sample of this deposit indicated an organic content of about 4 per cent.

### 4.2.4 Bedrock

Bedrock was encountered below the sand/gravelly sand to silt and sand deposit in both boreholes. The approximate depths to top of bedrock below ground surface and corresponding top of bedrock surface elevations are summarized below and are shown on Drawing 2 and on the borehole records in Appendix A.

| Location | Borehole Designation | Approximate Depth to Bedrock Surface (m) | Approximate Bedrock Surface Elevation (m) | Remarks |
|---|---|---|---|---|
| 10 m S of culvert centreline | 17-12 | 4.8 | 355.5 | Cored (3.2 m length) |
| 10 m N of culvert centreline | 17-13 | 6.2 | 354.3 | Cored (3.0 m length) |

Based on review of the bedrock core samples, the bedrock consists predominantly of gneiss and is generally described as fresh, foliated, pink and black, medium-grained and non-porous. The bedrock details are presented on the drillhole records found in Appendix A. Bedrock core photographs are shown in Appendix B.

The Total Core Recovery (TCR) measured on the recovered rock core samples ranges between 95 per cent and 100 per cent, and the Solid Core Recovery (SCR) ranges between 74 per cent and 88 per cent. The Rock Quality Designation (RQD) measured on the rock core samples ranges from about 71 per cent to 95 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of CFEM (2006)[4].

Two unconfined compressive strength (UCS) tests (ASTM D7012)[5] were carried out on selected samples of the gneiss recovered from Boreholes 17-12 and 17-13. The UCS test results are summarized below.

| Location | Borehole Designation | Sample Depth (m) (Elevation, m) | UCS (MPa) | Unit Weight (kN/m$^3$) |
|---|---|---|---|---|
| 10 m S of culvert centreline | 17-12 | 5.06 – 5.17 (355.44 – 355.33) | 72.0 | 25.6 |
| 10 m N of culvert centreline | 17-13 | 6.86 – 7.06 (353.44 - 353.24) | 79.4 | 25.7 |

The test results are also shown on the drillhole records in Appendix A and provided in Appendix B. Based on the laboratory UCS tests and in accordance with Table 3.5 of CFEM (2006), the gneiss bedrock is classified as strong.

## 4.3 Groundwater Conditions

The water levels were observed inside the casing of Boreholes 17-12 and 17-13 upon completion of wash boring and prior to bedrock coring. The measured depths range from 3.4 m to 3.0 m below ground surface, corresponding to between Elevations 357.1 m and 357.3 m, respectively. These water levels, as noted on the borehole records,

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

[5] Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

may not represent the longer-term, stabilized groundwater level at the site due to the addition of water to the boreholes for wash boring and coring.

The groundwater levels are subject to seasonal fluctuations and precipitation events, and are expected to be higher during wet seasons and sustained periods of precipitation.

# 5.0 CLOSURE

The field work for this investigation was supervised by Mr. Michael Bentley, B.A.Sc. This Foundation Investigation Report was prepared by Ms. Alysha Kobylinski, B.A.Sc. with input from Mr. David Marmor E.I.T. and reviewed by Ms. Sarah Poot, P.Eng., a geotechnical engineer and Associate at Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact for Golder, conducted an independent quality control review of the report.

# Report Signature Page

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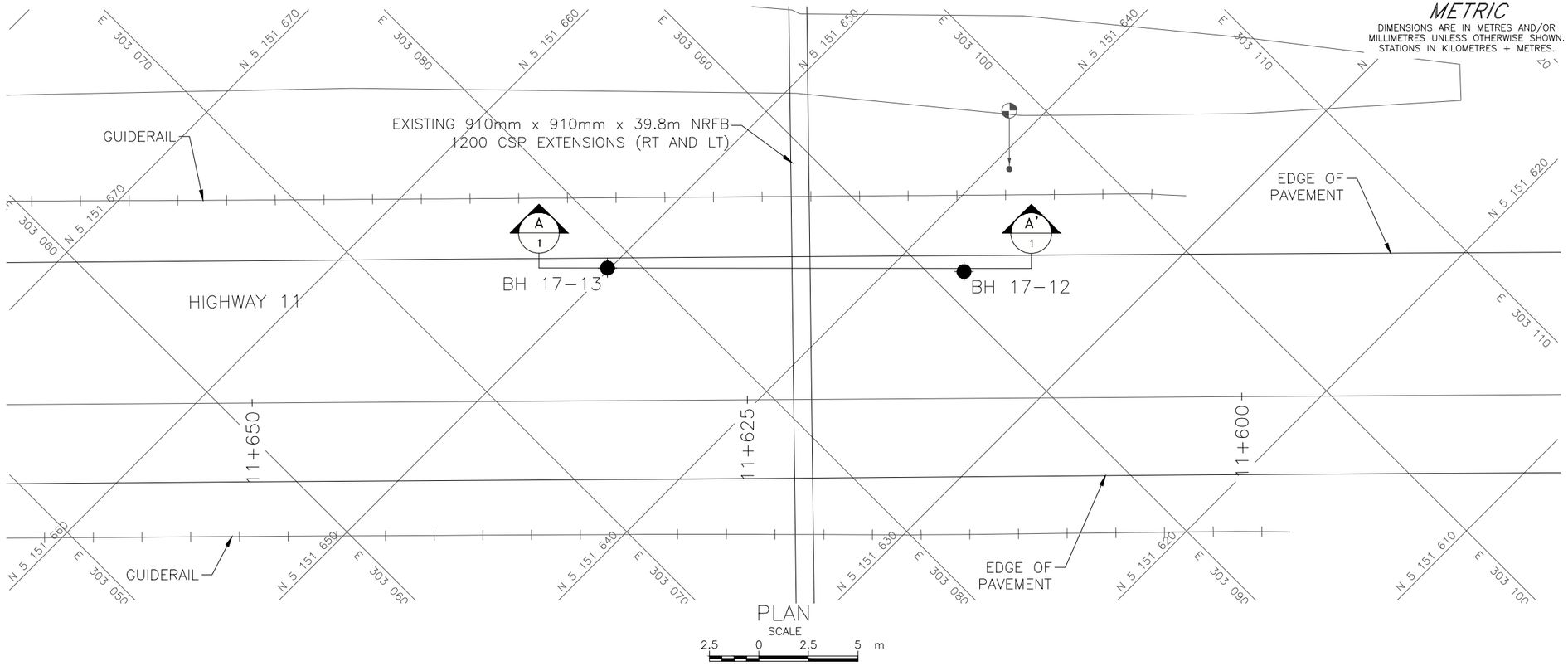
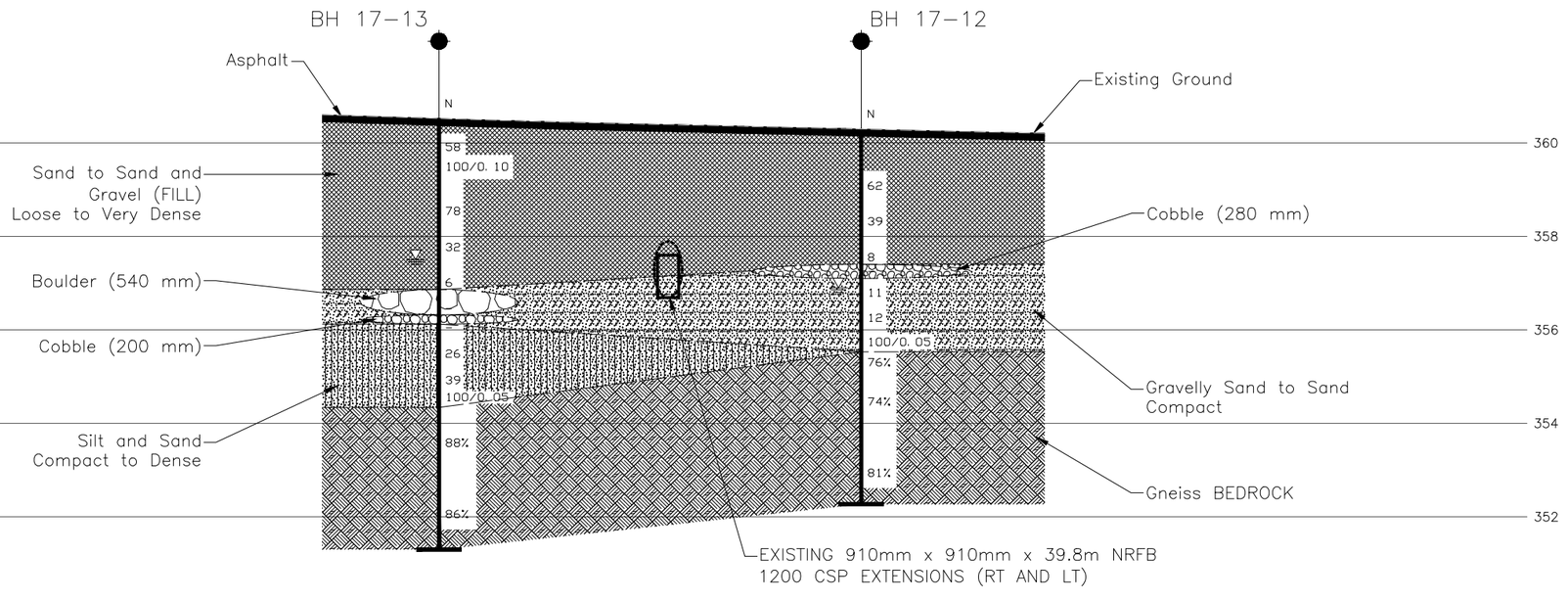
https://golderassociates.sharepoint.com/sites/14855g/deliverables/003 foundations/reporting/final/r5 - temporary protection system/fir/1671122_final hwy 11 tempprotection fir_feb 26 2018.docx

MINISTRY OF TRANSPORTATION, ONTARIO




A-A' / 1 CROSS-SECTION A-A'
TEMPORARY PROTECTION SYSTEM

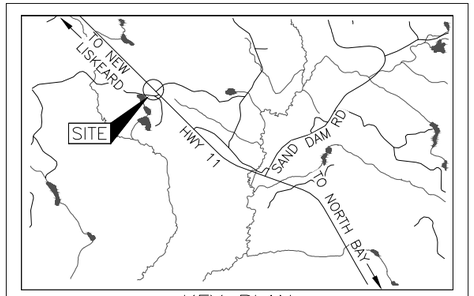
HORIZONTAL SCALE 2.5 0 2.5 5 m
VERTICAL SCALE 1.25 0 1.25 2.5 m

CONT No.
GWP No. 5186-14-00

HIGHWAY 11
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates




## LEGEND

- Borehole – 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 measured in open borehole upon completion of drilling

| BOREHOLE CO-ORDINATES | | | |
|---|---|---|---|
| No. | ELEVATION | NORTHING | EASTING |
| BH 17-12 | 360.3 | 5151637.2 | 303091.3 |
| BH 17-13 | 360.5 | 5151650.1 | 303078.7 |

## 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 Morrison Hershfield, drawing file no. WP51871400SA.dwg, received SEPT. 15, 2017.

LICENSED PROFESSIONAL ENGINEER S.E.M. POOT 90471921 Feb. 26, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER L.L.C. COYNER Feb. 26, 2018 PROVINCE OF ONTARIO

| NO. | DATE | BY | REVISION |
|---|---|---|---|
| . | . | . | . |

Geocres No. 31L-209

| | | | |
|---|---|---|---|
| HWY. 11 | | PROJECT NO. 1671122 | DIST. NORTHEAST |
| SUBM'D. DPM | CHKD. DPM | DATE: 2/26/2018 | SITE: . |
| DRAWN: JM | CHKD. SEMP | APPD. LCC | DWG. 1 |

PLOT DATE: February 26, 2018
FILENAME: N:\Active\Sudbi...\MTO\Hwy11\99_PROJ\1671122_Mtl_AlgonquinAveFoundations\40_PROD\0005_Culvertinstall\1671122-0005-BS-0001.dwg

# APPENDIX A

## Record of Boreholes

# LIST OF SYMBOLS

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

## I. GENERAL

| | |
|---|---|
| $\pi$ | 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

| | |
|---|---|
| $\gamma$ | shear strain |
| $\Delta$ | change in, e.g. in stress: $\Delta\sigma$ |
| $\varepsilon$ | linear strain |
| $\varepsilon_v$ | volumetric strain |
| $\eta$ | coefficient of viscosity |
| $\upsilon$ | Poisson's ratio |
| $\sigma$ | total stress |
| $\sigma'$ | effective stress ($\sigma' = \sigma - u$) |
| $\sigma'_{vo}$ | initial effective overburden stress |
| $\sigma_1, \sigma_2, \sigma_3$ | principal stress (major, intermediate, minor) |
| $\sigma_{oct}$ | mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$ |
| $\tau$ | 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 |
| $\gamma'$ | 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 $\rho$. Unit weight symbol is $\gamma$ 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 |
| $C_\alpha$ | 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 |
| $\sigma'_p$ | pre-consolidation stress |
| OCR | over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$ |

### (d) Shear Strength

| | |
|---|---|
| $\tau_p, \tau_r$ | peak and residual shear strength |
| $\phi'$ | effective angle of internal friction |
| $\delta$ | angle of interface friction |
| $\mu$ | 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**

| Density Index / Relative Density | 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) |
| $\gamma$ | 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 With (cohesive) | Sand and Gravel / Silty Clay with sand / Clayey Silt with sand |

# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## 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 $90^{o}$ 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
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

Golder Associates

# RECORD OF BOREHOLE No 17-12

SHEET 1 OF 1 **METRIC**

PROJECT 1671122
G.W.P. 5186-14-00
LOCATION N 5151637.2; E 303091.3 MTM ZONE 10 (LAT. 46.504392; LONG. -79.522263)
ORIGINATED BY MB
DIST Northeast HWY 11
BOREHOLE TYPE Wash Boring, NQ Coring
COMPILED BY ZS
DATUM Geodetic
DATE August 23, 2017
CHECKED BY AK

| ELEV / DEPTH | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 360.3 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | ASPHALT (200 mm) | | | | | | | | | | |
| 0.2 | Sand to gravelly sand, some silt (FILL) Loose to very dense Brown Moist to wet | | 1 | SS | 62 | | 360 | | | | 11 76 (13) |
| | | | 2 | SS | 39 | | 359 | | | | |
| | | | 3 | SS | 8 | | 358 | | | | |
| 357.4 | | | | | | | | | | | |
| 357.1 | COBBLE (280 mm) | | - | RC | - | | | | | | |
| 356.8 | SAND, some gravel, trace silt, trace clay, trace organics | | 4 | SS | 11 | ▽ | 357 | | | 96 | |
| 3.5 | Compact Black Wet | | 5 | SS | 12 | | | | | | OC = 4.1% 10 81 5 4 |
| | Gravelly SAND to SAND, some silt, trace organics Compact | | | | | | 356 | | | | |
| 355.5 | Black to brown | | 6 | SS | 100/0.05 | | | | | | |
| 4.8 | Wet | | 1 | RC | REC 95% | | | | | | RQD = 71% |
| | Gneiss (BEDROCK) Bedrock cored from depths of 4.8 m to 8.0 m For bedrock coring details refer to Record of Drillhole 17-12. | | 2 | RC | REC 100% | | 355 | | | | RQD = 74% |
| | | | 3 | RC | REC 100% | | 354 | | | | RQD = 84% |
| 352.3 | | | | | | | 353 | | | | |
| 8.0 | END OF BOREHOLE | | | | | | | | | | |

Notes:

1. "N" Value for sample "SS6" not representative of relative density due to spoon bouncing on bedrock surface.

2. Water level in open borehole after wash boring and prior to rock coring at a depth of 3.4 m below ground surface (Elev. 356.9 m).

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1671122

# RECORD OF DRILLHOLE: 17-12

SHEET 1 OF 1

LOCATION: N 5151637.2 ;E 303091.3

DRILLING DATE: August 23, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: NQ Coring

DRILLING CONTRACTOR: Landcore

**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 | HYDRAULIC CONDUCTIVITY K, cm/sec | WEATHERING INDEX | FEATURES | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Refer to previous page | | 355.53 | | | | | | | | | | | | | | |
| 5 | Rotary Drill / NQ Core | Gneiss<br>Fresh<br>Foliated<br>Pink and black<br>Medium grained<br>Non-porous<br>Strong | | 4.77 | 1 | | | | | | | FR,PL,RO | | | | | | UCS = 72.0 MPa |
| | | | | | | | | | | | | FR,ST,RO | | | | | | |
| | | | | | 2 | | | | | | | FO,PL,RO<br>JN,PL,RO<br>FO,IR,RO | | | | | | |
| 6 | | | | | | | | | | | | JN,UN,RO<br>FO,PL,RO<br>FR,IR,RO<br>FO,PL,SM | | | | | | |
| | | | | | | | | | | | | FR,IR,RO | | | | | | |
| 7 | | | | | | | | | | | | FO,PL,RO | | | | | | |
| | | | | | 3 | | | | | | | FO,PL,RO<br>JN,PL,RO | | | | | Broken core | |
| | | | | | | | | | | | | JN,PL,RO<br>JN,IR,RO | | | | | | |
| 8 | | | | 352.27 | | | | | | | | FO,PL,RO<br>FO,PL,RO | | | | | | |
| | | END OF DRILLHOLE | | 8.03 | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | |

DEPTH SCALE
1 : 50

LOGGED: MB
CHECKED: AK

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY11\02_DATA\GINT\1671122\1671122.GPJ GAL-MISS.GDT 12/14/17 ZS

Golder Associates

# RECORD OF BOREHOLE No 17-13

SHEET 1 OF 1

**METRIC**

PROJECT 1671122

G.W.P. 5186-14-00 LOCATION N 5151650.1; E 303078.7 MTM ZONE 10 (LAT. 46.504507; LONG. -79.522427) ORIGINATED BY MB

DIST Northeast HWY 11 BOREHOLE TYPE Wash Boring, NQ Coring COMPILED BY ZS

DATUM Geodetic DATE August 24, 2017 CHECKED BY AK

| 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 $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 360.5 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | ASPHALT (150 mm) | | | | | | | | | | |
| 0.2 | Sand to sand and gravel, some fines (FILL)<br>Loose to very dense<br>Brown to brown mottled black<br>Moist to wet | | 1 | SS | 58 | | 360 | | ○ | | |
| | | | 2 | SS | 100/0.10 | | | | | | |
| | | | 3 | SS | 78 | | 359 | | ○ | | 40 50 9 1 |
| | | | 4 | SS | 32 | ▽ | 358 | | ○ | | |
| 356.8 | | | 5 | SS | 6 | | 357 | | | | |
| 3.7 | BOULDER (540 mm) | | - | RC | - | | | | | | |
| 356.3 | COBBLE (200 mm) | | - | RC | - | | | | | | |
| 4.4 | SILT and SAND, trace gravel, trace clay<br>Compact to dense<br>Grey<br>Wet | | 6 | SS | 26 | | 356 | | ○ | | |
| | | | 7 | SS | 39 | | 355 | | ○ | | 5 39 54 2 |
| 354.3 | | | 8 | SS | 100/0.05 | | | | | | |
| 6.2 | Gneiss (BEDROCK)<br><br>Bedrock cored from depths of 6.2 m to 9.2 m<br><br>For bedrock coring details refer to Record of Drillhole 17-13. | | 1 | RC | REC 98% | | 354 | | | | RQD = 89% |
| | | | 2 | RC | REC 100% | | 353 | | | | RQD = 95% |
| 351.3 | | | | | | | 352 | | | | |
| 9.2 | END OF BOREHOLE<br><br>Notes:<br><br>1. "N" Value for sample "SS8" not representative of relative density due to spoon bouncing on bedrock surface.<br><br>2. Water level in open borehole after wash boring and prior to rock coring at a depth of 3.0 m below ground surface (Elev. 357.5 m). | | | | | | | | | | |

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1671122

# RECORD OF DRILLHOLE: 17-13

SHEET 1 OF 1

LOCATION: N 5151650.1 ;E 303078.7

DRILLING DATE: August 24, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: NQ Coring

DRILLING CONTRACTOR: Landcore

**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 | HYDRAULIC CONDUCTIVITY K, cm/sec | WEATHERING INDEX | FEATURES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Refer to previous page | | 354.35 | | | | | | | | | | | | | |
| 7 | Rotary Drill / NQ Core | Gneiss<br>Fresh<br>Foliated<br>Pink and black<br>Medium grained<br>Non-porous<br>Strong | | 6.17 | 1 | | | | | | | FR,PL,RO<br>FR,IR,RO<br>FO,PL,RO<br>FO,PL,RO<br>FO,PL,RO | | | | | Lost core<br>UCS = 79.4 MPa |
| 8 | | | | | 2 | | | | | | | FO,PL,RO<br>FR,PL,SM<br>FR,ST,SM | | | | | |
| 9 | | | | 351.30 | | | | | | | | | | | | | |
| | | END OF DRILLHOLE | | 9.22 | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | |

DEPTH SCALE
1 : 50

LOGGED: MB
CHECKED: AK

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GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY11\02_DATA\GINT\1671122\1671122.GPJ GAL-MISS.GDT 12/8/17 ZS

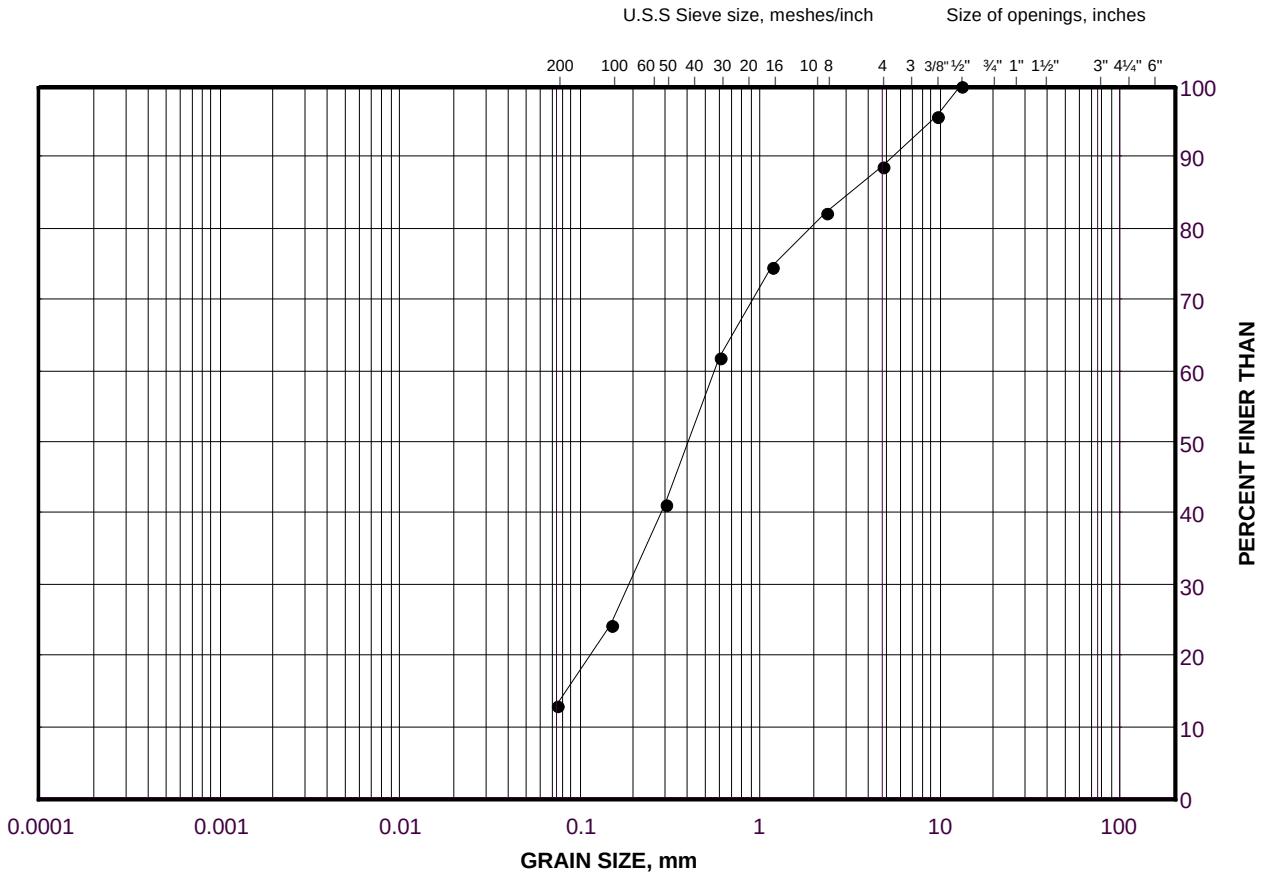
# APPENDIX B

## Laboratory Test Results

# GRAIN SIZE DISTRIBUTION

SAND (FILL)

FIGURE B1




**LEGEND**

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 17-12 | 1 | 359.50 - 358.90 |

Project Number: 1671122 2000/2300

Checked By: JN

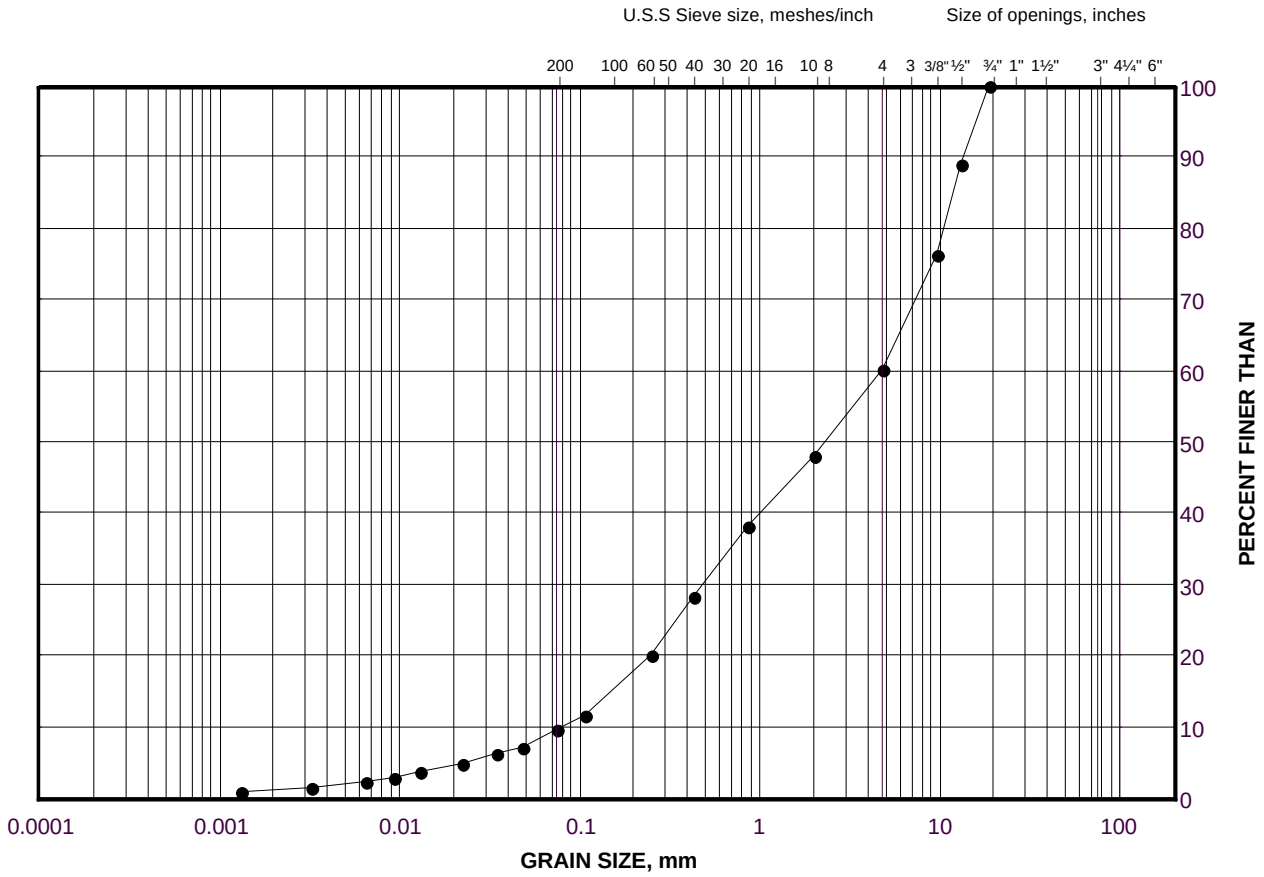
**Golder Associates**

Date: 30-Nov-17

# GRAIN SIZE DISTRIBUTION

SAND and GRAVEL (FILL)

FIGURE B2




**LEGEND**

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 17-13 | 3 | 359.00 - 358.40 |

Project Number: 1671122 2000/2300

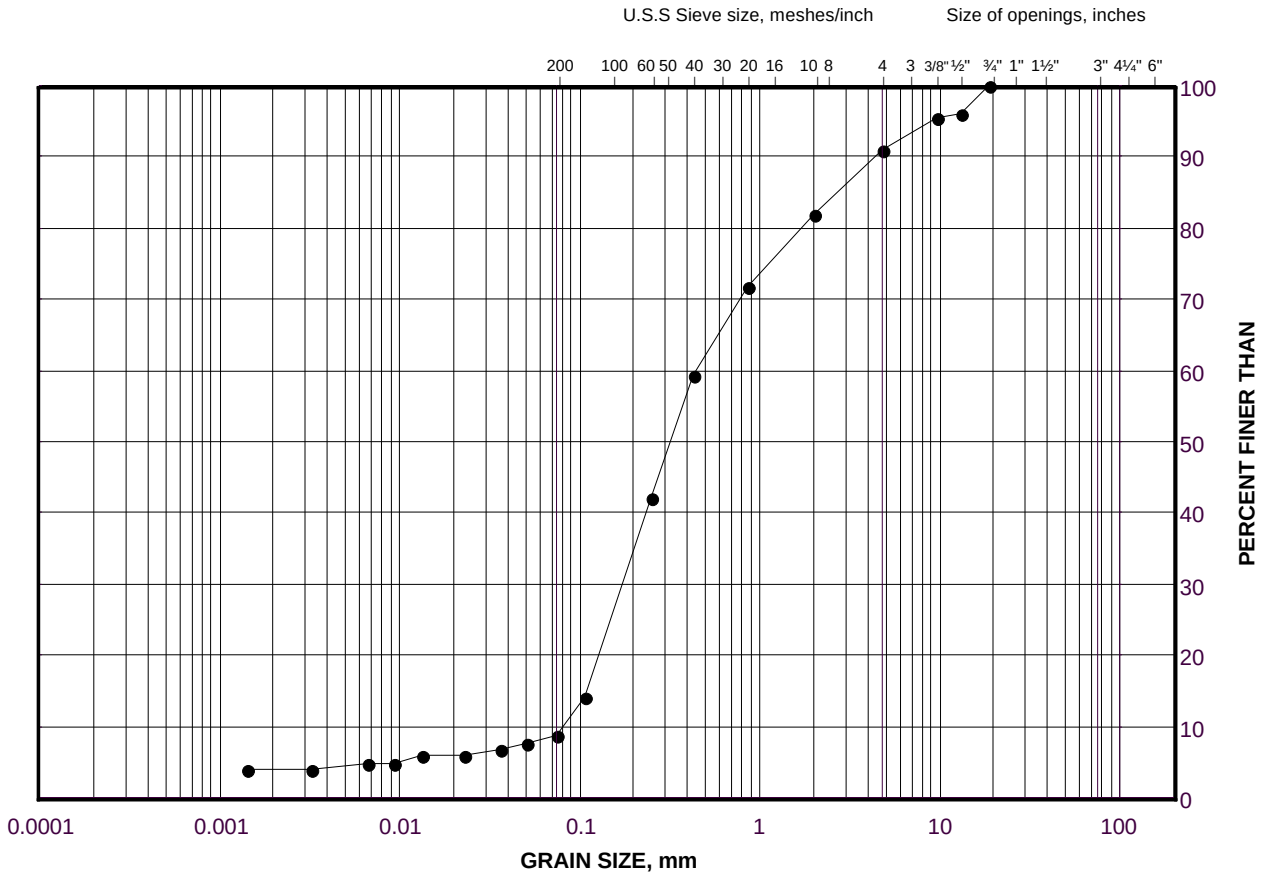
Checked By: JN

**Golder Associates**

Date: 30-Nov-17

# GRAIN SIZE DISTRIBUTION
SAND

FIGURE B3




## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 17-12 | 5 | 356.50 - 355.90 |

Project Number: 1671122 2000/2300

Checked By: JN

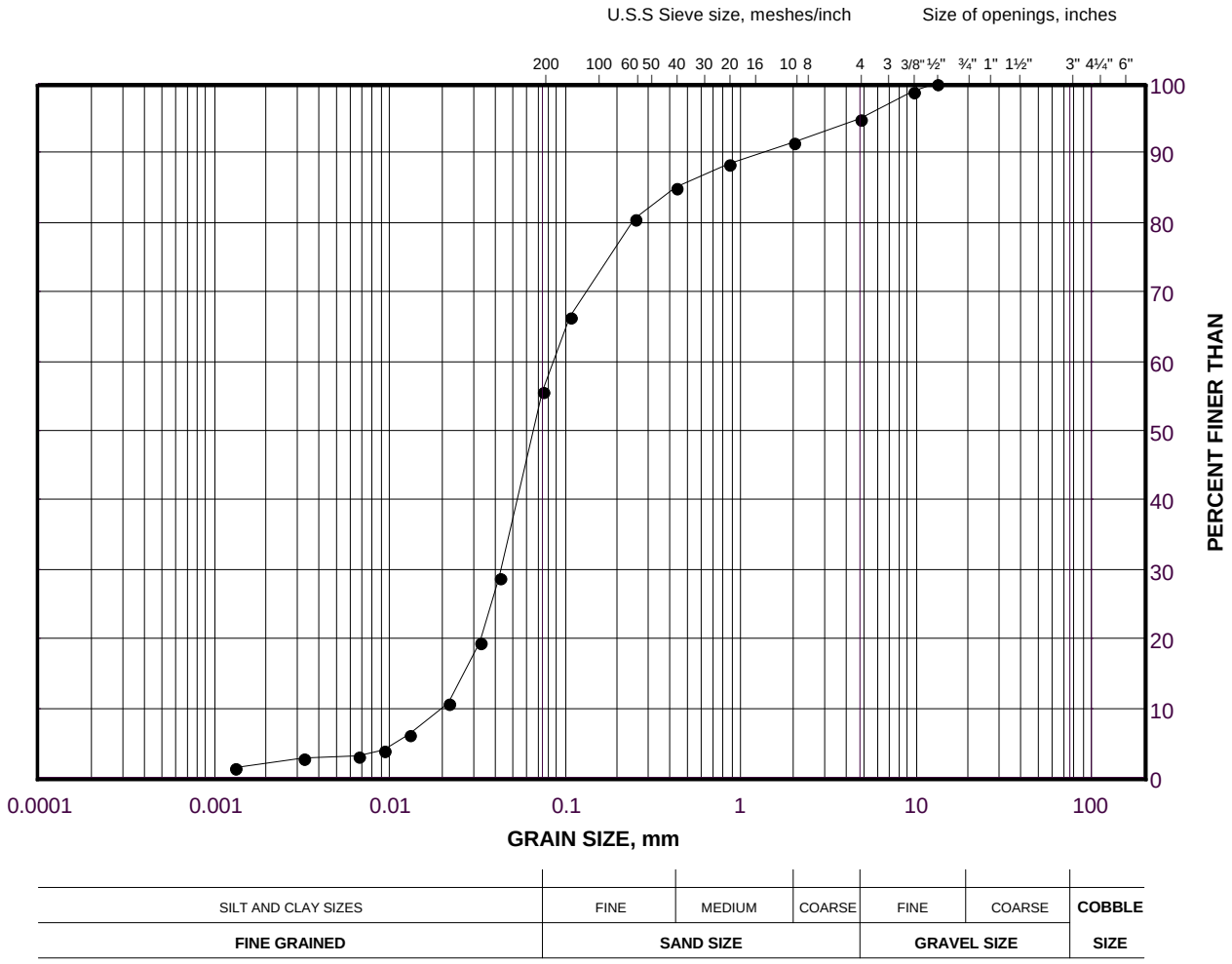
**Golder Associates**

Date: 30-Nov-17

# GRAIN SIZE DISTRIBUTION

SILT and SAND

FIGURE B4




**LEGEND**

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 17-13 | 7 | 355.20 - 354.60 |

Project Number: 1671122 2000/2300

Checked By: JN

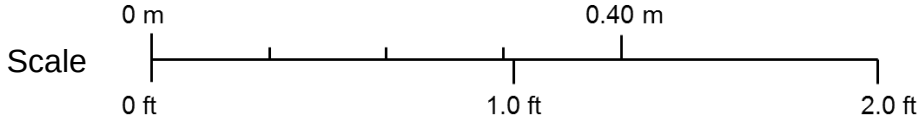
**Golder Associates**

Date: 30-Nov-17

# APPENDIX C

## Bedrock Core Photographs

Box 1: 4.8 m to 8.0 m




PROJECT

**MTO / 5016-E-0031**
**Highway 11**

TITLE

**Bedrock Core Photographs**
**Borehole 17-12 6.2 m to 8.0 m**

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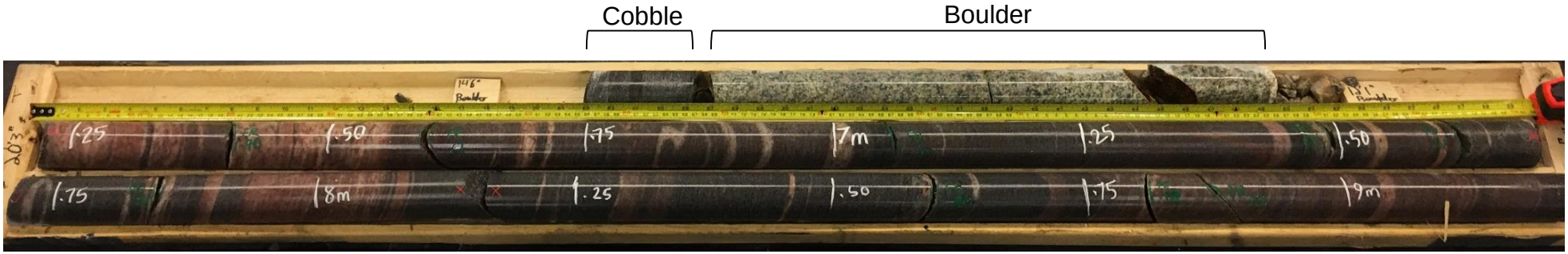
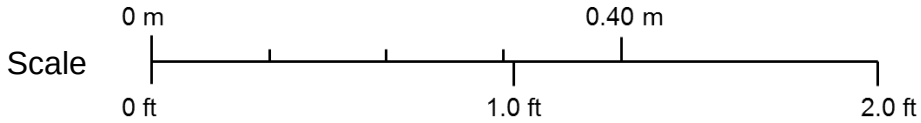
| | | | | | |
|---|---|---|---|---|---|
| PROJECT No. 1671122 | | | FILE No. ---- | | |
| DESIGN | DJ | 20170913 | SCALE | NTS | VER. 1. |
| CADD | -- | | **FIGURE C1** | | |
| CHECK | ACK | 20180226 | | | |
| REVIEW | DPM | 20180226 | | | |

REVISION DATE: December 5, 2017 BY: AK Project: 1671122




Box 1: 4.4 m to 9.2 m




PROJECT

**MTO / 5016-E-0031**
**Highway 11**

TITLE

**Bedrock Core Photographs**
**Borehole 17-13 4.4 m to 9.2 m**

Golder Associates

| | | | | | |
|---|---|---|---|---|---|
| PROJECT No. 1671122 | | | FILE No. ---- | | |
| DESIGN | DJ | 20170913 | SCALE | NTS | VER. 1. |
| CADD | -- | | **FIGURE C2** | | |
| CHECK | ACK | 20180226 | | | |
| REVIEW | DPM | 20180226 | | | |

REVISION DATE: December 5, 2017 BY: AK Project: 1671122

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| Europe | + 44 1628 851851 |
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