



April 10, 2018

## PRELIMINARY FOUNDATION INVESTIGATION REPORT

**SOUTH FLOODWOOD RIVER BRIDGE REPLACEMENT  
SITE NO. 39E-202, LAT. 49.483885, LONG. -80.363791  
HIGHWAY 652, COCHRANE DISTRICT  
TOWNSHIP OF TWEED  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5416-15-00; WP 5416-15-03**

**Submitted to:**

Kyle Hampton, P.Eng.  
AECOM Canada Ltd.  
189 Wyld Street, Suite 103  
North Bay, ON P1B 1Z2



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**Distribution:**

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REPORT





## Table of Contents

### **PART A – FOUNDATION INVESTIGATION REPORT**

|   |          |
|---|----------|
| <b>1.0 INTRODUCTION.....</b>                                | <b>1</b> |
| <b>2.0 SITE DESCRIPTION AND BACKGROUND INFORMATION.....</b> | <b>1</b> |
| <b>3.0 INVESTIGATION PROCEDURE .....</b>                    | <b>1</b> |
| <b>4.0 SUBSURFACE CONDITIONS.....</b>                       | <b>3</b> |
| 4.1 Regional Geology .....                                  | 3        |
| 4.2 Subsoil Conditions .....                                | 3        |
| 4.3 Groundwater Conditions .....                            | 5        |
| <b>5.0 CLOSURE.....</b>                                     | <b>6</b> |

### **SITE PHOTOGRAPHS**

Photographs 1 to 4

### **DRAWINGS**

|           |                                    |
|-----------|------------------------------------|
| Drawing 1 | Borehole Locations and Soil Strata |
| Drawing 2 | Soil Strata                        |

### **APPENDIX A                      Borehole Records**

|                                    |              |
|------------------------------------|--------------|
| Lists of Abbreviations and Symbols |              |
| Records of Boreholes               | SF-1 to SF-4 |

### **APPENDIX B                      Laboratory Test Results**

|           |   |
|-----------|---|
| Table B1  | Summary of Analytical Testing of South Floodwood River Soil Samples |
| Figure B1 | Grain Size Distribution –Gravelly Sand to Sand (Fill)               |
| Figure B2 | Grain Size Distribution –Clayey Silt                                |
| Figure B3 | Plasticity Chart – Clayey Silt                                      |
| Figure B4 | Grain Size Distribution – Silt                                      |
| Figure B5 | Grain Size Distribution – Sand                                      |
| Figure B6 | Grain Size Distribution – Gravelly Silty Sand to Silty Sand (Till)  |





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**PRELIMINARY FOUNDATION REPORT - HIGHWAY 652 SOUTH  
FLOODWOOD RIVER**

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# **PART A**

**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
SOUTH FLOODWOOD RIVER BRIDGE REPLACEMENT, SITE NO.39E-202  
HIGHWAY 652, COCHRANE DISTRICT  
TOWNSHIP OF TWEED  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5416-15-00; WP 5416-15-03**





### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO), to provide preliminary foundation engineering services for the replacement of the South Floodwood River Bridge (Site 39E-202). The existing South Floodwood River Bridge is located in the Cochrane District in the Township of Tweed, Ontario at about Sta. 10+345 on Highway 652 (approximately 60 km north of Translimit Road). The general location of this section of Highway 652 is shown on the Key Plan on Drawing 1.

### 2.0 SITE DESCRIPTION AND BACKGROUND INFORMATION

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 Drawing 1. For the purpose of this report, Highway 652 is considered to be oriented in a north-south direction.

In general, the topography in the area of the South Floodwood River Bridge consists of rolling/valley terrain with densely forested areas immediately beyond the Highway 652 right-of-way and in the vicinity of the river. The existing South Floodwood River Bridge consists of an approximately 48.8 m long by 4.6 m wide, three-span, single-lane Temporary Modular Bridge (TMB). Based on the previous General Arrangement (GA) drawing, the existing bridge abutments are supported by timber cribs founded on granular fill pads with the piers founded on driven steel piles (HP310x79). Based on the survey drawing provide by AECOM, the bridge deck is at approximately Elevation 286.1 m at the south abutment and 286.0 m at the north abutment.

The existing front slopes are about 10 m high relative to the river bottom and the approach embankment side slopes are about 5 m to 6 m high. The front slopes and sides slopes are inclined at about 2 Horizontal to 1 Vertical (2H:1V). The ground surface conditions in the vicinity of the bridge abutments are shown on Photographs 1 to 4.

Based on the 2016 Ontario Structural Inspection Manual (OSIM) report, our July 2017 site review, and the available site photographs, the existing embankments appear to be performing well.

### 3.0 INVESTIGATION PROCEDURE

The field work for the subsurface investigation was carried out on July 21, 22, and 29, 2017, during which time a total of four boreholes (SF-1 to SF-4) were advanced at the locations shown on Drawing 1. Boreholes SF-1 and SF-3 were advanced through the existing highway embankment at the north and south abutments, respectively. Borehole SF-2 was advanced at the east toe of the north approach embankment and SF-4 was advanced at the west toe of the south approach embankment.

Boreholes SF-1 to SF-4 were advanced using a track-mounted CME 55LC drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville-sur-la-Rouge, Quebec. All boreholes were advanced using 108 mm inside diameter hollow-stem augers, NW casing with washing boring, and NQ coring (as required). Soil samples were obtained at depth intervals of 0.75 m and 1.5 m, using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). The groundwater level in the open boreholes was observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes advanced at the existing bridge abutments were backfilled





## PRELIMINARY FOUNDATION REPORT - HIGHWAY 652 SOUTH FLOODWOOD RIVER

with a full column of bentonite grout. The boreholes advanced at the toe of the embankment slopes were backfilled with bentonite pellets and soil cuttings upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The fieldwork was supervised by a member of our technical staff, who observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and took custody of the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. Index and classification testing consisting of water content, grain size distribution and Atterberg limits was carried out on selected samples. The geotechnical laboratory testing was performed in accordance with MTO LS standards.

Soil samples were obtained on July 29, 2017, from Boreholes SF-1 and SF-3, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain-of-custody procedures for testing for a suite of parameters including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations of the boreholes were measured and surveyed by a member of our technical staff, referenced to the highway centerline and existing bridge structure and converted to northings/easting coordinates on the plan drawing. The ground surface elevations were referenced to local benchmarks in the vicinity of the bridge and the benchmark elevations were obtained from the survey drawing [Feature\_B652TW1 (South Floodwood River).dwg] provided by AECOM on September 26, 2017. The MTM NAD83 Zone 12 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 Record of Borehole Sheets in Appendix A and summarized below.

| <b>Borehole Number</b> | <b>MTM NAD83 Northing (Latitude)</b> | <b>MTM NAD83 Easting (Longitude)</b> | <b>Ground Surface Elevation</b> | <b>Borehole Depth</b> |
|------------------------|--------------------------------------|--------------------------------------|---------------------------------|-----------------------|
| SF-1                   | 5483100.9 m<br>(49.483992)           | 350913.6 m<br>(-80.363535)           | 286.1 m                         | 11.3 m                |
| SF-2                   | 5483086.0 m<br>(49.483857)           | 350920.6 m<br>(-80.363440)           | 281.0 m                         | 18.9 m                |
| SF-3                   | 5483072.2 m<br>(49.483737)           | 350869.5 m<br>(-80.364147)           | 285.9 m                         | 11.3 m                |
| SF-4                   | 5483088.6 m<br>(49.483885)           | 350861.9 m<br>(-80.36425)            | 280.1 m                         | 17.4 m                |





## 4.0 SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)<sup>1</sup> Mapping, the South Floodwood River Bridge site is located within a ground moraine deposit consisting primarily of clay till bordered by esker, esker complex and crevasse filling deposits.

Based on geological mapping by the Ontario Ministry of Northern Development and Mines (MNDM)<sup>2</sup>, the site is underlain by mafic to intermediate metavolcanic rocks consisting of basaltic and andesitic flows, tuffs and breccias, chert, iron formations, minor metasedimentary and intrusive rock and related migmatites bordered closely by mafic massive to foliated granodiorite to granite bedrock.

### 4.2 Subsoil Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are provided on the Record of Borehole sheets contained in Appendix A. The results of the geotechnical laboratory testing are contained in Appendix B. The results of the in situ tests (i.e., SPT 'N'-values and field vanes) as presented on the borehole records and described in Section 4 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile on Drawing 1 and in the sections on Drawing 2 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.

During the previous 1981 foundation investigation performed at the site by the MTO (formerly Ministry of Transportation and Communications) prior to construction of the existing embankments and bridge, the subsurface soil conditions were generally described as consisting of peat overlying deposits of loose to compact sandy silt and a very dense granular-type till stratum. The subsoil conditions encountered during the current borehole investigation consist of granular embankment fill underlain by native deposits of organic silt to silt, clayey silt, sand and silty sand till containing cobbles and boulders. A more detailed description of the soil deposits encountered in the boreholes for the current investigation is provided below.

| Deposit/Layer Description           | Boreholes    | Deposit Thickness (m) | Deposit Surface Elevation (m) | N-Values (blows/0.3 m) / Shear Strength | Laboratory Testing             |
|-------------------------------------|--------------|-----------------------|-------------------------------|---|--------------------------------|
|                                     |              |                       |                               | Consistency or Relative Density         |                                |
| Asphalt                             | SF-1 & SF-3  | 0.080                 | 286.1 & 285.9                 | n/a                                     | n/a                            |
| (FILL) Gravelly Sand to Sand, trace | SF-1 to SF-4 | 0.6 – 10.1            | 286.0 – 280.0                 | N = 4 – 21                              | w = 2% – 5%<br>4 – M (Fig. B1) |

<sup>1</sup> Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS). Ontario Geological Survey, Miscellaneous Release – Date 160, Map 42HNE.

<sup>2</sup> Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543





## PRELIMINARY FOUNDATION REPORT - HIGHWAY 652 SOUTH FLOODWOOD RIVER

| Deposit/Layer Description  | Boreholes    | Deposit Thickness (m)                                     | Deposit Surface Elevation (m) | N-Values (blows/0.3 m) / Shear Strength                    | Laboratory Testing  |
|--|--------------|---|-------------------------------|--|---|
|  |              |   |                               | Consistency or Relative Density                            |   |
|  |              |   |                               | Very Loose to Compact                                      |   |
| to some silt, trace organics, brown; moist to wet,<br><b>Organic Silt</b> , trace wood fragments, trace sand; black; wet | SF-4         | 2.3   | 279.4                         | N = 3 - 4<br><br><b>Very Loose</b>                         | n/a   |
| <b>Sandy Clayey Silt to Clayey Silt</b> , trace to some sand, trace gravel; grey; wet                                    | SF-2 & SF-4  | 2.4 & 1.6   | 280.2 & 277.1                 | N = 3 - 6<br>S <sub>u</sub> = 43 kPa<br>S <sub>t</sub> = 2 | w = 20% - 21%<br>1 - MH (Fig. B2)<br>2 - AL (Fig. B3)<br>w <sub>l</sub> = 29% - 34%<br>w <sub>p</sub> = 14% - 15%<br>I <sub>p</sub> = 15% - 18% |
|  |              |   |                               | <b>Firm</b>  |   |
| <b>Sandy Silt to Silt</b> , trace to some sand, trace to some clay; grey; wet  | SF-1 to SF-4 | 1.0 - 5.2 (not fully penetrated in boreholes SF-1 & SF-3) | 277.8 - 275.5                 | N = 3 - 23   | w = 17% - 24%<br>3 - MH (Fig. B4)<br>2 - AL (NP)  |
|  |              |   |                               | <b>Very loose to compact</b>                               |   |
| <b>Sand</b> , trace to some silt, trace to some clay   | SF-2         | 3.3   | 272.6                         | N = 5  | w = 19%<br>1 - MH (Fig. B5)   |
|  |              |   |                               | <b>Loose</b>   |   |
| <b>Gravelly Silty Sand to Silty Sand (Till)</b> , some gravel, trace to some clay; grey; wet                             | SF-2 & SF-4  | 7.2 & 11.8 (boreholes terminated in this deposit)         | 269.3 & 274.5                 | N = 3 - 197  | w = 10% - 16%<br>3 - MH (Fig. B6)<br>3 - AL (NP)  |
|  |              |   |                               | <b>Very Loose to Very Dense</b>                            |   |

### Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration (uncorrected)  
 S<sub>u</sub> = Undrained Shear Strength from in situ field 'N'-vane (kPa) (uncorrected)  
 S<sub>t</sub> = Sensitivity  
 w = Natural Moisture Content (%)  
 M = Sieve analysis  
 MH = Combined Sieve and Hydrometer analysis  
 AL = Atterberg Limits Test  
 w<sub>p</sub> = Plastic Limit (%)  
 w<sub>l</sub> = Liquid Limit (%)  
 I<sub>p</sub> = Plasticity Index (%)  
 NP = Non-Plastic test result





### Gravelly Sand to Sand Fill

At a few depths within the fill, SPT 'N'-values of 0 (weight of hammer) were recorded. However, these low values are anticipated to be due to basal heaving in the borehole and are not considered to be indicative of the compactness condition of the sand fill.

### Topsoil

A 0.1 m thick surficial layer of was encountered at ground surface in Borehole SF-4.

### Sand

Within the sand deposit in Borehole SF-2, a SPT-'N' value, of 4 blows per 0.15 m of penetration was recorded followed by split-spoon refusal (i.e., hammer bouncing) requiring NW casing and NQ coring techniques to advance the borehole through a 150 mm diameter cobble.

### Gravelly Silty Sand to Sand Till

In one instance, a SPT 'N'-value of 36 blows per 0.13 m of penetration was recorded followed by split-spoon refusal (i.e., hammer bouncing) requiring NW casing and NQ coring techniques to advance the borehole through a 870 mm diameter boulder. Auger grinding was also noted throughout the remainder of the deposit.

## 4.3 Groundwater Conditions

The unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The river water level was measured by others to be at Elevation 277.4 m in August 2017. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

| Borehole | Ground Surface Elevation (m) | Depth to Groundwater (m)         | Groundwater Elevation (m)               |
|----------|------------------------------|----------------------------------|---|
| SF-1     | 286.1                        | Dry<br>(samples wet below 7.6 m) | Possible perched water at about 278.5 m |
| SF-2     | 281.0                        | 1.5                              | 279.5 *                                 |
| SF-3     | 285.9                        | Dry<br>(samples wet below 7.6 m) | Possible perched water at about 278.3 m |
| SF-4     | 280.1                        | 0                                | 280.1 *                                 |

\* Boreholes SF-2 and SF-4 were advanced using NW casing and wash boring techniques. As such, water levels may not be representative of stabilized groundwater conditions.





## **5.0 CLOSURE**

This Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and the technical aspects were reviewed by Mr. David Muldowney, P.Eng. Mr. Paul Dittrich, Ph.D., P.Eng., MTO Foundations Designated Contact and Principal with Golder, conducted an independent quality control review of this report.





## Report Signature Page

GOLDER ASSOCIATES LTD.

Adam Core, P.Eng.  
Geotechnical Engineer



David Muldowney, P.Eng.  
Geotechnical Engineer



Paul Dittrich, Ph.D., P.Eng.  
MTO Foundations Designated Contact, Principal

AC/AB/JPD/kp/ca

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[https://golderassociates.sharepoint.com/sites/19476g/wo5\\_5\\_bridges\\_hwy\\_652/11\\_reporting/003-south\\_floodwood\\_river/final/1651997-003-r-rev0\\_south\\_floodwood\\_river\\_bridge\\_fidr\\_10apr\\_18.docx](https://golderassociates.sharepoint.com/sites/19476g/wo5_5_bridges_hwy_652/11_reporting/003-south_floodwood_river/final/1651997-003-r-rev0_south_floodwood_river_bridge_fidr_10apr_18.docx)





## PHOTOGRAPHS

**Photograph 1: South Floodwood River Bridge  
North Approach Looking South (August 2017)**



**Photograph 2: South Floodwood River Bridge  
Southwest Approach Looking North at Borehole SF-4 (August 2017)**







## PHOTOGRAPHS

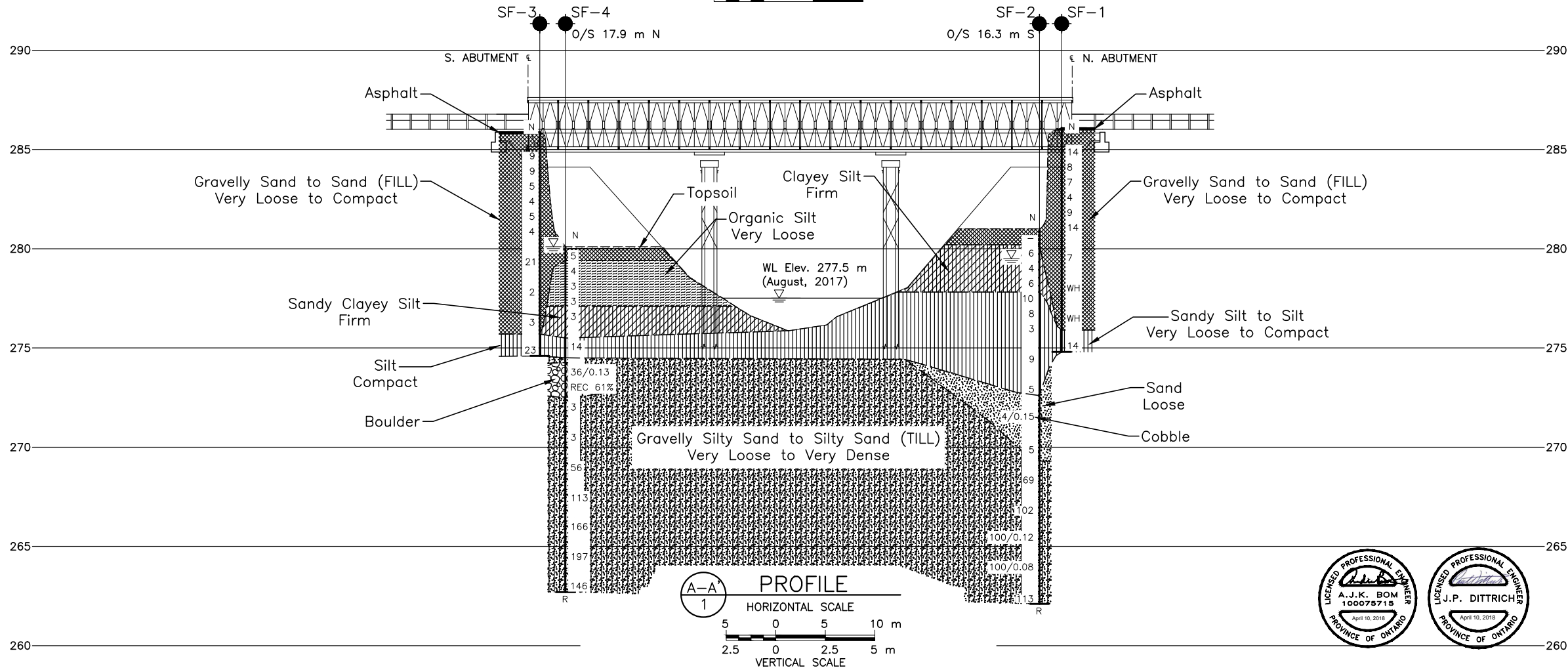
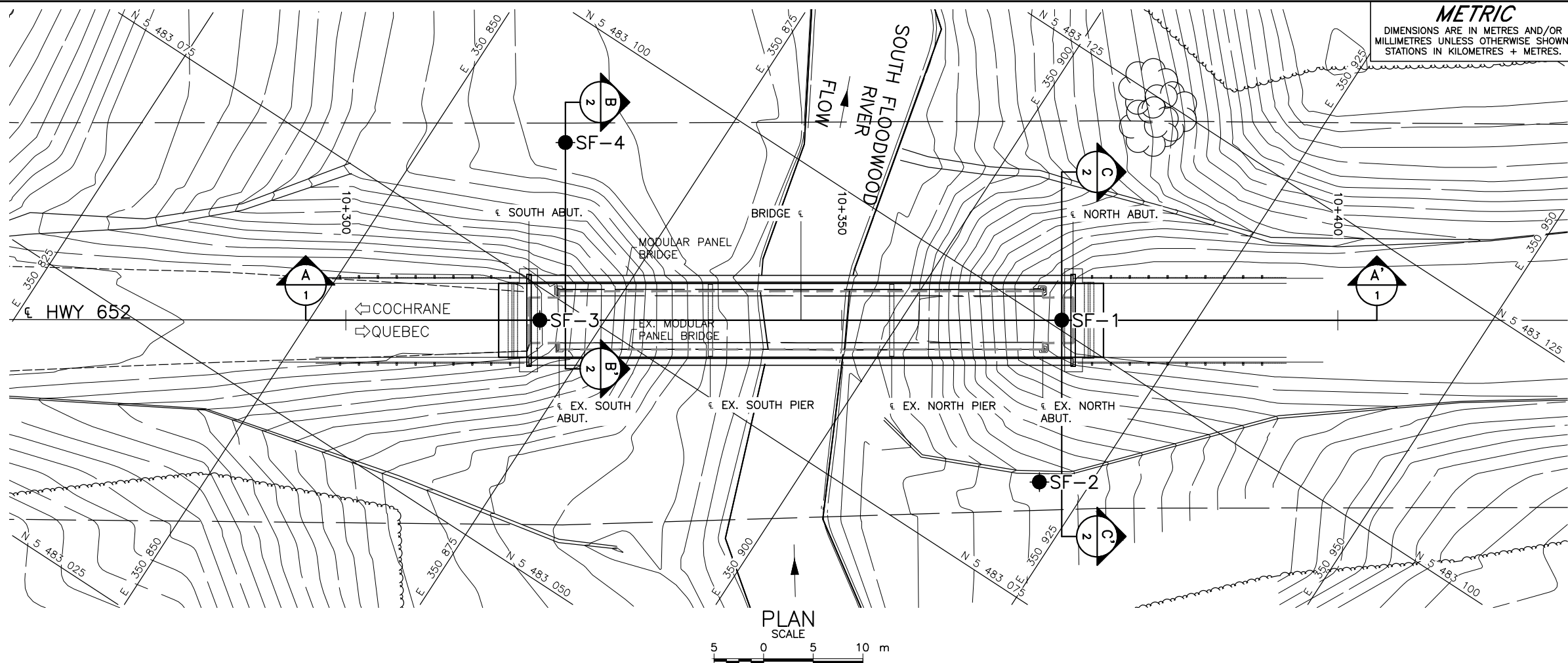
**Photograph 3: South Floodwood River Bridge  
North Approach Looking South at Borehole SF-3 (August 2017)**



**Photograph 4: South Floodwood River Bridge  
East Elevation (OSIM Report – June 2015)**



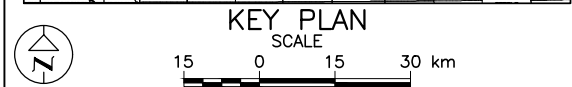
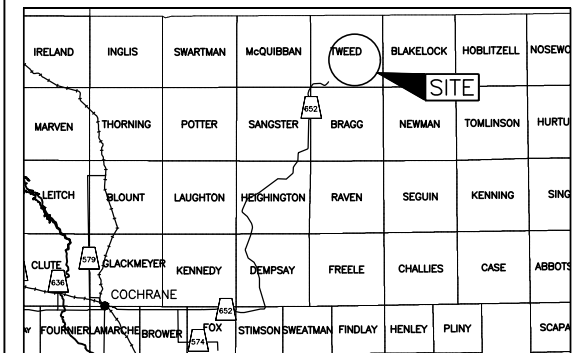




**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No. GWP No. 5416-15-00

HIGHWAY 652  
SOUTH FLOODWOOD RIVER BRIDGE  
LAT. 49.483885, LONG. -80.363791  
BOREHOLE LOCATIONS AND SOIL STRATA



LEGEND

Borehole - Current Investigation  
 Standard Penetration Test Value  
 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)  
 WL upon completion of drilling  
 Refusal  
 Recovery

| BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12) |           |           |          |
|--|-----------|-----------|----------|
| No.  | ELEVATION | NORTHING  | EASTING  |
| SF-1                                       | 286.1     | 5483100.9 | 350913.6 |
| SF-2                                       | 281.0     | 5483086.0 | 350920.6 |
| SF-3                                       | 285.9     | 5483072.2 | 350869.5 |
| SF-4                                       | 280.1     | 5483088.6 | 350861.9 |

**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 AECOM, drawing file no. Features\_B652TWE1 (SOUTH FLOODWOOD RIVER).dwg, received SEPT 26, 2017. General Arrangement provided by AECOM, drawing file no. 60546679-P20.dwg, received DEC 20, 2017.



| NO.                | DATE                | BY              | REVISION      |
|--------------------|---------------------|-----------------|---------------|
|                    |                     |                 |               |
| Geocres No. 42H-76 |                     |                 |               |
| HWY. 652           | PROJECT NO. 1651997 | DIST. .         |               |
| SUBM'D. AC         | CHKD. .             | DATE: 4/10/2018 | SITE: 39E-202 |
| DRAWN: JLL/TB      | CHKD. DAM           | APPD. JPD       | DWG. 1        |



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



CONT No.  
GWP No. 5416-15-00

**HIGHWAY 652**  
SOUTH FLOODWOOD RIVER BRIDGE  
LAT. 49.483885, LONG. -80.363791  
**SOIL STRATA**

**SHEET**



### LEGEND

- |   |  |
|---|--|
|  | Borehole — Current Investigation                                   |
| N   | Standard Penetration Test Value                                    |
| 16  | Blows/0.3m unless otherwise stated<br>(Std. Pen. Test, 475 j/blow) |
|  | WL upon completion of drilling                                     |
| R   | Refusal  |
| REC %   | Recovery   |

## BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)

| No.  | ELEVATION | NORTHING  | EASTING  |
|------|-----------|-----------|----------|
| SF-1 | 286.1     | 5483100.9 | 350913.6 |
| SF-2 | 281.0     | 5483086.0 | 350920.6 |
| SF-3 | 285.9     | 5483072.2 | 350869.5 |
| SF-4 | 280.1     | 5483088.6 | 350861.9 |

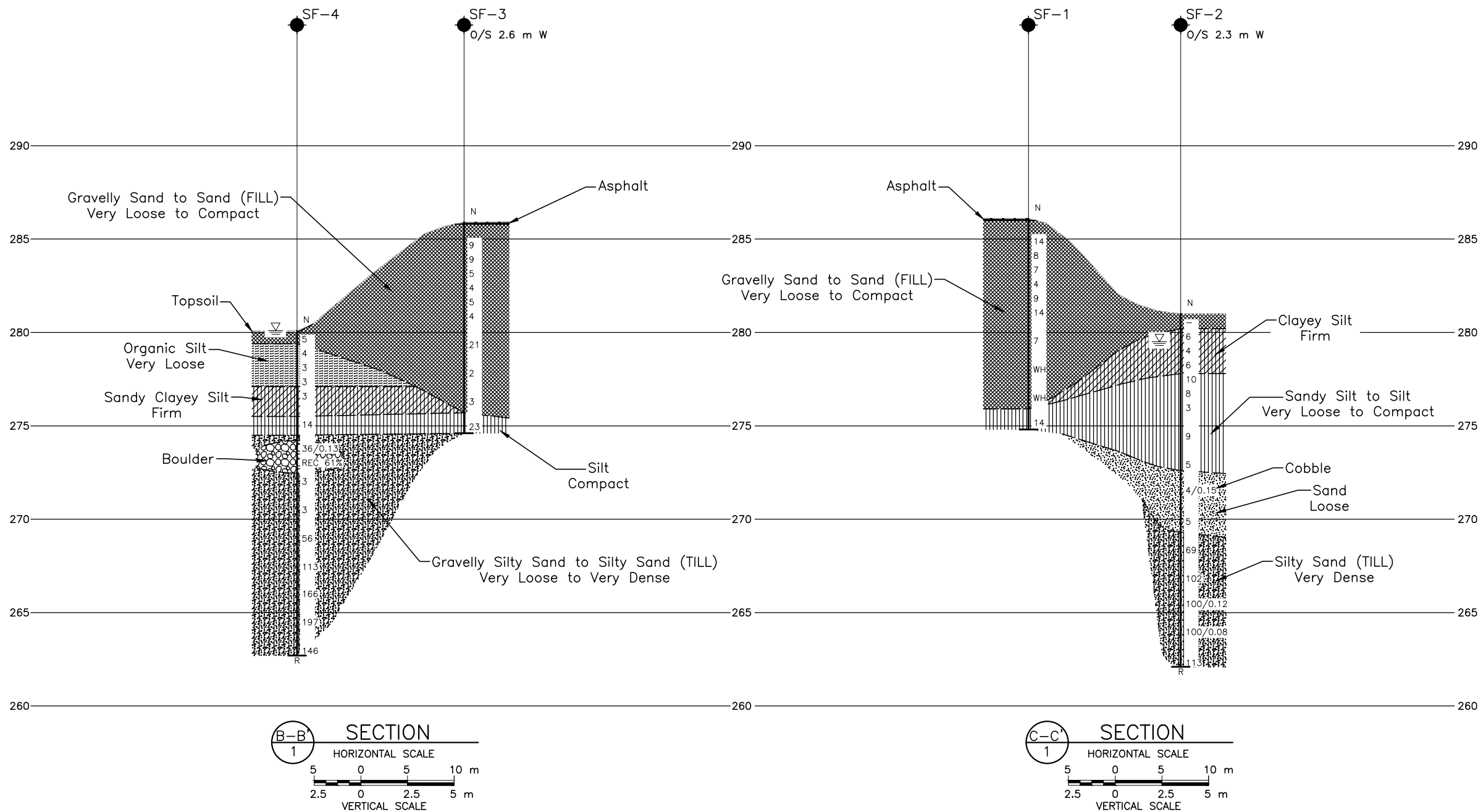
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|                    |      |                     |                 |
|--------------------|------|---------------------|-----------------|
| NO.                | DATE | BY                  | REVISION        |
| Geocres No. 42H-76 |      |                     |                 |
| HWY. 652           |      | PROJECT NO. 1651997 | DIST. .         |
| SUBM'D. AC         |      | CHKD. .             | DATE: 4/10/2018 |
| DRAWN: JJL/TB      |      | CHKD. DAM           | APPD. JPD       |
|                    |      |                     | DWG. 2          |





# **APPENDIX A**

## **Borehole Records**





## 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   |
| $\nu$                          | 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<br>$= (\sigma_1 + \sigma_2 + \sigma_3)/3$ |
| $\tau$                         | shear stress   |
| u                              | porewater pressure   |
| E                              | modulus of deformation   |
| G                              | shear modulus of deformation   |
| K                              | bulk modulus of compressibility  |

### III. SOIL PROPERTIES

|                    |  |
|--------------------|--|
| <b>(a)</b>         | <b>Index Properties</b>  |
| $\rho(\gamma)$     | 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<br>( $\gamma' = \gamma - \gamma_w$ )                                   |
| $D_R$              | 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   |

### (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 = $(e_{max} - e) / (e_{max} - e_{min})$<br>(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<br>(coefficient of permeability) |
| j | seepage force per unit volume                           |

### (c) Consolidation (one-dimensional)

|             |   |
|-------------|---|
| $C_c$       | compression index<br>(normally consolidated range)    |
| $C_r$       | recompression index<br>(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  |

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

Notes: 1  
2

$$\tau = c' + \sigma' \tan \phi'$$
$$\text{shear strength} = (\text{compressive strength})/2$$





## 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 (DCPT); $N_d$ :

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, 60° 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<sup>2</sup> 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    | N                        |
|------------------|--------------------------|
| Relative Density | 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        | 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 <sup>1</sup>                                       |
| CIU             | consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup> |
| $D_R$           | 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 <sub>4</sub> | 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<br>Silty Clay with sand / Clayey Silt with sand |



|                                       |  |  |  |                         |  |
|---------------------------------------|--|--|--|-------------------------|--|
| PROJECT <u>1651997-WO5</u>            |  | <b>RECORD OF BOREHOLE No SF-1</b>  |  | 1 OF 2 <b>METRIC</b>    |  |
| G.W.P. <u>5416-15-00</u>              |  | LOCATION <u>N 5483100.9; E 350913.6 MTM ZONE 12 (LAT. 49.483992; LONG. -80.363535)</u> |  | ORIGINATED BY <u>MR</u> |  |
| DIST <u>          </u> HWY <u>652</u> |  | BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>                                    |  | COMPILED BY <u>AC</u>   |  |
| DATUM <u>GEODETIC</u>                 |  | DATE <u>July 29, 2017</u>  |  | CHECKED BY <u>DAM</u>   |  |

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION<br>SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    | PLASTIC LIMIT NATURAL MOISTURE<br>CONTENT LIQUID LIMIT |     |                   | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |    |    |         |    |                |
|---------------|--|------------|---------|------|------------|----------------------------|--------------------|---|----|----|--|-----|-------------------|---|---|----|----|---------|----|----------------|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                    | SHEAR STRENGTH kPa                          |    |    |  |     | WATER CONTENT (%) |   |   | GR | SA | SI      | CL |                |
|               |  |            |         |      |            |                            |                    | 20  | 40 | 60 | 80   | 100 | W <sub>p</sub>    |   | W   |    |    |         |    | W <sub>L</sub> |
| 286.1         | GROUND SURFACE   |            |         |      |            |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
| 0.0           | ASPHALT (80 mm)  |            |         |      |            |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
| 0.1           | Gravelly sand to sand, trace to some silt (FILL)<br>Very loose to compact<br>Brown to grey<br>Moist to wet |            | 1       | SS   | 14         |                            |                    |   |    |    |  |     |                   |   |   |    | 28 | 65 (7)  |    |                |
|               |  |            | 2       | SS   | 8          |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
|               |  |            | 3       | SS   | 7          |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
|               |  |            | 4       | SS   | 4          |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
|               |  |            | 5       | SS   | 9          |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
|               |  |            | 6       | SS   | 14         |                            |                    |   |    |    |  |     |                   |   |   |    | 19 | 78 (3)  |    |                |
|               |  |            | 7       | SS   | 7          |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
|               |  |            | 8       | SS   | WH         |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
|               |  |            | 9       | SS   | WH         |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
| 275.9         |  |            |         |      |            |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
| 10.2          | SILT, trace to some sand, trace to some clay<br>Compact<br>Grey<br>Wet                                     |            | 10      | SS   | 14         |                            |                    |   |    |    |  |     |                   |   |   |    | 0  | 10 82 8 |    |                |
| 274.8         |  |            |         |      |            |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |
| 11.3          |  |            |         |      |            |                            |                    |   |    |    |  |     |                   |   |   |    |    |         |    |                |

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1651997 AECOM\_5015-E-0045\_NE RETAINER02\_DATA\GINTV1651997.GPJ GAL-MISS.GDT 12/20/17 TB



|                             |  |  |  |                         |  |
|-----------------------------|--|--|--|-------------------------|--|
| PROJECT <u>1651997-WO5</u>  |  | <b>RECORD OF BOREHOLE No SF-1</b>  |  | 2 OF 2 <b>METRIC</b>    |  |
| G.W.P. <u>5416-15-00</u>    |  | LOCATION <u>N 5483100.9; E 350913.6 MTM ZONE 12 (LAT. 49.483992; LONG. -80.363535)</u> |  | ORIGINATED BY <u>MR</u> |  |
| DIST <u></u> HWY <u>652</u> |  | BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>                                    |  | COMPILED BY <u>AC</u>   |  |
| DATUM <u>GEODETIC</u>       |  | DATE <u>July 29, 2017</u>  |  | CHECKED BY <u>DAM</u>   |  |

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                  |   |   |            | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |                |   | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m³ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |    |    |    |  |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|------------------|---|---|------------|---|----------------|---|--------------------------------------|---|----|----|----|--|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |                  |   |   |            | WATER CONTENT (%)                                       |                |   |                                      | GR  | SA | SI | CL |  |
|               |   |            |         |      |            |                            |                 | ○ UNCONFINED                                | ● QUICK TRIAXIAL | + | × | FIELD VANE | REMOULDED   | W <sub>p</sub> | W |                                      | W <sub>L</sub>                                    |    |    |    |  |
|               | --- CONTINUED FROM PREVIOUS PAGE ---                      |            |         |      |            |                            |                 |   |                  |   |   |            |   |                |   |                                      |   |    |    |    |  |
|               | END OF BOREHOLE   |            |         |      |            |                            |                 |   |                  |   |   |            |   |                |   |                                      |   |    |    |    |  |
|               | Note:<br><br>1. Borehole dry upon completion of drilling. |            |         |      |            |                            |                 |   |                  |   |   |            |   |                |   |                                      |   |    |    |    |  |

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| PROJECT 1651997-WO5 |   |            | <b>RECORD OF BOREHOLE No SF-2</b>  |      |            |                            | 1 OF 2 <b>METRIC</b> |   |  |                                    |                                     |                                   |   |  |
|---------------------|---|------------|--|------|------------|----------------------------|----------------------|---|--|------------------------------------|-------------------------------------|-----------------------------------|---|--|
| G.W.P. 5416-15-00   |   |            | LOCATION N 5483086.0; E 350920.6 MTM ZONE 12 (LAT. 49.483857; LONG. -80.3634401) |      |            |                            | ORIGINATED BY MR     |   |  |                                    |                                     |                                   |   |  |
| DIST _____ HWY 652  |   |            | BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring            |      |            |                            | COMPILED BY AC       |   |  |                                    |                                     |                                   |   |  |
| DATUM GEODETIC      |   |            | DATE July 21, 2017   |      |            |                            | CHECKED BY DAM       |   |  |                                    |                                     |                                   |   |  |
| SOIL PROFILE        |   |            | SAMPLES  |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE      | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
| ELEV<br>DEPTH       | DESCRIPTION   | STRAT PLOT | NUMBER   | TYPE | "N" VALUES |                            |                      | SHEAR STRENGTH kPa                          |  |                                    |                                     |                                   |   |  |
| 281.0               | GROUND SURFACE  |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 0.0                 | Sand, some silt, trace gravel, trace organics (FILL)<br>Brown<br>Moist  |            | 1  | AS   | -          |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 280.2               |   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 0.8                 | CLAYEY SILT, trace gravel, trace to some sand<br>Firm<br>Brown<br>Wet   |            | 2  | SS   | 6          |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            | 3  | SS   | 4          |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            | 4  | SS   | 6          |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 277.8               | Trace organics below 3.0 m depth.   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 3.2                 | Sandy SILT to SILT, trace to some sand, trace to some clay<br>Very loose to loose<br>Grey<br>Wet<br>Trace organics above 3.8 m depth. |            | 5  | SS   | 10         |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            | 6  | SS   | 8          |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     | Switched to NW Casing at 4.6 m depth.   |            | 7  | SS   | 3          |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            | 8  | SS   | 9          |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            | 9  | SS   | 5          |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 272.6               |   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 8.4                 | SAND, trace to some silt, trace to some clay<br>Loose<br>Grey<br>Wet  |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     | Split-spoon refusal (hammer bouncing) at 9.5 m depth. Switched to NQ coring. A 150 mm diameter cobble recovered in core barrel.       |            | 10   | SS   | 4/0.15     |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            | 11   | SS   | 5          |                            |                      |   |  |                                    |                                     |                                   |   |  |
|                     |   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 269.3               |   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |
| 11.7                |   |            |  |      |            |                            |                      |   |  |                                    |                                     |                                   |   |  |

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+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

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| PROJECT <u>1651997-WO5</u>            |   |  | <b>RECORD OF BOREHOLE No SF-2</b>   |      |            |                            | 2 OF 2 <b>METRIC</b>    |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|---------------------------------------|---|--|---|------|------------|----------------------------|-------------------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|--|--|-------------------|----|----|
| G.W.P. <u>5416-15-00</u>              |   |  | LOCATION <u>N 5483086.0; E 350920.6 MTM ZONE 12 (LAT. 49.483857; LONG. -80.3634401)</u> |      |            |                            | ORIGINATED BY <u>MR</u> |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
| DIST <u>          </u> HWY <u>652</u> |   |  | BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring</u>            |      |            |                            | COMPILED BY <u>AC</u>   |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
| DATUM <u>GEODETIC</u>                 |   |  | DATE <u>July 21, 2017</u>   |      |            |                            | CHECKED BY <u>DAM</u>   |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
| SOIL PROFILE                          |   |  | SAMPLES   |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE         | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |                   |    |    |
| ELEV<br>DEPTH                         | DESCRIPTION   | STRAT PLOT   | NUMBER  | TYPE | "N" VALUES |                            |                         | SHEAR STRENGTH kPa                          |    |    |    |     |                                    |                                     |                                   |  |  | WATER CONTENT (%) |    |    |
|                                       |   |  |   |      |            |                            |                         | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |  |  | 20                | 40 | 60 |
| --- CONTINUED FROM PREVIOUS PAGE ---  |   |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       | Silty SAND, some gravel, trace to<br>some clay (TILL)<br>Very dense<br>Grey<br>Wet  |  | 12  | SS   | 69         |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  | 13  | SS   | 102        |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  | 14  | SS   | 100/0.12   |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  | 15  | SS   | 100/0.08   |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
|                                       |   |  | 16  | SS   | 113        |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
| 262.1                                 |   |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |
| 18.9                                  | END OF BOREHOLE<br>SPLIT-SPOON REFUSAL<br><br>Note:<br><br>1. Water level at a depth of 1.5 m<br>below ground surface (Elev. 279.5 m)<br>upon completion of drilling. |  |   |      |            |                            |                         |   |    |    |    |     |                                    |                                     |                                   |  |  |                   |    |    |

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|                                  |  |  |  |                         |  |
|----------------------------------|--|--|--|-------------------------|--|
| <b>PROJECT</b> 1651997-WO5       |  | <b>RECORD OF BOREHOLE No SF-3</b>  |  | 1 OF 2 <b>METRIC</b>    |  |
| <b>G.W.P.</b> 5416-15-00         |  | <b>LOCATION</b> N 5483072.2; E 350869.5 MTM ZONE 12 (LAT. 49.483737; LONG. -80.364147) |  | <b>ORIGINATED BY</b> MR |  |
| <b>DIST</b> _____ <b>HWY</b> 652 |  | <b>BOREHOLE TYPE</b> 108 mm I.D. Hollow Stem Augers                                    |  | <b>COMPILED BY</b> AC   |  |
| <b>DATUM</b> GEODETIC            |  | <b>DATE</b> July 29, 2017  |  | <b>CHECKED BY</b> DAM   |  |

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |   |                | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |    |    |    |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|---|---|----------------|---|---|----|----|----|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |    |    |    |     | WATER CONTENT (%)                                   |   |                |   | GR  | SA | SI | CL |
|               |   |            |         |      |            |                            |                 | 20  | 40 | 60 | 80 | 100 | W <sub>p</sub>                                      | W | W <sub>L</sub> |   |   |    |    |    |
| 285.9         | GROUND SURFACE  |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
| 0.0           | ASPHALT (80 mm)   |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
| 0.1           | Gravelly sand to sand, trace to some silt (FILL)<br>Very loose to compact<br>Brown<br>Moist |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 1       | SS   | 9          |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 2       | SS   | 9          |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 3       | SS   | 5          |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 4       | SS   | 4          |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 5       | SS   | 5          |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 6       | SS   | 4          |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 7       | SS   | 21         |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 8       | SS   | 2          |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 9       | SS   | 3          |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
| 275.7         |   |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
| 10.2          | SILT, some sand, trace to some clay<br>Compact<br>Grey<br>Wet                               |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
|               |   |            | 10      | SS   | 23         |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
| 274.6         |   |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |
| 11.3          |   |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MT01651997 AECOM\_5015-E-0045\_NE RETAINER02\_DATA\GINTV1651997.GPJ GAL-MISS.GDT 12/20/17 TB



|                                       |  |  |  |                         |  |
|---------------------------------------|--|--|--|-------------------------|--|
| PROJECT <u>1651997-WO5</u>            |  | <b>RECORD OF BOREHOLE No SF-3</b>  |  | 2 OF 2 <b>METRIC</b>    |  |
| G.W.P. <u>5416-15-00</u>              |  | LOCATION <u>N 5483072.2; E 350869.5 MTM ZONE 12 (LAT. 49.483737; LONG. -80.364147)</u> |  | ORIGINATED BY <u>MR</u> |  |
| DIST <u>          </u> HWY <u>652</u> |  | BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>                                    |  | COMPILED BY <u>AC</u>   |  |
| DATUM <u>GEODETIC</u>                 |  | DATE <u>July 29, 2017</u>  |  | CHECKED BY <u>DAM</u>   |  |

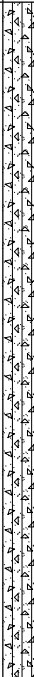
| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |   |                | UNIT<br>WEIGHT<br><br>$\gamma$<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |    |    |    |  |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|---|---|----------------|---|---|----|----|----|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |    |    |    |     | WATER CONTENT (%)                                   |   |                |   | GR  | SA | SI | CL |  |
|               |  |            |         |      |            |                            |                 | 20  | 40 | 60 | 80 | 100 | W <sub>p</sub>                                      | W | W <sub>L</sub> |   |   |    |    |    |  |
|               | --- CONTINUED FROM PREVIOUS PAGE ---<br><br>END OF BOREHOLE<br><br>Note:<br><br>1. Borehole dry upon completion of drilling. |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |   |    |    |    |  |

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1651997 AECOM\_5015-E-0045\_NE RETAINER02\_DATA\GINTV1651997.GPJ GAL-MISS.GDT 12/2017 TB



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



| PROJECT 1651997-WO5                  |   |  | <b>RECORD OF BOREHOLE No SF-4</b>  |      |            |                            | 2 OF 2 <b>METRIC</b> |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
|--------------------------------------|---|--|--|------|------------|----------------------------|----------------------|---|----|----|----|------------------------------------|-------------------------------------|-----------------------------------|---|--|-------------------|----|
| G.W.P. 5416-15-00                    |   |  | LOCATION N 5483088.6; E 350861.9 MTM ZONE 12 (LAT. 49.483885; LONG. -80.36425) |      |            |                            | ORIGINATED BY MR     |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
| DIST _____ HWY 652                   |   |  | BOREHOLE TYPE NW Casing and NQ Coring  |      |            |                            | COMPILED BY AC       |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
| DATUM GEODETIC                       |   |  | DATE July 22, 2017   |      |            |                            | CHECKED BY DAM       |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
| SOIL PROFILE                         |   |  | SAMPLES  |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE      | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |                   |    |
| ELEV<br>DEPTH                        | DESCRIPTION   | STRAT PLOT   | NUMBER   | TYPE | "N" VALUES |                            |                      | SHEAR STRENGTH kPa                          |    |    |    |                                    |                                     |                                   |   |  | WATER CONTENT (%) |    |
|                                      |   |  |  |      |            |                            |                      | 20  | 40 | 60 | 80 |                                    |                                     |                                   |   |  | 100               | 20 |
| --- CONTINUED FROM PREVIOUS PAGE --- |   |  |  |      |            |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
|                                      | Gravelly Silty SAND to Silty SAND,<br>some gravel, trace to some clay (TILL)<br>Very loose to very dense<br>Grey<br>Wet   |  | 11   | SS   | 103        |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
|                                      | Split-spoon refusal (hammer bouncing)<br>at 6.2 m depth. Switched to NQ<br>Coring.  |  |  |      |            |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
|                                      | A 870 mm diameter boulder recovered<br>in core barrel.  |  | 12   | SS   | 166        |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
|                                      |   |  |  |      |            |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
|                                      |   |  | 13   | SS   | 197/0.28   |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
|                                      |   |  |  |      |            |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
| 262.7<br>17.4                        | END OF BOREHOLE<br>SPLIT-SPOON REFUSAL  |  |  |      |            |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |
|                                      | Notes:<br><br>1. Water level at ground surface (Elev.<br>280.1 m) upon completion of drilling.<br><br>2. NW casing refusal at 8.2 m depth.<br>Bottom 1.5 m of casing and casing<br>shoe sheared off while attempting to<br>pull NW casing from borehole.<br><br>3. Moved borehole 1.0 m south and<br>advanced to 9.1 m depth to continue<br>sampling. |  |  |      |            |                            |                      |   |    |    |    |                                    |                                     |                                   |   |  |                   |    |

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\SMTO\1651997 AECOM\_5015-E-0045\_NE RETAINER02\_DATA\GINTV1651997.GPJ GAL-MISS.GDT 12/20/17 TB





# **APPENDIX B**

## **Laboratory Test Results**





## PRELIMINARY FOUNDATION REPORT - HIGHWAY 652 SOUTH FLOODWOOD RIVER

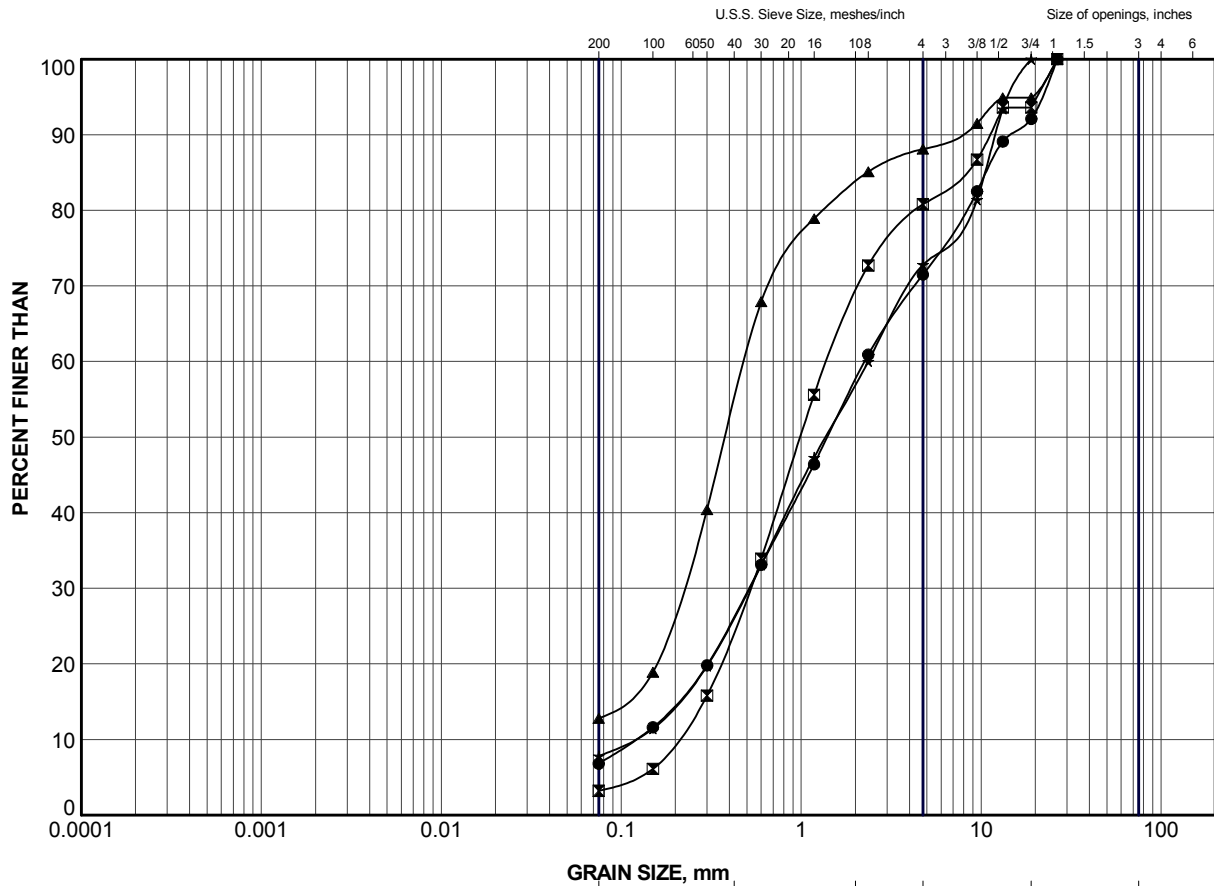
**Table B1: Summary of Analytical Testing of South Floodwood River Soil Samples**

| <b>Location</b>              | <b>Parameter</b>  | <b>Units</b> | <b>Result</b> |
|------------------------------|-------------------|--------------|---------------|
| North Abutment<br>(SF-1 SA6) | Chloride (CL)     | ug/g         | ND            |
|                              | Sulphate (SO4)    | ug/g         | ND            |
|                              | Conductivity (EC) | umho/cm      | 80            |
|                              | Resistivity       | ohm-cm       | 12,000        |
|                              | pH                | n/a          | 8.02          |
| South Abutment<br>(SF-3 SA4) | Chloride (CL)     | ug/g         | 21            |
|                              | Sulphate (SO4)    | ug/g         | ND            |
|                              | Conductivity (EC) | umho/cm      | 115           |
|                              | Resistivity       | ohm-cm       | 8,700         |
|                              | pH                | n/a          | 7.80          |

Notes: 1. Samples from Boreholes SF-1 and SF-3 obtained on July 29 and July 21, 2017, respectively and submitted to Maxxam on November 22, 2017, which is beyond the standard hold time.  
2. Analytical testing carried out by Maxxam.

Prepared by: AC  
Checked by: DAM






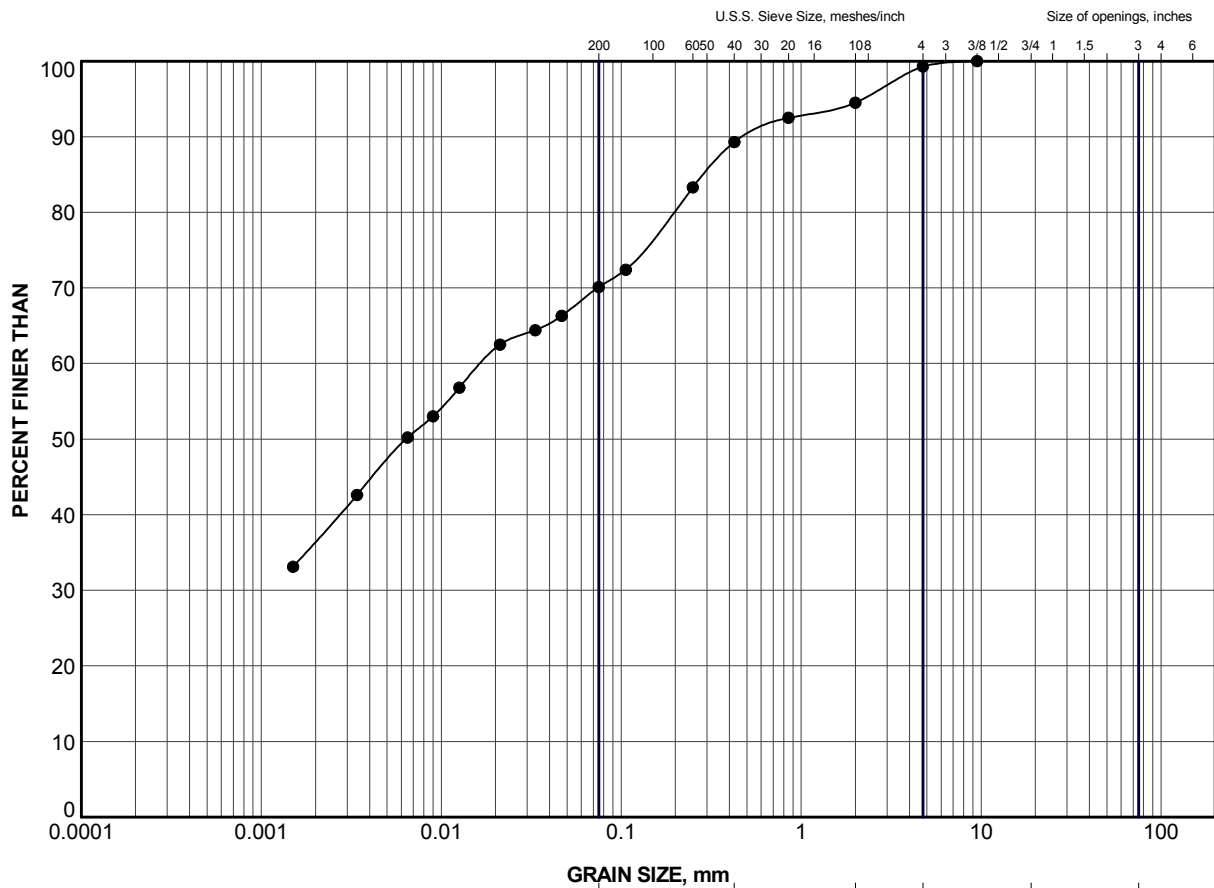
|               |                 |        |        |             |        |                |
|---------------|-----------------|--------|--------|-------------|--------|----------------|
| CLAY AND SILT | GRAVEL SIZE, mm |        |        |             |        | Cobble<br>Size |
|               | fine            | medium | coarse | fine        | coarse |                |
|               | SAND SIZE       |        |        | GRAVEL SIZE |        |                |

### LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|----------|--------|----------|
| ●      | SF-1     | 2      | 284.3    |
| ⊠      | SF-1     | 6      | 281.2    |
| ▲      | SF-3     | 4      | 282.5    |
| ★      | SF-3     | 6      | 281.0    |

|  |  |        |  |          |  |   |  |     |  |      |  |
|--|--|--------|--|----------|--|---|--|-----|--|------|--|
| PROJECT  |  |        |  |          |  | HIGHWAY 652<br>SOUTH FLOODWOOD RIVER BRIDGE             |  |     |  |      |  |
| TITLE  |  |        |  |          |  | GRAIN SIZE DISTRIBUTION<br>GRAVELLY SAND to SAND (FILL) |  |     |  |      |  |
| PROJECT No.  |  |        |  |          |  | FILE No. 1651997.GPJ                                    |  |     |  |      |  |
| DRAWN  |  | J.J.L. |  | Dec 2017 |  | SCALE   |  | N/A |  | REV. |  |
| CHECK  |  | DAM    |  | Dec 2017 |  |   |  |     |  |      |  |
| APPR   |  | JPD    |  | Dec 2017 |  |   |  |     |  |      |  |
|  <b>Golder Associates</b><br>SUDBURY, ONTARIO |  |        |  |          |  | <b>FIGURE B1</b>  |  |     |  |      |  |






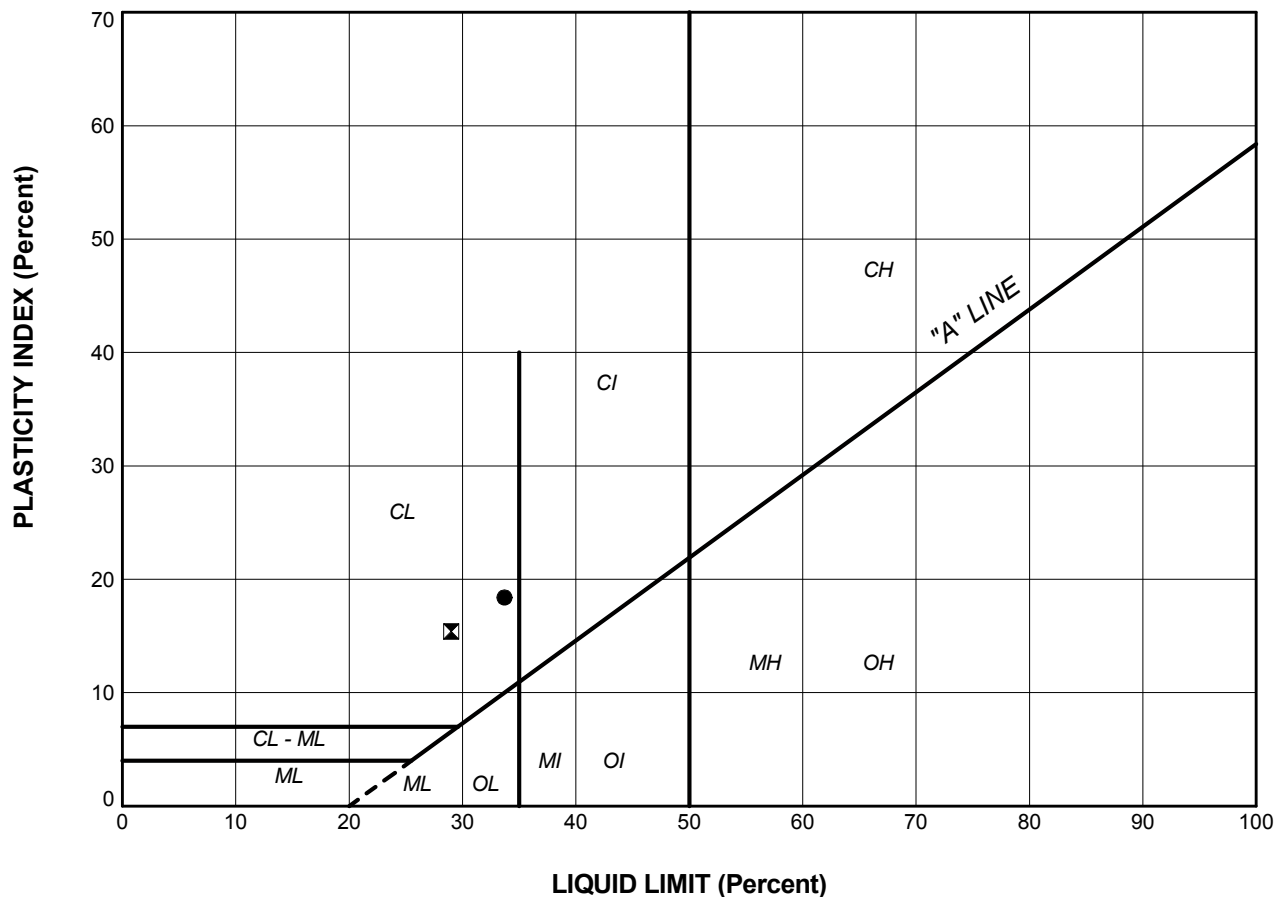
| GRAIN SIZE, mm |           |        |        |             |        |             |
|----------------|-----------|--------|--------|-------------|--------|-------------|
| CLAY AND SILT  | fine      | medium | coarse | fine        | coarse | Cobble Size |
|                | SAND SIZE |        |        | GRAVEL SIZE |        |             |

### LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|----------|--------|----------|
| ●      | SF-4     | 5      | 276.7    |

|  |     |          |       |     |      |   |  |  |  |  |  |
|--|-----|----------|-------|-----|------|---|--|--|--|--|--|
| PROJECT  |     |          |       |     |      | HIGHWAY 652<br>SOUTH FLOODWOOD RIVER BRIDGE |  |  |  |  |  |
| TITLE  |     |          |       |     |      | GRAIN SIZE DISTRIBUTION<br>CLAYEY SILT      |  |  |  |  |  |
| PROJECT No.  |     |          |       |     |      | FILE No. 1651997.GPJ                        |  |  |  |  |  |
| DRAWN  | JJL | Dec 2017 | SCALE | N/A | REV. |   |  |  |  |  |  |
| CHECK  | DAM | Dec 2017 |       |     |      |   |  |  |  |  |  |
| APPR   | JPD | Dec 2017 |       |     |      |   |  |  |  |  |  |
|  <b>Golder Associates</b><br>SUDBURY, ONTARIO |     |          |       |     |      | <b>FIGURE B2</b>                            |  |  |  |  |  |





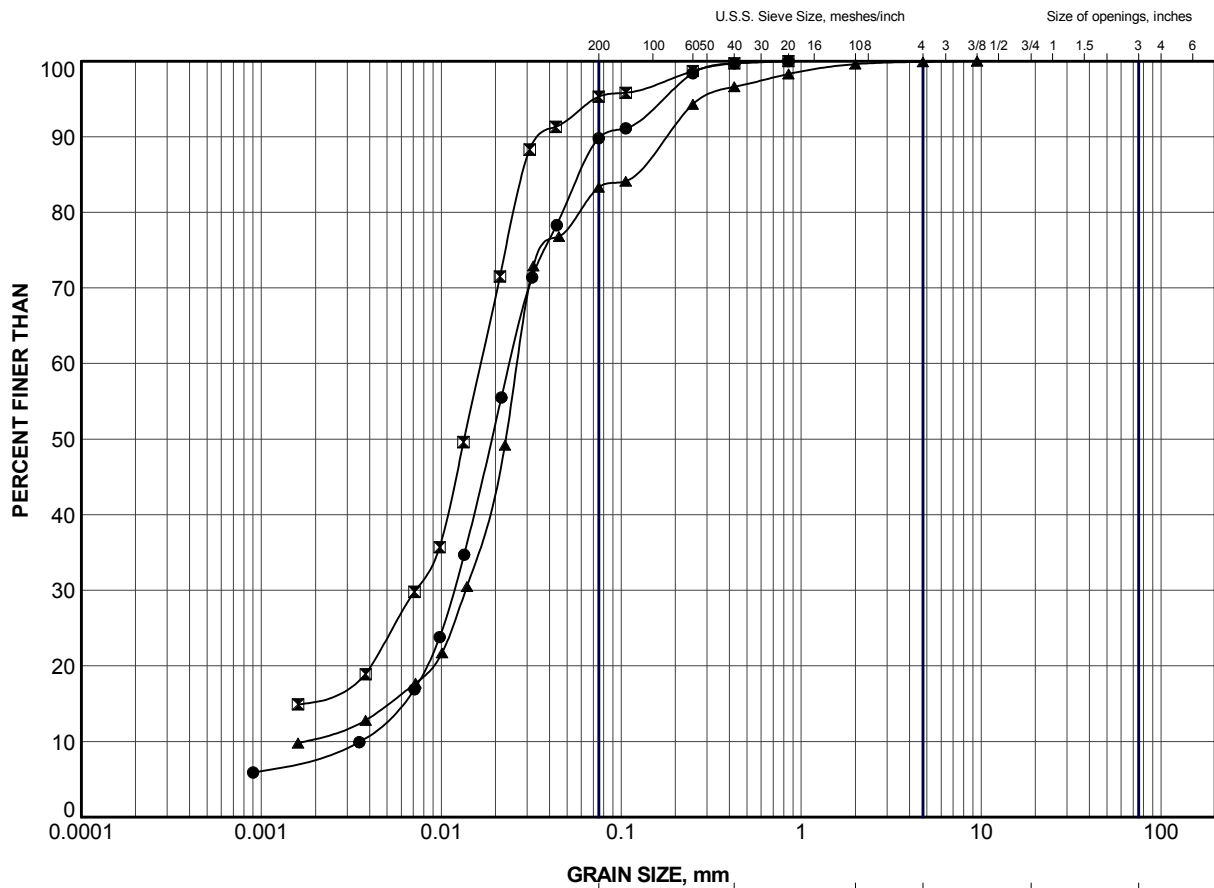
### LEGEND

| SYMBOL | BOREHOLE | SAMPLE | LL(%) | PL(%) | PI   |
|--------|----------|--------|-------|-------|------|
| ●      | SF-2     | 3      | 33.7  | 15.3  | 18.4 |
| ⊠      | SF-4     | 5      | 29.0  | 13.6  | 15.4 |

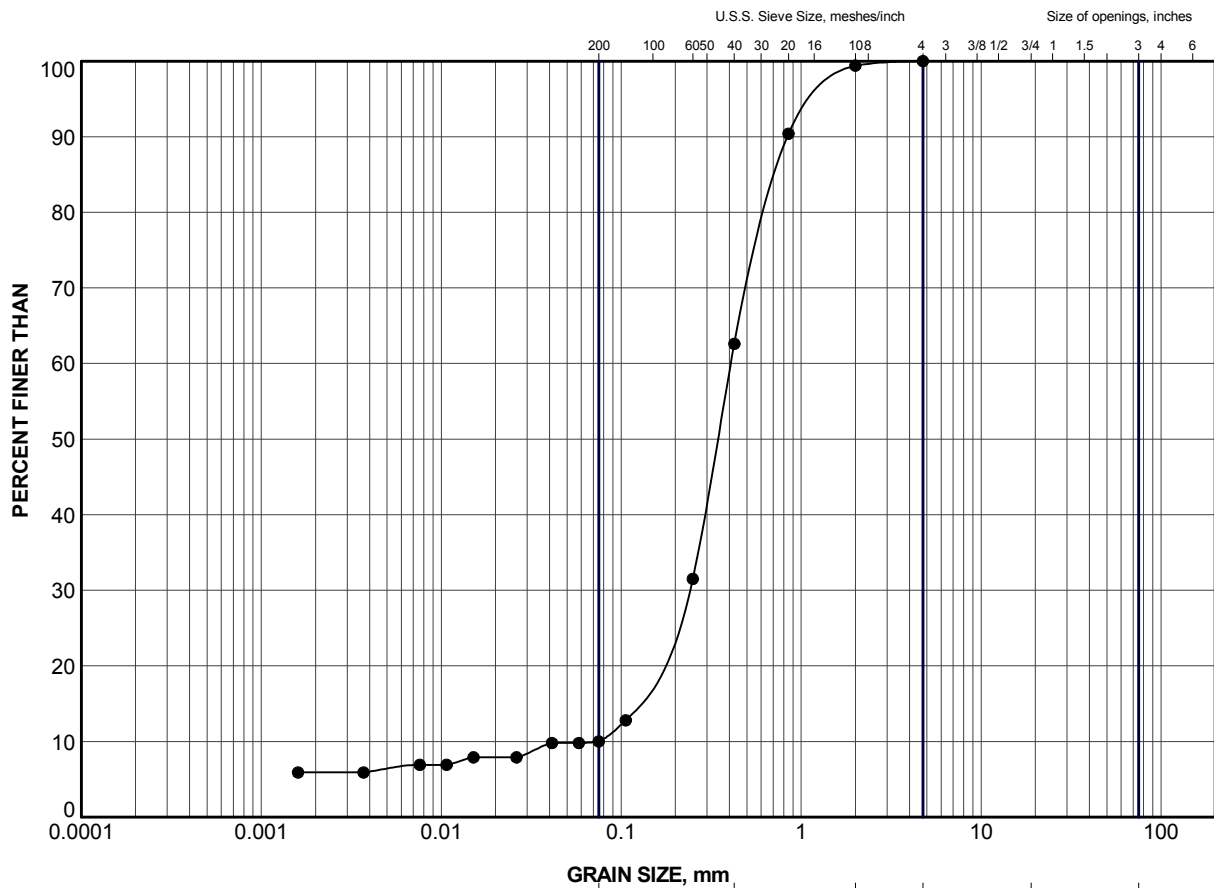
|   |     |          |                      |     |      |
|---|-----|----------|----------------------|-----|------|
| PROJECT                                     |     |          |                      |     |      |
| HIGHWAY 652<br>SOUTH FLOODWOOD RIVER BRIDGE |     |          |                      |     |      |
| TITLE                                       |     |          |                      |     |      |
| PLASTICITY CHART<br>CLAYEY SILT             |     |          |                      |     |      |
| PROJECT No.                                 |     |          | FILE No. 1651997.GPJ |     |      |
| DRAWN                                       | JJL | Dec 2017 | SCALE                | N/A | REV. |
| CHECK                                       | DAM | Dec 2017 | FIGURE B3            |     |      |
| APPR  | JPD | Dec 2017 |                      |     |      |












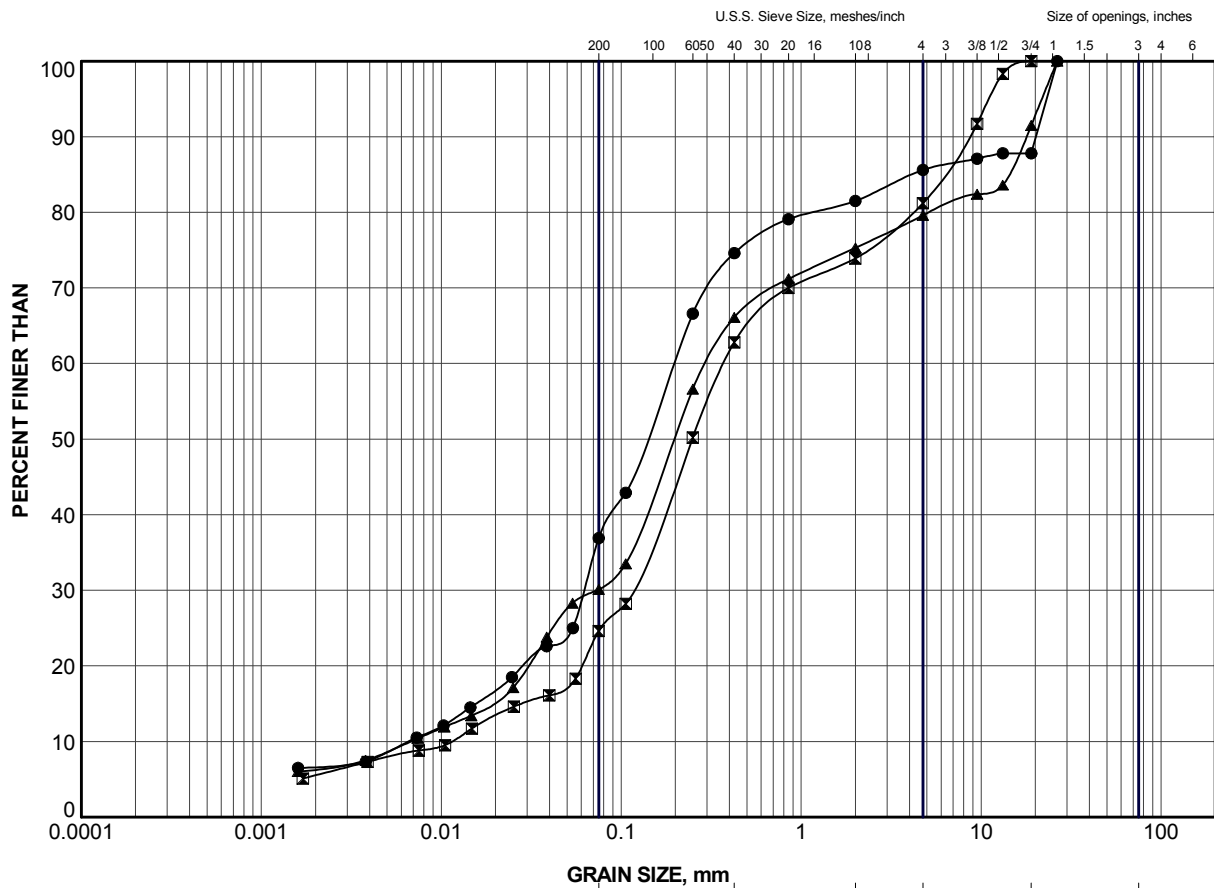
|               |           |        |        |             |        |                |
|---------------|-----------|--------|--------|-------------|--------|----------------|
| CLAY AND SILT | fine      | medium | coarse | fine        | coarse | Cobble<br>Size |
|               | SAND SIZE |        |        | GRAVEL SIZE |        |                |

### LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|----------|--------|----------|
| ●      | SF-2     | 10     | 271.7    |

|   |  |  |  |  |  |   |     |          |                      |     |      |
|---|--|--|--|--|--|---|-----|----------|----------------------|-----|------|
| PROJECT   |  |  |  |  |  | HIGHWAY 652<br>SOUTH FLOODWOOD RIVER BRIDGE |     |          |                      |     |      |
| TITLE   |  |  |  |  |  | GRAIN SIZE DISTRIBUTION<br>SAND             |     |          |                      |     |      |
|  <b>Golder Associates</b><br>SUDBURY, ONTARIO |  |  |  |  |  | PROJECT No.                                 |     |          | FILE No. 1651997.GPJ |     |      |
|   |  |  |  |  |  | DRAWN                                       | JJL | Dec 2017 | SCALE                | N/A | REV. |
|   |  |  |  |  |  | CHECK                                       | DAM | Dec 2017 | <b>FIGURE B5</b>     |     |      |
|   |  |  |  |  |  | APPR  | JPD | Dec 2017 |                      |     |      |





| GRAIN SIZE, mm |           |        |        |             |        |             |
|----------------|-----------|--------|--------|-------------|--------|-------------|
| CLAY AND SILT  | fine      | medium | coarse | fine        | coarse | Cobble Size |
|                | SAND SIZE |        |        | GRAVEL SIZE |        |             |

### LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|----------|--------|----------|
| ●      | SF-2     | 13     | 267.0    |
| ■      | SF-4     | 8      | 272.2    |
| ▲      | SF-4     | 13     | 264.6    |

PROJECT

HIGHWAY 652  
SOUTH FLOODWOOD RIVER BRIDGE

TITLE

**GRAIN SIZE DISTRIBUTION**  
GRAVELLY SILTY SAND to SILTY SAND (TILL)



**Golder Associates**  
SUDBURY, ONTARIO

|             |     |          |                      |     |      |
|-------------|-----|----------|----------------------|-----|------|
| PROJECT No. |     |          | FILE No. 1651997.GPJ |     |      |
| DRAWN       | JJL | Dec 2017 | SCALE                | N/A | REV. |
| CHECK       | DAM | Dec 2017 | <b>FIGURE B6</b>     |     |      |
| APPR        | JPD | Dec 2017 |                      |     |      |



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[solutions@golder.com](mailto:solutions@golder.com)  
[www.golder.com](http://www.golder.com)

**Golder Associates Ltd.**  
**33 Mackenzie Street, Suite 100**  
**Sudbury, Ontario, P3C 4Y1**  
**Canada**  
**T: +1 (705) 524 6861**

